THE INTERNATIONAL TELEGRAPH AND TELEPHONE CONSULTATIVE COMMITTEE
(C.C.I.T.T.)

FIFTH PLENARY ASSEMBLY

GENEVA, 4 - 15 DECEMBER 1972

GREEN BOOK

VOLUME VIII

Data transmission

Published by
THE INTERNATIONAL TELECOMMUNICATION UNION
1973

THE INTERNATIONAL TELEGRAPH AND TELEPHONE CONSULTATIVE COMMITTEE

(C.C.I.T.T.)

FIFTH PLENARY ASSEMBLY

GENEVA, 4-15 DECEMBER 1972

GREEN BOOK

VOLUME VIII

Data transmission

Published by
THE INTERNATIONAL TELECOMMUNICATION UNION
1973

CONTENTS OF THE C.C.I.T.T. BOOKS APPLICABLE AFTER THE FIFTH PLENARY ASSEMBLY (1972)

GREEN BOOK

Volume I — Minutes and reports of the Fifth Plenary Assembly of the C.C.I.T.T.
— Resolutions and opinions issued by the C.C.I.T.T.
— General table of Study Groups and Working Parties for the period 1973-1976.
— Summary table of questions under study in the period 1973-1976.
— Recommendations (Series A) on the organization of the work of the C.C.I.T.T.
— Recommendations (Series B) relating to means of expression.
— Recommendations (Series C) for general telecommunication statistics.

Volume II A — Recommendations (Series D) and Questions (Study Group III) relating to the lease of circuits.
— Recommendations (Series E) and Questions (Study Group II) relating to telephone operation and tariffs.

Volume II B — Recommendations (Series F) and Questions (Study Group I) relating to telegraph operation and tariffs.

Volume III — Recommendations (Series G, H and J) and Questions (Study Groups XV, XVI, Special Study Groups C and D) relating to line transmission.

Volume IV — Recommendations (Series M, N, and O) and Questions (Study Group IV) relating to the maintenance of international lines, circuits and chains of circuits.

Volume V — Recommendations (Series P) and Questions (Study Group XII) relating to telephone transmission quality, local networks, telephone sets equipment.

Volume VI — Recommendations (Series Q) and Questions (Study Groups XI and XIII) relating to telephone signalling and switching.

Volume VII — Recommendations (Series R, S, T and U) and Questions (Study Groups VIII, IX, X and XIV) relating to telegraph technique.

Volume VIII — Recommendations (Series V and X) and Questions (Study Group VII and Special Study Group A) relating to data transmission.

Volume IX — Recommendations (Series K) and Questions (Study Group V) relating to protection against interference.
— Recommendations (Series L) and Questions (Study Group VI) relating to the protection of cable sheaths and poles.

Each volume also contains, where appropriate:

— Definitions of the specific terms used in the field of this volume;

— Supplements for information and documentary purposes.

TABLE OF CONTENTS
OF C.C.I.T.T. GREEN BOOK, VOLUME VIII

DATA TRANSMISSION

	Page
Recommendation A.20	5
Definitions	7
Series V Recommendations	43
Series X Recommendations	181
Questions for study by Special Study Group A	219
Questions for study by Study Group VII	271
Supplements to Volume VIII	293

INTRODUCTORY NOTE

To lighten the text of the Recommendations in this Volume, the term " Administration " has been used as a brief designation for both a telecommunication Administration and a recognized private operating Agency.

PAGE INTENTIONALLY LEFT BLANK

PAGE LAISSEE EN BLANC INTENTIONNELLEMENT

Recommendation A.20

COLLABORATION WITH OTHER INTERNATIONAL ORGANIZATIONS OVER DATA TRANSMISSION

(Geneva, 1964, revised at Mar del Plata, 1968, and at Geneva, 1972)

The C.C.I.T.T.,

considering

that, according to Article 1 of the agreement between the United Nations and the International Telecommunication Union, the United Nations recognizes the International Telecommunication Union as the specialized agency responsible for taking such action as may be appropriate under its basic instrument for the accomplishment of the purposes set forth therein;

that Article 4 of the International Telecommunication Convention states that the purposes of the Union are:

a) to maintain and extend international co-operation for the improvement and rational use of telecommunications of all kinds;

b) to promote the development of technical facilities and their most efficient operation with a view to improving the efficiency of telecommunication services, increasing their usefulness and making them, so far as possible, generally available to the public;

that Article 30 of the Convention states that, in furtherance of complete international co-ordination on matters affecting telecommunication, the Union shall co-operate with international organizations having related interests and activities;

that in the study of data transmission the C.C.I.T.T. has to collaborate with the organizations dealing with data processing and particularly the International Organization for Standardization (I.S.O.) and the International Electrotechnical Commission (I.E.C.);

that this collaboration has to be organized in a manner that will avoid duplication of work and decisions that would be contrary to the principles set out above,

unanimously declares the view

that international standards for data transmission should be established with the following considerations in mind:

1. Clearly it will be the responsibility of the C.C.I.T.T. to lay down standards for *transmission channels*, i.e. aspects of data transmission which require a knowledge of telecommunication networks or affect performance of these networks.

2. The standardization of signal conversion terminal equipment (modems) is the province of the C.C.I.T.T.; the standardization of the junction (interface) between modem and the data terminal equipment is a matter for agreement between the C.C.I.T.T. and the I.S.O. or the I.E.C.

3. Devices designed to detect and (or) correct errors must take account of:

— the error rate tolerable to the user;
— the line transmission conditions;
— the code, which has to meet the exigencies of the data alphabet and the requirements of error-control (this must be such as to give an output satisfactory to the user) together with the requisite signalling (synchronism, repetition signals, etc.).

Standardization here may not come wholly within the C.C.I.T.T.'s province, but the C.C.I.T.T. has very considerable interests at stake.

4. The alphabet (definition 52.02 in the *List of definitions*) is a " table of correspondence between an agreed set of characters and the signals which represent them ".

The C.C.I.T.T. and the I.S.O. reached agreement on an alphabet for general (but not exclusive) use for data and message transmission and have standardized a common alphabet which is known as International Alphabet No. 5 (C.C.I.T.T. Recommendation V.3) (ISO/646-1972: seven-bit coded character sets for information processing interchange).

Complementary study of some control characters of the alphabet should be effected in co-operation with each other.

5. Coding (definition 52.05 in the *List of definitions*) is " a system of rules and conventions according to which the telegraph signals forming a message or the data signals forming a block should be formed, transmitted, received and processed." Hence, it consists of a transformation of the format of the signals in the alphabet for taking account of synchronous methods, and introduction of redundancy in accordance with the error-control system. This is not a field in which the C.C.I.T.T. alone may be able to decide; however, no decision should be taken without reference to the Committee, because of the possible restrictions which transmission and switching peculiarities may impose on coding.

When the general switched network is used (telephone or telex) and when the error-control devices are subject to restrictions (switching signals—reserved sequences), it is the C.C.I.T.T. which is in fact responsible for any necessary standardization in conjunction with other bodies.

6. The limits to be observed for transmission performance on the transmission path (modem included) fall within the competence of the C.C.I.T.T.; the limits for the transmission performance of the sending equipment and the margin of terminal data equipment (depending on the terminal apparatus and the transmission path limits) should be fixed by agreement between the I.S.O. and the C.C.I.T.T.

7. In all instances, the C.C.I.T.T. alone can lay down manual and automatic operating procedures for the setting-up, holding and clearing of calls for data communications when the general switched network is used, including type and form of signals to be interchanged at the interface between data terminal equipment and data circuit-terminating equipment.

LIST OF DEFINITIONS OF ESSENTIAL TECHNICAL TERMS IN THE FIELD OF TELEGRAPHY AND DATA TRANSMISSION APPLICABLE AFTER THE FIFTH PLENARY ASSEMBLY

Series	Title	Page
02	General transmission processes	8
31	General alphabetic telegraphy: codes, alphabets, signals, modulation	11
32	Telegraph channels	14
33	Quality of telegraph transmission Telegraph distortion	18
34	Apparatus for alphabetic telegraphy	21
35	Telegraph switching	24
52	Definitions involving both telegraphy and data transmission	25
53	Definitions of special concern in data transmission	32

* = Amended definition.
** = New definition.

L.D. = *List of definitions of essential telecommunication terms (Yellow Book)*, part I.

sup. 1 = 1st supplement to part I of the *List of definitions of essential telecommunication terms.*

sup. 2 = 2nd supplement to part I of the *List of definitions of essential telecommunication terms.*

SERIES 02. GENERAL TRANSMISSION PROCESSES

No.	Terms	Definition to be found in
02.01	a) *(electric) circuit* b) ... *circuit (specific function)*	L.D.
02.02	*channel*	L.D.
** 02.021 (32.34)	*multiplex* *multichannel*	sup. 2 (51.05)
** 02.022 (32.35)	*time-division multiplex*	sup. 2 (51.06)
** 02.023 (32.36)	*frequency-division multiplex*	sup. 2 (51.07)
** 02.024 (32.361)	*frequency-derived channel*	sup. 2 (51.08)
** 02.025 (32.351)	*time-derived channel*	sup. 2 (51.09)
02.03	*(telecommunication) circuit*	L.D.
02.04	*two-wire circuit*	L.D.
02.05	a) *four-wire circuit* b) *four-wire type circuit*	L.D.
02.06	*telephone circuit*	L.D.
02.07	*telegraph circuit*	L.D.
02.08	*hypothetical reference circuit* [nominal maximum circuit]	L.D.
* 02.09	*line* 1) The portion of a circuit external to the apparatus, consisting of the conductors connecting a telegraph set or telephone set or data circuit-terminating equipment to the exchange or connecting two exchanges. 2) The group of conductors on the same overhead route or in the same cable.	
02.10	*radio link*	L.D.
02.11	*radio circuit*	L.D.
02.12	*land-line extension (to a radio-link)* *trunk circuit connected to a radio circuit* (G.B., Am)	L.D.
02.13	*transducer*	L.D.
02.14	*active transducer*	L.D.
02.15	*passive transducer*	L.D.
02.16	*linear transducer*	L.D.
02.17	*ideal transducer* (for connecting a specific source to a specified load) (G.B.)	L.D.
02.18	*instantaneous frequency*	L.D.
02.19	*natural frequency*	L.D.

No.	Terms	Definition to be found in
02.20	*passband*	L.D.
** 02.201	*channel passband*	sup. 2 (51.01)
02.21	*spectrum*	L.D.
02.22	*audio-frequency*	L.D.
02.23	*voice-frequency* *telephone-frequency*	L.D.
02.24	a) *sub-audio frequency* b) *sub-telephone frequency* *[sub-audio frequency]*	L.D.
02.25	a) *super-audio frequency* b) *super-telephone frequency* *[super-audio frequency]*	L.D.
02.26	*frequency translation* (of a channel or group of channels) (G.B.)	L.D.
02.27	*signal* (general sense)	L.D.
** 02.271	*basic signal*	sup. 2 (51.02)
02.28	*modulation*	L.D.
02.29	*modulation products*	L.D.
02.30	*carrier* *carrier wave* *carrier current*	L.D.
02.31	*sideband*	L.D.
02.32	*modulation frequency* *modulating frequency*	L.D.
02.33	*double modulation*	L.D.
02.34	*anode modulation*	L.D.
02.35	*over-modulation*	L.D.
02.36	*main sideband* (G.B.) *transmitted sideband* (Am)	L.D.
02.37	*vestigial sideband*	L.D.
** 02.371	*vestigial sideband transmission*	sup. 2 (51.03)
** 02.372	*asymmetric sideband transmission* *transmission with partial sideband suppression*	sup. 2 (51.04)
02.38	*demodulation*	L.D.
02.39	*detection*	L.D.
02.40	*linear detection*	L.D.
02.41	*square law detection*	L.D.
02.42	*modulation percentage* (of an amplitude-modulated wave); *modulation factor*	L.D.
02.43	*frequency swing*	L.D.
02.44	*frequency deviation*	L.D.
02.45	*modulation index*	L.D.
02.46	*deviation ratio*	L.D.
02.47	*discrimination*	L.D.
02.48	*frequency discrimination*	L.D.
02.49	*feedback*	L.D.

No.	Terms	Definition to be found in
02.50	*negative feedback*	L.D.
02.51	*pre-emphasis*	L.D.
02.52	*de-emphasis*	L.D.
02.53	*coupling*	L.D.
02.54	*coupling coefficient*	L.D.
02.55	*automatic volume range regulator*	L.D.
02.56	*automatic gain-control*	L.D.
02.57	*forward-acting regulator* (Am)	L.D.
02.58	*backward-acting regulator* (Am)	L.D.
02.59	*vogad* (Am) *No English term* (G.B.)	L.D.
02.60	*compressor* *automatic volume-contractor* (G.B.)	L.D.
02.61	*expander* (G.B.) *automatic volume-expander* (G.B.) *expandor* (Am)	L.D.
02.62	*compandor*	L.D.
02.63	*audio-frequency peak limiter*	L.D.
02.64	*singing suppressor*	L.D.
** 02.65 (32.391)	*clock*	sup. 2 (51.10)

SERIES 31. GENERAL ALPHABETIC TELEGRAPHY: CODES, ALPHABETS, SIGNALS, MODULATION

No.	Terms	Definition to be found in
** 31.01 (52.01)	*character* 1. A printed symbol such as a letter, figure, punctuation sign and, by extension, a non-printing function such as a space shift, carriage return or line feed contained in a message. 2. Information corresponding to such a symbol or function.	
** 31.011	*telegraph signal* A signal representing all or part of one or more telegraph messages.	
** 31.012 (52.03)	*character signal* A set of signal elements representing a character or in PCM the quantized value of a sample. *Note.* — In PCM, the term "PCM word" may be used in this sense.	
* 31.02 (52.04)	*signal element*	sup. 2
31.03	*telegraph signal element* (in alphabetic system)	L.D.
31.04	*alphabetic signal*	L.D.
31.05	*start signal* (in a start-stop system)	L.D.
31.06	*stop signal* (in a start-stop system)	L.D.
* 31.07 (52.05)	*code (telegraph or data)*	sup. 2
** 31.071 (52.06)	*redundant code*	sup. 2
* 31.08 (52.02)	*alphabet (telegraph or data)*	sup. 2
31.10	*equal-length code*	L.D.
31.11	*five-unit code*	L.D.
* 31.12 (52.54)	*code conversion* Automatic conversion of character signals or groups of character signals in one code into corresponding signals or groups of signals in another code.	
(31.13)	*modulation*	cancelled
* 31.14 (52.07)	*telegraph modulation*	sup. 2

No.	Terms	Definition to be found in
* 31.15 (52.09)	*restitution*	sup. 2
31.16	*"semator" (no English equivalent)*	L.D.
31.17	*signal-train ("semateme" not used in English)*	L.D.
31.18	*"sémation" (no English equivalent)*	L.D.
31.19	*modulation (or restitution) element*	L.D.
* 31.20 (52.08)	*significant condition of a (telegraph) modulation*	sup. 2
(31.21)	*significant conditions of a restitution*	cancelled
* 31.22 (52.11)	*significant interval*	sup. 2
** 31.221 (52.115)	*minimum interval*	sup. 2
31.23	*theoretical duration of a significant interval (of modulation or of restitution)*	L.D.
* 31.24 (52.10)	*significant instants*	sup. 2
31.25	*restitution delay*	L.D.
** 31.251 (52.12)	*telegraph modulator*	sup. 2
** 31.252 (52.13)	*telegraph demodulator*	sup. 2
31.26 (52.116)	*unit interval* *signal element* (Am)	L.D.
31.27	*modulation rate* *[telegraph speed]*	L.D.
31.28	*baud*	L.D.
* 31.29 (52.14)	*isochronous transmission* A transmission process such that between any two significant instants there is always an integral number of unit intervals.	
** 31.291 (52.15)	*anisochronous transmission* A transmission process such that between any two significant instants in the same group[1], there is always an integral number of unit intervals. Between two significant instants located in different groups, there is not always an integral number of unit intervals. [1] In data transmission this group is a block or a character; in telegraphy this group is a character.	
** 31.292 (52.16)	*serial transmission*	sup. 2

No.	Terms	Definition to be found in
** 31.293 (52.17)	*parallel transmission* The simultaneous transmission of code elements constituting one or more character signals.	
31.30	*start-stop modulation (or restitution)*	L.D.
31.31	*auxiliary conditions of a modulation*	L.D.
31.32	*curbed modulation*	L.D.
31.33	*earthing percentage*	L.D.
31.34	*marking percentage*	L.D.
31.35	*number of significant conditions (of a modulation or a restitution)*	L.D.
31.36	*"travail"; "repos"* Designation of the two significant conditions of a binary modulation (or restitution)	L.D.
31.37	*marking; spacing* *mark; space*	L.D.
31.38	*position A; position Z*	L.D.
31.39	*unit element*	L.D.
31.40	*code elements* *unit*	L.D.
31.41	*... sequential; coincident (signal elements)*	L.D.
31.42	*Morse code*	L.D.
31.43	*Morse dot*	L.D.
31.44	*Morse dash*	L.D.
31.45	*Morse space*	L.D.
31.46	*cable code*	L.D.
31.47	*two-condition cable code* *[double current cable code (DCCC/DC)]*	L.D.
31.48	*three-condition cable code* *cable Morse code* (Am)	L.D.

SERIES 32. TELEGRAPH CHANNELS

No.	Terms	Definition to be found in
* 32.01 (52.18)	*(telegraph) channel* *telegraph channel* (Am)	

The transmission media and intervening apparatus involved in the transmission of telegraph signals in a given direction, between two terminal sets or, more generally, between two intermediate telegraph installations.

A means of one-way transmission of telegraph signals.

A telegraph channel is characterized by the number of significant conditions and by the modulation rate it is designed to transmit.

Example: a 50-baud channel for two-condition modulation.

Notes:

1. Separate telegraph channels can have common constituent parts (e.g. side and phantom circuits) or share a common path (as in the case of a multiplex).

2. When it is a question of a channel between two terminal sets, it can be referred to as a *complete telegraph channel.*

3. A retransmitter with storage of signals is considered a terminal set and terminates a complete channel.

4. A complete channel may include regenerative repeaters (without storage).
A channel not including any regenerative repeater is called an *ordinary channel.*

* 32.02 (52.19) *(telegraph) circuit*
telegraph channel (Am)

A means of both-way communication between two points comprising associated " send " and " receive " channels.

The two associated channels may be symmetrical (that is to say, they may offer users the same possibilities in either direction of transmission), or, on the other hand, asymmetrical.

Example of a symmetrical telegraph channel: the two channels together making one standardized voice-frequency telegraph circuit.

Example of an asymmetrical telegraph circuit: for data transmission, a channel offering a rate of 1200 bauds in one direction, associated with a channel offering only 100 bauds in the other direction.

Note 1. — The circuit includes the signal conversion equipment in the case of data transmission.

Note 2. — Notes 1, 2, 3 and 4 of 32.01 apply to definition 32.02, *mutatis mutandis.*

No.	Terms	Definition to be found in
** 32.021	*frequency channel* A channel essentially characterized by its passband (definition 02.20). This passband is designated by its upper and lower frequencies. Should the channel be made up by joining several sections in tandem its passband is that which will result from the whole. Several frequency channels may share a common path, as in carrier systems; in which case each frequency channel is characterized by a particular frequency band reserved to it.	
32.03	*(transmission) link*	L.D.
32.04	*(physical) extension circuit* *[tail]*	L.D.
32.05	*local line*	L.D.
32.06	*(telegraph) repeater*	L.D.
32.07	*converter*	L.D.
32.08	*code converter*	L.D.
32.09	*broadcast (telegraph) repeater*	L.D.
32.10	*conference (telegraph) repeater*	L.D.
32.11	*regenerative repeater*	L.D.
32.12	*direct-current transmission*	L.D.
32.13	*single-current transmission* *(inverse) neutral direct current system* (Am)	L.D.
32.14	*double-current transmission* *polar direct-current system* (Am)	L.D.
32.15	*open-circuit working*	L.D.
32.16	*closed-circuit working*	L.D.
32.17	*simplex (circuit)*	L.D.
32.18	*duplex (circuit)*	L.D.
32.19	*differential duplex (system)*	L.D.
32.20	*bridge duplex (system)*	L.D.
32.21	*incremental duplex*	L.D.
32.22	*opposition duplex*	L.D.
32.23	*half duplex (circuit)*	L.D.
32.24	*... diplex*	L.D.
32.25	*two-way simplex ...*	L.D.

No.	Terms	Definition to be found in
32.26	*one way (connection)* *unidirectional*	L.D.
32.27	*duplex, two-way simplex (connection)*	L.D.
32.28	*carrier telegraphy* *carrier current telegraphy*	L.D.
* 32.29 (52.20)	*amplitude modulation*	sup. 2
* 32.30 (52.21)	*frequency modulation*	sup. 2
** 32.301 (52.22)	*phase modulation*	sup. 2
** 32.302 (52.24)	*phase-inversion modulation*	sup. 2
** 32.303 (52.25)	*differential modulation*	sup. 2
** 32.304 (52.26)	*modulation with a fixed reference*	sup. 2
** 32.305 (52.27)	*modulation coherence*	sup. 2
** 32.306 (52.28 and 53.30)	*bit error rate* *element error rate* *character error rate* *block error rate*	sup. 2
* 32.31 (52.23)	*frequency shift signalling* *frequency shift keying (F.S.K.)*	sup. 2
(32.32)	*frequency-exchange signalling*	cancelled
32.33	*sub-carrier frequency modulation*	L.D.
* 32.34 (02.021)	*multiplex* *multichannel*	sup. 2 (51.05)
* 32.35 (02.022)	*time-division multiplex*	sup. 2 (51.06)
** 32.351 (02.025)	*time-derived channel*	sup. 2 (51.09)
32.36	*frequency-division multiplex*	sup. 2 (51.07)
** 32.361 (02.024)	*frequency-derived channel*	sup. 2 (51.08)
32.37	*voice-frequency multichannel telegraphy*	L.D.

No.	Terms	Definition to be found in
32.38	*voice-frequency multichannel system*	L.D.
32.39	*arm* *sector*	L.D.
** 32.391 (02.65)	*clock*	sup. 2 (51.10)
32.40	*multi-tone circuit*	L.D.
32.41	*two-tone telegraph system* *two-tone keying*	L.D.
32.42	*four-tone telegraph system*	L.D.
32.43	*varioplex*	L.D.
32.44	*omnibus (telegraph) system* *way circuit* (Am)	L.D.
32.45	*echelon telegraphy* *extended telegraph circuit*	L.D.
32.46	*forked working*	L.D.
32.47	*superposed circuit* *[by-product circuit]*	L.D.
32.48	*composited circuit*	L.D.
32.49	*phantom telegraph circuit*	L.D.
32.50	*earth-return phantom circuit*	L.D.
32.51	*earth-return double circuit*	L.D.
32.52	*double phantom balanced telegraph circuit*	L.D.
32.53	*sub-audio telegraphy*	L.D.
32.54	*super-audio telegraphy*	L.D.
32.55	*interband telegraphy*	L.D.
32.56	*intraband telegraphy* *[simultaneous telegraphy and telephony]*	L.D.
32.57	*speech plus simplex (equipment)* *S+S (equipment)*	L.D.
32.58	*speech plus duplex (equipment)* *S+D (equipment)*	L.D.
32.59	*static relay* *static modulator*	L.D.
32.60	*telegraph magnifier*	L.D.
32.61	*(v.f.t.) reserve circuit* *fall back circuit* (Am)	L.D.
32.62	*(engineering, traffic) speaker circuit*	L.D.

SERIES 33. QUALITY OF TELEGRAPH TRANSMISSION TELEGRAPH DISTORTION

No.	Terms	Definition to be found in
33.01	*perfect modulation (or restitution)*	L.D.
* 33.02	*ideal instants of a modulation (or of a restitution)* Instants with which the significant instants would coincide in certain conditions. It will be necessary to indicate, in each particular case, how these ideal instants are determined. a) *Start-stop modulation* The ideal instant of a start element is the instant at which this element begins. The ideal instant of each of the other elements is *n* times the theoretical unit interval later than the ideal instant of the start element of the same signal, *n* being the rank of this element in the signal. The standardized unit interval should be taken as the theoretical unit interval. The interval corresponding to the real mean modulation rate can also be taken, provided that it is specified. The instant corresponding to the beginning of the start element of a signal should be known as the *reference ideal instant* for this signal. b) *Isochronous modulation* An ideal reference instant can be chosen arbitrarily. All the others are deduced from it by intervals equal to the corresponding theoretical significant intervals. In the absence of any other deciding reason, the reference ideal instant shall be chosen so that the mean value of the deviations with respect to it is equal to zero.	
33.03	*incorrect modulation (or restitution)* *[defective modulation (or restitution)]*	L.D.
* 33.04 (52.61)	*telegraph distortion (of a modulation or a restitution)* 1. A modulation (or restitution) suffers from telegraph distortion when the significant intervals have not all exactly their theoretical durations. 2. A modulation (or restitution) is affected by telegraph distortion when significant instants do not coincide with the corresponding theoretical instants.	
33.05	*displacement (region)* *spread*	L.D.
33.059	*transmitter distortion*	sup. 1
33.06 (52.62)	*degree of individual distortion of a particular significant instant (of a modulation or of a restitution)*	L.D.

No.	Terms	Definition to be found in
* 33.07 (52.63)	*degree of isochronous distortion* 1. Ratio to the unit interval of the maximum measured difference, irrespective of sign, between the actual and the theoretical intervals separating any two significant instants of modulation (or of restitution), these instants being not necessarily consecutive. 2. Algebraical difference between the highest and the lowest values of individual distortion affecting the significant instants of an isochronous modulation. (This difference is independent of the choice of the reference ideal instant.) The degree of distortion (of an isochronous modulation or restitution) is usually expressed as a percentage. *Note.* — The result of the measurement should be completed by an indication of the period, usually limited, of the observation. For a prolonged modulation (or restitution) it will be appropriate to consider the probability that an assigned value of the degree of distortion will be exceeded. In accordance with definition 31.23, in practical measurements the unit interval and the theoretical significant intervals considered are those corresponding to the actual average rate of modulation.	
* 33.08	*degree of start-stop distortion* a) Ratio to the unit interval of the maximum measured difference, irrespective of sign, between the actual and theoretical intervals separating any significant instant of modulation (or of restitution) from the significant instant of the start element immediately preceding it. b) The highest absolute value of individual distortion affecting the significant instants of a start-stop modulation. The degree of distortion of a start-stop modulation (or restitution) is usually expressed as a percentage. *Note 1.* — Same as the note to definition 33.07. *Note 2.* — Distinction can be made between the degree of *late* (or positive) distortion and the degree of *early* (or negative) distortion. *Note 3.* — The theoretical intervals are related to the mean actual incoming modulation rate and not necessarily to the nominal modulation rate.	
* 33.09 (52.64)	*degree of gross start-stop distortion* Degree of distortion determined when the unit interval and the theoretical intervals assumed are exactly those appropriate to the nominal modulation rate. *Note:* As for definition 33.07.	
33.10 (52.65)	*degree of synchronous start-stop distortion (i.e. at the actual mean modulation rate)*	L.D.
33.11	*degree of distortion in service*	L.D.

No.	Terms	Definition to be found in
33.12	*degree of standardized test distortion*	L.D.
33.13 (52.66)	*degree of inherent distortion (of a channel)*	L.D.
33.14	*conventional degree of distortion*	L.D.
33.15	*characteristic distortion*	L.D.
33.16	*fortuitous distortion*	L.D.
33.17	*bias distortion* *asymmetrical distortion*	L.D.
33.18	*cyclic distortion*	L.D.
33.19	*error rate of a telegraph communication*	L.D.+sup. 1
33.191	*mutilation rate*	sup. 1
33.20	*error rate of keying*	L.D.
33.21	*error rate of a translation*	L.D.
33.22	*quality index of a channel or of a telegraph apparatus*	L.D.
33.23	*efficiency factor in time* (of a telegraph communication with automatic repetition for the correction of errors)	L.D.
33.24	*mutilation*	L.D.
33.25	*transposition*	L.D.
33.26	*controlling testing station (on a circuit)*	L.D.
33.27	*sub-control station*	L.D.
33.28	*system control station*	L.D.
33.29	*test section*	L.D.
33.30	*principal test section*	L.D.
33.31	*automatic repetition* *Verdan system*	L.D.
33.32	*precorrection*	L.D.
* 33.33 (52.30)	*error-detecting code*	sup. 2
* 33.34 (52.32)	*error-detecting and feedback system* *decision feedback system* *request repeat system* *ARQ system*	sup. 2
* 33.35 (52.33)	*error-correcting code*	sup. 2

SERIES 34. APPARATUS FOR ALPHABETIC TELEGRAPHY

No.	Terms	Definition to be found in
34.01	*translation*	L.D.
34.02	*selection*	L.D.
34.025	*local end (with its termination)*	sup. 1
* 34.03	*margin of a telegraph apparatus* (or of the local end with its termination) The maximum degree of distortion compatible with a correct translation when the signals are presented to a receiver under the most unfavourable conditions so far as the composition of the signals and of the distortion is concerned. The maximum degree of distortion which results in incorrect translation applies without reference to the form of distortion affecting the signals. In other words it is the maximum value of the most unfavourable distortion causing incorrect translation which determines the value of the margin.	
** 34.031 (52.68)	*net margin* The margin represented by the degree of distortion indicated in 34.03, when the rate of modulation applied to the apparatus is exactly equal to the standard theoretical rate.	
34.04	*effective margin*	sup. 1
34.05	*nominal margin*	sup. 1
34.06	*theoretical margin*	sup. 1
34.07 (52.67)	*margin of start-stop apparatus (or of the local end with its termination)*	sup. 1
(34.08)	*normal, or net-margin of start-stop apparatus*	cancelled
34.09	*synchronous margin*	sup. 1
** 34.091	*margin of a synchronous receiver* Margin, as defined in 34.03, when the degree of distortion taken into account is the degree of isochronous distortion.	
34.10	*printing telegraphy*	L.D.
34.11	*signal-recording telegraphy*	L.D.
34.12	*synchronous system*	L.D.
34.13	*start-stop system*	L.D.
34.14	*start-stop apparatus*	L.D.
34.15	*teleprinter* *teletypewriter* (Am)	L.D.

No.	Terms	Definition to be found in
34.16	*stepped start-stop system*	L.D.
34.17	*mosaic telegraphy*	L.D.
34.18	*Hellschreiber system*	L.D.
34.19	*Wheatstone automatic system*	L.D.
34.20	*duplex apparatus*	L.D.
34.21	*quadruplex system*	L.D.
34.22	*single needle system*	L.D.
34.23	*(telegraph) transmitter*	L.D.
34.24	*local record*	L.D.
34.25	*answer-back code*	L.D.
34.26	*answer-back unit*	L.D.
34.27	*automatic transmitter*	L.D.
34.28	*automatic transmitter with controlled tape-feed mechanism*	L.D.
34.29	*tape-reader* *tape-reading head*	L.D.
34.30	*automatic numbering transmitter*	L.D.
34.31	*cable code direct printer*	L.D.
34.32	*Morse or five-unit printer*	L.D.
34.33	*perforator*	L.D.
34.34	*keyboard perforator*	L.D.
34.35	*reperforator* *[receiving perforator]*	L.D.
34.36	*printing keyboard perforator*	L.D.
34.37	*printing-reperforator* *printer perforator* (Am)	L.D.
34.38	*chadless perforation*	L.D.
34.39	*coupled reperforator and tape reader* *F.R.X.D.* (Am) = *fully automatic reperforator transmitter distributor*	L.D.
34.40	*recording* *storage*	L.D.
34.41	*automatic retransmission*	L.D.
34.42	*automatic retransmitter*	L.D.

No.	Terms	Definition to be found in
34.43	*perforated-tape retransmitter*	L.D.
34.44	*synchronous correction*	L.D.
34.45	*correcting signal*	L.D.
34.46	*correction from signals*	L.D.
34.47	*orientation*	L.D.
34.48	*orientation range*	L.D.
34.49	*motorized keyboard*	L.D.
34.50	*saw-tooth keyboard*	L.D.
34.51	*storage keyboard*	L.D.
34.52	*shift-lock keyboard*	L.D.
34.53	*(case) shift*	L.D.
34.54	*letters-case*	L.D.
34.55	*figures-case*	L.D.
34.56	*unshift-on-space*	L.D.
34.57	*telegraph electro-magnet*	L.D.
34.58	*telegraph relay*	L.D.
34.59	*side-stable relay*	L.D.
34.60	*telegraph vibrating relay*	L.D.
34.61	*(telegraph) electronic relay*	L.D.
34.62	*(telegraph) rectifier relay*	L.D.
34.63	*siphon recorder*	L.D.
34.64	*undulator*	L.D.

SERIES 35. TELEGRAPH SWITCHING

No.	Terms	Definition to be found in
35.01	*switching centre*	L.D.
35.02	*sub-centre*	L.D.
35.03	*reperforator switching*	L.D.
35.04	*(fully) automatic reperforator switching*	L.D.
35.05	*semi-automatic reperforator switching* *push-button switching* (Am)	L.D.
35.06	*(teleprinter) keyboard selection* *[permutation code switching system]*	L.D.
35.07	*switching by means of equal-length code*	L.D.
35.08	*control unit, dialling unit, signalling unit*	L.D.
35.09	*concentrator*	L.D.
35.10	*overflow* *spill-over* (Am)	L.D.
35.11	*subscriber's line* *station line*	L.D.
35.12	*trunk (telegraph) circuit* *junction*	L.D.
35.13	*free circuit condition*	L.D.
35.14	*idle circuit condition*	L.D.
35.15	*calling signal*	L.D.
35.16	*call-confirmation signal*	L.D.
35.17	*proceed-to-select signal*	L.D.
35.18	*proceed-to-transmit signal*	L.D.
35.19	*call-connected signal*	L.D.
35.20	*clearing signal*	L.D.
35.21	*gentex*	L.D.

SERIES 52. DEFINITIONS INVOLVING BOTH TELEGRAPHY AND DATA TRANSMISSION

No.	Terms	Definition to be found in
* 52.01 (31.01)	*character*	31.01
** 52.011	*control character* *[service character]* A character whose occurrence in a particular context initiates, modifies or stops a control operation. Such a character may be recorded for use in a subsequent action; it may have a graphic representation in some circumstances.	
52.02 (31.08)	*alphabet (telegraph or data)*	sup. 2
* 52.03 (31.012)	*character signal*	31.012
52.04 (31.02)	*signal element*	sup. 2
52.05 (31.07)	*code (telegraph or data)*	sup. 2
52.06 (31.071)	*redundant code*	sup. 2
52.07 (31.14)	*telegraph modulation*	sup. 2
52.08 (31.20)	*significant condition of a (telegraph) modulation*	sup. 2
52.09 (31.15)	*restitution*	sup. 2
52.10 (31.24)	*significant instants*	sup. 2
52.11 (31.22)	*significant interval*	sup. 2
52.115 (31.221)	*minimum interval*	sup. 2
** 52.116 (31.26)	*unit interval*	L.D.
52.12 (31.251)	*telegraph modulator*	sup. 2
52.13 (31.252)	*telegraph demodulator*	sup. 2

No.	Terms	Definition to be found in
* 52.14 (31.29)	*isochronous transmission*	31.29
* 52.15 (31.291)	*anisochronous transmission*	31.291
52.16 (31.292)	*serial transmission*	sup. 2
** 52.161	*character-serial transmission* Transmission in which successive characters follow one another in sequence. *Note.* — The elements (bits) of each character may be transmitted serially (described as serial by bit and character) or simultaneously (described as parallel by bit, serial by character).	
** 52.162	*byte-serial transmission* Transmission in which successive bytes follow one another in sequence. *Note.* — The individual bits of each byte may be transmitted serially (described as serial by bit and byte) or simultaneously (described as parallel by bit, serial by byte).	
** 52.163	*bit-order of transmission* The property of a serial transfer of data which concerns the arrangement of digits, e.g. most significant digit [1] first, least significant digit first, or any other desired order [2].	
* 52.17 (31.293)	*parallel transmission*	31.293
* 52.18 (32.01)	*(telegraph) channel* *telegraph channel* (Am)	32.01
* 52.19 (32.02)	*(telegraph) circuit* *telegraph channel* (Am)	32.02
52.20 (32.29)	*amplitude modulation*	sup. 2
52.21 (32.30)	*frequency modulation*	sup. 2
52.22 (32.301)	*phase modulation*	sup. 2
52.23 (32.31)	*frequency shift signalling* *frequency shift keying (F.S.K.)*	sup. 2
52.24 (32.302)	*phase-inversion modulation*	sup. 2

[1] This term is defined by the I.S.O. as follows:
Significant digits
Those digits of a numeral which have meaning for a certain purpose; particularly those which must be kept to preserve a specific accuracy.

[2] The terms "high order bit first" or "lower order bit first" should be deprecated.

No.	Terms	Definition to be found in
52.25 (32.303)	*differential modulation*	sup. 2
52.26 (32.304)	*modulation with a fixed reference*	sup. 2
52.27 (32.305)	*modulation coherence*	sup. 2
52.28 (32.306 and 53.30)	*bit error rate* *element error rate* *character error rate* *block error rate*	sup. 2
52.29 (53.31)	*character check*	sup. 2
** 52.291	*cyclic code* A code in which every cyclic shift of a code word is itself a code word.	
** 52.292	*parity digit* An *n*-ary digit appended to an array of *n*-ary digits to make the sum modulo *n* of all the digits always equal to 0 or to any predetermined digit. In the case of the radix 2, parity digit becomes parity bit.	
52.30 (33.33)	*error-detecting code*	sup. 2
52.31	*error-detecting system*	sup. 2
52.32 (33.34)	*error-detecting and feedback system* *decision feedback system* *request repeat system* *ARQ system*	sup. 2
** 52.321	*data signal quality detection* *[analogue error detection]* Determination that a received data signal has departed from an acceptable form, based on criteria such as amplitude of signal, signal-to-noise ratio or telegraph distortion, without involving checks of the significance or the value of the restituted digital signal.	
** 52.322	*data signal quality detector* (see 52.321)	
52.33 (33.35)	*error-correcting code*	sup. 2
52.34	*error-correcting system*	sup. 2
52.35	*residual error-date* *undetected error-rate*	sup. 2
52.36	*track*	sup. 2

No.	Terms	Definition to be found in
** 52.37	*answer-back unit simulator* A device or programme routine, not a part of a teleprinter, but which performs the same function as the answer-back unit on receipt of a specific "who are you" signal.	
** 52.38	*centralized control signalling* The system of exchanging call control signals relating to a group of data transmission circuits by means of a transmission channel (or channels) dedicated to control signalling.	
** 52.39	*decentralized control signalling* The system of exchanging call control signals relating to a particular data transmission circuit by transmitting signals over that circuit.	
** 52.40	*call control signals* The entire set of signals necessary to establish, maintain and release a call.	
** 52.41	*selection signals* The sequence of characters which indicates all the information required to establish a call. The content of the sequence may be different in different parts of the network. *Note.* — The selection signals include the address and possibly additional network selection signals.	
** 52.42	*network selection signals* Those selection signals which indicate call control information other than the address which is required by the network for establishing a call.	
** 52.43	*address* The sequence of characters which indicates the destination of a call. These characters may have different representations in different parts of the network.	
** 52.44	*user service or facility* A user service or facility which is available on demand to users of the network.	
** 52.45	*circuit-switched connection* A connection which is established on demand between two or more DTE's giving the exclusive use of a data circuit and which is maintained until the connection is released.	
** 52.46	*packet-mode operation* *packet switching* The transmission of data by means of addressed packets whereby a transmission channel is occupied for the duration of transmission of the packet only. The channel is then available for use by packets being transferred between different data terminal equipments. *Note.* — In certain data communication networks the data may be formatted into a packet or divided and then formatted into a number of packets (either by the data terminal equipment or by equipment within the network) for transmission and multiplexing purposes.	

No.	Terms	Definition to be found in
** 52.47	*user class of service* The data signalling rate, transmission mode and code structure (if any) of the service which is provided.	
** 52.48	*closed user group* A number of users of a public switched data communication service who have the facility that they can communicate with one another but access is barred to and from all other users of the service. *Note 1.* — A special facility permitting a user in a closed user group to call any other user connected to a public switched data communication service or to any other network with which interworking is permitted, may be offered. This is termed "closed user group with outgoing access". Access to users of this facility is restricted to other members of the closed user group. *Note 2.* — A closed user group may incorporate the direct call or abbreviated address calling facilities.	
** 52.49	*direct call* A facility which avoids the need for use of an address. The network interprets the calling signal as an instruction to establish a connection with a single destination or group of destinations previously designated by the user. *Note.* — This facility may permit faster call set-up than usual. No special priority is implied over other users of the network in establishing a connection. The designated address(es) may be changed as required by means of a suitable procedure.	
** 52.50	*abbreviated address calling* A facility which enables a user to employ an address having fewer characters than the full address when initiating a call. *Note.* — Networks may allow a user to designate up to Y abbreviated address codes. The allocation of abbreviated address codes to a destination or group of destinations may be changed as required by means of a suitable procedure.	
** 52.51	*multi-address calling* A facility which permits a user to nominate more than one address for the sending of the same data. *Note 1.* — The network may undertake this by one of two distinct forms: a) Sequentially b) Simultaneously and if both forms are provided may allow the user to opt for a preferred form. *Note 2.* — The procedure for using this facility may i) be as defined for a direct call, or	

No.	Terms	Definition to be found in
	ii) use a special code or codes in the abbreviated address calling facility to designate all the required destinations, or iii) indicate the individual full or abbreviated address of each user to which data are to be transmitted. *Note 3.* — This facility may also be used in association with the delayed delivery facility.	
** 52.52	*bit sequence independence* A facility which enables the transfer of digital data in the form of a sequence of binary digits from one user to another without placing any restriction upon the sequence of the binary digits. *Note.* — This implies that an indefinitely long string of consecutive binary ones or zeros is admitted in the data signal.	
** 52.53	*delayed delivery* A facility which employs storage within the data network whereby data from a user destined for delivery to one or more addresses may be held for subsequent delivery at a later time. *Note.* — Two modes may be required 1) where the called data terminal equipment is busy when called and the network holds the data until the destination is free; 2) where the network accepts data and undertakes to deliver them at some pre-determined time.	
** 52.54 (31.12)	*code conversion*	31.12
** 52.55 (37.27)	*duplex operation* 1. In the telegram service a method of working between two telegraph sets in which the transmission of telegrams may take place simultaneously in both directions. 2. In data transmission, a method of working between two data terminal equipments in which the transmission of digital data may take place simultaneously in both directions.	
** 52.56	*interworking between networks* The means whereby a data terminal equipment connected to one public network may communicate to a data terminal equipment in another public network. *Note.* — The networks referred to may be public data networks, public telephone networks or public telex networks.	
** 52.57	*network parameter* A feature which is inherent in the design of a network.	
** 52.58	*call set-up time* The overall length of time required to establish a circuit switched call between data terminal equipments. It is the summation of: a) *call request time* = the time from the initiation of a calling signal to the delivery to the caller of a " proceed-to-select " signal.	

No.	Terms	Definition to be found in
	b) *Selection time* = the time from the delivery of the proceed-to-select signal until all the selection signals have been transmitted. c) *Post selection time* = the time from the end of the transmission of the selection signals until the delivery of the call-connected signal to the originating data terminal equipment. *Note 1.* — The selection time may be minimized by the use of the direct call or abbreviated address facility. *Note 2.* — The call set-up time for a given connection depends upon the network topology, user data rate, mode of working, grade of service, distance between users and the procedure employed (e.g. direct call).	
** 52.59	*call release time* *call clear-down time* The time from the initiation of a clearing signal by a terminal installation until the free circuit condition appears on the originating data terminal equipment.	
** 52.60	*transfer time* The time that elapses between the initial offering of a unit of the user's data to a network by a transmitting data terminal equipment and the complete delivery of that unit to a receiving data terminal equipment. *Note 1.* — A unit of data may be a bit, byte, packet, message, etc. *Note 2.* — A specific example of transfer time applied to packet mode operation may be defined as follows: packet transfer time is the time that elapses between the initial offering of a packet to the network by a transmitting data terminal equipment and the complete delivery of that packet to a receiving data terminal equipment.	
** 52.61 (33.04)	*telegraph distortion*	33.04
** 52.62 (33.06)	*degree of individual distortion of a particular significant instant*	L.D.
** 52.63 (33.07)	*degree of isochronous distortion*	33.07
** 52.64 (33.09)	*degree of gross start-stop distortion*	33.09
** 52.65 (33.10)	*degree of synchronous start-stop distortion*	L.D.
** 52.66 (33.13)	*degree of inherent distortion*	L.D.
** 52.67 (34.07)	*margin of start-stop apparatus*	sup. 1
** 52.68 (34.031)	*net margin*	34.031

SERIES 53. DEFINITIONS OF SPECIAL CONCERN IN DATA TRANSMISSION

No.	Terms	Definition to be found in
	Note. — For definitions concerning both data transmission and pulse code modulation (PCM), see Recommendation G.702 (*Green Book*, Volume IV).	
* 53.01	*binary digit* A member selected from a binary set. *Note 1.* — Bit is an abbreviation for binary digit. *Note 2.* — In the interest of clarity, it is recommended that the term " bit " shall not be used in two-condition start-stop modulation instead of " unit-element ".	
** 53.011	*byte* A group of binary digits normally operated upon as an entity.	
** 53.012	*envelope* A group of binary digits formed by a byte augmented by a number of additional bits which are required for the operation of the data network.	
** 53.013	*packet* A group of binary digits including data and call control signals which is switched as a composite whole. The data, call control signals and possibly error control information are arranged in a specified format.	
* 53.02	*digit* A member selected from a finite set. *Note 1.* — In digital transmission, a digit may be represented by a signal element, being characterized by its dynamic nature, discrete condition and discrete timing, e.g. it may be represented as a pulse of specified amplitude and duration. *Note 2.* — In equipment used in digital transmission, a digit may be represented by a stored condition being characterized by a specified physical condition, e.g. it may be represented as a binary magnetic condition of a ferrite core. *Note 3.* — The context of the use of the term should indicate the radix of notation. (The meaning of " digit " in Notes 1, 2, 3 translates into French as " élément numérique ".) *Note 4.* — In telephone subscriber numbering, any of the numbers 1, 2, 3 . . . 9 or 0 forming the elements of a telephone number (Recommendation Q.10). (This meaning of " digit " translates into French as " chiffre ".)	
** 53.021	*Hamming distance* 1. The number of digit positions in which the corresponding digits of two binary words of the same length are different.	

No.	Terms	Definition to be found in

2. By extension, the number of digit positions in which the corresponding digits of two words of the same length in any radix are different, for example, the Hamming distance between 21415926 and 11475916 is 3.

Note. — In the C.C.I.T.T. context, the term " signal distance " which is synonymous for this term in data processing may cause confusion and therefore is deprecated.

** 53.029 *information*

In the special context of teleprocessing, information is deemed to mean any transmission of signals via telecommunication channels. This information may take the form of data or message.

53.03 *data signal* sup. 2

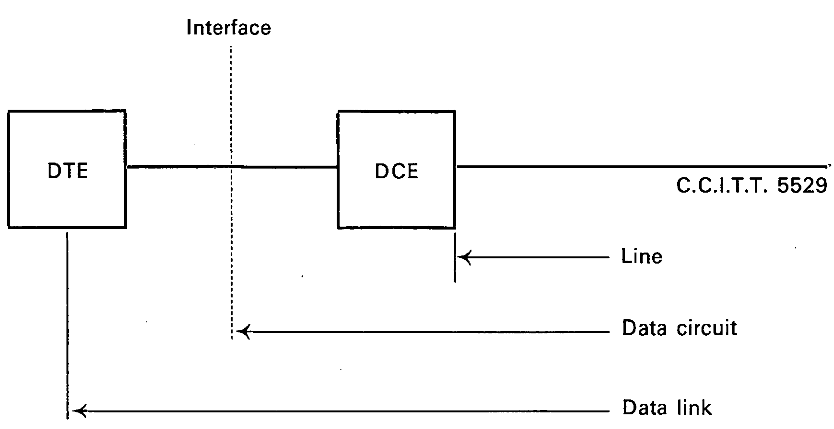
* 53.04 *shannon*
[bit]

The unit of selective information, i.e. the amount of information derived from knowledge of the occurrence of one of two equiprobable, exclusive and exhaustive events.

* 53.05 *terminal installation for data transmission*

Installation comprising: the data terminal equipment (DTE), the data circuit-terminating equipment (DCE), and any intermediate equipment.

Note. — In some instances, the data terminal equipment may be connected directly to a data-processing machine or may be a part of it.



** 53.051 *data circuit-terminating equipment (DCE)*

The equipment installed at the user's premises which provides all the functions required to establish, maintain and terminate a connection, the signal conversion and coding between the data terminal equipment

No.	Terms	Definition to be found in
	(DTE) interface and the line. It may or may not be a specific, or separate piece of, equipment. *Note.* — When the data circuit is provided in a specialized data network, a simplified form of DCE may be provided and this has been referred to as a network terminating unit.	
** 53.052	*data link* (see also 53.05) This is an ensemble of terminal installations and the interconnecting network operating in a particular mode that permits information to be exchanged between terminal installations.	
53.06	*data source*	sup. 2
53.07	*data sink*	sup. 2
53.08	*data terminal equipment*	sup. 2
53.09	*intermediate equipment*	sup. 2
53.10	*signal-conversion equipment*	sup. 2
** 53.101	*first data multiplexer* The equipment that accepts a number of streams of binary digits at the same or different standard data signalling rates and combines these on a time division basis into a single stream of binary digits signalled at a rate equivalent to that of a PCM channel time slot.	
** 53.102	*second data multiplexer* The equipment that accepts a number of streams of binary digits each signalled from first data multiplexers or signals at equal rate and combines these on a time division basis into a single stream of binary digits signalled at the digit rate of a PCM primary block.	
53.11	*modem*	sup. 2
53.12	*interface*	sup. 2
53.13	*storage register* *store* *[memory]*	sup. 2
** 53.131	*shift register* A *register* composed of *binary storage cells* in which the state of each cell is transferred to the adjacent cell in a predetermined direction by the application of a *shift* pulse applied to all stages of the register.	
53.14	*information transfer*	sup. 2
53.15	*information channel*	sup. 2
** 53.151	*information bearer channel* A channel provided for data transmission which is capable of carrying all the necessary information to permit communication including users' data synchronizing sequences, control signals, etc. It may therefore operate at a greater signalling rate than that required solely for the users' data.	

No.	Terms	Definition to be found in
53.16	*forward channel*	sup. 2
53.17	*backward channel*	sup. 2
53.18	*block*	sup. 2
53.19	*start-of-block signal* *synch* (Am)	sup. 2
53.20	*end-of-block signal*	sup. 2
53.21	*information bits*	sup. 2
53.22	*overhead bits*	sup. 2
53.23	*service bits*	sup. 2
53.24	*check bit*	sup. 2
53.25	*erroneous bit*	sup. 2
53.26	*single error*	sup. 2
53.27	*double, triple, ... error*	sup. 2
53.28	*error burst*	sup. 2
53.29	*erroneous block*	sup. 2
53.30 (32.306 and 52.28)	*bit error rate* *element error rate* *character error rate* *block error rate*	sup. 2
53.31 (52.29)	*character check*	sup. 2
53.32	*block check*	sup. 2
53.33	*loop checking* *message feedback* *information feedback*	sup. 2
53.34	*information feedback system*	sup. 2
53.35	*even parity check (odd parity check)*	sup. 2
* 53.36	*data signalling rate*	

The aggregate signalling rate in the transmission path of a data transmission system, expressed in normalized form in binary digits (bits) per second.

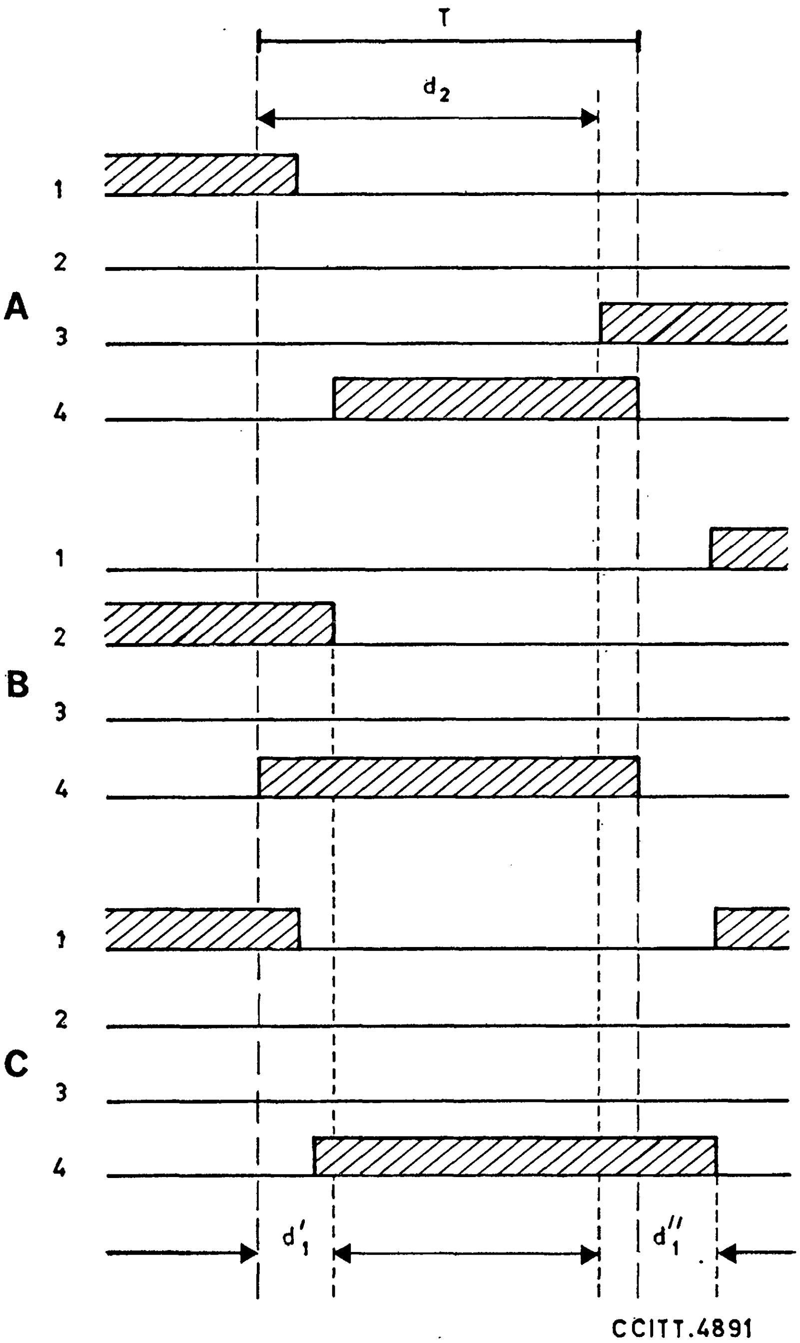
It is given by

$$\sum_{i=1}^{m} \frac{1}{T_i} \log_2 n_i$$

where m is the number of parallel channels, T_i is the minimum interval for the i-th channel expressed in seconds, n_i is the number of significant conditions of the modulation in the i-th channel.

Note. — a) For a single channel (serial transmission) it reduces to $\frac{1}{T} \log_2 n$; with a two-condition modulation ($n=2$), it is $\frac{1}{T}$;

No.	Terms	Definition to be found in
	b) For a parallel transmission with equal minimum intervals and equal number of significant conditions on each channel, it is $m \frac{1}{T} \log_2 n$ ($\frac{m}{T}$ in case of a two-condition modulation).	
** 53.361	*binary serial signalling rate* In the particular case of a serial two-state transmission this is expressed as the reciprocal of the unit interval measured in seconds and expressed in bits per second.	
53.37	*data transfer rate*	sup. 2
** 53.38	*minimum acceptable interval* The duration of the shortest acceptable significant interval expressed in terms of the unit interval.	
** 53.39	*degree of late anisochronous parallel distortion* Ratio to the theoretical duration of the significant interval of the maximum measured difference between the latest and the earliest coherent significant instants of a modulation (or restitution) within all parallel channels (see figure on next page).	
** 53.40	*degree of early anisochronous parallel distortion* Ratio to the theoretical duration of the significant interval of the maximum measured difference between this theoretical duration and the duration of the interval between the earliest of all coherent significant instants of a modulation (or restitution) and the earliest of the following set of coherent significant instants (see figure on next page).	
** 53.41	*coherent significant instant* In parallel transmission the significant instant of a modulation or restitution which normally occurs at the same instant on all channels.	
** 53.42	*inter-character rest condition* In a data system which contains no clock, the distinctive condition which exists for a time between two successive transfers of data characters.	
** 53.43	*burst isochronous* *interrupted isochronous* A transmission process which may be used where the information bearer channel rate is higher than the input data signalling rate. The binary digits being transferred are signalled at the digit rate of the information bearer channel and the transfer is interrupted at intervals in order to produce the required mean data signalling rate. The interruption is always for an integral number of digit periods. *Note.* — e.g. this has particular application where envelopes are being transmitted and received by the data circuit-terminating equipment but only the bytes contained within the envelopes are transferred between the data circuit-terminating equipment and the data terminal equipment.	



Degree of late distortion: $\delta_l = \dfrac{d_1 \max}{T}$

Degree of early distortion: $\delta_e = \dfrac{T - d_2 \min}{T} = \dfrac{(T - d_2) \max}{T}$

T = theoretical duration of the significant interval

Degree of anisochronous parallel distortion

No.	Terms	Definition to be found in
** 53.44	*code independent system* *[code insensitive system]* A system which does not depend, for its correct functioning, upon the character set or code used for transmission by the data terminal equipment.	
** 53.45	*code dependent system* *[code sensitive system]* A system which depends, for its correct functioning, upon the character set or code used for transmission by the data terminal equipment.	
** 53.46	*data switching exchange* The set of equipments installed at a single location to switch data traffic.	
** 53.47	*acoustic coupling (to telephone line)* A method of coupling a data terminal equipment or similar device to a telephone line by means of transducers which utilize sound waves to or from a telephone handset or equivalent.	

INDEX OF RECOMMENDATIONS APPLYING TO DATA TRANSMISSION AFTER THE FIFTH PLENARY ASSEMBLY OF THE C.C.I.T.T. (1972)

Series V Recommendations — Data transmission over telephone or telex networks

Number	Title	*Page*
V.1	Equivalence between binary notation symbols and the significant conditions of a two-condition code	43
V.2	Power levels for data transmission over telephone lines	44
V.3	International Alphabet No. 5	47
V.4	General structure of signals of International Alphabet No. 5 code	61
V.10	Use of the telex network for data transmission at the modulation rate of 50 bauds	63
V.11	Automatic calling and/or answering on the telex network	67
V.13	Answer-back unit simulators	78
V.15	Use of acoustic coupling for data transmission	79
V.21	200-baud modem standardized for use in the general switched telephone network	80
V.22	Standardization of data-signalling rates for synchronous data transmission in the general switched telephone network	84
V.22 bis	Standardization of data-signalling rates for synchronous data transmission on leased telephone-type circuits	85
V.23	600/1200-baud modem standardized for use in the general switched telephone network	86
V.24	List of definitions for interchange circuits between data-terminal equipment and data circuit-terminating equipment	92
V.25	Automatic calling and/or answering on the general switched telephone network including disabling of echo-suppressors on manually established calls	107
V.26	2400 bits per second modem standardized for use on four-wire leased circuits	117
V.26 bis	2400/1200 bits per second modem standardized for use in the general switched telephone network	121
V.27	4800 bits per second modem standardized for use on leased circuits	127
V.28	Electrical characteristics for unbalanced double-current interchange circuits	132
V.30	Parallel data transmission modems standardized for universal use in the general switched telephone network	136
V.31	Electrical characteristics for single-current interchange circuits controlled by contact closure	140
V.35	Data transmission at 48 kilobits per second using 60 to 108 kHz group band circuits	143
V.40	Error indication with electromechanical equipment	152
V.41	Code-independent error control system	152
V.50	Standard limits for transmission quality of data transmission	163

Number	Title	Page
V.51	Organization of the maintenance of international telephone-type circuits used for data transmission	164
V.52	Characteristics of distortion and error-rate measuring apparatus for data transmission	168
V.53	Limits for the maintenance of telephone-type circuits used for data transmission	170
V.55	Impulsive noise measuring instrument for data transmission	172
V.56	Comparative tests of modems for use over telephone-type circuits	175
V.57	Comprehensive data test set for high data signalling rates	179

Series X Recommendations — Data transmission over public data networks

Section 1: Services and facilities

X.1	User classes of service for public data networks	181
X.2	Recommended user facilities available in public data networks	182

Section 2: Data terminal equipment and interfaces

X.20	Interface between data-terminal equipment and data circuit-terminating equipment for start-stop services in user classes 1 and 2 on public data networks	184
X.21	Interface between data-terminal equipment and data circuit-terminating equipment for synchronous operation on public data networks	192
X.30	Standardization of basic model page-printing machine in accordance with International Alphabet No. 5	195
X.31	Characteristics, from the transmission point of view, at the interchange point between data-terminal equipment and data circuit-terminating equipment when a 200-baud start-stop data-terminal equipment in accordance with International Alphabet No. 5 is used	196
X.32	Answer-back units for 200-bauds start-stop machines in accordance with International Alphabet No. 5	197
X.33	Standardization of an international text for the measurement of the margin of start-stop machines in accordance with International Alphabet No. 5	198

Section 3: Transmission, signalling and switching

X.40	Standardization of frequency shift modulated transmission systems for the provision of telegraph and data channels by frequency division of a primary group	199

Number	Title	Page
X.50	Fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks	201
X.70	Terminal and transit-control signalling system for start-stop services on international circuits between anisochronous data networks.	203

SECTION 4: **Network parameters**

SECTION 5: **Charging methods and accounting**

PAGE INTENTIONALLY LEFT BLANK

PAGE LAISSEE EN BLANC INTENTIONNELLEMENT

SERIES V RECOMMENDATIONS

Data transmission over telephone or telex networks

Recommendation V.1

EQUIVALENCE BETWEEN BINARY NOTATION SYMBOLS AND THE SIGNIFICANT CONDITIONS OF A TWO-CONDITION CODE

(New Delhi, 1960, amended at Geneva, 1964 and 1972)

Binary numbering expresses numbers by means of two digits normally represented by the symbols 0 and 1. Transmission channels are especially well suited to the transmission of signals by a modulation having two significant conditions (two-condition modulation). These two significant conditions are sometimes called " space " and " mark " or " start " and " stop ", or they may be called condition A or condition Z [1].

It is very useful to make the two conditions of a two-condition modulation correspond to the binary digits 0 and 1. Such equivalence will facilitate the transmission of numbers resulting from binary calculation, the conversion of codes for binary numbers and of codes for decimal numbers, maintenance operations and relations between transmission personnel and the personnel in charge of data-processing machines.

At first sight, it does not seem to matter whether the symbol 0 corresponds in transmission to condition A or condition Z, the symbol 1 then corresponding to condition Z or condition A or vice versa.

In telegraphy, however, when a telegraphic communication is set up and the sending of signals is stopped (called the idle condition of the line), the signal sent over the line consists of condition Z throughout the suspension of transmission.

It is logical (and for certain v.f. telegraph systems also essential) to use the same rule in data transmission. During the " idle periods " of transmission, condition Z should be applied to the circuit input.

Data transmission on a circuit is often controlled by perforated tape. On perforated tapes used for telegraphy, condition Z is represented by perforation. When binary numbers are represented by means of perforations, it is customary to represent the symbol 1 by a perforation. It is therefore logical to make this symbol 1 correspond to condition Z.

For these reasons, the C.C.I.T.T. *unanimously declares the following view:*

1. In transmitting data by two-condition code, in which the digits are formed using binary notation, the symbol 1 of the binary notation will be equivalent to condition Z of the modulation, and the symbol 0 of the binary notation will be equivalent to condition A of the modulation.

2. During periods when there is no signal sent to the input of the circuit, the circuit input condition is condition Z.

3. If perforation is used, one perforation corresponds to one unit interval under condition Z.

4. In accordance with C.C.I.T.T. Recommendation R.31 (*Green Book*, Volume VII), the sending of symbol 1 (condition Z) corresponds to the tone being sent on a channel using amplitude modulation.

---

[1] Definitions of condition A and condition Z: *List of Definitions*—Part I—No. 31.38.

5. In accordance with C.C.I.T.T. Recommendation R.35 (*Green Book*, Volume VII), when frequency modulation is used, the sending of symbol 0 corresponds to the higher frequency, while the sending of symbol 1 corresponds to the lower frequency.

6. a) for phase modulation with reference phase:

the symbol 1 corresponds to a phase equal to the reference phase;

the symbol 0 corresponds to a phase opposed to the reference phase.

b) for differential two-phase modulation where the alternative phase changes are 0 degree or 180 degrees:

the symbol 1 corresponds to a phase inversion from the previous element;

the symbol 0 corresponds to a no-phase inversion from the previous element.

SUMMARY TABLE OF EQUIVALENCE

	Digit 0 " Start " signal in start-stop code Line available condition in telex switching " Space " element of start-stop code Condition A	Digit 1 " Stop " signal in start-stop code Line idle condition in telex switching (Note 2) " Mark " element of start-stop code Condition Z
Amplitude modulation	Tone-off	Tone-on
Frequency modulation	High frequency	Low frequency
Phase modulation with reference phase	Opposite phase to the reference phase	Reference phase
Differential two-phase modulation where the alternative phase changes are 0 degree or 180 degrees	No-phase inversion	Inversion of the phase
Perforations	No perforation	Perforation

Note 1. — The standardization described in this Recommendation is general, whether over telegraph-type circuits or over circuits of the telephone type, making use of electromechanical or electronic devices.

Note 2. — It primarily applies to anisochronous use.

Recommendation V.2

POWER LEVELS FOR DATA TRANSMISSION OVER TELEPHONE LINES

(New Delhi, 1960, amended at Geneva, 1964)

The objectives in specifying data signal levels are as follows:

a) to ensure satisfactory transmission and to permit co-ordination with devices such as signalling receivers or echo suppressors, the data signal levels on international circuits should be controlled as closely as possible;

b) to ensure correct performance of multichannel carrier systems from the point of view of loading and noise, the mean power of data circuits should not differ much from the conventional value of channel loading (—15 dBm0 for each direction of transmission: see note below). This conventional value makes allowance for a reasonable proportion (under 5%) of the channels in a multichannel system being used for non-speech applications at fixed power levels at about —10 dBm0 simultaneously in both directions of transmission.

If the proportion of non-speech applications (including data) does not exceed the above figure of 5% then the mean power of —10 dBm0 simultaneously in both directions of transmission would be allowable for data transmission also.

However, assuming an appreciably higher (e.g. 10 to 20%) proportion of non-speech circuits (due to the development of data transmission) on an international carrier system, a reduction of this power by 3 dB might be reasonable. In this way the sum of the mean powers in both directions of transmission in a duplex (i.e. transmitting tones in both directions simultaneously) system would be —10 dBm0 (i.e. —13 dBm0 for each direction). The power transmitted on the channel of a simplex (i.e. transmitting in one direction only) system or on either channel of a half duplex (i.e. transmitting in opposite directions consecutively) would be —10 dBm0 (assuming that there were no echoes);

Note. — The distribution of long-term mean power among the channels in a multichannel carrier telephone system (conventional mean value of —15 dBm0), probably has a standard deviation in the neighbourhood of 4 dB (*Green Book*, Volume III, Supplement No. 5).

c) it is probable that Administrations will wish to fix specific values for the signal power level of data modulators either at the subscriber's line terminals or at the local exchanges. The relation between these values and the power levels on international circuits depends on the particular national transmission plan; in any case, a wide range of losses among the possible connections between the subscriber and the input to international circuits must be expected;

d) considerations a) to c) suggest that specification of the maximum data signal level only is not the most useful form. One alternative proposal would be to specify the nominal power at the input to the international circuit. The nominal power would be the statistically estimated mean power obtained from measurement on many data transmission circuits.

For these reasons, the C.C.I.T.T. *unanimously declares the following view*:

A. Data transmission over leased telephone circuits (private wires) set up on carrier systems

1. The maximum power output of the subscriber's apparatus into the line shall not exceed 1 mW.

2. For systems transmitting tones continuously, for example frequency-modulation systems, the maximum power level at the zero relative level point shall be —10 dBm0. When transmission of data is discontinued for any appreciable time, the power level should preferably be reduced to —20 dBm0 or lower.

3. For systems not transmitting tones continuously, for example amplitude-modulation systems, a higher level up to —6 dBm0 at the zero relative level point may be used provided that the sum of the mean powers during the busy hour on both directions of transmission does not exceed 64 microwatts (corresponding to a mean level of —15 dBm0 on each direction of transmission simultaneously). Further,

the level of any tones above 2400 Hz should not be so high as to cause interference on adjacent channels on carrier-telephone systems (see Recommendation G.224).[1]

Note 1. — In suggesting these limits, the C.C.I.T.T. has in mind that the recommended maximum level of −5 dB referred to the zero relative level point for private circuits for alternate telephony and telegraphy may no longer be acceptable having regard to the recommendation that " to avoid overloading carrier systems, the mean power should be limited to 32 μW if such systems are subject to considerable extension ".

Note 2. — The proposed limit of −10 dBm0 for continuous tone systems is in line with the existing Recommendation H.41 (T.11) of the C.C.I.T.T. for frequency-modulation phototelegraph transmissions.

Note 3. — It is not possible to give any firm estimate of the proportion of international circuits which will at any time be carrying data transmissions. If the proportion should reach a high level, the provisional limits now proposed would need to be reconsidered.

B. Data transmission over the switched telephone system

The maximum power output of the subscriber's equipment into the line shall not exceed 1 mW at any frequency.

In systems continuously transmitting tone, such as frequency or phase-modulation systems, the power level of the subscriber's equipment should be adjusted to make allowance for loss between his equipment and the point of entry to an international circuit; so that the corresponding nominal level of the signal at the international circuit input shall not exceed −10 dBm0 (simplex systems) or −13 dBm0 (duplex systems).

In systems not transmitting tones continuously, such as amplitude-modulation systems and multi-frequency systems, higher levels may be used, provided always that the mean power of all the signals at the international circuit input during any one hour in both directions of transmission does not exceed 64 microwatts (representing a mean level of −15 dBm0 in each direction of transmission simultaneously).

Furthermore, the frequency level in carrier telephone systems which are part of a circuit should not be so high that it might cause interference in adjacent channels. Recommendation G.224 could be referred to with a view to providing adequate levels.[1]

Note 1. — In practice, it is no easy matter to assess the loss between a subscriber's equipment and the international circuit, so that this part of the present Recommendation should be taken as providing general planning guidance. As mean level at the international circuit input, the mean figure obtained from measurement or calculation (on numerous transmission data) may be adopted.

[1] *Note by the Secretariat.* — During the study period 1968-1972 Special Study Group C proposed the following text for this clause:

" However, the sending level conditions must be such that on an international connection they do not exceed the values specified in Recommendation Q.16 (G.224)."

This point requires further study.

Note 2. — In switched connections the loss between subscribers' telephones may be high: 30 to 40 dB. The level of the signals received will then be very low, and these signals may suffer disturbance from the dialling pulses sent over other circuits. Hence the transmission level should be as high as possible.

If there is likely to be a heavy demand for data-transmission international connections over the switched network, some Administrations might want to provide special four-wire subscribers' lines. If so, the levels to be used might be those proposed for leased circuits.

Recommendation V.3

INTERNATIONAL ALPHABET No. 5

(Mar del Plata, 1968, amended at Geneva, 1972)

Introduction

A new alphabet capable of meeting the requirements of private users on leased circuits and of users of data transmission by means of connections set up by switching on the general telephone network or on telegraph networks has been established jointly by the C.C.I.T.T. and the International Organization for Standardization (I.S.O.).

This new alphabet—Alphabet No. 5—is not intended to replace Alphabet No. 2. It is a supplementary alphabet for the use of those who might not be satisfied with the more limited possibilities of Alphabet No. 2. In such cases it is considered as the alphabet to be used as common basic language for data transmission and for elaborated message systems.

This new Alphabet No. 5 does not exclude the use of any other alphabet that might be better adapted to special needs.

1. *Scope and field of application*

1.1 This Recommendation contains a set of 128 characters (control characters and graphic characters such as letters, digits and symbols) with their coded representation. Most of these characters are mandatory and unchangeable, but provision is made for some flexibility to accommodate special national and other requirements.

1.2 The need for graphics and controls in data processing and in data transmission has been taken into account in determining this character set.

1.3 This Recommendation consists of a general table with a number of options, notes, a legend and explanatory notes. It also contains a specific International Reference Version, guidance on the exercise of the options to define specific national versions and application oriented versions.

1.4 This character set is primarily intended for the interchange of information within message transmission systems and between data processing systems and associated equipment.

1.5 This character set is applicable to all Latin alphabets.

1.6 The character set includes facilities for extension where its 128 characters are insufficient for particular applications.

1.7 The definition of some control characters in this Recommendation assumes that data associated with them is to be processed serially in a forward direction. Their effect when included in strings of data which are processed other than serially in a forward direction or included in data formated for fixed record processing may have undesirable effects or may require additional special treatment to ensure that the control characters have their desired effect.

2. *Implementation*

2.1 This character set should be regarded as a basic alphabet in an abstract sense. Its practical use requires definitions of its implementation in various media. For example, this could include punched tapes, punched cards, magnetic tapes and transmission channels, thus permitting interchange of data to take place either indirectly by means of an intermediate recording in a physical medium, or by local electrical connection of various units (such as input and output devices and computers) or by means of data transmission equipment.

2.2 The implementation of this coded character set in physical media and for transmission, taking also into account the need for error checking, is the subject of I.S.O. publications (see the Appendix).

3. *Basic code table*

Notes about Table 1

1. The Format Effectors are intended for equipment in which horizontal and vertical movements are effected separately. If equipment requires the action of CARRIAGE RETURN to be combined with a vertical movement, the Format Effector for that vertical movement may be used to effect the combined movement. For example, if NEW LINE (symbol NL, equivalent to CR + LF) is required, FE_2 shall be used to represent it. This substitution requires agreement between the sender and the recipient of the data.
The use of these combined functions may be restricted for international transmission on general switched telecommunication networks (telegraph and telephone networks).

2. The symbol £ is assigned to position 2/3 and the symbol $ is assigned to position 2/4. In a situation where there is no requirement for the symbol £ the symbol # (number sign) may be used in position 2/3. Where there is no requirement for the symbol $ the symbol ¤ (currency sign) may be used in position 2/4. The chosen allocations of symbols to these positions for international information interchange should be agreed between the interested parties. It should be noted that, unless otherwise agreed between sender and recipient, the symbols £, $ or ¤ do not designate the currency of a specific country.

3. National use positions. The allocations of characters to these positions lies within the responsibility of national standardization bodies. These positions are primarily intended for alphabet extensions. If they are not required for that purpose, they may be used for symbols.

4. Positions 5/14, 6/0 and 7/14 are provided for the symbols UPWARD ARROW HEAD, GRAVE ACCENT and OVERLINE. However, these positions may be used for other graphical characters when it is necessary to have 8, 9 or 10 positions for national use.

5. Position 7/14 is used for the graphic character ‾ (OVERLINE), the graphical representation of which may vary according to national use to represent ˜ (TILDE) or another diacritical sign provided that there is no risk of confusion with another graphic character included in the table.

6. The graphic characters in positions 2/2, 2/7, 2/12 and 5/14 have respectively the significance of QUOTATION MARK, APOSTROPHE, COMMA and UPWARD ARROW HEAD; however, these characters take on the significance of the diacritical signs DIAERESIS, ACUTE ACCENT, CEDILLA and CIRCUMFLEX ACCENT when they are preceded or followed by the BACKSPACE character (0/8).

TABLE 1. — BASIC CODE

				b_7	0	0	0	0	1	1	1	1
				b_6	0	0	1	1	0	0	1	1
				b_5	0	1	0	1	0	1	0	1
b_4	b_3	b_2	b_1		0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	TC_7 (DLE)	SP	0	[3]	P	` [4]	p
0	0	0	1	1	TC_1 (SOH)	DC_1	!	1	A	Q	a	q
0	0	1	0	2	TC_2 (STX)	DC_2	" [6]	2	B	R	b	r
0	0	1	1	3	TC_3 (ETX)	DC_3	£(#) [2]	3	C	S	c	s
0	1	0	0	4	TC_4 (EOT)	DC_4	$(¤) [2]	4	D	T	d	t
0	1	0	1	5	TC_5 (ENQ)	TC_8 (NAK)	%	5	E	U	e	u
0	1	1	0	6	TC_6 (ACK)	TC_9 (SYN)	&	6	F	V	f	v
0	1	1	1	7	BEL	TC_{10} (ETB)	' [6]	7	G	W	g	w
1	0	0	0	8	FE_0 (BS)	CAN	(	8	H	X	h	x
1	0	0	1	9	FE_1 (HT)	EM	)	9	I	Y	i	y
1	0	1	0	10	FE_2 (LF) [1]	SUB	*	:	J	Z	j	z
1	0	1	1	11	FE_3 (VT) [1]	ESC	+	;	K	[3]	k	[3]
1	1	0	0	12	FE_4 (FF) [1]	IS_4 (FS)	, [6]	<	L	[3]	l	[3]
1	1	0	1	13	FE_5 (CR) [1]	IS_3 (GS)	−	=	M	[3]	m	[3]
1	1	1	0	14	SO	IS_2 (RS)	.	>	N	^ [4][5]	n	‾ [4][5]
1	1	1	1	15	SI	IS_1 (US)	/	?	O	_	o	DEL

CCITT.5610

4. *Legend*

4.1 *Control characters*

Abbreviation	Note	Meaning	Position in the code table
ACK		Acknowledge	0/6
BEL		Bell	0/7
BS		Backspace	0/8
CAN		Cancel	1/8
CR	1	Carriage return	0/13
DC		Device control	—
DEL		Delete	7/15
DLE		Data link escape	1/0
EM		End of medium	1/9
ENQ		Enquiry	0/5
EOT		End of transmission	0/4
ESC		Escape	1/11
ETB		End of transmission block	1/7
ETX		End of text	0/3
FE		Format effector	—
FF	1	Form feed	0/12
FS		File separator	1/12
GS		Group separator	1/13
HT		Horizontal tabulation	0/9
IS		Information separator	—
LF	1	Line feed	0/10
NAK		Negative acknowledge	1/5
NUL		Null	0/0
RS		Record separator	1/14
SI		Shift-in	0/15
SO		Shift-out	0/14
SOH		Start of heading	0/1
SP		Space (see 7.2)	2/0
STX		Start of text	0/2
SUB		Substitute character	1/10
SYN		Synchronous idle	1/6
TC		Transmission control	—
US		Unit separator	1/15
VT	1	Vertical tabulation	0/11

4.2 *Graphic characters*

Graphic	Note	Name	Position in the code table
(space)		Space (see 7.2)	2/0
!		Exclamation mark	2/1
"	6	Quotation mark, Diaeresis	2/2
£	2	Pound sign	2/3
#	2	Number sign	2/3
$	2	Dollar sign	2/4
¤	2	Currency sign	2/4
%		Percent sign	2/5
&		Ampersand	2/6
'	6	Apostrophe, Acute accent	2/7
(		Left parenthesis	2/8
)		Right parenthesis	2/9
*		Asterisk	2/10
+		Plus sign	2/11
,	6	Comma, Cedilla	2/12
—		Hyphen, Minus sign	2/13
.		Full stop (period)	2/14
/		Solidus	2/15
:		Colon	3/10
;		Semi-colon	3/11
<		Less-than sign	3/12
=		Equal sign	3/13
>		Greater-than sign	3/14
?		Question mark	3/15
^	4,6	Upward arrow head, Circumflex accent	5/14
_		Underline	5/15
`	4	Grave accent	6/0
‾	4,5	Overline, Tilde	7/14

5. *Explanatory notes*

5.1 *Numbering of the positions in Table 1*

Within any one character the bits are identified by b_7, b_6 . . . b_1, where b_7 is the highest order, or most significant bit, and b_1 is the lowest order, or least significant bit. If desired these may be given a numerical significance in the binary system, thus:

Bit identification:	b_7	b_6	b_5	b_4	b_3	b_2	b_1
Significance:	64	32	16	8	4	2	1

In the table the columns and rows are identified by numbers written in binary and decimal notations.

Any one position in the table may be identified either by its bit pattern, or by its column and row numbers. For instance, the position containing the digit 1 may be identified:

— by its bit pattern in order of decreasing significance, e.g. 011 0001 [1]

— by its column and row numbers, e.g. 3/1.

The column number is derived from bits b_7, b_6 and b_5 giving them weights of 4, 2 and 1 respectively. The row number is derived from bits b_4, b_3, b_2 and b_1 giving them weights of 8, 4, 2 and 1 respectively.

[1] Order of transmitting bits is not necessarily the same as shown here. For the order of the transmission of bits, see Section I in Recommendation V.4.

5.2 *Diacritical signs*

In the character set, some printing symbols may be designed to permit their use for the composition of accented letters when necessary for general interchange of information. A sequence of three characters, comprising a letter, BACKSPACE and one of these symbols, is needed for this composition, and the symbol is then regarded as a diacritical sign. It should be noted that these symbols take on their diacritical significance when they are preceded or followed by one BACKSPACE character; for example, the symbol corresponding to the code combination 2/7 normally has the significance of APOSTROPHE, but becomes the diacritical sign ACUTE ACCENT when it precedes or follows a BACKSPACE character.

In order to increase efficiency, it is possible to introduce accented letters (as single characters) in the positions marked by Note 3 in the code table. According to national requirements, these positions may contain special diacritical signs.

5.3 *Names, meanings and fonts of graphic characters*

This Recommendation assigns at least one name to denote each of the graphic characters displayed in Tables 1 and 2. The names chosen to denote graphic characters are intended to reflect their customary meanings. However, this Recommendation does not define and does not restrict the meanings of graphic characters. Nor does it specify a particular style or font design for the graphic characters.

Under the provision of Note 3 of Table 1 graphic characters which are different from the characters of the international reference version may be assigned to the national use positions. When such assignments are made, the graphic characters should have distinct forms and be given distinctive names which are not in conflict with any of the forms or the names of any of the graphic characters in the international reference version.

5.4 *Uniqueness of character allocation*

A character allocated to a position in Table 1 may not be placed elsewhere in the table. For example, in the case of position 2/3 the character not used cannot be placed elsewhere. In particular the POUND sign (£) can never be represented by the bit combination of position 2/4.

6. *Versions of Table 1*

6.1 *General*

6.1.1 In order to use Table 1 for information interchange, it is necessary to exercise the options left open, i.e. those affected by Notes 2 to 5. A single character must be allocated to each of the positions for which this freedom exists or it must be declared to be unused. A code table completed in this way is called a VERSION.

6.1.2 The Notes to Table 1, the Explanatory Notes and the Legend apply in full to any version.

6.2 *International reference version*

This version is available for use when there is no requirement to use a national or an application-oriented version. In international information processing interchange the international reference version (Table 2) is assumed unless a particular agreement exists between sender and recipient of the data.

TABLE 2. — INTERNATIONAL REFERENCE VERSION

				b_7	0	0	0	0	1	1	1	1
				b_6	0	0	1	1	0	0	1	1
				b_5	0	1	0	1	0	1	0	1
b_4	b_3	b_2	b_1		0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	TC$_7$ (DLE)	SP	0	@	P	`	p
0	0	0	1	1	TC$_1$ (SOH)	DC$_1$	!	1	A	Q	a	q
0	0	1	0	2	TC$_2$ (STX)	DC$_2$	"	2	B	R	b	r
0	0	1	1	3	TC$_3$ (ETX)	DC$_3$	#	3	C	S	c	s
0	1	0	0	4	TC$_4$ (EOT)	DC$_4$	¤	4	D	T	d	t
0	1	0	1	5	TC$_5$ (ENQ)	TC$_8$ (NAK)	%	5	E	U	e	u
0	1	1	0	6	TC$_6$ (ACK)	TC$_9$ (SYN)	&	6	F	V	f	v
0	1	1	1	7	BEL	TC$_{10}$ (ETB)	'	7	G	W	g	w
1	0	0	0	8	FE$_0$ (BS)	CAN	(	8	H	X	h	x
1	0	0	1	9	FE$_1$ (HT)	EM	)	9	I	Y	i	y
1	0	1	0	10	FE$_2$ (LF)	SUB	*	:	J	Z	j	z
1	0	1	1	11	FE$_3$ (VT)	ESC	+	;	K	[	k	{
1	1	0	0	12	FE$_4$ (FF)	IS$_4$ (FS)	,	<	L	\	l	|
1	1	0	1	13	FE$_5$ (CR)	IS$_3$ (GS)	-	=	M	]	m	}
1	1	1	0	14	SO	IS$_2$ (RS)	.	>	N	^	n	‾
1	1	1	1	15	SI	IS$_1$ (US)	/	?	O	_	o	DEL

CCITT. 5611

The following characters are allocated to the optional positions of Table 1:

#	Number sign	2/3
¤	Currency sign	2/4
@	Commercial at	4/0
[	Left square bracket	5/11
\	Reverse solidus	5/12
]	Right square bracket	5/13
{	Left curly bracket	7/11
|	Vertical line	7/12
}	Right curly bracket	7/13

CCITT 4929

It should be noted that no substitution is allowed when using the international reference version.

6.3 *National versions*

6.3.1 The responsibility for defining national versions lies with the national standardization bodies. These bodies shall exercise the options available and make the required selection.

6.3.2 If so required, more than one national version can be defined within a country. The different versions shall be separately identified. In particular when for a given national use position, e.g. 5/12 or 6/0, alternative characters are required, two different versions shall be identified, even if they differ only by this single character.

6.3.3 If there is in a country no special demand for specific characters, it is strongly recommended that the characters of the international reference version be allocated to the same national use positions.

6.4 *Application-oriented versions*

Within national or international industries, organizations or professional groups, application-oriented versions can be used. They require precise agreement among the parties concerned, who will have to exercise the options available and to make the required selection.

7. *Functional characteristics related to control characters*

Some definitions in this section are stated in general terms and more explicit definitions of use may be needed for specific implementation of the code table on recording media or on transmission channels. These more explicit definitions and the use of these characters are the subject of I.S.O. publications (see the Appendix).

7.1 *General designations and control characters*

The general designation of control characters involves a specific class name followed by a subscript number.

They are defined as follows:

TC — *Transmission control characters*

Control characters intended to control or facilitate transmission of information over telecommunication networks.

The use of the TC characters on the general telecommunication networks is the subject of I.S.O. publications (see the Appendix).

The transmission control characters are:

ACK, DLE, ENQ, EOT, ETB, ETX, NAK, SOH, STX and SYN.

FE — *Format effectors*

Control characters mainly intended for the control of the layout and positioning of information on printing and/or display devices. In the definitions of specific format effectors, any reference to printing devices should be interpreted as including display devices.

The definitions of format effectors use the following concept:

a) A page is composed of a number of lines of characters;

b) The characters forming a line occupy a number of positions called character positions;

c) The active position is that character position in which the character about to be processed would appear if it were to be printed. The active position normally advances one character position at a time.

The format effector characters are:

BS, CR, FF, HT, LF and VT (see also Note 1 to Table 1 above).

DC — *Device control characters*

Control characters for the control of a local or remote ancillary device (or devices) connected to a data processing and/or telecommunication system. These control characters are not intended to control telecommunication systems; this should be achieved by the use of TCs.

Certain preferred uses of the individual DCs are given in Section 7.2.

IS — *Information separators*

Control characters that are used to separate and qualify data logically. There are four such characters. They may be used either in hierarchical order or non-hierarchically; in the latter case their specific meanings depend on their applications.

When they are used hierarchically, the ascending order is:

US, RS, GS, FS.

In this case data normally delimited by a particular separator cannot be split by a higher order separator but will be considered as delimited by any higher order separator.

7.2 *Specific control characters*

Individual members of the classes of controls are sometimes referred to by their abbreviated class name and a subscript number (e.g. TC_5) and sometimes by a specific name indicative of their use (e.g. ENQ).

Different but related meanings may be associated with some of the control characters but in an interchange of data this normally requires agreement between the sender and the recipient.

ACK — *Acknowledge*

A transmission control character transmitted by a receiver as an affirmative response to the sender.

BEL — *Bell*

A control character that is used when there is a need to call for attention; it may control alarm or attention devices.

BS — *Backspace*

A format effector which moves the active position one character position backwards on the same line.

CAN — *Cancel*

A character, or the first character of a sequence, indicating that the data preceding it is in error. As a result this data is to be ignored. The specific meaning of this character must be defined for each application and/or between sender and recipient.

CR — *Carriage return*

A format effector which moves the active position to the first character position on the same line.

Device controls

DC1 — A device control character which is primarily intended for turning on or starting an ancillary device. If it is not required for this purpose, it may be used to restore a device to the basic mode of operation (see also DC2 and DC3), or for any other device control function not provided by other DCs.

DC2 — A device control character which is primarily intended for turning on or starting an ancillary device. If it is not required for this purpose, it may be used to set a device to a special mode of operation (in which case DC1 is used to restore the device to the basic mode), or for any other device control function not provided by other DCs.

DC3 — A device control character which is primarily intended for turning off or stopping an ancillary device. This function may be a secondary level stop, e.g. wait, pause, stand-by or halt (in which case DC1 is used to restore normal operation). If it is not required for this purpose, it may be used for any other device control function not provided by other DCs.

DC4 — A device control character which is primarily intended for turning off, stopping or interrupting an ancillary device. If it is not required for this purpose, it may be used for any other device control function not provided by other DCs.

Examples of use of the device controls :

1) One switching

	on – DC2	off – DC4

2) Two independent switchings

First one	on – DC2	off – DC4
Second one	on – DC1	off – DC3

3) Two dependent switchings

General	on – DC2	off – DC4
Particular	on – DC1	off – DC3

4) Input and output switching

Output	on – DC2	off – DC4
Input	on – DC1	off – DC3

DEL — *Delete*

A character used primarily to erase or obliterate an erroneous or unwanted character in punched tape. DEL characters may also serve to accomplish media-fill or time-fill. They may be inserted into or removed from a stream of data without affecting the information content of that stream, but then the addition or removal of these characters may affect the information layout and/or the control of equipment.

DLE — *Data link escape*

A transmission control character which will change the meaning of a limited number of contiguously following characters. It is used exclusively to provide supplementary data transmission control functions. Only graphic characters and transmission control characters can be used in DLE sequences.

EM — *End of medium*

A control character that may be used to identify the physical end of a medium, or the end of the used portion of a medium, or the end of the wanted portion of data recorded on a medium. The position of this character does not necessarily correspond to the physical end of the medium.

ENQ — *Enquiry*

A transmission control character used as a request for a response from a remote station—the response may include station identification and/or station status. When a " Who are you? " function is required on the general switched transmission network, the first use of ENQ after the connection is established shall have the meaning " Who are you? " (station identification). Subsequent use of ENQ may, or may not, include the function " Who are you? ", as determined by agreement.

EOT — *End of transmission*

A transmission control character used to indicate the conclusion of the transmission of one or more texts.

ESC — *Escape*

A control character which is used to provide an additional control function. It alters the meaning of a limited number of contiguously following bit combinations which constitute the escape sequence.
Escape sequences are used to obtain additional control functions which may provide among other things graphic sets outside the standard set. Such control functions must not be used as additional transmission controls.
The use of the character ESC and of the escape sequences in conjunction with code extension techniques is the subject of an I.S.O. Standard referred to in the Appendix.

ETB — *End of transmission block*

A transmission control character used to indicate the end of a transmission block of data where data is divided into such blocks for transmission purposes.

ETX — *End of text*

A transmission control character which terminates a text.

FF — *Form feed*

A format effector which advances the active position to the same character position on a pre-determined line of the next form or page.

HT — *Horizontal tabulation*

A format effector which advances the active position to the next pre-determined character position on the same line.

Information separators

IS_1 (US) — A control character used to separate and qualify data logically; its specific meaning has to be defined for each application. If this character is used in hierarchical order as specified in the general definition of IS, it delimits a data item called a UNIT.

IS_2 (RS) — A control character used to separate and qualify data logically; its specific meaning has to be defined for each application. If this character is used in hierarchical order as specified in the general definition of IS, it delimits a data item called a RECORD.

IS_3 (GS) — A control character used to separate and qualify data logically; its specific meaning has to be defined for each application. If this character is used in hierarchical order as specified in the general definition of IS, it delimits a data item called a GROUP.

IS_4 (FS) — A control character used to separate and qualify data logically; its specific meaning has to be defined for each application. If this character is used in hierarchical order as specified in the general definition of IS, it delimits a data item called a FILE.

LF — *Line feed*

A format effector which advances the active position to the same character position of the next line.

NAK — *Negative acknowledge*

A transmission control character transmitted by a receiver as a negative response to the sender.

NUL — *Null*

A control character used to accomplish media-fill or time-fill. NUL characters may be inserted into or removed from a stream of data without affecting the information content of that stream, but then the addition or removal of these characters may affect the information layout and/or the control of equipment.

SI — *Shift-in*

A control character which is used in conjunction with SHIFT-OUT and ESCAPE to extend the graphic character set of the code. It may reinstate the standard meanings of the bit combinations which follow it. The effect of this character when using code extension techniques is described in an I.S.O. Standard mentioned in the Appendix.

SO — *Shift-out*

A control character which is used in conjunction with SHIFT-IN and ESCAPE to extend the graphic character set of the code. It may alter the meaning of the bit combinations of columns 2 to 7 which follow it until a SHIFT-IN character is reached. However, the characters SPACE (2/0) and DELETE (7/15) are unaffected by SHIFT-OUT. The effect of this character when using code extension techniques is described in an I.S.O. Standard mentioned in the Appendix.

SOH — *Start of heading*

A transmission control character used as the first character of a heading of an information message.

SP — *Space*

A character which advances the active position one character position on the same line.
This character is also regarded as a non-printing graphic.

STX — *Start of text*

A transmission control character which precedes a text and which is used to terminate a heading.

SUB — *Substitute character*

A control character used in the place of a character that has been found to be invalid or in error. SUB is intended to be introduced by automatic means.

SYN — *Synchronous idle*

A transmission control character used by a synchronous transmission system in the absence of any other character (idle condition) to provide a signal from which synchronism may be achieved or retained between data-terminal equipment.

VT — *Vertical tabulation*

A format effector which advances the active position to the same character position on the next pre-determined line.

APPENDIX

Bibliography of relevant I.S.O. Recommendations and Standards

ISO/646	7-bit coded character set for information processing interchange
ISO/R 961	Implementation of the 6- and 7-bit coded character sets on 7-track 12.7 mm (½") magnetic tape
ISO/R 962	Implementation of the 7-bit coded character sets on 9-track 12.7 mm (½") magnetic tape
ISO/R 963	Guide for the definition of 4-bit character sets derived from the I.S.O. 7-bit coded character set for information processing interchange
ISO/R 1113	Representation of 6- and 7-bit coded character sets on punched tape
ISO/R 1155	The use of longitudinal parity to detect errors in information messages
ISO/R 1177	Character structure for start/stop and synchronous transmission
ISO/R 1679	Representation of I.S.O. 7-bit coded character set on 12-row punched cards
ISO/R 1745	Basic mode control procedures for data communication systems
ISO/2022	Code extension techniques for use with the 7-bit coded character set of ISO/646
ISO/2047	Graphical representations for the control characters of the I.S.O. 7-bit coded character set

Recommendation V.4

GENERAL STRUCTURE OF SIGNALS OF INTERNATIONAL ALPHABET No. 5 CODE

(Mar del Plata, 1968)

The C.C.I.T.T.,

I. *considering, firstly,*

the agreement between the International Organization for Standardization (I.S.O.) and the C.C.I.T.T. on the main characteristics of a seven-unit alphabet (International Alphabet No. 5) to be used for data transmission and for telecommunications requirements that cannot be met by the existing five-unit International Alphabet No. 2;

the interest, both to the users and to the telecommunication services, of an agreement concerning the chronological order of transmission of bits in serial working,

declares the view

that the agreed rank number of the unit in the alphabetical table of combinations should correspond to the chronological order of transmission in serial working on telecommunication circuits;

that, when this rank in the combination represents the order of the bit in binary numbering, the bits should be transmitted in serial working with the low order bit first;

that the numerical meaning corresponding to each information unit considered in isolation is that of the digit:

0 for a unit corresponding to condition A (travail = space), and
1 for a unit corresponding to condition Z (repos = mark),

in accordance with the definitions of these conditions for a two-condition transmission system;

II. *considering, moreover,*

that it is often desirable, in data and messages transmission, to add an extra " parity " unit to allow for the detection of errors in received signals;

the possibility offered by this addition for the detection of faults in terminal telegraph equipment;

the need to reserve the possibility of making this addition during the transmission itself, after the seven information units proper have been sent;

that for the majority of data users the 50-baud telex network is not suitable for this seven-unit alphabet, the data transfer rate being too low, and therefore the code limitations due to this network need not extensively be considered,

declares the view

that signals of the telegraph code using combinations of the seven-unit alphabet for data and messages transmission should in general include an additional " parity " unit;

that the rank of this unit and, hence, the chronological order of the transmission in serial working should be the eighth of the combination thus completed;

III. *considering*

that, in start-stop systems working with electromechanical equipment, the margin of such equipment and the reliability of the connection are considerably increased by the use of a stop element corresponding to the duration of two unit intervals of the modulation;

that for transmissions over telephone circuits via modems installed on the user's premises, the latter must be able to use the connections at the highest possible practical rate in characters per second, and that in such a case a single stop unit leads to a gain of about 10% as regards this practical rate;

that, however, it does not appear that the production of electronic devices capable of working at will with start-stop signals having a stop element equal to one- or two-unit intervals should lead to costly complications and that such an arrangement can have the advantage of appreciably limiting the error rate without greatly reducing the practical efficiency of the connection,

declares the view

that in start-stop systems using combinations of the new seven-unit alphabet normally followed by a parity unit, the first information unit of the transmitted combination should be preceded by a start element corresponding to condition A (space);

that the duration of this start element should be one-unit interval for the modulation rate under consideration, at transmitter output;

that the combination of seven information units, normally completed by its parity unit, should be followed by a stop element corresponding to condition Z (mark);

that for start-stop systems using the seven-unit code on switched telegraph and telephone networks, a two-unit stop element should be used with electromechanical data terminal equipments operating at modulation rates up to and including 200 bauds. In other cases, the use of a one-unit stop element is preferable. However, this is subject to a mutual agreement between Administrations concerned;

that similar situations when a one-unit stop element can be used may apply to leased circuits;

that the start-stop receivers should be capable of correctly receiving start-stop signals comprising a single-unit stop element, whose duration will be reduced by a time interval equal to the deviation corresponding to the degree of gross start-stop distortion permitted at receiver input. However, for electromechanical equipment which must use a two-unit stop element (eleven-unit code signal) with a modulation rate of 200 bauds or less, receivers should be capable of correctly receiving signals with a stop element reduced to one unit;

IV. *considering, finally,*

that the direction of the parity unit can only be that of the even parity on the perforated tapes, particularly owing to the possibility of deletion (combination 7/15 of the alphabet) which causes a hole to appear in all tracks;

that, on the other hand, the odd parity is considered essential in the equipment which depends on transitions in the signals to maintain synchronism (in cases where combination 1/6 (SYNC) of the alphabet does not permit of an economical solution), *declares the view*

that the parity unit of the signal should correspond to the even parity in links or connections operated on the principle of the start-stop system,

that this parity should be odd on links or connections using end-to-end synchronous operation,

that arrangements should be made when necessary to reverse the direction of the parity unit at the input and output of the synchronous equipment connected either to apparatus working on the start-stop principle or receiving characters on perforated tape.

Recommendation V.10

USE OF THE TELEX NETWORK FOR DATA TRANSMISSION AT THE MODULATION RATE OF 50 BAUDS

(Geneva, 1964, amended at Mar del Plata, 1968)

The telex network is well adapted for the economical transmission of data at fairly slow speeds, for the equipment required for binary transmission of data by telex stations, over and above the normal equipment, is relatively simple.

But some limits have to be imposed on data transmission codes used in the telex network because of:

— the need to make sure that telex calls will not be abruptly released;

— exaggerated distortion which may be introduced by amplitude-modulation voice-frequency telegraph systems when an excessively long-duration " start (condition A) " modulation element appears in a signal;

— the fact that in some networks there is regenerative repetition of start-stop signals which can be handled only as if they were constructed like five-unit start-stop information signals;

— the possibility that certain long-distance calls are established over synchronous systems which can handle only five-unit start-stop signals.

The limitation due to regenerative repeaters and synchronous systems imposes the use of a five-unit start-stop code for information hence the first part of the Recommendation (dealing with the most general procedure); this deals with data transmission with a five-unit code on start-stop systems.

But in certain circumstances alphabets with more than five units can be used for data transmission, whence the second part of the Recommendation.

For these reasons, the C.C.I.T.T. *unanimously declares the following view:*

I. Part I — Data transmission with a five-unit code on start-stop systems

Telex calls for data transmission may be set up in the international telex network, subject to the following provisions:

I.a) The call shall be set up between the caller and the called subscriber in accordance with the procedure recommended by the C.C.I.T.T. for the setting-up of a telex call and its supervision by exchange of answer-back codes (C.C.I.T.T. Recommendations F.60—Volume II B and U.1—Volume VII, *Green Book*).

I.b) When one of the subscribers concerned wishes to introduce data transmission equipment into the connection, he shall transmit the sequence SSSS (or '''') of signals No. 19 from Alphabet No. 2 (signal for transfer to data).

Upon reception of this sequence of signals, the data transmission or reception equipment, as the case may be, shall be connected to the line. This changeover to the data position may be effected:

a) manually at both terminals;

b) automatically at both terminals;

c) manually at one terminal and automatically at the other.

In order to avoid any misunderstanding between the stations concerned, the calling operator should first check the equipment of the distant station (whether manual changeover or automatic changeover).

Case a) — Manual changeover at both terminals

Once the connection has been set up, the following procedure should be followed:

1. The operator of the calling station sends the sequence of four No. 19 combinations. This sequence should not connect the data equipment locally.

2. Upon reception of the SSSS (or '''') sequence, the operator of the called station likewise sends the sequence of four No. 19 combinations, and then connects his data equipment to the line.

3. Upon reception of this answer sequence, the calling operator connects his data equipment to the line.

Case b) — Automatic changeover at both terminals

Once the connection has been set up, the following procedure should be followed:

1. The calling station sends the sequence of four No. 19 combinations, which must connect its data equipment to the line automatically within less than 500 milliseconds, starting from the end of transmission of the last signal of this sequence.

2. Reception of the sequence at the other terminal of the connection connects the called station to the data equipment line automatically within less than 500 milliseconds, starting from the end of reception of the last signal of this sequence.

3. The data transmission should not commence before the end of the 500-millisecond delay.

Case c) — Manual changeover at one terminal and automatic changeover at the other

i) *Calling station with manual changeover and called station with automatic changeover*

Once the connection has been set up, the following procedure is followed:

1. The operator of the calling station sends the sequence of four No. 19 combinations, and then immediately connects his data equipment to the line.

2. Upon reception of the sequence of four No. 19 combinations at the called station, the data equipment must be connected to the line within less than 500 milliseconds, starting from the end of reception of this sequence.

3. The data signals should not be transmitted before the end of the 500-millisecond delay.

ii) *Calling station with automatic changeover and called station with manual changeover*

Once the connection has been set up, the following procedure should be followed:

1. The calling station invites its called correspondent, by a brief preliminary message, to send the sequence of four No. 19 combinations. This message must not include within itself the sequence of four No. 19 combinations. If the calling station is not equipped with teleprinter attended by an operator, this preliminary message must be sent automatically.

2. The operator of the called station then sends the sequence of four No. 19 combinations and immediately connects his data equipment to the line.

3. Upon reception of this sequence at the calling station, connection of the data equipment to the line must be effected within less than 500 milliseconds, starting from the end of reception of the last No. 19 signal of the sequence.

4. Transmission of the data signals should not begin before the end of the 500-millisecond delay.

Note. — The arrangements envisaged by Recommendation V.10, point I.b, run counter to the inclusion of the sequence of four No. 19 combinations in the answer-back code of telex lines equipped with a simulator and at the same time in the answer-back of teleprinters equipped with an automatic device for changeover to data transmission. (This fact should be borne in mind in the further study of this Recommendation.)

I.c) The sequence of four combinations No. 19 will make ineffective, where necessary:

— devices which might conceivably emit signals disturbing to data transmissions, in particular the answer-back or, possibly, the delay signal used in connection with error-correcting synchronous radio systems (Recommendation U.22, *Green Book*, Volume VII);

— devices which might be falsely operated by data signals, such as devices for operator-recall (Recommendation U.21, *Green Book*, Volume VII).

I.d) Data transmission should be made by means of a start-stop formed according to the structure of Alphabet No. 2. Users should be left free to decide how combinations should be allocated to the various components of the alphabet (of course, Alphabet No. 2 may itself be used).

I.e) When error-control is necessary, one of the following methods of error-control may be used:

— return of information to the transmitting station (information feedback system);

— block transmission with check characters at the end of the block;

— character-by-character transmission with check bits (in the case of five-unit signals with redundancy).

I.f) Unless the exception stated in paragraph I.g is employed at the end of the data transmission, the telex clearing signal described in Recommendation U.1 shall be emitted; this will cause the call to be cleared down and the terminal equipment to return to the telex position, and will cause the devices which might have been rendered inoperative on certain special circuits (see I.c) to go back to normal. This clearing signal must set off the clear-confirmation (see Recommendation U.1).

Note. — Users may expect that some combinations No. 32, possibly followed by other combinations, may be received before the connection is cleared.

I.g) As soon as the telex connection has been transferred to the data transmission equipment, the transmission must be controlled by the data equipment at each terminal.

If it is useful, for some reason, to return to telex operation, the data terminal equipment must control the transfer back to telex.

This possibility of returning to the telex condition is used by a subscriber who considers it useful, after a data transmission, to return to teleprinter operation for a telex connection, instead of sending the clearing signal as mentioned in paragraph I.f above. This return should be accompanied by the re-entry into service of the answer-back device.

This control may be caused:

1. by the transmission of a special data signal over the line, causing the receiving installation to return to the telex position. The received data terminal equipment must send the same signal in the reverse direction to the opposite terminal before it causes transfer to the telex condition. This mutual signalling identifies the situations at the two terminals;

2. by a local control causing return to the telex situation, set off if no data or supervisory signal is transmitted or received during a given time interval agreed upon by the users.

Note. — Telex connections which include error-correcting synchronous radio systems often insert long pauses into the message and due attention should be paid to this in selecting the agreed interval.

For these control operations, a special circuit should be set aside in the interface connecting the data terminal equipment to the transfer device.

Note. — The above provisions of paragraph I.g could be applied with advantage to the case of telex lines not equipped with teleprinter equipment but simply with answer-back unit simulators.

I.h) The signals transmitted by the data transmission devices must meet the exigencies set forth in items 1, 2, 3 and 5 of Recommendation S.3 (*Green Book*, Volume VII). The receiving equipment of the data-reception devices must meet the exigencies set forth in items 1, 2, 4 and 6 of Recommendation S.3.

II. Part II — Data transmission with codes different from the start-stop code of International Alphabet No. 2

The attention of Administrations is drawn to the fact that it is impossible to send signals other than those of a five-unit start-stop code over international connections via time-division multiplex sections specially designed for a five-unit code.

However, telex connections for data transmission may be set up over such relations in the conditions set out in part I of this Recommendation for the transmission of messages composed of signals different from those of the five-unit start-stop code. A service of this nature may be obtained by regrouping the units of these signals in the form of five-unit signals. Such regrouping calls for the use of additional code converters at the sending and receiving terminals.

Between telex networks which can take signals different from those of the five-unit start-stop code (that is to say, when telex calls between such networks do not call for regenerative repeaters, or for certain synchronous systems which would clash with them), by agreement between the Administrations concerned, data transmission with data transmission alphabets using these signals may be made, subject to the following:

II.a) Application of the procedure described under l.a.

II.b) Application of the procedure described under I.b.

II.c) Application of the procedure described under I.c.

II.d) Use of a code with a modulation rate of 50 bauds should avoid composition of signals having more than seven consecutive elements of start polarity.

Note. — This limit is imposed to avoid clearing the connection unexpectedly in the exchanges as well as not to introduce excessive distortion on AM voice-frequency telegraph channels.

Data may be transmitted by start-stop, or isochronously.

II.e) When error control is necessary, one of the following methods of error control may be used:

— return of information to the transmission station (information feedback system);

— block transmission with check characters at the end of the block;

— character-by-character protection by means of a parity check or a constant ratio code, for example the seven-unit code (Alphabet No. 3) standardized in Recommendation S.13 (*Green Book*, Volume VII).

In all cases restrictions given in the above paragraph II.d should be taken into consideration.

II.f) Application of the procedure described under I.f.

II.g) Application of the procedure described under I.g.

Recommendation V.11

AUTOMATIC CALLING AND/OR ANSWERING ON THE TELEX NETWORK

(Mar del Plata, 1968)

1. *General*

1.1 This Recommendation provides a method of automatically originating and answering calls on the telex network. Manual calling or answering with automatic facilities is also provided. At this stage the application of that part of this Recommendation for automatic origination of calls is limited to those networks where route selection is by means of dial pulses. The automatic answering procedure, however, is generally applicable.

1.2 In order to simplify and reduce the costs of overall data terminal systems in the particular cases where calls are originated for data transmission over the telex as well as the switched telephone networks, the interface and data terminal procedures have been arranged to be similar (see Recommendation V.25 for automatic calling and/or answering on the general switched telephone network).

1.3 The object is to standardize the call establishment and answering procedures between the data terminal equipment and the data circuit-terminating equipment. In addition, the essential interchange circuits, according to Recommendation V.24, have been defined between the two equipments.

1.4 It is recognized that other simpler methods may be possible for automatic calling by data terminals connected only to the switched telegraph networks, and these are still under study.

Ultimately it may be technically possible to extend the application of this Recommendation to route selection signals of the telegraph character type (commonly known as keyboard selection). This requires further study.

2. *Interchange circuits*

2.1 *Automatic answering*

These circuits are required to be connected between the data terminal equipment and the control unit within the data circuit-terminating equipment.

Circuit numbers

CT 101 [1]	Protective ground
CT 102	Signal ground
CT 103	Transmitted data
CT 104	Received data
CT 106	Ready for sending (see Note)
CT 107	Data set ready (see Note)
CT 108/2	Data terminal ready
CT 109	Data channel received line signal detector (see Note)
CT 125	Calling indicator
CT 132	Return to non-data mode

Note. — In so far as the operation of the data circuit-terminating equipment is concerned, circuits CT 106 and CT 109 are not required. But to provide an interface common to that for the telephone case these two circuits are included and are both coupled to CT 107 at the data circuit-terminating equipment.

2.2 *Automatic calling*

For automatic calling by data terminals connected to telex networks with dial pulse selection, in addition to the above circuits, the following circuits should also be employed between the data terminal equipment and the automatic calling equipment within the data circuit-terminating equipment:

Circuit numbers

CT 201	Signal ground
CT 202	Call request
CT 203	Data line occupied
CT 204	Distant station connected
CT 205	Abandon call
CT 206	Binary digit signal 1
CT 207	Binary digit signal 2
CT 208	Binary digit signal 4
CT 209	Binary digit signal 8
CT 210	Present next digit
CT 211	Digit present
CT 212 [1]	Protective ground
CT 213	Power indication

The above sets of interface circuits are applicable only to a single data terminal equipment connected to a single telex terminal.

The impedances of these interface circuits and the signals (voltages, etc.) on the circuits must be as specified in Recommendation V.28.

Note 1. — The use of a common auto-calling equipment for the connection of several data terminal equipments to one, or more, telex lines and any additional interchange circuits thus required remains for further study.

Note 2. — It may be technically possible to extend the application of this automatic calling interface for " route selection " signals of the telegraph character type (commonly known as keyboard selection). This possibility requires further study.

[1] May be excluded if so required by local safety regulations.

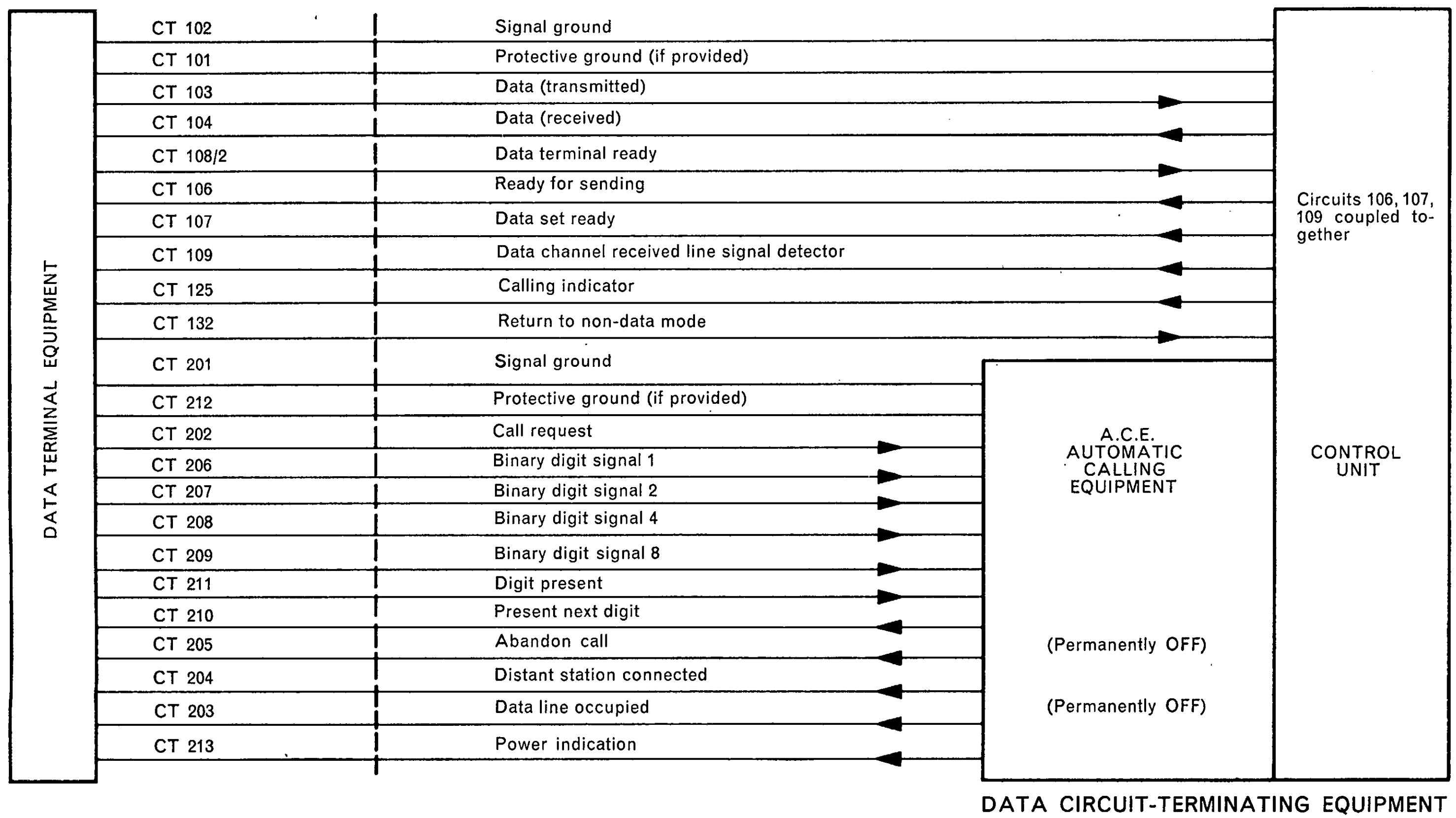


FIGURE 1/V.11. — **Proposed interface for telex A.C.E.**

3. *Procedures*

The connections between various types of terminals covered by the following recommended procedures are:

I) Telex terminal, with manual calling	⟶	Data terminal, with automatic answering
II) Telex and data terminal, with manual calling, manual or automatic changeover to data	⟶	Data terminal, with automatic answering
III) Data terminal, with automatic calling	⟶	Telex terminal, with teleprinter answering
IV) Data terminal, with automatic calling	⟶	Telex and data terminal, with teleprinter answering, automatic changeover
V) Data terminal, with automatic calling	⟶	Data terminal with automatic answering

The recommended procedures are:

CASE I

A Station (calling)	B Station (answering)
TELEX TERMINAL: *Manual calling*	DATA TERMINAL: *Automatic answering*
1.A Call telex exchange.	1.B Incoming call indication at control unit switches CT 125 to ON and " Call connected " signal is transmitted.
2.A Operator dials, or keys, route selection signals and establishes connection in normal way.	2.B If DTE is going to accept incoming call, CT 108/2 must be switched ON within 2 seconds after CT 125 is ON.
	3.B Upon receipt of WRU signal, then a) if CT 108/2 is OFF, control unit sends " answer-back " (A/B) signals followed by the service signals ABS and then the " clearing " signal, b) if CT 108/2 is ON, control unit sends A/B signals. It then connects CT 103 and CT 104 to line; CT 106, CT 107, CT 109 are switched ON. (A/B unit simulator remains enabled.)
3.A Receives A/B signals, either automatically or after sending WRU signal by the operator.	
4.A Data exchange may commence.	4.B Data exchange may commence.
TELEX OPERATOR CLEARS 5.A i) If the operator requires to clear down, he initiates clearing signal in the normal telex manner.	5.B i) Upon receipt of the clearing signal, the DCE returns the clearing signal, switches CT 125, CT 106, CT 107 and CT 109 to OFF. The line is disconnected from CT 103 and CT 104. 6.B i) DTE might or might not switch CT 108/2 to OFF.
	DATA TERMINAL CLEARS 5.B ii) DTE switches CT 108/2 to OFF. 6.B ii) The control unit switches CT 106, CT 107, CT 109 and CT 125 to OFF. 7.B ii) The control unit disconnects the line from CT 103 and CT 104; transmits the clearing signal.
5.A ii) Clearing signal received, terminal clears down automatically in normal telex manner.	8.B ii) DTE might or might not switch CT 108/2 to ON

CASE II

A Station (calling)	B Station (answering)
TELEX AND DATA TERMINAL: *Manual calling—Manual or automatic changeover*	DATA TERMINAL: *Automatic answering*
1.A Call telex exchange.	

DCE: Data circuit-terminating equipment.
DTE: Data terminal equipment.

CASE II (continued)

A Station (calling)	B Station (answering)
2.A Operator dials, or keys, route selection signals and establishes connection in normal way.	1.B Incoming call indication at control unit switches CT 125 to ON and " Call connected " signal is transmitted.
	2.B If DTE is going to accept incoming call, CT 108/2 must be switched ON within 2 seconds after CT 125 is ON.
3.A Receives A/B signals, either automatically or after sending WRU signal by the operator.	3.B Upon receipt of WRU signal, then a) if CT 108/2 is OFF, control unit sends A/B signals followed by the service signals ABS and then the clearing signal, b) if CT 108/2 is ON, control unit sends A/B signals. It then connects CT 103 and CT 104 to line; CT 106, CT 107, CT 109 are switched ON. (A/B unit simulator remains enabled.)
4.A Operator transmits four times signal No. 19 of Alphabet No. 2 and: a) immediately switches the line manually to the DTE, or b) (With automatic changeover). The transfer of the line from the teleprinter to CT 103 and CT 104 is effected automatically within the control unit by the transmission of the last signal of the sequence four times signal No. 19. Control unit switches CT 106, CT 107 and CT 109 to ON. A/B unit disabled.	4.B The receipt of the sequence four times signal No. 19 of the No. 2 Alphabet indicates to the DTE that the data equipment at the A station is connected to line. DCE disables the A/B unit simulator.
5.A Data exchange may commence.	5.B Data exchange may commence.
TELEX OPERATOR CLEARS: *Manual changeover only*	
6.A i) Operator manually switches the line to the telex terminal.	
7.A i) Operator initiates clearing signal in the normal telex manner, and A/B unit is re-enabled.	6.B i) Upon receipt of the clearing signal, the DCE returns the clearing signal, switches CT 125, CT 106, CT 107 and CT 109 to OFF. The line is disconnected from CT 103 and CT 104.
	7.B i) DTE might or might not switch CT 108/2 to OFF.
	8.B i) A/B unit simulator is re-enabled by DCE.
DATA TERMINAL CLEARS	
6.A ii) DTE switches CT 108/2 to OFF.	

CASE II (continued)

A Station (calling)	B Station (answering)
7.A ii) The control unit of DCE switches CT 106, CT 107 and CT 109 to OFF, transfers the line from CT 103 and CT 104 to the telex terminal and transmits the clearing signal. A/B unit is re-enabled.	6.B ii) Upon receipt of the clearing signal, the DCE returns the clearing signal, switches CT 125, CT 106, CT 107 and CT 109 to OFF. The line is disconnected from CT 103 and CT 104. A/B unit simulator is re-enabled. 7.B ii) DTE might or might not switch CT 108/2 to OFF.
	DATA TERMINAL CLEARS 6.B iii) DTE switches CT 108/2 to OFF. 7.B iii) The control unit switches CT 106, CT 107, CT 109 and CT 125 to OFF. 8.B iii) The control unit disconnects the line from CT 103 and CT 104; transmits the clearing signal.
6.A iii) Clearing signal received, terminal clears down automatically in normal telex manner. A/B unit is re-enabled.	A/B unit simulator is re-enabled.

CASE III

A Station (calling)	B Station (answering)
DATA TERMINAL: *Automatic calling*	TELEX TERMINAL: *Teleprinter answering—No data equipment*
1.A DTE checks CT 213 is ON and CT 203 is OFF.	
2.A DTE switches CT 202 to ON.	
3.A DTE switches CT 108/2 to ON.	
4.A DCE (auto-calling equipment and control unit) calls telex exchange and switches CT 203 to ON.	
5.A " Proceed to select " signal is received from telex exchange.	
6.A DCE switches CT 210 to ON.	
7.A DTE presents first digit on CT 206, CT 207, CT 208, CT 209.	
8.A DTE switches CT 211 to ON.	
9.A DCE sends the " route selection " signals for the first digit, then switches CT 210 to OFF.	
10.A DTE switches CT 211 to OFF.	
11.A The sequence of steps 6.A–10.A are repeated for each digit, including the last to be transmitted.	
12.A DCE switches CT 210 to ON.	1.B Call received in normal way.
13.A DTE presents the " end of number " (EON) signals on CT 206, CT 207, CT 208 and CT 209, then switches CT 211 to ON.	2.B " Call connected " signal sent.
14.A DCE switches CT 210 to OFF and holds it in this condition for the remainder of call.	
15.A DTE switches CT 211 to OFF.	
16.A " Call connected " signal received, DCE connects CT 103 and CT 104 through to line and switches CT 106, CT 107 and CT 109 to ON. (A/B unit simulator in DCE still connected.)	

CASE III (continued)

A Station (calling)		B Station (answering)	
17.A	If A/B signals are not automatically received within 3 seconds [1] (see Note 2) DTE transmits signals No. 30 and No. 4 of the No. 2 Alphabet (WRU). The A/B unit simulator of the DCE must not respond to this WRU signal.	3.B	Upon receipt of the WRU signals, the A/B signals are transmitted.
18.A	The A/B signals having been received by the DTE data exchange may commence.	4.B	Data exchange may commence.
[1] See Notes 1 and 5.			
DATA TERMINAL CLEARS			
19.A i)	DTE switches CT 108/2 and CT 202 to OFF.		
20.A i)	CT 108/2 being switched OFF, the control unit of DCE switches CT 106, CT 107 and CT 109 to OFF. Disconnects CT 103 and CT 104 from the line. Transmits the clearing signal.	5.B i)	Clearing signal received, telex terminal clears down in normal telex way.
		TELEX OPERATOR CLEARS	
		5.B ii)	If operator requires to clear down, he initiates the clearing signal in the normal telex way.
19.A ii)	On receipt of clearing signal monitored from line by control unit, DCE switches CT 106, CT 107 and CT 109 to OFF, disconnects CT 103 and CT 104 from the line and returns the clearing signal to line.		
20.A ii)	DTE switches CT 202 and CT 108/2 to OFF.		

CASE IV

A Station (calling)		B Station (answering)	
DATA TERMINAL: *Automatic calling*		TELEX + DATA TERMINAL: *Automatic changeover*	
1.A	DTE checks CT 213 is ON and CT 203 is OFF.		
2.A	DTE switches CT 202 to ON.		
3.A	DTE switches CT 108/2 to ON.		
4.A	DCE (auto-calling equipment and control unit) calls telex exchange and switches CT 203 to ON.		
5.A	" Proceed to select " signal is received from telex exchange.		
6.A	DCE switches CT 210 to ON.		
7.A	DTE presents first digit on CT 206, CT 207, CT 208, CT 209.		
8.A	DTE switches CT 211 to ON.		
9.A	DCE sends the route selection signals for the first digit, then switches CT 210 to OFF.		
10.A	DTE switches CT 211 to OFF.		
11.A	The sequence of steps 6.A-10.A are repeated for each digit, including the last to be transmitted.		
12.A	DCE switches CT 210 to ON.	1.B	Incoming call indication received, DCE switches CT 125 to ON.

CASE IV (continued)

A Station (calling)	B Station (answering)
13.A DTE presents the end of numbers (EON) signals on CT 206, CT 207, CT 208 and CT 209, then switches CT 211 to ON.	2.B " Call connected " signal sent.
14.A DCE switches CT 210 to OFF and holds it in this condition for the remainder of call.	
15.A DTE switches CT 211 to OFF.	
16.A " Call connected " signal received, DCE connects CT 103 and CT 104 through to line and switches CT 106, CT 107 and CT 109 to ON. (A/B unit simulator in DCE still connected.)	
17.A If A/B signals are not automatically received within 3 seconds [1] (see Note 2) DTE transmits signals No. 30 and No. 4 of the No. 2 Alphabet (WRU). The A/B unit simulator of the DCE must not respond to this WRU signal.	3.B Upon receipt of the WRU signals, the A/B signals are transmitted.
18.A Upon receipt of A/B signals (all coded in accordance with Alphabet No. 2), the DTE transmits over CT 103 the signal sequence of four times signal No. 19 of Alphabet No. 2.	
19.A Upon recognition of the sequence of four times signal No. 19 by the DCE the A/B unit simulator is disabled.	4.B Upon receipt of the signal sequence of four times signal No. 19 a) if CT 108/2 is ON, DCE transfers the line from the telex terminal to CT 103 and CT 104; CT 106, CT 107 and CT 109 are switched ON. A/B unit is disabled. b) If CT 108/2 is OFF, the call is cleared by DCE.
20.A After a minimum delay of 500 ms data exchange may commence.	5.B Data exchange may commence.
21.A If the DTE requires to communicate with the telex terminal at the B station after data have been exchanged a special data signal should be sent from the DTE to effect this.	6.B Upon receipt of the appropriate data signal, DTE switches CT 132 to ON.
	7.B The control unit of the DCE restores the line connection to the telex terminal and switches CT 106, CT 107, CT 109 and CT 125 to OFF.
22.A After 2 seconds " telegraph " characters, encoded in accordance with the No. 2 Alphabet, may now be exchanged.	
	8.B Normal telegraph transmission may commence.
[1] See Notes 1 and 5.	9.B DTE switches CT 132 to OFF.
DATA TERMINAL CLEARS	DATA TERMINAL STILL CONNECTED
23.A i) DTE switches CT 108/2 and CT 202 to OFF.	
24.A i) CT 108/2 being switched OFF, the control unit of DCE switches CT 106, CT 107 and CT 109 to OFF, disconnects CT 103 and CT 104 from the line, and transmits the clearing signal. A/B unit simulator is re-enabled.	10.B i) On receipt of the clearing signal monitored from the line by the control unit of DCE, CT 106, CT 107, CT 109 and CT 125 are switched OFF. Line is transferred from CT 103 and CT 104 to the telex terminal and the clearing signal is returned to line in the normal telex manner. A/B unit is re-enabled.

CASE IV (continued)

A Station (calling)	B Station (answering)
DATA TERMINAL CLEARS 23.A ii) DTE switches CT 108/2 and CT 202 to OFF. 24.A ii) CT 108/2 being switched OFF, the control unit of DCE switches CT 106, CT 107 and CT 109 to OFF, disconnects CT 103 and CT 104 from the line. Transmits the clearing signal. A/B unit simulator is re-enabled.	TELEX TERMINAL RECONNECTED 10.B ii) Clearing signal received, terminal clears down in normal telex manner. A/B unit is re-enabled.
23.A iii) On receipt of the clearing signal monitored from line by control unit, DCE switches CT 106, CT 107 and CT 109 to OFF, disconnects CT 103 and CT 104 from the line and returns the clearing signal to line. A/B unit simulator is re-enabled. 24.A iii) DTE switches CT 202 and CT 108/2 to OFF.	DATA TERMINAL CLEARS (not having returned to telex terminal) 10.B iii) DTE switches CT 108/2 to OFF. 11.B iii) The control unit switches CT 106, CT 107, CT 109 and CT 125 to OFF. 12.B iii) The control unit transfers the line from CT 103 and CT 104 to the telex terminal and transmits the clearing signal. A/B unit is re-enabled.
23.A iv) On receipt of the clearing signal monitored from line by control unit, DCE switches CT 106, CT 107 and CT 109 to OFF, disconnects CT 103 and CT 104 from the line and returns the clearing signal to line. A/B unit simulator is re-enabled. 24.A iv) DTE switches CT 202 and CT 108/2 to OFF.	TELEX OPERATOR CLEARS (having returned to telex terminal) 10.B iv) If operator requires to clear down, he initiates the clearing signal in the normal telex way.

CASE V

A Station (calling)	B Station (answering)
DATA TERMINAL: *Automatic calling* 1.A DTE checks CT 213 is ON and CT 203 is OFF. 2.A DTE switches CT 202 to ON. 3.A DTE switches CT 108/2 to ON. 4.A DCE (auto-calling equipment and control unit) calls telex exchange and switches CT 203 to ON. 5.A " Proceed to select " signal is received from telex exchange. 6.A DCE switches CT 210 to ON.	DATA TERMINAL: *Automatic answering*

CASE V (continued)

A Station (calling)	B Station (answering)
7.A DTE presents first digit on CT 206, CT 207, CT 208, CT 209.	
8.A DTE switches CT 211 to ON.	
9.A DCE sends the " route selection " signals for the first digit, then switches CT 210 to OFF.	
10.A DTE switches CT 211 to OFF.	
11.A The sequence of steps 6.A-10.A are repeated for each digit, including the last to be transmitted.	
12.A DCE switches CT 210 to ON.	
13.A DTE presents the end of numbers (EON) signals on CT 206, CT 207, CT 208 and CT 209, then switches CT 211 to ON.	1.B Incoming call indication at control unit switches CT 125 to ON and " call connected " signal is transmitted.
14.A DCE switches CT 210 to OFF and holds it in this condition for the remainder of call.	2.B If DTE is going to accept incoming call, CT 108/2 must be switched ON within 2 seconds after CT 125 is ON.
15.A DTE switches CT 211 to OFF.	
16.A " Call connected " signal received, DCE connects CT 103 and CT 104 through to line and switches CT 106, CT 107 and CT 109 to ON. (A/B unit simulator in DCE still connected.)	3.B Upon receipt of WRU signal, then
17.A If A/B signals are not automatically received within 3 seconds [1] (see Note 2) DTE transmits signals No. 30 and No. 4 of the No. 2 Alphabet (WRU). The A/B unit simulator of the DCE must not respond to this WRU signal.	a) if CT 108/2 is OFF, control unit sends A/B signals followed by the service signals ABS and then the clearing signal. b) if CT 108/2 is ON, control unit sends A/B signals. It then connects CT 103 and CT 104 to line; CT 106, CT 107, CT 109 are switched ON. (A/B unit simulator remains enabled.)
18.A Upon receipt of A/B signals (all coded in accordance with Alphabet No. 2), the DTE transmits over CT 103 the signal sequence of four times signal No. 19 of Alphabet No. 2.	
19.A Upon recognition of the sequence of four times signal No. 19 by the DCE the A/B unit simulator is disabled.	4.B The receipt of the sequence four times signal No. 19 of the No. 2 Alphabet indicates to the DTE that the data equipment at the A station is connected to line. DCE disables the A/B unit simulator.
20.A After a minimum delay of 500 ms data exchange may commence.	5.B Data exchange may commence.
[1] See Notes 1 and 5.	
DATA TERMINAL CLEARS	
21.A i) DTE switches CT 108/2 and CT 202 to OFF.	
22.A i) CT 108/2 being switched OFF, the control unit of DCE switches CT 106, CT 107 and CT 109 to OFF, disconnects CT 103 and CT 104 from the line and transmits the clearing signal. A/B unit simulator is re-enabled.	6.B i) Upon receipt of the clearing signal, the DCE returns the clearing signal, switches CT 125, CT 106, CT 107 and CT 109 to OFF. The line is disconnected from CT 103 and CT 104. A/B unit simulator is re-enabled.
	7.B i) DTE might or might not switch CT 108/2 to OFF.

CASE V (concluded)

A Station (calling)	B Station (answering)
	DATA TERMINAL CLEARS 6.B ii) DTE switches CT 108/2 to OFF. 7.B ii) The control unit switches CT 106, CT 107, CT 109 and CT 125 to OFF.
21.A ii) On receipt of the clearing signal monitored from the line by control unit, DCE switches CT 106, CT 107 and CT 109 to OFF, disconnects CT 103 and CT 104 from the line and returns the clearing signal to line. A/B unit simulator is re-enabled. 22.A ii) DTE switches CT 202 and CT 108/2 to OFF.	8.B ii) The control unit disconnects the line from CT 103 and CT 104; transmits the clearing signal. A/B unit simulator is re-enabled.

Note 1. — In some national telex systems the " answer-back " from the A station is automatically tripped by a WRU signal from the telex exchange. Therefore the DTE at both A and B stations must be prepared for these signals to be transmitted before data can be reliably exchanged. The telex operator at the A station in the above cases I and II must also be prepared for these signals to be transmitted before attempting to send the sequence of four times signal No. 19.

Note 2. — This is a provisional time of three seconds. It is considered that a finally agreed figure may be in excess of this.

Note 3. — On the occasions when a call, for various reasons, is not connected through to a B station, service signals (e.g. OCC, DER) will be sent from the telex exchange to the A station. Since those service signals are always prefixed by a continuous signal of " Stop " polarity for minimum duration of 200 milliseconds, the lines at the A station will have been extended to the DTE and the service signals will pass straight to the DTE. The call will be cleared automatically by the telex exchange. The general question of service signals and the responses which the DTE should make to them (e.g. number of attempts to establish the call and timing between successive attempts) is to be studied.

Note 4. — The particular case of a data terminal with automatic calling working into a telex + data terminal with manual changeover has not been included as the indefinite delay of an operator in switching to data could be unacceptable.

Note 5. — Because of the possible reception by data terminal equipments of normal telegraph supervisory and/or service signals (see Notes 1 and 3) it might be advisable for the data terminal equipments at either end of the connection to exchange " message prefix " signals before commencing to exchange data. The coding and decision to use such message prefixes remain the responsibility of the data user.

Recommendation V.13

ANSWER-BACK UNIT SIMULATORS

(Mar del Plata, 1968)

a) The answer-back code must be released by a device capable of recognizing the " who are you? " signal of Alphabet No. 2 (five-unit code). Hence, this device must keep in a store unit the " figures " situation indicated by combination No. 30 received before combination No. 4 of this alphabet.

b) In view of the procedure adopted for the use of the sequence of four No. 19 combinations as the signal for passage from the " telex " position to the " data " position in terminal equipment, the introduction of this sequence (four times combination No. 19) in the 20 signals of the simulator answer-back code is to be avoided, since it is incompatible with the procedure already adopted.

Note. — It should be noted that, for the same reason of procedure, this four times combination No. 19 sequence should not be introduced in the answer-back code signals of a teleprinter associated with a manual or automatic call-transfer device.

c) The composition of the signals of the answer-back unit simulator can obviously be used for identification of the station obtained by the station which requests the call. If the identification is negative, it is up to this calling station to interrupt the unwanted connection.

Note. — On the other hand, it was agreed that identification in the opposite direction could not be achieved in a simple way by the answer-back unit simulator, since the answer-back code to be checked in this direction is that of the opposite station which is normally the one which has requested the connection.

d) In a telex installation intended for data transmission and equipped with an answer-back unit simulator instead of a teleprinter, the device for changeover from telex to data working—by the passage of the sequence of four No. 19 combinations—must be automatic.

e) The characteristics of the answer-back unit simulator should conform with Recommendation S.6, paragraphs 2 to 6, of Volume VII.

Recommendation V.15

USE OF ACOUSTIC COUPLING FOR DATA TRANSMISSION

(Geneva, 1972)

Considering that there is a wide variety of telephone instruments in existence and that the acoustic path involved in the use of any coupling device cannot be accurately prescribed for all cases, and hence it will be difficult to ensure satisfactory transmission in all situations,

The C.C.I.T.T. *recommends* that acoustic coupling of data transmission equipment via telephone instruments to the telephone transmission network should not be used for permanent installations.

It is, however, recognized that there may be a need for a means to provide temporary connection of portable data transmission equipment to the network in circumstances where it may not be possible to obtain convenient access to the subscriber's line terminals.

The use of acoustic coupling for temporary communications is subject to the agreement of the Administration in charge of the telephone network to which the equipment will be connected.

If an Administration decides to permit acoustic coupling for temporary data transmission stations, the acoustic coupling equipment should conform to the following:

1. The maximum power output of the subscriber's equipment into the line shall not exceed 1 mW at any frequency.

The mean permitted telephone line signal power shall not exceed −13 dBm0 for duplex operation and −10 dBm0 for simplex operation when integrated over any period of approximately 3 seconds. (See introductory paragraphs b) and c) of Recommendation V.2.)

2. If p is the signal power in the frequency band 0-4 kHz, the signal power outside this band shall not exceed the following values when integrated over any period of approximately 3 seconds:

p − 20 dB in the band 4 to 8 kHz

p − 40 dB in the band 8 to 12 kHz

p − 60 dB in each 4-kHz band above 12 kHz.

3. The frequencies emitted by the transducer shall be such as not to interfere with national and international telephone signalling systems and pilot signals involved in telephone connection envisaged.

4. Adequate protection shall be provided in the transducer to avoid causing any dangerous electric potential and currents to the telephone system.

5. It shall not be possible to cause acoustic shock to telephone users under any normal condition or when the acoustic coupler develops any single fault.

6. The mechanical arrangements of the transducer shall not cause mechanical damage to the telephone instrument.

7. In addition to the contents of this Recommendation, the regulations of the national Administration must also be complied with.

Recommendation V.21

200-BAUD MODEM STANDARDIZED FOR USE IN THE GENERAL SWITCHED TELEPHONE NETWORK

(Geneva, 1964, amended at Mar del Plata, 1968, and at Geneva, 1972)

Note. — The modem, designed for use on connections set up by switching in the general public network, can obviously be used on leased lines.

A system of data transmission at a low modulation rate, such that data could be transmitted over a telephone circuit operated alternatively for telephone calls and data transmissions, using simple input/output equipment and easy operating procedures, would be economical.

The modulation rate must be such as to allow the use of current types of data sources and sinks, especially electromechanical devices.

The system for data transmission will be duplex, either for simultaneous two-way data transmission or for the transmission of signals sent in the backward direction for error-control purposes. The transmission must be such that use can be made of normal telephone circuits, and this applies both to the bandwidth available and to the restrictions imposed by signalling in the telephone networks.

The two correspondents are brought into contact by a telephone call, and the circuit is put into the data-transmission position:

a) manually by agreement between the operators, or

b) automatically.

For these reasons, the C.C.I.T.T. *unanimously declares the following view:*

1. Data transmission may take place at low modulation rates on telephone calls set up on switched telephone circuits (or on leased telephone circuits).

2. The communication circuit for data transmission is a duplex circuit whereby data transmission in both directions simultaneously is possible at 200 bauds or less.

The modulation is a binary modulation obtained by frequency shift.

3. For channel No. 1, the nominal mean frequency is 1080 Hz.

For channel No. 2, it is 1750 Hz.

The frequency deviation is $\pm$ 100 Hz. In each channel, the higher characteristic frequency corresponds to the symbol 0.

The characteristic frequencies [1] as measured at the modulator output must not differ by more than $\pm$ 6 Hz from the nominal figures.

A maximum drift of frequency of $\pm$ 6 Hz is assumed for the line. Hence the demodulation equipment must tolerate drifts of $\pm$ 12 Hz between the frequencies received and their nominal values.

4. Data may be transmitted by synchronous or asynchronous procedures. With synchronous transmission, the modem will not have to provide the signals which would be necessary to maintain synchronism when transmission is not proceeding.

5. It will be for the user to decide whether, in view of the connections he makes with this system, he will have to request that the data circuit-terminating equipment be equipped with facilities for disabling echo suppressors. The international characteristics of the echo suppressor tone disabler have been standardized by the C.C.I.T.T. (Recommendation G.161, section C) and the disabling tone should have the following characteristics:

— disabling tone transmitted: 2100 $\pm$ 15 Hz at a level of -12 ± 6 dBm0,

— the disabling tone to last at least 400 ms, the tone disabler should hold in the disabled mode for any single-frequency sinusoid in the band from 390-700 Hz having a level of -27 dBm0 or greater, and from 700-3000 Hz having a level of -31 dBm0 or greater. The tone disabler should release for any signal in the band from 200-3400 Hz having a level of -36 dBm0 or less.

— the tolerable interruptions by the data signal to last not more than 100 ms.

6. The maximum power output of the subscriber's equipment into the line shall not exceed 1 mW at any frequency.

The power level of the subscriber's equipment should be adjusted to make allowance for loss between his equipment and the point of entry to an international circuit; so that the corresponding nominal level of the signal at the international circuit input shall not exceed -13 dBm0. (See Recommendation V.2, section B.)

7. a) When both channels are used for simultaneous both-way data transmission, channel No. 1 is used for transmission of the caller's data (i.e. the person making the telephone call) towards the called station, while channel No. 2 is used for transmission in the other direction.

b) When one channel is used for data transmission and the other is used for transmission of check signals, service signals, etc., only, it is channel No. 1 which is used for transmission from the calling to the called station regardless of the direction in which the data are transmitted.

c) The procedure for the assignment of the channels described under a) and b) above applies in the case of the general service of data transmission, making it possible to transmit data or check signal, service signal, etc., bilaterally between any two subscribers. In special cases which do not come under this rule, the procedure of assignment of the channels is determined by the prior agreement between the correspondents, bearing in mind the requirement proper to each service.

[1] The nominal characteristic frequencies:
Channel No. 1 (F_A = 1180 Hz and F_Z = 980 Hz);
Channel No. 2 (F_A = 1850 Hz and F_Z = 1650 Hz).

8. *Interchange circuits*

a) Interchange circuits essential for the modems when used on the general switched telephone network or non-switched leased telephone circuits

The configurations of interchange circuits are those essential for the particular switched network or leased circuit requirement indicated. Where one or more of such requirements are provided in a modem, then all of the appropriate interchange circuit facilities should be provided.

Interchange circuit		General switched telephone network including terminals equipped for manual calling, manual answering, automatic calling, automatic answering	Non-switched leased telephone circuits	
Number	Designation		Point-to-point	Multipoint
101 [a]	Protective ground or earth	X	X	X
102	Signal ground or common return	X	X	X
103	Transmitted data	X	X	X
104	Received data	X	X	X
105	Request to send	—	X (Note 4)	X
106	Ready for sending	X	X	X
107	Data set ready	X	X	X
108/1	Connect data set to line	X (Note 1)	X	X
108/2	Data terminal ready	X (Note 1)	X (Note 2)	—
109	Data channel received line signal detector	X	X	X
125	Calling indicator	X	—	—
126	Select transmit frequency	—	—	X (Note 3)

[a] May be excluded if so required by local safety regulations.

Note 1. — This circuit shall be capable of operation as circuit 108/1 " Connect data set to line " or circuit 108/2 " Data terminal ready " depending on its use. For automatic calling it shall be used as 108/2 only.

Note 2. — In the leased point-to-point case, where alternate voice/data service is to be provided, circuit 108/2 may be used optionally.

Note 3. — Circuit 126 controls the functions of circuits 126 and 127 as defined in Recommendation V.24.

Note 4. — Circuit 105 is not required when alternate voice/data service is used on non-switched leased point-to-point circuits.

Note 5. — Interchange circuits indicated by X must be properly terminated according to Recommendation V.24 in the data terminal equipment and data circuit-terminating equipment.

b) *Response times of circuits 106 and 109*

Definitions

i) Circuit 109 response times are the times that elapse between the connection or removal of a tone to or from the modem receive line terminals and the appearance of the corresponding ON or OFF condition on circuit 109.

The test tone should have a frequency corresponding to the characteristic frequency of binary 1 and be derived from a source with an impedance equal to the nominal input impedance of the modem under test.

The level of the test tone should fall into the level range between 1 dB above the actual threshold of the received line signal detector and the maximum admissible level of the received signal. At all levels within this range the measured response times shall be within the specified limits.

ii) Circuit 106 response times are the times from the connection of an ON or OFF condition on:

— circuit 105 (where it is provided) to the appearance of the corresponding OFF or ON condition on circuit 106;

— circuit 109 (where circuit 105 is not provided) to the appearance of the corresponding ON or OFF condition on circuit 106.

c) *Response times*

	Note 1	Note 2
Circuit 106		
OFF to ON	20-50 ms	400-1000 ms
ON to OFF	$\leqslant$ 2 ms	$\leqslant$ 2 ms
Circuit 109		
OFF to ON	$\leqslant$ 20 ms	300-700 ms
ON to OFF	20-80 ms	20-80 ms

Note 1. — These times are used on leased point-to-point networks without alternate voice-data facilities and on leased multipoint facilities.

Note 2. — These times are used on general switch network service and on leased point-to-point circuits with alternate voice-data.

d) *Threshold of data channel received line signal detector*

Level of received line signal at received line signal terminals of modem for all types of connection, i.e. general switched telephone network or non-switched leased telephone circuit:

greater than	−43 dBm	circuit 109 ON
less than	−48 dBm	circuit 109 OFF

The condition of circuit 109 for levels between −43 dBm and −48 dBm is not specified except that the signal detector shall exhibit a hysteresis action such that the level at which the OFF to ON transition occurs shall be at least 2 dB greater than for the ON to OFF transition.

Where transmission conditions are known on switched or leased circuits, Administrations should be permitted at the time of modem installation to change these response levels of the received line signal detector to less sensitive values (e.g. −33 dBm and −38 dBm respectively).

e) *Clamping to binary 1 condition of circuit 104 (received data)*

Two options shall be provided in the modem:

i) When clamping is not used there is no inhibition of the signals on circuit 104 (received data). There is no protection against noise, supervisory and control tones, switching transients etc., appearing on circuit 104.

ii) When clamping is used, circuit 104 (received data) is held in a marking condition (binary 1) when circuit 109 (received line signal detector) is in the OFF condition. When circuit 109 is ON the clamp is removed and circuit 104 can respond to the input signals of the modem.

9. The following information is provided to assist equipment manufacturers:

a) The nominal range of attenuations in subscriber-to-subscriber connections is from 5 to 30 dB at the reference frequency (800 or 1000 Hz), assuming up to 35 dB attenuation at the frequency 1750 Hz.

b) The data modem should have no adjustment for send level or receive sensitivity under the control of the operator.

10. In case of interruption of a leased circuit, the use of a non-standardized modem over the switched connection established as a substitute for the leased circuit is not recommended.

Recommendation V.22

STANDARDIZATION OF DATA-SIGNALLING RATES FOR SYNCHRONOUS DATA TRANSMISSION IN THE GENERAL SWITCHED TELEPHONE NETWORK

(Geneva, 1964, amended at Mar del Plata, 1968, and at Geneva, 1972)

1. Data transmission by international communications carried on the general switched telephone network, using a synchronous transmission procedure, will be done with a specific mode of modulation (two or multi-condition) and serial transmission.

2. The data signalling rates for synchronous transmission in the general switched telephone network will be:

600, 1200 or 2400 bits per second.

The user will choose among these rates, in accordance with the facilities afforded by the connection.

3. Data signalling rates should in no case deviate from the nominal values by more than $\pm$ 0.01 %.

Note 1. — For data signalling rates standardized for synchronous data transmission on leased telephone-type circuits, see Recommendation V.22 bis.

Note 2. — For data transmission at 200 bauds, see Recommendation V.21.

Note 3. — For parallel transmission of multi-condition serial modulations and their modulation rates, see Recommendation V.30.

Recommendation V.22 bis

STANDARDIZATION OF DATA-SIGNALLING RATES FOR SYNCHRONOUS DATA TRANSMISSION ON LEASED TELEPHONE-TYPE CIRCUITS

(Geneva, 1972)

1. Data transmission by international communications carried on leased telephone-type circuits (either normal quality or special quality circuits) using a synchronous transmission procedure will be done with a specific mode of modulation, two or multi-condition, and serial transmission (see Note 1). For synchronous data transmission in the general switched telephone network see Recommendation V.22.

2. It is recommended that for synchronous transmission the data signalling rates should be divided into two distinct classes to be known as " preferred " and " supplementary ". The union of these classes is defined to be the " permitted " data signalling rates.

a) *Preferred range of data signalling rates (bits per second):*

600 (see Note 2)	4800 (see Note 2)
1200 (see Note 2)	7200
2400 (see Note 2)	9600
3600	

b) *Supplementary range of data signalling rates (bits per second):*

1800	6600
3000	7800
4200	8400
5400	9000
6000	10 200
	10 800

c) *Permitted range of data signalling rates (bits per second):*

The range is defined as 600 times " N " bits per second

where $1 \leq N \leq 18$ N: a positive integer.

This algorithm, with the addition of 2000 bits per second (see Note 3), yields the total range of data signalling rates which is the union of the preferred and supplementary data signalling rates.

In determining the permitted range, the C.C.I.T.T. has in mind the need to restrict the number of data signalling rates (and hence modem design required), yet at the same time to allow the best use to be made of technical progress in both modem development and improvement in the telephone plant. It is considered that a geometric progression in standard rates provides the most satisfactory basis of development.

3. Data signalling rates should in no case deviate from the nominal value by more than $\pm$ 0.01 %.

Note 1. — The application of parallel data transmission is a subject of another Recommendation.

Note 2. — For synchronous data transmission at 600/1200 bit/s, 2400 bit/s, and 4800 bit/s, see Recommendations V.23, V.26 and V.27 respectively.

Note 3. — It is recognized that there is substantial usage of a 2000 bit/s data signalling rate in some countries and that this usage will continue.

Recommendation V.23

600/1200-BAUD MODEM STANDARDIZED FOR USE IN THE GENERAL SWITCHED TELEPHONE NETWORK

(Geneva, 1964, amended at Mar del Plata, 1968, and at Geneva, 1972)

Note. — The modem, designed for use on connections set up by switching in the general public network, can obviously be used on leased lines.

1. The principal characteristics recommended for a modem to transmit data at medium speed in the general switched telephone network are as follows:

— use of modulation rates up to 600/1200 bauds on the communication channel (see Recommendation V.22);

— frequency modulation with synchronous or asynchronous mode of operation;

— inclusion of a backward channel at modulation rates up to 75 bauds for error control, use of this channel being optional.

2. *Modulation rates and characteristic frequencies for the forward data-transmission channel*

	F_0	F_Z (symbol 1, mark)	F_A (symbol 0, space)
Mode 1 : up to 600 bauds	1500 Hz	1300 Hz	1700 Hz
Mode 2 : up to 1200 bauds	1700 Hz	1300 Hz	2100 Hz

It is understood that the modem would be used in mode 1 when the presence of long loaded cables and/or the presence on some connections of signalling receivers operating close to 2000 Hz would prevent satisfactory transmission in mode 2. The modem could be used in mode 2 on suitable connections.

3. *Tolerances on the characteristic frequencies for the forward channel*

It should be possible with all rates of modulation to permit a tolerance, at the transmitter, of $\pm$ 10 Hz on both the F_A and F_Z frequencies. This tolerance should be considered as a limit.

Acceptance of these tolerances would give a tolerance of $\pm$ 10 Hz for the mean-frequency $F_0 = \dfrac{F_A+F_Z}{2}$.

The tolerance on the frequency difference $F_A - F_Z$ with regard to the nominal value would be $\pm$ 20 Hz.

A maximum frequency drift of $\pm$ 6 Hz has been assumed in the connection between the modems which might consist of several carrier circuits connected in tandem. This would make the tolerances on the mark and space frequencies at the receiving modem $\pm$ 16 Hz.

4. *Modulation rate and characteristic frequencies for the backward channel*

The modulation rate and characteristic frequencies for the backward channel are as follows:

	F_Z (symbol 1, mark)	F_A (symbol 0, space)
Modulation rate up to 75 bauds	390 Hz	450 Hz

In the absence of any signal on the backward channel interface, the Condition Z signal is to be transmitted.

5. *Tolerances on the characteristic frequencies of the backward channel*

As the backward channel is a v.f. telegraph-type channel, the frequency tolerances should be as recommended in Recommendation R.35 (*Green Book*, Volume VII) for frequency-shift voice-frequency telegraphy.

The $\pm$ 6 Hz frequency drift in the connection between the modems postulated in 3 above would produce additional distortion in the backward channel. This should be taken into account in the design.

6. *Division of power between the forward and backward channels*

Considering the following table which shows the relative levels of power for total power remaining equal to 0 dBm,

Forward channel level (dBm)	*Backward channel level* (dBm)
0	$-\infty$
−1	−7
−2	−4
−3	−3

equal division of power between the forward and backward channels could be recommended provisionally.

7. The following information is provided to assist equipment manufacturers:

a) The nominal range of attenuations in subscriber-to-subscriber connections is from 5 to 30 dB at the reference frequency (800 or 1000 Hz), assuming up to 35 dB attenuation at the recommended mean frequency (F_0) of the forward channel.

b) A convenient range of sensitivity at the mean frequency F_0 for data receivers has been found to be −40 to 0 dBm for the forward channel at the subscribers' terminals.

c) The data modem should have no adjustment for send level or receive sensitivity under the control of the operator.

8. *Interchange circuits*

The configurations of interchange circuits are those essential for the particular switched network or leased circuit requirement as indicated in Tables a) and b). Where one or more of such requirements are provided in a modem, then all the appropriate interchange circuits should be provided.

a) *Interchange circuits essential for the modems when used on the general switched telephone network, including terminals equipped for manual calling or answering or automatic calling or answering*

Interchange circuit		Forward (data) channel one-way system				Forward (data) channel either way system	
		Without backward channel		With backward channel		Without backward channel	With backward channel
No.	Designation	Transmit end	Receive end	Transmit end	Receive end		
101 [a]	Protective ground or earth	X	X	X	X	X	X
102	Signal ground or common return	X	X	X	X	X	X
103	Transmitted data	X	—	X	—	X	X
104	Received data	—	X	—	X	X	X
105	Request to send	—	—	—	—	X	X
106	Ready for sending	X	—	X	—	X	X
107	Data set ready	X	X	X	X	X	X
108/1 or 108/2 (Note 1)	Connect data set to line Data terminal ready	X	X	X	X	X	X
109	Data channel received line signal detector	—	X	—	X	X	X
111	Data signalling rate selector (DTE)	X	X	X	X	X	X
114 (Note 3)	Transmitter signal element timing (DCE)	X	—	X	—	X	X
115 (Note 3)	Receiver signal element timing (DCE)	—	X	—	X	X	X
118	Transmitted backward channel data	—	—	—	X	—	X
119	Received backward channel data	—	—	X	—	—	X
120	Transmit backward channel line signal	—	—	—	—	—	X
121	Backward channel ready	—	—	—	X	—	X
122	Backward channel received line signal detector	—	—	X	—	—	X
125	Calling indicator	X	X	X	X	X	X

[a] May be excluded if so required by local safety regulations.

Notes applicable to Tables in points 8a) and 8b):

Note 1. — This circuit shall be capable of operation as circuit 108/1 (connect data set to line) or circuit 108/2 (data terminal ready) depending on its use. For automatic calling it shall be used as 108/2 only.

Note 2. — Interchange circuits indicated by X must be properly terminated according to Recommendation V.24 in the data terminal equipment and data circuit-terminating equipment.

Note 3. — These circuits are required when the optional clock is implemented in the modem.

b) *Interchange circuits essential for the modems when used on non-switched leased telephone circuits*

Interchange circuit		Forward (data) channel one-way system				Forward (data) channel either way or both ways simultaneously system	
		Without backward channel		With backward channel			
No.	Designation	Transmit end	Receive end	Transmit end	Receive end	Without backward channel	With backward channel
101 [a]	Protective ground or earth	X	X	X	X	X	X
102	Signal ground or common return	X	X	X	X	X	X
103	Transmitted data	X	—	X	—	X	X
104	Received data	—	X	—	X	X	X
105	Request to send	X	—	X	—	X	X
106	Ready for sending	X	—	X	—	X	X
107	Data set ready	X	X	X	X	X	X
108/1 or	Connect data set to line	X	X	X	X	X	X
109	Data channel received line signal detector	—	X	—	X	X	X
111	Data signalling rate selector (DTE)	X	X	X	X	X	X
114 (Note 3)	Transmitter signal element timing (DCE)	X	—	X	—	X	X
115 (Note 3)	Receiver signal element timing (DCE)	—	X	—	X	X	X
118	Transmitted backward channel data	—	—	—	X	—	X
119	Received backward channel data	—	—	X	—	—	X
120	Transmit backward channel line signal	—	—	—	X	—	X
121	Backward channel ready	—	—	—	X	—	X
122	Backward channel received line signal detector	—	—	X	—	—	X

[a] May be excluded if so required by local safety regulations.

c) *Response times of circuits 106 and 109*

Definitions

i) Circuits 109 and 122 response times are the times that elapse between the connection or removal of a tone to or from the modem receive line terminals and the appearance of the corresponding ON or OFF condition on circuits 109 and 122.

The test tone should have a frequency corresponding to the characteristic frequency of binary 1 and be derived from a source with an impedance equal to the nominal input impedance of the modem.

The level of the test tone should fall within the level range between 3 dB above the actual threshold of the received line signal detector and the maximum admissible level of the received signal. At all levels within this range the measured response times shall be within the specified limits.

ii) Circuit 106 response times are from the connection of an ON or OFF condition on:

— circuit 105 (where it is provided) to the appearance of the corresponding ON or OFF condition on circuit 106;

— circuit 107 (where circuit 105 is not provided) to the appearance of the corresponding ON or OFF condition on circuit 106.

iii) Circuit 121 response times are from the connection of an ON or OFF condition on:

— circuit 120 (where it is provided) to the appearance of the corresponding ON or OFF condition on circuit 121;

— circuit 109 (where circuit 120 is not provided) to the appearance of the corresponding ON or OFF condition on circuit 121.

d) *Response times*

	Note 1	Note 2
Circuit 106		
OFF to ON	750 ms to 1400 ms	a) 20 ms to 40 ms b) 200 ms to 275 ms
ON to OFF	$\leqslant$ 2 ms	$\leqslant$ 2 ms
Circuit 109		
OFF to ON	300 ms to 700 ms	10 ms to 20 ms
ON to OFF	5 ms to 15 ms	5 ms to 15 ms
Circuit 121		
OFF to ON	80 ms to 160 ms	
ON to OFF	$\leqslant$ 2 ms	
Circuit 122		
OFF to ON	< 80 ms	
ON to OFF	15 ms to 80 ms	

Note 1. — For automatic calling and answering, the longer response times of circuits 106 and 109 are to be used during call establishment only.

Note 2. — The choice of response times depends upon the system application:

a) no protection given against line echoes;

b) protection given against line echoes.

Note 3. — The above parameters are provisional and are the subject of further study.

e) *Threshold of data channel and backward channel received line signal detectors*

Level of received line signal at receive line terminals of modem for all types of connections, i.e. general switched telephone network or non-switched leased telephone circuits:

greater than	−43 dBm	Circuits 109/122 ON
less than	−48 dBm	Circuits 109/122 OFF

The condition of circuits 109 and 122 for levels between −43 dBm and −48 dBm is not specified except that the signal detectors shall exhibit a hysteresis action such that the level at which the OFF to ON transition occurs is at least 2 dB greater than that for the ON to OFF transition.

Where transmission conditions are known on switched or leased circuits, Administrations should be permitted at the time of modem installation to change these response levels of the received line signal detectors to less sensitive values (e.g. −33 dBm and −38 dBm respectively).

f) *Clamping to binary condition 1 of circuit 104 (Received data) and circuit 119 (Received backward channel data)*

Two options shall be provided in the modem:

i) When clamping is not used there is no inhibition of the signals on circuits 104 and 119. There is no protection against noise, supervisory and control tones, switching transients etc. from appearing on circuits 104 and 119.

ii) When clamping is used, circuit 104 is held in a marking condition (binary 1) under the conditions defined below. When these conditions do not exist the clamp is removed and circuit 104 can respond to the input signals of the modem:

— when circuit 109 is in the OFF condition;

— when circuit 105 is in the ON condition and the modem is used in half duplex mode (turn-around systems). To protect circuit 104 from false signals a delay device shall be provided to maintain circuit 109 in the OFF condition for a period of 150 ± 25 ms after circuit 105 has been turned from ON to OFF. The use of this additional delay is optional.

iii) When clamping is used, circuit 119 is held in a marking condition (binary 1) under the conditions defined below. When these conditions do not exist the clamp is removed and circuit 119 can respond to the input signals of the modem:

— when circuit 122 is in the OFF condition.

9. *Equipment for the disablement of echo suppressors*

(See Recommendation V.21, section 5.)

10. *Inclusion of a clock in the modem*

A clock is not an essential item in the standardized modem. However, the modem may conveniently include a clock when used primarily for synchronous transmission.

If such a clock is included in the modem, a synchronizing pattern consisting of alternate binary 0 and binary 1 at clock rate should be transmitted for the whole interval between the OFF to ON transitions of interchange circuits 105 and 106. Users should note that part of this synchronizing pattern may appear at the distant receiver on circuit 104 after the OFF to ON transition of circuit 109. The data terminal equipment should make provision to differentiate between these false signals and true data.

Recommendation V.24

LIST OF DEFINITIONS FOR INTERCHANGE CIRCUITS BETWEEN DATA TERMINAL EQUIPMENT AND DATA CIRCUIT-TERMINATING EQUIPMENT [1]

(Geneva, 1964, amended at Mar del Plata, 1968, and at Geneva, 1972)

CONTENTS

Section I — Scope

II — Line of demarcation

III — Definitions of interchange circuits

1. 100-series. General application
2. 200-series. Specifically for automatic calling

IV — Operational requirements

I. Scope

I.1 This Recommendation applies to the interconnecting circuits being called interchange circuits at the interface between DTE and DCE for the transfer of binary data, control and timing signals and analogue signals as appropriate. This Recommendation also applies to both sides of separate intermediate equipment, which may be inserted between these two classes of equipment.

Electrical characteristics for interchange circuits are detailed in the appropriate Recommendations for electrical characteristics, or in certain special cases, in Recommendations for DCE.

In any type of practical equipment a selection will be made from the range of interchange circuits defined in this Recommendation, as appropriate. When by mutual arrangement other circuits are to be used, these additional circuits should conform to the electrical characteristics specified in the appropriate Recommendation.

The actual interchange circuits to be used in a particular DCE are those indicated in the appropriate C.C.I.T.T. Recommendation.

The usage and operational requirements of the interchange circuits and the interaction between them are recommended in Section IV of this Recommendation. For proper operation of the DCE it is important that the guide lines in section IV of this Recommendation are observed.

I.2 The DCE may include signal converters, timing generators, pulse regenerators, and control circuitry, together with equipment to provide other functions such as error control, automatic calling and automatic answering. Some of this equipment may be separate intermediate equipment or it may be located in the DTE.

---

[1] In this Recommendation the terms " data terminal equipment " and " data circuit-terminating equipment " are indicated by DTE and DCE respectively.

I.3 The range of interchange circuits defined in this Recommendation is applicable, for example:

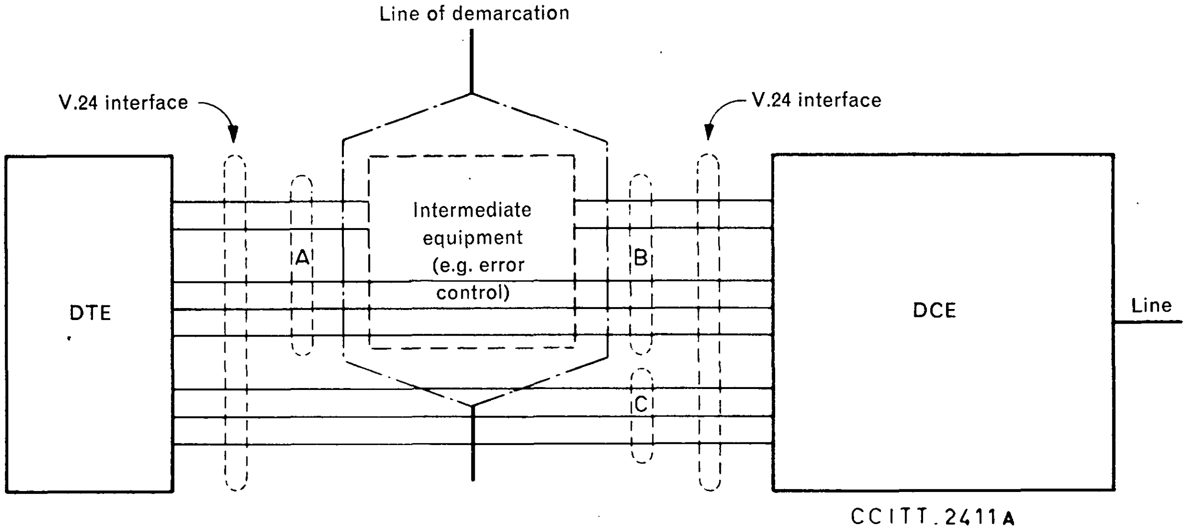
a) to synchronous and asynchronous data communications,

b) to data communication on leased line service, either two-wire or four-wire, either point-to-point or multipoint operation,

c) to data communication on switched network service, either two-wire or four-wire,

d) where short interconnecting cables are used between DTE and DCE. An explanation of short cables is given in section II.

II. Line of demarcation



Without intermediate equipment the selections A and B are identical.
Selection C may be a selection specifically for automatic calling.

Figure 1/V.24 — **Illustration of general layout of communication equipment**

The interface between DTE and DCE is located at a connector, which is the interchange point between these two classes of equipment. Separate connectors may be provided for the interchange circuits associated with the signal-conversion or similar equipment and those associated with the automatic calling equipment.

The connector(s) will not necessarily be physically attached to the DCE and may be mounted in a fixed position near the DTE.

An interconnecting cable or cables will normally be provided with the DTE. The use of short cables is recommended. Their length should be limited solely by the load capacitance and other electrical characteristics specified in the relevant Recommendation on electrical characteristics.

III. Definitions of interchange circuits

III.1 *100 series — General application*

A list of these interchange circuits is presented in tabular form in Figure 2/V.24.

Circuit 101—Protective ground or earth

This conductor shall be electrically bonded to the machine or equipment frame. It may be further connected to external grounds as required by applicable regulations.

Circuit 102—Signal ground or common return

This conductor establishes the signal common reference potential for unbalanced interchange circuits in the 100 series. Within the DCE, this circuit shall be brought to one point, and it shall be possible to connect this point to Circuit 101 by means of a metallic strap within the equipment. This metallic strap can be connected or removed at installation, as may be required to meet applicable regulations or to minimize the introduction of noise into electronic circuitry.

Circuit 103—Transmitted data

Direction: To DCE

The data signals originated by the DTE, to be transmitted via the data channel to one or more remote data stations, are transferred on this circuit to the DCE.

Circuit 104—Received data

Direction: From DCE

The data signals generated by the DCE, in response to data channel line signals received from a remote data station, are transferred on this circuit to the DTE.

Circuit 105—Request to send

Direction: To DCE

Signals on this circuit control the data channel transmit function of the DCE.

The ON condition causes the DCE to assume the data channel transmit mode.

The OFF condition causes the DCE to assume the data channel non-transmit mode, when all data transferred on Circuit 103 (Transmitted data) have been transmitted.

Circuit 106—Ready for sending

Direction: From DCE

Signals on this circuit indicate whether the DCE is conditioned to transmit data on the data channel.

The ON condition indicates that the DCE is conditioned to transmit data on the data channel.

The OFF condition indicates that the DCE is not prepared to transmit data on the data channel.

Circuit 107—Data set ready

Direction: From DCE

Signals on this circuit indicate whether the DCE is ready to operate.

The ON condition indicates that the signal-conversion or similar equipment is connected to the line and that the DCE is ready to exchange further control signals with the DTE to initiate the exchange of data.

The OFF condition indicates that the DCE is not ready to operate.

Circuit 108/1—Connect data set to line

Direction: To DCE

Signals on this circuit control switching of the signal-conversion or similar equipment to or from the line.

The ON condition causes the DCE to connect the signal-conversion or similar equipment to the line.

The OFF condition causes the DCE to remove the signal-conversion or similar equipment from the line, when the transmission to line of all data previously transferred on Circuit 103 and/or Circuit 118 has been completed.

Circuit 108/2—Data terminal ready

Direction: To DCE

Signals on this circuit control switching of the signal-conversion or similar equipment to or from the line.

The ON condition, indicating that the DTE is ready to operate, prepares the DCE to connect the signal-conversion or similar equipment to the line and maintains this connection after it has been established by supplementary means.

The DTE is permitted to present the ON condition on Circuit 108/2 whenever it is ready to transmit or receive data.

The OFF condition causes the DCE to remove the signal-conversion or similar equipment from the line, when the transmission to line of all data previously transferred on Circuit 103 and/or Circuit 118 has been completed.

Circuit 109—Data channel received line signal detector

Direction: From DCE

Signals on this circuit indicate whether the received data channel line signal is within appropriate limits, as specified in the relevant Recommendation for DCE.

The ON condition indicates that the received signal is within appropriate limits.

The OFF condition indicates that the received signal is not within appropriate limits.

Circuit 110—Data signal quality detector

Direction: From DCE

Signals on this circuit indicate whether there is a reasonable probability of an error in the data received on the data channel. The signal quality indicated conforms to the relevant DCE Recommendation.

The ON condition indicates that there is no reason to believe that an error has occurred.

The OFF condition indicates that there is a reasonable probability of an error.

Circuit 111—Data signalling rate selector (DTE source)

Direction: To DCE

Signals on this circuit are used to select one of the two data signalling rates of a dual rate synchronous DCE, or to select one of the two ranges of data signalling rates of a dual range asynchronous DCE.

The ON condition selects the higher rate or range of rates.

The OFF condition selects the lower rate or range of rates.

Circuit 112—Data signalling rate selector (DCE source)

Direction: From DCE

Signals on this circuit are used to select one of the two data signalling rates or ranges of rates in the DTE to coincide with the data signalling rate or range of rates in use in a dual rate synchronous or dual range asynchronous DCE.

The ON condition selects the higher rate or range of rates.

The OFF condition selects the lower rate or range of rates.

Circuit 113—Transmitter signal element timing (DTE source)

Direction: To DCE

Signals on this circuit provide the DCE with signal element timing information.

The condition on this circuit shall be ON and OFF for nominally equal periods of time, and the transition from ON to OFF condition shall nominally indicate the centre of each signal element on Circuit 103 (Transmitted data).

Circuit 114—Transmitter signal element timing (DCE source)

Direction: From DCE

Signals on this circuit provide the DTE with signal element timing information.

The condition on this circuit shall be ON and OFF for nominally equal periods of time. The DTE shall present a data signal on Circuit 103 (Transmitted data) in which the transitions between signal elements nominally occur at the time of the transitions from OFF to ON condition of Circuit 114.

Circuit 115—Receiver signal element timing (DCE source)

Direction: From DCE

Signals on this circuit provide the DTE with signal element timing information.

The condition of this circuit shall be ON and OFF for nominally equal periods of time, and a transition from ON to OFF condition shall nominally indicate the centre of each signal element on Circuit 104 (Received data).

Circuit 116—Select standby

Direction: To DCE

Signals on this circuit are used to select the normal or standby facilities, such as signal converters and communication channels.

The ON condition selects the standby mode of operation, causing the DCE to replace predetermined facilities by their reserves.

The OFF condition causes the DCE to replace the standby facilities by the normal. The OFF condition on this circuit shall be maintained whenever the standby facilities are not required for use.

Circuit 117—Standby indicator

Direction: From DCE

Signals on this circuit indicate whether the DCE is conditioned to operate in its standby mode with the predetermined facilities replaced by their reserves.

The ON condition indicates that the DCE is conditioned to operate in its standby mode.

The OFF condition indicates that the DCE is conditioned to operate in its normal mode.

Circuit 118—Transmitted backward channel data

Direction: To DCE

This circuit is equivalent to Circuit 103 (Transmitted data) except that it is used to transmit data via the backward channel.

Circuit 119—Received backward channel data

Direction: From DCE

This circuit is equivalent to Circuit 104 (Received data), except that it is used for data received on the backward channel.

Circuit 120—Transmit backward channel line signal

Direction: To DCE

This circuit is equivalent to Circuit 105 (Request to send), except that it is used to control the backward channel transmit function of the DCE.

The ON condition causes the DCE to assume the backward channel transmit mode.

The OFF condition causes the DCE to assume the backward channel non-transmit mode, when all data transferred on Circuit 118 (Transmitted backward channel data) have been transmitted to line.

Circuit 121—Backward channel ready

Direction: From DCE

This circuit is equivalent to Circuit 106 (Ready for sending), except that it is used to indicate whether the DCE is conditioned to transmit data on the backward channel.

The ON condition indicates that the DCE is conditioned to transmit data on the backward channel.

The OFF condition indicates that the DCE is not conditioned to transmit data on the backward channel.

Circuit 122—Backward channel received line signal detector

Direction: From DCE

This circuit is equivalent to Circuit 109 (Data channel received line signal detector), except that it is used to indicate whether the received backward channel line signal is within appropriate limits, as specified in the relevant Recommendation for DCE.

Circuit 123—Backward channel signal quality detector

Direction: From DCE

This circuit is equivalent to Circuit 110 (Data signal quality detector), except that it is used to indicate the signal quality of the received backward channel line signal.

Circuit 124—Select frequency groups

Direction: To DCE

Signals on this circuit are used to select the desired frequency groups available in the DCE.

The ON condition causes the DCE to use all frequency groups to represent data signals.

The OFF condition causes the DCE to use a specified reduced number of frequency groups to represent data signals.

Circuit 125—Calling indicator

Direction: From DCE

Signals on this circuit indicate whether a calling signal is being received by the DCE.

The ON condition indicates that a calling signal is being received.

The OFF condition indicates that no calling signal is being received, and this condition may also appear during interruptions of a pulse-modulated calling signal.

Circuit 126—Select transmit frequency

Direction: To DCE

Signals on this circuit are used to select the required transmit frequency of the DCE.

The ON condition selects the higher transmit frequency.

The OFF condition selects the lower transmit frequency.

Circuit 127—Select receive frequency

Direction: To DCE

Signals on this circuit are used to select the required receive frequency of the DCE.

The ON condition selects the lower receive frequency.

The OFF condition selects the higher receive frequency.

Circuit 128—Receiver signal element timing (DTE source)

Direction: To DCE

Signals on this circuit provide the DCE with signal element timing information.

The condition on this circuit shall be ON and OFF for nominally equal periods of time. The DCE shall present a data signal on Circuit 104 (Received data) in which the transitions between signal elements nominally occur at the time of the transitions from OFF to ON condition of the signal on Circuit 128.

Circuit 129—Request to receive

Direction: To DCE

Signals on this circuit are used to control the receive function of the DCE.

The ON condition causes the DCE to assume the receive mode.

The OFF condition causes the DCE to assume the non-receive mode.

Circuit 130—Transmit backward tone

Direction: To DCE

Signals on this circuit control the transmission of a backward channel tone.

The ON condition causes the DCE to transmit a backward channel tone.

The OFF condition causes the DCE to stop the transmission of a backward channel tone.

Circuit 131—Received character timing

Direction: From DCE

Signals on this circuit provide the DTE with character timing information, as specified in the relevant Recommendation for DCE.

Circuit 132—Return to non-data mode

Direction: To DCE

Signals on this circuit are used to restore the non-data mode provided with the DCE, without releasing the line connection to the remote station.

The ON condition causes the DCE to restore the non-data mode. When the non-data mode has been established, this circuit must be turned OFF.

Circuit 133—Ready for receiving

Direction: To DCE

Signals on this circuit control the transfer of data on Circuit 104 (Received data), indicating whether the DTE is capable of accepting a given amount of data (e.g. a block of data), specified in the appropriate Recommendation for intermediate equipment, for example, error control equipment.

The ON condition must be maintained whenever the DTE is capable of accepting data, and causes the intermediate equipment to transfer the received data to the DTE.

The OFF condition indicates that the DTE is not able to accept data, and causes the intermediate equipment to retain the data.

Circuit 134—Received data present

Direction: From DCE

Signals on this circuit are used to separate information messages from supervisory messages, transferred on Circuit 104 (Received data), as specified in the appropriate Recommendation for intermediate equipment, e.g. error control equipment.

The ON condition indicates the data which represent information messages.

The OFF condition shall be maintained at all other times.

Circuit 191—Transmitted voice answer

Direction: To DCE

Signals generated by a voice answer unit in the DTE are transferred on this circuit to the DCE.

The electrical characteristics of this analogue interchange circuit are part of the appropriate DCE Recommendation.

Circuit 192—Received voice answer

Direction: From DCE

Received voice signals, generated by a voice answering unit at the remote data terminal, are transferred on this circuit to the DTE.

The electrical characteristics of this analogue interchange circuit are part of the appropriate DCE Recommendation.

Interchange circuit number	Interchange circuit name	Ground	Data		Control		Timing	
			From DCE	To DCE	From DCE	To DCE	From DCE	To DCE
1	2	3	4	5	6	7	8	9
101	Protective ground or earth	X						
102	Signal ground or common return	X						
103	Transmitted data			X				
104	Received data		X					
105	Request to send					X		
106	Ready for sending				X			
107	Data set ready				X			
108/1	Connect data set to line					X		
108/2	Data terminal ready					X		
109	Data channel received line signal detector				X			
110	Signal quality detector				X			
111	Data signalling rate selector (DTE)					X		
112	Data signalling rate selector (DCE)				X			
113	Transmitter signal element timing (DTE)							X
114	Transmitter signal element timing (DCE)						X	
115	Receiver signal element timing (DCE)						X	
116	Select standby					X		
117	Standby indicator				X			
118	Transmitted backward channel data			X				
119	Received backward channel data		X					
120	Transmit backward channel line signal					X		
121	Backward channel ready				X			
122	Backward channel received line signal detector				X			
123	Backward channel signal quality detector				X			
124	Select frequency groups					X		
125	Calling indicator				X			
126	Select transmit frequency					X		
127	Select receive frequency					X		
128	Receiver signal element timing (DTE)							X
129	Request to receive					X		
130	Transmit backward tone					X		
131	Received character timing						X	
132	Return to non-data mode					X		
133	Ready for receiving					X		
134	Received data present				X			
191	Transmitted voice answer					X		
192	Received voice answer				X			

FIGURE 2/V.24 — **100-series interchange circuits by category**

III.2 *200-Series—Specifically for automatic calling*

A list of these interchange circuits is presented in tabular form in Figure 3/V.24.

For the proper procedures, refer to the relevant Recommendation for automatic calling procedures.

Circuit 201—Signal ground or common return

This conductor establishes the signal common reference potential for all 200-Series interchange circuits except Circuit 212 (Protective ground or earth). Within the automatic calling equipment this circuit shall be brought to one point, and it shall be possible to connect this point to Circuit 212 (Protective ground or earth) by means of a metallic strap within the equipment. This metallic strap can be connected or removed at installation as may be required to meet applicable regulations or to minimize the introduction of noise into electronic circuitry.

Circuit 202—Call request

Direction: To DCE

Signals on this circuit are used to condition the automatic calling equipment to originate a call and to switch the automatic calling equipment to or from the line.

The ON condition causes the DCE to condition the automatic calling equipment to originate a call and to connect this equipment to the line.

The OFF condition causes the automatic calling equipment to be removed from the line and indicates that the DTE has released the automatic calling equipment.

Circuit 203—Data line occupied

Direction: From DCE

Signals on this circuit indicate whether or not the associated communication channel is in use (e.g. for automatic calling, data or voice communication, test procedures).

The ON condition indicates that the communication channel is in use.

The OFF condition indicates that the communication channel is not in use, and that the DTE may originate a call.

Circuit 204—Distant station connected

Direction: From DCE

Signals on this circuit indicate whether a connection has been established to a remote data station.

The ON condition indicates the receipt of a signal from a remote DCE signalling that a connection to that equipment has been established.

The OFF condition shall be maintained at all other times.

Circuit 205—Abandon call

Direction: From DCE

Signals on this circuit indicate whether a preset time has elapsed between successive events in the calling procedure.

The ON condition indicates that the call should be abandoned.

The OFF condition indicates that call origination can proceed.

Digit signal circuits:

Circuit 206—Digit signal (2^0)

Circuit 207—Digit signal (2^1)

Circuit 208—Digit signal (2^2)

Circuit 209—Digit signal (2^3)

Direction: To DCE

On these circuits the DTE presents the following code combinations, being the digits to be called and associated control characters.

Information	*Binary states*			
	209	208	207	206
Digit 1	0	0	0	1
Digit 2	0	0	1	0
Digit 3	0	0	1	1
Digit 4	0	1	0	0
Digit 5	0	1	0	1
Digit 6	0	1	1	0
Digit 7	0	1	1	1
Digit 8	1	0	0	0
Digit 9	1	0	0	1
Digit 0	0	0	0	0
Control character EON	1	1	0	0
Control character SEP	1	1	0	1

The control character EON (end of number) causes the DCE to take the appropriate actions to await an answer from the called data station.

The control character SEP (separation) indicates the need for a pause between successive digits, and causes the automatic calling equipment to insert the appropriate time interval.

Circuit 210—Present next digit

Direction: From DCE

Signals on this circuit indicate whether the automatic calling equipment is ready to accept the next code combination.

The ON condition indicates that the automatic calling equipment is ready to accept the next code combination.

The OFF condition indicates that the automatic calling equipment is not ready to accept signals on the digit signal circuits.

Circuit 211—Digit present

Direction: To DCE

Signals on this circuit control the reading of the code combination presented on the digit signal circuits.

The ON condition causes the automatic calling equipment to read the code combination presented on the digit signal circuits.

The OFF condition on this circuit prevents the automatic calling equipment from reading a code combination on the digit signal circuits.

Circuit 212—Protective ground or earth

This conductor shall be electrically bonded to the machine or equipment frame. It may further be connected to external grounds as required by applicable regulations.

Circuit 213—Power indication

Direction: From DCE

Signals on this circuit indicate whether power is available within the automatic calling equipment.

The ON condition indicates that power is available within the automatic calling equipment.

The OFF condition indicates that power is not available within the automatic calling equipment.

Interchange circuit number	Interchange circuit name	From DCE	To DCE
201	Signal ground or common return	X	X
202	Call request		X
203	Data line occupied	X	
204	Distant station connected	X	
205	Abandon call	X	
206	Digit signal (2^0)		X
207	Digit signal (2^1)		X
208	Digit signal (2^2)		X
209	Digit signal (2^3)		X
210	Present next digit	X	
211	Digit present		X
212	Protective ground or earth	X	X
213	Power indication	X	

FIGURE 3/V.24. — **200-Series interchange circuits specifically for automatic calling**

IV. OPERATIONAL REQUIREMENTS

In this section operational requirements are given for the usage of interchange circuits. It also explains in further detail the required correlation between interchange circuits, where implemented. These guidelines can also be used for the selection of interchange circuits for DCE which are not currently covered by a C.C.I.T.T. Recommendation.

IV.1 *Data circuits*

It is evident that proper data transmission may be impaired when the required condition is not present on an implemented control interchange circuit. Therefore, the DTE shall not transfer data on Circuit 103 (transmitted data) unless an ON condition is present on all of the following four circuits, where implemented: Circuit 105 (request to send), Circuit 106 (ready for sending), Circuit 107 (data set ready) and Circuit 108.1/108.2 (connect data set to line/data terminal ready).

All data transferred on Circuit 103 during the time an ON condition is present on all of the above four circuits, where implemented, shall be transmitted by the DCE.

Refer also to paragraph IV.4 and paragraph IV.5 for further explanation.

The DTE shall not transfer data on Circuit 118 unless an ON condition is present on all of the following four circuits, where implemented: Circuit 120 (transmit backward channel line signal), Circuit 121 (backward channel ready), Circuit 107 (data set ready) and Circuit 108.1/108.2 (connect data set to line/data terminal ready).

All data transferred on Circuit 118 during the time an ON condition is present on all of the above four circuits, where implemented, shall be transmitted by the DCE.

IV.2 *Idle periods*

During intervals when Circuit 105 (request to send) and Circuit 106 (ready for sending) are in the ON condition and no data are available for transmission, the DTE may transmit binary 1 condition, reversals, or other sequences to maintain timing synchronization, e.g. SYN coded characters, idle characters according to the code used, etc.

Specific requirements, where applicable, are stated in the appropriate DCE Recommendations.

IV.3 *Clamping*

When clamping is used the following clamping conditions shall be provided by the DCE:

1. In all applications the DCE shall hold, where implemented:

a) Circuit 104 (received data) in the binary 1 condition when Circuit 109 (data channel received line signal detector) is in the OFF condition, and

b) Circuit 119 (received backward channel data) in the binary 1 condition when Circuit 122 (backward channel received line signal detector) is in the OFF condition.

2. In addition a DCE arranged for half-duplex (C.C.I.T.T. definition: simplex) operation (turn-around system), shall also hold, where implemented:

a) Circuit 104 in the binary 1 condition and Circuit 109 in the OFF condition when Circuit 105 (request to send) is in the ON condition, and for a short interval (to be specified in Recommendations for DCE) following the ON to OFF transition on Circuit 105, and

b) Circuit 119 in the binary 1 condition and Circuit 122 in the OFF condition, when Circuit 120 (transmit backward channel line signal) is in the ON condition, and for a short interval (to be specified in Recommendations for DCE) following the ON to OFF transition on Circuit 120.

Without these clamping conditions, there is no inhibition of signals due to excessive noise, supervisory and control signals, switching transients, feedback from the local transmitter, etc., from appearing on Circuit 104, Circuit 119, Circuit 109 and Circuit 122.

IV.4 *Operation of Circuits 107 and 108/1 and 108/2*

Signals on Circuit 107 (data set ready) are to be considered as responses to signals which initiate connection to line, e.g. Circuit 108/1 (connect data set to line). However, the conditioning of a data channel, such as equalization and clamp removal, cannot be expected to occur before Circuit 107 is turned ON.

When Circuit 108/1 or 108/2 (data terminal ready) is turned OFF, it shall not be turned ON again until Circuit 107 is turned OFF by the DCE.

A wiring option shall be provided within the DCE to select either Circuit 108/1 or Circuit 108/2 operation.

When the DCE is conditioned for automatic answering of calls, connection to the line occurs only in response to a combination of the calling signal and an ON condition on Circuit 108/2.

In certain special dedicated circuit (leased line) applications, Circuit 108/1 might not be implemented, in which case the condition on this circuit is assumed to be permanently ON.

Under certain test conditions, both the DTE and the DCE may exercise some of the interchange circuits. It is then to be understood that when Circuit 107 is OFF, the DTE is to ignore the conditions on any interchange circuit from the DCE except those on Circuit 125 (calling indicator) and the timing circuits. Additionally, when Circuit 108/1 or 108/2 is OFF the DCE is to ignore the conditions on any interchange circuit from the DTE. The ON conditions on Circuits 107 and 108/1 or 108/2 are therefore prerequisite conditions for accepting as valid the signals on interchange circuits from the DCE or DTE respectively, other than Circuit 125. The OFF condition on Circuit 108/1 or 108/2 shall not disable the operation of Circuit 125.

IV.5 *Interrelationship of Circuits 103, 105 and 106*

The DTE signals its intent to transmit data by turning ON Circuit 105 (request to send). It is then the responsibility of the DCE to enter the transmit mode, i.e. be prepared to transmit data, and also to alert the remote DCE and condition it to receive data. The means by which a DCE enters the transmit mode and alerts and conditions the remote DCE are described in the appropriate modem Recommendation.

When the transmitting DCE turns Circuit 106 (ready for sending) ON, the DTE is permitted to transfer data across the interface on Circuit 103 (transmitted data). By turning ON Circuit 106 it is implied that all data transferred across the interface prior to the time that any one of the four circuits: 105, 106, 107, 108.1/108.2 is again turned OFF, will be transferred to the telecommunication channels; however, the ON condition of Circuit 106 is not necessarily a guarantee that the remote DCE is in the receive mode. (Depending on the complexity and sophistication of the transmitting signal converter, there may be a delay ranging from less than a millisecond up to several seconds between the time a bit is transferred across the interface until the time a signal element representing this bit is transmitted on the telecommunication channel.)

The DTE shall not turn Circuit 105 OFF before the end of the last bit (data bit or stop element) transferred across the interface on Circuit 103. Similarly, in certain full duplex switched network applications where Circuit 105 is not implemented (see specific DCE Recommendations), this requirement applies equally when Circuit 108/1 or 108/2 is turned OFF to terminate a switched network call.

Where Circuit 105 is provided, the ON and OFF conditions on Circuit 106 shall be responses to the ON and OFF conditions on Circuit 105. For the appropriate response times of Circuit 106, and for the operation of Circuit 106 when Circuit 105 is not provided, refer to the relevant Recommendation for DCE.

When Circuit 105 or Circuit 106 or both are OFF, the DTE shall maintain a binary 1 condition on Circuit 103. When Circuit 105 is turned OFF it shall not be turned ON again until Circuit 106 is turned OFF by the DCE.

Note. — These conditions also apply to the relationship between Circuits 120 (transmit backward channel line signal), 121 (backward channel ready) and 118 (transmitted backward channel data).

IV.6 *Timing circuits*

It is desirable that the transfer of timing information across the interface shall not be restricted to periods when actual transmission of data is in progress; however, during intervals when timing information is not transferred across the interface, the circuit involved should be held in the OFF condition. The following conditions apply:

a) *Circuit 113* (*transmitter signal element timing*—DTE source)

Where Circuit 113 is used, the DTE shall transfer timing information across the interface on this circuit at all times that the timing source in the DTE is capable of generating this information, e.g. when the DTE is in a power-on condition.

b) *Circuit 114* (*transmitter signal element timing*—DCE source)

Where Circuit 114 is used, the DCE shall transfer timing information across the interface on this circuit at all times that the timing source in the DCE is capable of generating this information, e.g. when the DCE is in a power-on condition. It is recognized that a DCE which derives power from the central office battery over the local telephone loop is in a power-off condition when disconnected from the loop, i.e. on-hook.

c) *Circuit 115* (*receiver signal element timing*—DCE source)

Where Circuit 115 is used, the DCE shall transfer timing information across the interface on this circuit at all times that the timing source is capable of generating this information.

It is recognized that a DCE which derives power from the serving central office via the local telephone loop, is in a power-off condition with timing sources stopped, when the DCE is disconnected from the line. It is also recognized that some timing sources will not continue to run indefinitely without a driving (external synchronization) signal.

Accuracy and stability of this signal as defined in the DCE Recommendations is required only when Circuit 109 is ON. Drift during the OFF condition of Circuit 109 is acceptable; however, resynchronization of the signal on Circuit 115 must be accomplished as rapidly as possible following the turning ON of Circuit 109 for the next transmission as indicated in the relevant DCE Recommendation.

d) *Circuit 128* (*receiver signal element timing*—DTE source)

Where Circuit 115 is used, the DTE may also provide timing information on Circuit 128 under conditions established by mutual agreement (e.g. when a synchronous DCE has asynchronous standby facilities).

IV.7 *Circuit 125* (*Calling indicator*)

The operation of Circuit 125 shall not be impaired or disabled by any condition on any other interchange circuit.

IV.8 *Usage of Circuits 126 and 127*

Originally, these circuits were defined for operational control of a 2-wire, frequency-divided duplex DCE, such as the V.21 type modem. Transmitter and receiver control were separated, so that local testing of both data channels might be performed as national Administrations required.

The modem according to Recommendation V.21 does not require separate operational control by the DTE of Circuits 126 and 127. Some modems, however, select the transmit and receive frequencies according to the condition of Circuit 125 (calling indicator). In these cases external operation of Circuit 126 may not be required except to override the condition selected according to Circuit 125.

The use of Circuit 127 may become necessary in certain types of 4-wire operation on multidrop circuits.

IV.9 *Interrelationship of Circuits 202 to 211*

Circuit 202

Circuit 202 must be turned OFF between calls or call attempts and shall not be turned ON before Circuit 203 (data line occupied) is turned OFF.

Circuit 204

The ON condition of this circuit must be maintained until the DTE has released the automatic calling equipment, i.e. until Circuit 202 (call request) is turned OFF.

Circuit 205

The OFF condition shall be maintained on this circuit after Circuit 204 (distant station connected) comes ON.

The initial time interval starts when Circuit 202 (call request) comes on. Subsequent time intervals start each time Circuit 210 (present next digit) is turned OFF.

Circuits 206, 207, 208 and 209

The conditions on these four circuits shall not change whilst Circuit 211 (digit present) is ON.

Circuit 210

When Circuit 210 is turned OFF, it shall not be turned ON again before Circuit 211 (digit present) is turned OFF.

Circuit 211

Circuit 211 shall neither be turned ON when Circuit 210 (present next digit) is in the OFF condition, nor before the DTE has presented the required code combination on the digit signal circuits.

Circuit 211 shall not be turned OFF before Circuit 210 (present next digit) is turned OFF.

Recommendation V.25

AUTOMATIC CALLING AND/OR ANSWERING EQUIPMENT ON THE GENERAL SWITCHED TELEPHONE NETWORK, INCLUDING DISABLING OF ECHO SUPPRESSORS ON MANUALLY ESTABLISHED CALLS

(Mar del Plata, 1968, amended at Geneva, 1972)

1. *Scope*

1.1 This Recommendation is concerned with the setting-up of a data connection when automatic calling and/or answering equipment is used over international circuits.

Automatic calling and answering systems used within any single Administration's area or between two Administrations by bilateral agreement are not necessarily constrained by these proposals. In particular the use of 2100 Hz answering tone, as described in the text, could be substituted by another tone when the equipment is used over circuits not equipped with echo suppressors. Similarly the calling tone could be omitted by bilateral agreements, but attention is drawn to sections 8 and 9.

1.2 This standard describes the sequences of events involved in establishing a connection between an automatic calling data terminal and an automatic answering data terminal for the cases of both V.21 and V.23 modems. The system configuration proposed is shown in Figure 1/V.25.

Consideration is given only to: a) the events which affect the interfaces between the data terminal equipment and the data circuit-terminating equipment; and b) the events on the line during establishment of a data call. Interactions within the data circuit-terminating equipment are not considered, since such consideration is unnecessary for purposes of international standardization.

1.3 The proposed procedures are intended to be suitable for the four types of calls, namely:

a) automatic calling terminal to automatic answering terminal;

b) manual data terminal to automatic answering terminal;

c) automatic calling terminal to manual data terminal;

d) disabling of echo suppressors in the case of manual data stations.

1.4 The data terminal equipment is responsible for:

a) during call establishment:

i) ensuring that the data circuit-terminating equipment is available for operation;

ii) providing the telephone number;

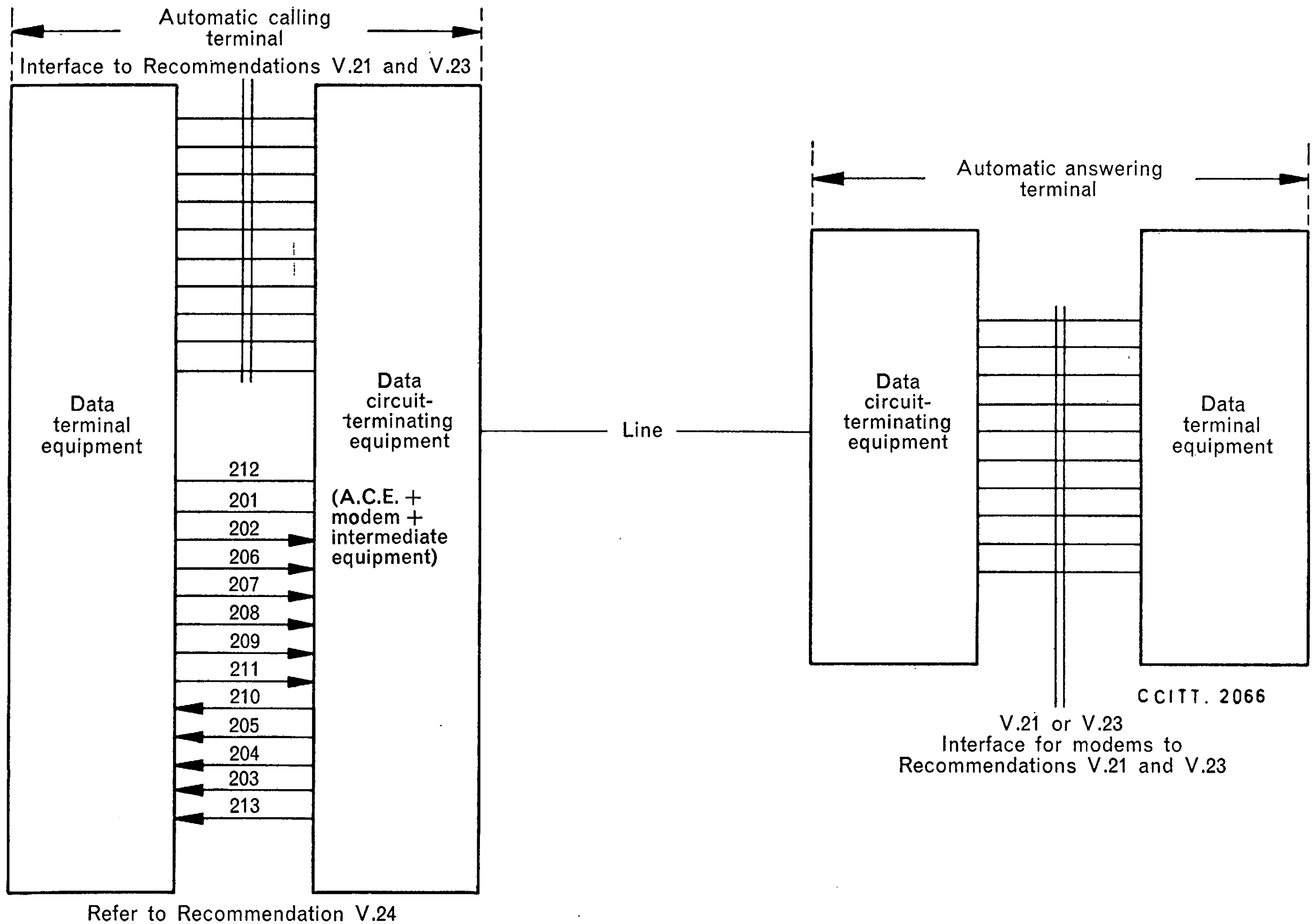

Automatic calling terminal
Interface to Recommendations V.21 and V.23
Data terminal equipment
Data circuit-terminating equipment
(A.C.E. + modem + intermediate equipment)
212
201
202
206
207
208
209
211
210
205
204
203
213
Refer to Recommendation V.24
Line
Automatic answering terminal
Data circuit-terminating equipment
Data terminal equipment
CCITT. 2066
V.21 or V.23
Interface for modems to Recommendations V.21 and V.23

FIGURE 1/V.25

iii) deciding to abandon the call if it is unsuccessfully completed.

b) after call is established:

i) establish identities;

ii) disable echo-suppressors (in the case of manual data stations);

iii) exchange such traffic as is appropriate;

iv) to initiate disconnect at calling and answering terminals.

2. *Abbreviations and definitions*

The following abbreviations are used in this Recommendation:

CT 104	Circuit 104, " Received data " interchange circuit
CT 105	Circuit 105, " Request to send " interchange circuit
CT 106	Circuit 106, " Ready for sending " interchange circuit
CT 107	Circuit 107, " Data set ready " interchange circuit
CT 108	Circuit 108, *either* 108/1 " Connect data set to line " interchange circuit *or* 108/2 " Data terminal ready " interchange circuit
CT 109	Circuit 109, " Data channel received line signal detector " interchange circuit
CT 119	Circuit 119, " Received backward channel data " interchange circuit
CT 120	Circuit 120, " Transmit backward channel line signal " interchange circuit
CT 121	Circuit 121, " Backward channel ready " interchange circuit
CT 122	Circuit 122, " Backward channel received line signal detector " interchange circuit
CT 125	Circuit 125, " Calling indicator " interchange circuit
CT 201	Signal ground
CT 202	" Call request " interchange circuit
CT 203	" Data line occupied " interchange circuit
CT 204	" Distant station connected " interchange circuit
CT 205	" Abandon call " interchange circuit
CT 206	" Digit signal (2^0) " interchange circuit
CT 207	" Digit signal (2^1) " interchange circuit
CT 208	" Digit signal (2^2) " interchange circuit
CT 209	" Digit signal (2^3) " interchange circuit
CT 210	" Present next digit " interchange circuit
CT 211	" Digit present " interchange circuit
CT 212	Protective ground
CT 213	" Power indication " interchange circuit
ACE	Automatic calling equipment
DCE	Data circuit-terminating equipment
DTE	Data terminal equipment
EON	" End of number " control character
SEP	" Separation " control character
FES	Echo suppressor at the answering terminal (" Far end suppressor ")
NES	Echo suppressor at the calling terminal (" Near end suppressor ")

The following definitions apply to this Recommendation:

Calling tone—The tone transmitted from the calling end.

Answering tone—The tone transmitted from the called end.

3. *Interface procedures at call-originating station*

Event

1. DTE checks if CT 213 ON, and the following circuits OFF: CT 202, CT 210, CT 205, CT 204, CT 203.

2. DTE puts CT 202 ON.

3. DTE puts CT 108/2 ON (CT 108/2 can be placed in the ON condition at any time up to and including event 16).

4. For modem to Recommendation V.23 with backward channel, DTE puts CT 105 ON if the calling end wishes to transmit first, and DTE puts CT 120 ON if the calling end wishes to receive. CT 105 and CT 120 can be placed ON at any time up to and including event 20.

5. Line goes " off-hook ".

6. DCE puts CT 203 ON.

7. Telephone system puts dial tone on line.

8. DCE puts CT 210 ON.

9. DTE presents the first or appropriate digit on CT 206, 207, 208 and 209.

10. DTE puts CT 211 ON.

11. DCE dials first digit; then takes CT 210 OFF.

12. DTE takes CT 211 OFF.

13. Steps 8 to 12 are repeated (but this process may be interrupted by SEP) until the last digit is presented and used. Step 8 is then repeated but step 14 follows.

14. DTE presents EON on CT 206, 207, 208 and 209, it then puts CT 211 ON.

15. DCE takes CT 210 OFF.

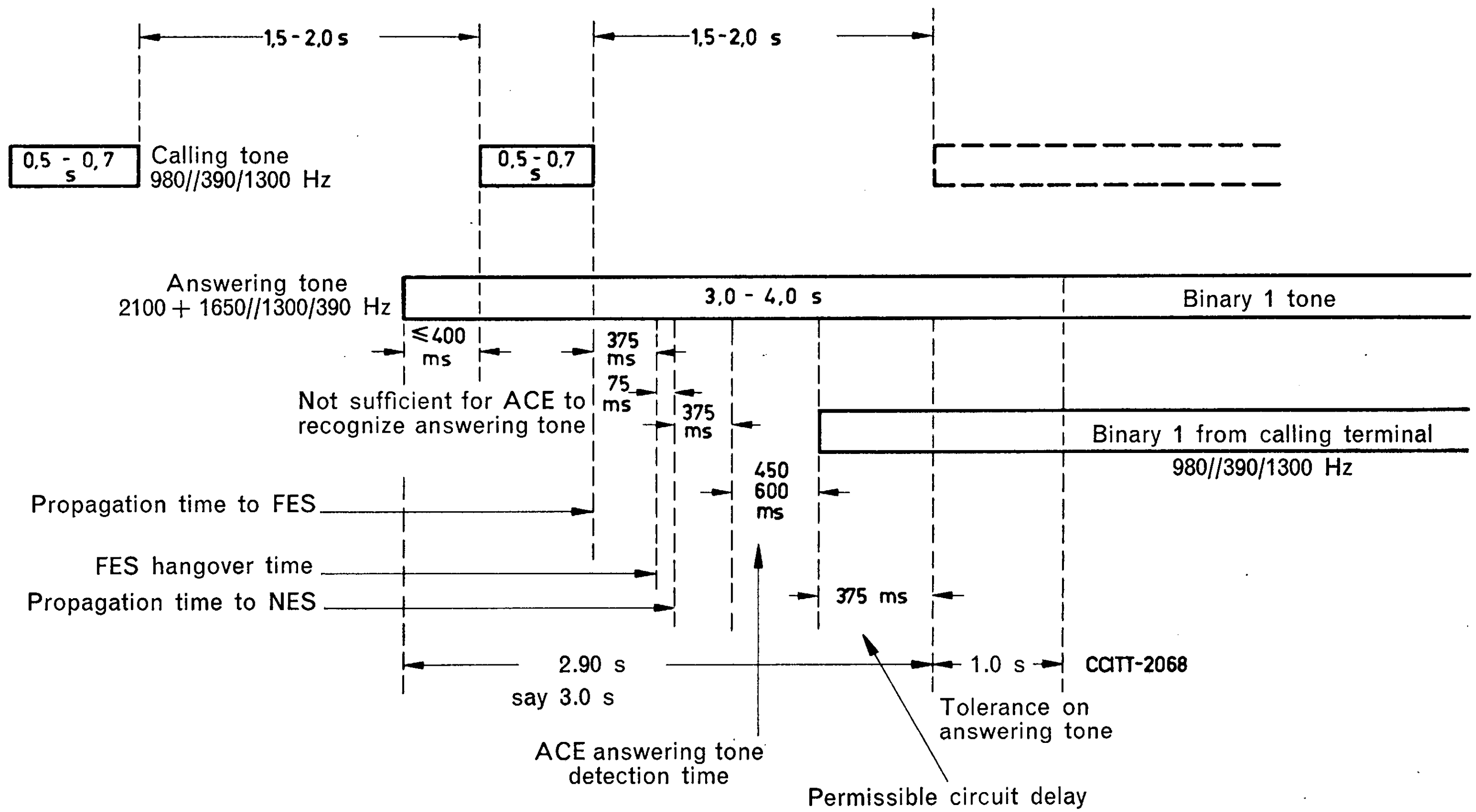
16. DTE takes CT 211 OFF and puts CT 108/2 ON, if not previously ON.

17. Interrupted tone, as shown in Figure 2/V.25, is transmitted to line from the calling DCE terminal.

18. a) If the call is answered by data terminal, then 2100 Hz tone is received by calling DCE. Echo suppressors are disabled during coincidence of a silent period in the calling tone (17) and 2100 Hz.

b) If the call is not answered, or is answered by a non-data station, then no 2100 Hz is received at the calling terminal. If no answering tone is received after an elapsed time CT 205 comes ON. This time is measured from event 15 and selectable in the range of 10–40 seconds.

19. When 2100 Hz has been recognized by the DCE for a period of 450 to 600 ms, the interrupted calling tone is discontinued by the DCE as shown in Figure 2/V.25. The DCE transfers control of the connection to the telephone line from CT 202 to CT 108/2.



Abbreviations used:

ACE = automatic calling equipment
FES = echo suppressor at the answering terminal
NES = echo suppressor at the calling terminal

FIGURE 2/V.25. — **Timing of line signals under " worst case " tolerance conditions, where all timing is related to the calling terminal in the duplex mode using either V.21 modems or V.23 modems which are equipped with both forward and backward channels**

Duplex case V.21 and V.23 modems

20-A. The DCE puts circuit 107 ON

a) For V.21 modem, DCE puts 980 Hz signal on line.

b) For V.23 modem,

i) if CT 105 is ON, DCE puts 1300 Hz signal on line,

ii) if CT 120 is ON, DCE puts 390 Hz signal on line.

The 2 100 Hz answering tone must not activate CT 104, 109, 119, or 122.
Step 20-A may be delayed, if desired, until the end of the answering tone.

21-A. The DCE turns ON CT 204. The DTE then may turn OFF CT 202 without disconnecting the call.

22-A. a) For the V.21 modem case, the DCE waits to receive 1 650 Hz. It then puts ON CT 109 and CT 106 after normal delays. The DTE can then transmit data.

b) For the V.23 modem case

i) if CT 105 is ON the DCE puts CT 106 ON after its normal delay. The DTE can then transmit data;

ii) if CT 120 is ON the DCE puts CT 121 ON after its normal delay and the DTE awaits for CT 109 to come ON in the expectation of receiving data.

Half-duplex case V.23 modem only

20-B. The DCE examines the line to determine the end of the 2100 Hz answering tone.

i) If CT 105 is ON and the DCE detects an absence of 2100 Hz tone for 50 to 100 ms, CT 107 comes ON and at the same time 1300 Hz is put on the line. After its normal delay, CT 106 comes ON and the terminal can then transmit data.

ii) If CT 105 is OFF and the DCE detects an absence of 2100 Hz tone for 50 to 100 ms, CT 107 comes ON. When the 1300 Hz tone is recognized and after its normal delay, the DCE puts CT 109 ON to allow the examination of CT 104 by the DTE.

21-B. The DCE turns ON CT 204. The DTE then may turn OFF CT 202 without disconnecting the call.

22-B. No action.

Note. — Prior to event 19, CT 202 is turned OFF to disconnect the call regardless of the condition of CT 108/2. After event 19, both CT 202 and CT 108/2 must be turned OFF to disconnect. The ON condition of CT 205 is an indication to DTE to disconnect.

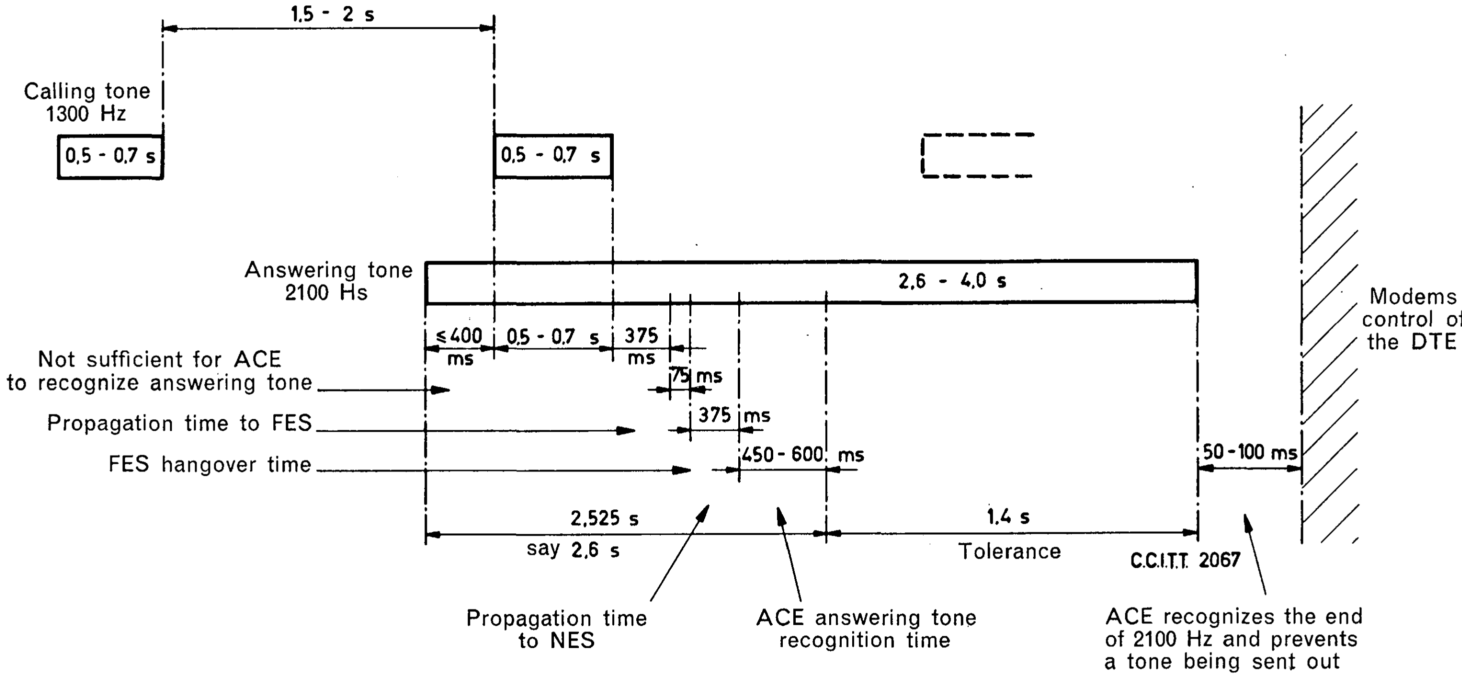
4. *Interface procedure at called station*

Event

1. Ringing received on line. DCE puts CT 125 ON.

2. a) If CT 108/2 is ON, DCE goes " off-hook ".

b) If CT 108/1 or CT 108/2 is OFF, the DCE waits for CT 108/1 or CT 108/2 to come ON, and then goes " off-hook ". If CT 108/1 or CT 108/2 does not turn ON, then the call is not answered.



Abbreviations used :

ACE = automatic calling equipment
FES = echo suppressor at the answering terminal.
NES = echo suppressor at the calling terminal
DTE = data terminal equipment

FIGURE 3/V.25. — **Timing of line signals under " worst case " tolerance conditions where all the timing is related to the calling terminal in the half duplex (simplex) mode using V.23 modems without a backward channel**

3. The DCE goes " off-hook ", maintains silence on the line for a period between 1.8 and 2.5 seconds then transmits 2100 Hz for a period as shown in Figures 2/V.25 or 3/V.25 as appropriate.

4. At the end of the 2100 Hz transmission, the DCE puts CT 107 ON. (See also section 6.)

In the duplex case

a) In the V.21 modem case, the DCE immediately transmits 1650 Hz (binary 1). When the DCE receives 980 Hz, it puts CT 109 ON and, after its normal delay, puts CT 106 ON.

The DTE can then transmit data.

b) In the V.23 modem case:

i) If CT 105 is ON, the DCE transmits 1300 Hz (binary 1). After its normal delay, the DCE puts CT 106 ON. When the DCE receives the 390 Hz signal from the calling terminal, it switches CT 122 ON after its normal delay.

The DTE can then transmit data.

ii) If CT 120 is ON, the DCE transmits 390 Hz (binary 1) and after its normal delay puts CT 121 ON. When the DCE receives the 1300 Hz from the calling terminal, it switches CT 109 ON after its normal delay, in expectation of receiving data.

In the half-duplex case

Where V.23 modems are used without a backward channel, the DCE times out the 2100 Hz answering tone.

i) If CT 105 is ON, the DCE waits 50 to 100 ms before putting 1300 Hz (binary 1) on the line, and after its normal delay CT 106 is switched ON.

The DTE can then transmit data.

ii) If CT 105 is OFF, the DCE waits for 1300 Hz on the line. After receiving 1300 Hz and its normal delay, CT 109 is switched ON to allow the DTE to receive data.

5. If within an appropriate time after CT 107 has been turned ON, no recognizable signals are received the DTE should turn OFF CT 108/1 or 108/2.

5. *Proposed line procedure for duplex modems*

Figure 2/V.25 shows the timings of line signals when automatic calling and answering are employed in a system employing duplex modems. The sequence of operations is as follows:

After the ACE has pulsed out the digits for calling the answering station and control has been extended to the modem and calling signals are sent to line. These calling signals comprise interrupted binary 1 tones which are ON for not more than 0.7 second and not less than 0.5 second and OFF for not more than 2.0 seconds and not less than 1.5 second. These interrupted tones are repeated until an answering tone is received from the called station. The answering tone must be a 2100 Hz signal to enable echo suppressors to be disabled. Its duration should be not less than 3.0 seconds and not more than 4.0 seconds. This answering tone must be followed immediately by the binary 1 tone from the called station modem.

At the calling station, the DCE must examine the line, and if, during the silent periods in the calling tone, it receives the answering tone for not less than 0.45 second (with an upper tolerance on this timing circuit of 0.6 second) the calling terminal modem must send the binary 1 condition to the called terminal. On receipt of binary 1 conditions at both terminals, station identification and data transmission can commence.

To keep the echo suppressors disabled it is necessary to ensure that following the transmission of the 2100 Hz answering signal from the called station, which also serves to disable the echo suppressor during the silent period in the calling tone, energy is maintained in the frequency spectrum 800-3000 Hz with gaps no longer than 100 milliseconds. Thus, if the called station is required to initially receive data in the V.23 case, the binary 1 condition will be 390 Hz, which may be inadequate for holding the echo suppressor disabled. However, if binary 1 from the calling terminal is applied immediately the recognition time of 0.45 to 0.6 second has expired, the circuit will be able to tolerate a permissible loop delay of 0.75 second under " worst case " conditions. Reference to Figure 2/V.25 shows that this figure is derived from summing all the signal durations prior to the receipt of binary 1 at the answering terminal. The initial period of $\leqslant$ 400 ms represents a condition where the answering tone duration is insufficient to disable the NES. The propagation delay following the calling tone burst is the time taken for the " trailing edge " of the calling tone to reach the FES. The FES will then take up to 75 ms to disable. The answering tone has a propagation delay to reach the NES. The DCE then requires 0.4 to 0.65 second to detect this answering tone. A further allowance must be made for the binary 1 condition to reach the answering terminal, if the FES is not to be allowed to drop out again. Thus a minimum answering tone duration of 2.9 seconds is determined. This is rounded to give safe figures of 3.0 to 4.0 seconds for the answer tone duration.

6. *Proposed line procedures for half duplex modems*

The line procedures outlined consider the case of the V.23 modem used in half duplex mode.

Systems which operate in the half duplex mode and which employ automatic calling equipment shall determine by pre-arrangement which of the two stations—calling or answering—shall first transmit to the other upon the establishment of the connection. As indicated in sections 3 and 4, the data terminal equipment at the terminal which is to transmit first must put CT 105 ON, at the appropriate point in the call-establishment sequence.

Figure 3/V.25 shows the timings of line signals when automatic calling and automatic answering are employed in a system employing half duplex modems. The sequence of operation is as follows:

After the DCE has dialled the digits of the directory number for the automatic answering station followed by the EON character, the DCE sends calling tone to the answering terminal. The calling tone consists of a series of interrupted bursts of binary 1 signal (1300 Hz) ON for a duration of not less than 0.5 second and not more than 0.7 second and OFF for a duration of not less than 1.5 second and not more than 2.0 seconds.

1.8 to 2.0 seconds after the called station is connected to the line (i.e. CT 125 and 108 are ON and the station is " off-hook "), it sends a continuous 2100 Hz answering tone for a duration of not less than 2.6 seconds and not more than 4.0 seconds.

This answering tone propagates towards the calling station and, during the course of one or two interruptions between bursts of calling tone, causes any echo suppressors in the circuit to disable. The answer tone is recognized by the calling station for a period of between 0.45 and 0.60 second after its arrival. The calling station terminates the calling tone burst sequence and recognizes the end of the answer tone for a period of between 50 and 100 milliseconds after its arrival at the calling terminal.

At the end of this delay, the DCE puts CT 107 ON.

Similarly, the answering station DCE delays for a period of between 50 and 100 milliseconds after terminating the answer tone before putting CT 107 ON.

The DCE at the station at which CT 105 had been turned ON (by pre-arrangement) commences to send binary 1 (1300 Hz). Data communication can commence after CT 106 is put ON at that station.

During the automatic calling and answering procedures the echo suppressors will be disabled. If signal gaps exceed 100 ms at any time, e.g. during modem turn around, they may become re-enabled.

7. *Manual data terminal calling automatic answering station*

The procedure for establishment of a call from a manual data terminal to an automatic answering data station is similar to that from an automatic calling data terminal, except that no tone is transmitted from the calling terminal until the called station has answered. The manual operator dials the required number, hears 2100 Hz returned from the automatic answering terminal and then presses his data button to connect the data circuit-terminating equipment to the line during the period that 2100 Hz is being received. Circuit 107 (data set ready) comes ON at the time as specified in event 20.

Satisfactory disabling of echo suppressors by the answering tone, however, will require that no speech signals from the microphone at the calling station enter the telecommunications circuit for a period of at least 400 ms during the receipt of answering tone. This may be accomplished by a handset switch or other appropriate means.

8. *Automatic calling terminal calling manual data station*

An operator answering a call from an automatic calling equipment hears an interrupted tone of 0.5 to 0.7 second ON and 1.5 to 2.0 seconds OFF. The data button must be depressed to connect the modem to line. A period of about 3 to 4 seconds of 2100 Hz tone is transmitted to the calling terminal to disable echo suppressors and notify the calling station that the connection is being established. This sequence is followed by data transmission as required.

9. *Disabling of echo suppressors in the case of manual data stations*

The procedures as described in Sections 7 and 8 above with regard to the manually operated data stations can obviously be used for disabling echo suppressors when manual switching from voice conversation to data is required, which is the preferred principle of operation. Considering the type of DCE designed to be used in conjunction with manual connection set-up it will be necessary to equip the DCE with a 2100 Hz answering-tone generator. To avoid modifying existing equipment at the station which receives the answering tone the following procedure may replace the operation principle of Section 7.

The manual operator operates his data key after the end of the 2100 Hz answering tone. The station which is to transmit the answering tone is to be agreed between the operators while still in the voice mode.

Care must be exercised in cases where transmission of data is started from the station which transmits the answering tone and where a V.23 modem is used without the backward channel since initially data may be garbled.

10. *Protection of ordinary telephone users*

As both automatic calling and automatic answering data terminals transmit tones to line during call establishment, a normal telephone user who becomes inadvertently connected to one will receive tone signals for a period of sufficient duration to indicate clearly to him that he is incorrectly connected.

11. *Manual selection of automatic answering, data mode and voice mode*

It is recognized that, at the data station, means should be provided to allow the operator to select between automatic and manual answering of calls. If a call is manually answered, voice mode shall be established. Subsequent switching to the data mode shall be performed by the procedure as specified in Section 8 above.

Selection of manual or automatic answering of subsequent calls shall be possible after entering the data mode. As an option, automatic answering may be arranged for all subsequent incoming calls. In this case, manual answering may still be achieved by keeping CT 108/2 OFF to cause an audible signal to occur at the telephone instrument.

The data circuit-terminating equipment shall be disconnected from the line whenever CT 108/1 or 108/2 is turned OFF, whatever means was employed in establishing the connection.

Procedures for switching to the voice mode between data transmission within the same call shall ensure that CT 107 is turned OFF whilst in the voice mode.

It may be necessary to prearrange a non-connected data station for preference to incoming calls by switching CT 203 to ON condition. This option is subject to further study.

Recommendation V.26

2400 BITS PER SECOND MODEM STANDARDIZED FOR USE ON FOUR-WIRE LEASED CIRCUITS

(Mar del Plata, 1968, amended at Geneva, 1972)

On leased circuits, considering that there exist and will come into being many modems with features designed to meet the requirements of the Administrations and users, this Recommendation in no way restricts the use of any other modems.

1. The principal characteristics for this recommended modem for transmitting data at 2400 bits per second on four-wire leased point-to-point and multipoint circuits conforming to Recommendation M.102 are as follows:

a) it is capable of operating in a full-duplex mode;

b) four-phase modulation with synchronous mode of operation;

c) inclusion of a backward (supervisory) channel at modulation rates up to 75 bauds in each direction of transmission, the use of these channels being optional.

2. *Line signals*

2.1 The carrier frequency is to be 1800 $\pm$ 1 Hz. No separate pilot frequencies are provided. The power levels used will conform to Recommendation V.2.

2.2 *Division of power between the forward and backward channels*

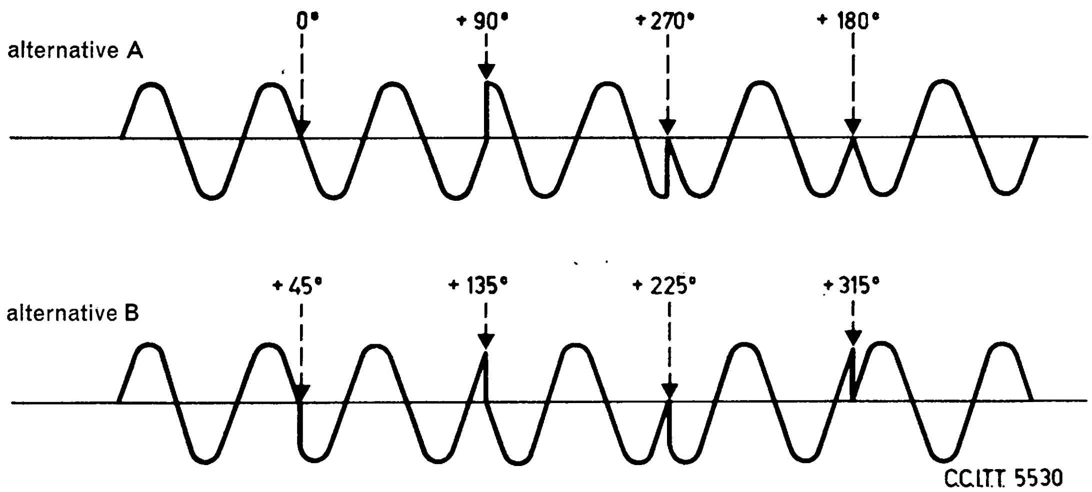
If simultaneous transmission of the forward and backward channels occurs in the same direction, a backward channel shall be 6 dB lower in power level than the data channel.

2.3 The data stream to be transmitted is divided into pairs of consecutive bits (dibits). Each dibit is encoded as a phase change relative to the phase of the immediately preceding signal element. At the receiver the dibits are decoded and the bits are reassembled in correct order. Two alternative arrangements of coding are listed in the table below. The left-hand digit of the dibit is the one occurring first in the data stream.

Dibit	Phase change [a]	
	Alternative A	Alternative B
00	0°	+45°
01	+90°	+135°
11	+180°	+225°
10	+270°	+315°

[a] The phase change is the actual on-line phase shift in the transition region from the end of one signalling element to the beginning of the following signalling element.

The meaning of phase change for alternatives A and B is illustrated by the line signal diagram given below:



2.4 *Synchronizing signal*

For the whole duration of the interval between the OFF to ON transitions of circuits 105 and 106, the line signal shall be that corresponding to the continuous transmission of dibit 11. This shall be known as the synchronizing signal.

Note. — Owing to several causes the stability of timing recovery at the receiver is liable to be data-pattern sensitive. The presence of dibit 11 provides a stabilizing influence irrespective of the cause of lack of stability. Users are advised to include sufficient binary 1s in the data which will ensure that the dibit 11 will occur frequently.

3. *Data signalling and modulation rates*

The data signalling rate shall be 2400 bits per second $\pm$ 0.01 %, i.e. the modulation rate is 1200 bauds $\pm$ 0.01 %.

4. *Received signal frequency tolerance*

Noting that the carrier frequency tolerance allowance at the transmitter is $\pm$ 1 Hz and assuming a maximum frequency drift of $\pm$ 6 Hz in the connection between the modems, then the receiver must be able to accept errors of at least $\pm$ 7 Hz in the received frequencies.

5. *Backward channel*

The modulation rate, characteristic frequencies, tolerances, etc., to be as recommended for backward channel in Recommendation V.23.

6. *Interchange circuits*

6.1 *List of interchange circuits concerned*

Interchange circuit		Forward (data) channel half-duplex or full duplex	
No.	Designation	Without backward channel	With backward channel
101 [a]	Protective ground or earth	X	X
102	Signal ground or common return	X	X
103	Transmitted data	X	X
104	Received data	X	X
105	Request to send	X	X
106	Ready for sending	X	X
107	Data set ready	X	X
108/1	Connect data set to line	X	X
109	Data channel received line signal detector	X	X
113	Transmitter signal element timing (DTE source)	X	X
114	Transmitter signal element timing (DCE source)	X	X
115	Receiver signal element timing (DCE source)	X	X
118	Transmitted backward channel data	—	X
119	Received backward channel data	—	X
120	Transmit backward channel line signal	—	X
121	Backward channel ready	—	X
122	Backward channel received line signal detector	—	X

[a] May be excluded if so required by local safety regulations.

6.2 *Threshold and response times of circuit 109*

A fall in level of the incoming line signal to −31 dBm or lower for more than 10 ± 5 ms will cause circuit 109 to be turned OFF. An increase in level to −26 dBm or higher will within 10 ± 5 ms turn this circuit ON. The condition of circuit 109 for levels between −26 dBm and −31 dBm is not specified except that the signal level detector shall exhibit a hysteresis action such that the level at which the OFF to ON transition occurs is at least 2 dB greater than that for the ON to OFF transition. These values shall be measured when the synchronizing signal as defined in paragraph 2.4 is being transmitted. It should be noted that the aforementioned times relate only to the defined function of circuit 109 and do not necessarily include the time for the modem to achieve bit synchronism.

Note. — The signal levels specified in this paragraph shall apply unless completion of Recommendation M.102 indicates otherwise.

6.3 *Response times of circuits 106, 121 and 122*

Circuit 106	Note 1	Note 2
OFF to ON	65-100 ms (Provisional)	25-45 ms (Provisional)
ON to OFF	≤ 2 ms	≤ 2 ms

Circuit 121

OFF to ON	80 ms to 160 ms
ON to OFF	≤ 2 ms

Circuit 122

OFF to ON	< 80 ms
ON to OFF	15 ms to 80 ms

Note 1. — These times shall be used when infrequent operation of circuit 105 is required, e.g. as in many cases of point-to-point usage. Further study is required to verify the range quoted.

Note 2. — These times shall be used when frequent operation of circuit 105 is required, e.g. in many cases of multipoint usage. Further study is required with a view to reducing these times.

6.4 *Threshold of Circuit 122*

Greater than −34 dBm	circuit 122 ON
Less than −39 dBm	circuit 122 OFF

The condition of Circuit 122 for levels between −34 dBm and −39 dBm is not specified except that the signal detector shall exhibit a hysteresis action such that the level at which the OFF to ON transition occurs is at least 2 dB greatei than that for the ON to OFF transition.

6.5 *Clamping of Circuit 104*

Two options shall be provided in the modem.

i) When clamping is not used there is no inhibition of the signals on Circuit 104. There is no protection against noise, line transients, etc. from appearing on Circuit 104.

ii) When clamping is used Circuit 104 is held in the marking condition (binary 1) when Circuit 109 is in the OFF condition. When this condition does not exist the clamp is removed and Circuit 104 can respond to the input signals of the modem.

6.6 *Clamping of Circuit 119*

Two options shall be provided in the modem.

i) When clamping is not used there is no inhibition of the signals on Circuit 119. There is no protection against noise, line transients, etc. from appearing on Circuit 119.

ii) When clamping is used, Circuit 119 is held in the marking condition (binary 1) when Circuit 122 is in the OFF condition. When this condition does not exist, the clamp is removed and Circuit 119 can respond to the input signals of the modem.

7. *Timing arrangements*

Clocks should be included in the modem to provide the data terminal equipment with transmitter signal element timing (Recommendation V.24, Circuit 114) and receiver signal element timing (Recommendation V.24, Circuit 115). Alternatively, the transmitter signal element timing may be originated in the data terminal equipment instead of in the data circuit-terminating equipment and be transferred to the modem via the appropriate interchange circuit (Recommendation V.24, Circuit 113).

8. The following information is provided to assist equipment manufactures:

The data modem should have no adjustment for send level or receive sensitivity under the control of the operator.

Recommendation V.26 bis

2400/1200 BITS PER SECOND MODEM STANDARDIZED FOR USE IN THE GENERAL SWITCHED TELEPHONE NETWORK

(Geneva, 1972)

The C.C.I.T.T.,

considering

1. that there is a demand for data transmission at 2400 bit/s over the general switched telephone network;

2. that a majority of connections over the general switched telephone network within some countries are capable of carrying data at 2400 bit/s;

3. that a much lower proportion of international connections in the general switched telephone service are capable of carrying data at 2400 bit/s,

unanimously declares the view

A. that transmission at 2400 bit/s should be allowed on the general switched telephone network. Reliable transmission cannot be guaranteed on every connection or routing and tests should be made between the most probable terminal points before a service is provided.

The C.C.I.T.T. expects that developments during the next few years in modern technology will bring about modems of more advanced design enabling reliable transmission to be given on a much higher proportion of connections.

Note 1. — The provisions of this Recommendation are to be regarded as provisional in order to provide service where it is urgently required and between locations where it is expected that a reasonably satisfactory service can be given.

Note 2. — The alternative methods of coding will remain in being until the VIth Plenary Assembly at which it is the intention to recommend that only one method of coding shall be used, namely type B. At the same time the study of improved methods of transmission at 2400 bit/s or above over the general switched telephone network will be urgently continued with the aim to recommend a method of transmission which will enable a more reliable service to be given over a high proportion of the connections encountered in normal service.

B. that the characteristics of the modems for this service shall provisionally be the following:

1. *Principal characteristics*

— use of a data signalling rate of 2400 bit/s with carrier frequency, modulation and coding according to Recommendation V.26 on the communication channel. Administrations and users should note that the performance of this modem on international connections may not be always suitable for this service without prior testing and conditioning if required;

— reduced rate capability at 1200 bit/s;

— inclusion of a backward channel at modulation rates up to 75 bauds, use of this channel being optional.

2. *Line signals at 2400 and 1200 bit/s*

2.1 The carrier frequency is to be 1800 ± 1 Hz. No separate pilot frequencies are provided. The power levels used will conform to Recommendation V.2.

2.2 *Division of power between forward and backward channels*

Equal division of power between the forward and backward channels is recommended provisionally.

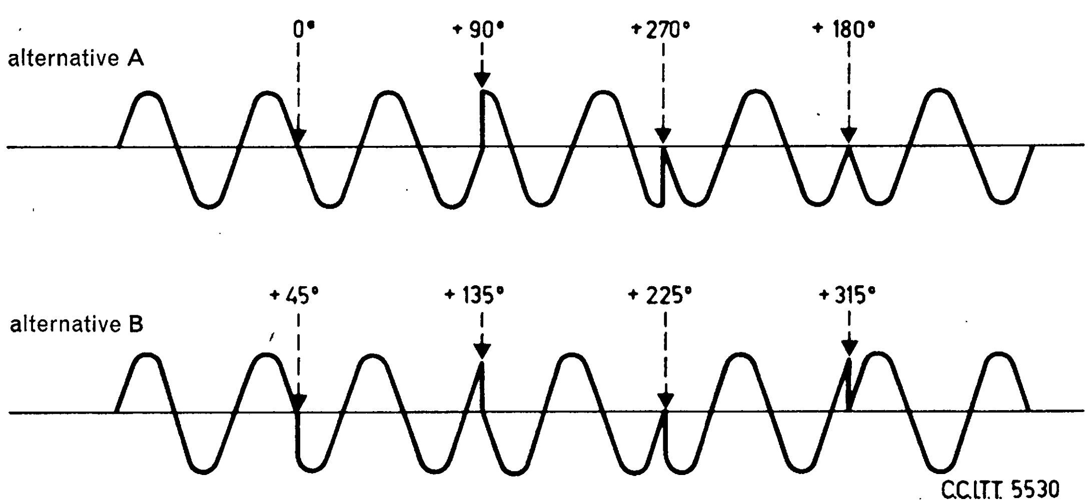
2.3 *Operation at 2400 bit/s*

2.3.1 The data stream to be transmitted is divided into pairs of consecutive bits (dibits). Each dibit is encoded as a phase change relative to the phase of the immediately preceding signal element. At the receiver the dibits are decoded and the bits are reassembled in correct order. Two alternative arrangements of coding are listed in the table below. The left-hand digit of the dibit is the one occurring first in the data stream.

Dibit	Phase change [a]	
	Alternative A	Alternative B
00	0°	+45°
01	+90°	+135°
11	+180°	+225°
10	+270°	+315°

[a] The phase change is the actual on-line phase shift in the transition region from the end of one signalling element to the beginning of the following signalling element.

The meaning of phase change for alternatives A and B is illustrated by the line signal diagram given below:



2.3.2 *Synchronizing signal*

For the whole duration of the interval between the OFF to ON transitions of circuits 105 or 107 and 106, the line signal shall be that corresponding to the continuous transmission of dibit 11. This shall be known as the synchronizing signal (see 5.2.ii).

Note. — Owing to several causes the stability of timing recovery at the receiver is liable to be data-pattern sensitive. The presence of dibit 11 provides a stabilizing influence irrespective of the cause of lack of stability. Users are advised to include sufficient binary 1s in the data which will ensure that the dibit 11 will occur frequently.

2.3.3 *Data signalling and modulation rates*

The data signalling rate shall be 2400 bit/s $\pm$ 0.01%, i.e. the modulation rate is 1200 bauds $\pm$ 0.01%.

2.4 *Operation at 1200 bit/s*

2.4.1 Coding and modulation used are 2-phase differential modulation with binary 0 for $+90°$ and binary 1 for $+270°$.

2.4.2 The data signalling rate shall be 1200 bit/s $\pm$ 0.01%, the modulation rate remains at 1200 bauds $\pm$ 0.01%.

3. *Received signal frequency tolerance*

Noting that the carrier frequency tolerance allowance at the transmitter is $\pm$ 1 Hz and assuming a maximum frequency drift of $\pm$ 6 Hz in the connection between the modems, then the receiver must be able to accept errors of at least $\pm$ 7 Hz in the received frequencies.

4. *Backward channel*

4.1 *Modulation rate and characteristic frequencies for the backward channel*

The modulation rate and characteristic frequencies for the backward channel are as follows:

	F_Z (symbol 1, mark)	F_A (symbol 0, space)
Modulation rate up to 75 bauds	390 Hz	450 Hz

In the absence of any signal on the backward channel interface, the condition Z signal is to be transmitted.

4.2 *Tolerances on the characteristic frequencies of the backward channel*

As the backward channel is a v.f. telegraph-type channel, the frequency tolerances should be as recommended in Recommendation R.35 for frequency-shift voice-frequency telegraphy.

The $\pm$ 6 Hz frequency drift in the connection between the modems postulated in 3 above would produce additional distortion in the backward channel. This should be taken into account in the design.

5. *Interchange circuits*

5.1 Interchange circuits essential for the modems when used on the general switched telephone network, including terminals equipped for manual calling or answering or automatic calling or answering.

Interchange circuit		Forward (data) channel one-way system				Forward (data) channel either way system	
		Without backward channel		With backward channel			
No.	Designation	Transmit end	Receive end	Transmit end	Receive end	Without backward channel	With backward channel
101 [a]	Protective ground or earth	X	X	X	X	X	X
102	Signal ground or common return	X	X	X	X	X	X
103	Transmitted data	X	—	X	—	X	X
104	Received data	—	X	—	X	X	X
105	Request to send	X	—	X	—	X	X
106	Ready for sending	X	—	X	—	X	X
107	Data set ready	X	X	X	X	X	X
108/1 or 108/2 (Note 1)	Connect data set to line Data terminal ready	X	X	X	X	X	X
109	Data channel received line signal detector	—	X	—	X	X	X
111	Data signalling rate selector (DTE)	X	X	X	X	X	X
113	Transmitter signal element timing (DTE source)	X	—	X	—	X	X
114	Transmitter signal element timing (DCE source)	X	—	X	—	X	X
115	Receiver signal element timing (DCE source)	—	X	—	X	X	X
118	Transmitted backward channel data	—	—	—	X	—	X
119	Received backward channel data	—	—	X	—	—	X
120	Transit backward channel line signal	—	—	—	—	—	X
121	Backward channel ready	—	—	—	X	—	X
122	Backward channel received line signal detector	—	—	X	—	—	X
125	Calling indicator	X	X	X	X	X	X

[a] May be excluded if so required by local safety regulations.

Note 1. — This circuit shall be capable of operation as circuit 108/1 (connect data set to line) or circuit 108/2 (data terminal ready) depending on its use. For automatic calling it shall be used as 108/2 only.

Note 2. — Interchange circuits indicated by X must be properly terminated according to Recommendation V.24 in the data terminal equipment and data circuit-terminating equipment.

5.2 *Response times of circuits 106, 109, 121 and 122*

Definition

i) Circuit 109 response times are the times that elapse between the connection or removal of the test synchronizing signal to or from the modem receive line terminals and the appearance of the corresponding ON and OFF condition on circuit 109.

The level of the test synchronizing signal should fall within the level range between 3 dB above the actual OFF to ON threshold of the received line signal detector and the maximum admissible level of the received signal. At all levels within this range, the measured response times shall be within the specified limits.

ii) Circuit 106 response times are from the connection of an ON or OFF condition on:

— circuit 105 to the appearance of the corresponding ON or OFF condition on circuit 106; or

— circuit 107 (where circuit 105 is not required to initiate the synchronizing signal) to the appearance of the corresponding ON or OFF condition on circuit 106.

Response times

	Note 1	Note 2
Circuit 106		
OFF to ON	750 ms to 1400 ms	a) 65 ms to 100 ms b) 200 ms to 275 ms
ON to OFF	≤ 2 ms	≤ 2 ms
Circuit 109		
OFF to ON	300 ms to 700 ms	5 ms to 15 ms
ON to OFF	5 ms to 15 ms	5 ms to 15 ms

Circuit 121	
OFF to ON	80 ms to 160 ms
ON to OFF	≤ 2 ms
Circuit 122	
OFF to ON	< 80 ms
ON to OFF	15 ms to 80 ms

Note 1. — For automatic calling and answering, the longer response times of circuits 106 and 109 are to be used during call establishment only.

Note 2. — The choice of response times depends upon the system application:

a) limited protection given against line echoes;

b) protection given against line echoes.

Note 3. — The above parameters and procedures, particularly in the case of automatic calling and answering are provisional and are the subject of further study. Especially the shorter response times for circuit 109 may need revision to prevent remnants of the synchronizing signal from appearing on circuit 104.

5.3 *Threshold of data channel and backward channel received line signal detectors*

Level of received line signal at receive line terminals of modem for all types of connections, i.e. general switched telephone network or non-switched leased telephone circuits:

greater than	-43 dBm	circuits 109/122 ON
less than	-48 dBm	circuits 109/122 OFF

The condition of circuits 109 and 122 for levels between -43 dBm and -48 dBm is not specified except that the signal detectors shall exhibit a hysteresis action such that the level at which the OFF to ON transition occurs is at least 2 dB greater than that for the ON to OFF transition.

Where transmission conditions are known and allowed, it may be desirable at the time of modem installation to change these response levels of the received line signal detector to less sensitive values (e.g. -33 dBm and -38 dBm respectively).

5.4 *Clamping to binary condition 1 of circuit 104 (Received data)*

Two options shall be provided in the modem:

i) When clamping is not used there is no inhibition of the signals on circuit 104. There is no protection against noise, supervisory and control tones, switching transients etc. from appearing on circuit 104.

ii) When clamping is used, circuit 104 is held in a marking condition (binary 1) under the conditions defined below. When these conditions do not exist the clamp is removed and circuit 104 can respond to the input signals of the modem:

— when circuit 109 is in the OFF condition;

— when circuit 105 is in the ON condition and the modem is used in half duplex mode (turn-around systems). To protect circuit 104 from false signals a delay device shall be provided to maintain circuit 109 in the OFF condition for a period of 150 ± 25 ms after circuit 105 has been turned from ON to OFF. The use of this additional delay is optional.

6. *Timing arrangements*

Clocks should be included in the modem to provide the data terminal equipment with transmitter signal element timing (Recommendation V.24, circuit 114) and receiver signal element timing (Recommendation V.24, circuit 115). Alternatively, the transmitter signal element timing may be originated in the data terminal equipment instead of in the data circuit-terminating equipment and be transferred to the modem via the appropriate interchange circuit (Recommendation V.24, circuit 113).

7. The following information is provided to assist equipment manufacturers:

The data modem should have no adjustment for send level or receive sensitivity under the control of the operator.

8. It will be for the user to decide whether, in view of the connections he makes with this system, he will have to request that the data circuit-terminating equipment be equipped with facilities for disabling echo suppressors. The international characteristics of the echo suppressor tone disabler have been standardized by the C.C.I.T.T. (Recommendation G.161, section C) and the disabling tone should have the following characteristics:

— disabling tone transmitted: 2100 ± 15 Hz at a level of −12 ± 6 dBm0,

— the disabling tone to last at least 400 ms, the tone disabler should hold in the disabled mode for any single-frequency sinusoid in the band from 390-700 Hz having a level of −27 dBm0 or greater, and from 700-3000 Hz having a level of −31 dBm0 or greater. The tone disabler should release for any signal in the band from 200-3400 Hz having a level of −36 dBm0 or less,

— the tolerable interruptions by the data signal to last not more than 100 ms.

9. *Fixed compromise equalizer*

A fixed compromise equalizer shall be incorporated into the receiver. The characteristics of this equalizer may be selected by Administrations but this should be the matter for further study.

Recommendation V.27

4800 BITS PER SECOND MODEM STANDARDIZED FOR USE ON LEASED CIRCUITS

(Geneva, 1972)

1. *Introduction*

This modem is intended to be used primarily on M.102 circuits but this does not preclude the use of this modem over circuits of lower quality at the discretion of the concerned Administration.

On leased circuits, considering that there exist and will come into being many modems with features designed to meet the requirements of the Administrations and users, this Recommendation in no way restricts the use of any other modems.

The principal characteristics for this recommended modem for transmitting data at 4800 bits per second on leased circuits are as follows:

a) it is capable of operating in a full-duplex mode or half-duplex mode;

b) differential eight-phase modulation with synchronous mode of operation;

c) possibility of a backward (supervisory) channel at modulation rates up to 75 bauds in each direction of transmission, the use of these channels being optional;

d) inclusion of an adjustable equalizer.

2. *Line signals*

2.1 The carrier frequency is to be 1800 ± 1 Hz. No separate pilot frequencies are provided. The power levels used will conform to Recommendation V.2.

2.2 Division of power between the forward and backward channels.

If simultaneous transmission of the forward and backward channels occurs in the same direction, a backward channel should be 6 dB lower in power level than the forward (data) channel.

2.3 The data stream to be transmitted is divided into groups of three consecutive bits (tribits). Each is encoded as a phase change relative to the phase of the immediately preceding signal tribits element. At the receiver the tribits are decoded and the bits are reassembled in correct order. The left-hand digit of the tribit is the one occurring first in the data stream as it enters the modulator portion of the modem after the scrambler.

Tribit values			Phase change
0	0	1	0°
0	0	0	45°
0	1	0	90°
0	1	1	135°
1	1	1	180°
1	1	0	225°
1	0	0	270°
1	0	1	315°

The phase change is the actual on-line phase shift in the transition region from the end of one signalling element to the beginning of the following signalling element.

3. *Data signalling and modulation rates*

The data signalling rate shall be 4800 bits per second ± 0.01 %, i.e. the modulation rate is 1600 bauds ± 0.01 %.

4. *Received signal frequency tolerance*

The carrier frequency tolerance allowance at the transmitter is ± 1 Hz and assuming a maximum frequency drift of ± 6 Hz in the connection between the modems, then the receiver must be able to accept errors of at least ± 7 Hz in the received frequencies.

5. *Backward channel*

The modulation rate, characteristic frequencies, tolerances, etc. to be as recommended for backward channel in Recommendation V.23. This does not preclude the use of a higher speed backward channel with operational capability of 75 bauds or higher bearing the same characteristic frequencies as the V.23 backward channel.

6. *Essential interchange circuits*

Interchange circuit		Forward (data) channel half-duplex or full duplex	
No.	Designation	Without backward channel	With backward channel
101 [a]	Protective ground or earth	X	X
102	Signal ground or common return	X	X
103	Transmitted data	X	X
104	Received data	X	X
105 [b]	Request to send	X	X
106	Ready for sending	X	X
107	Data set ready	X	X
108/1	Connect data set to line	X	X
109	Data channel received line signal detector	X	X
113	Transmitter signal element timing (DTE source)	X	X
114	Transmitter signal element timing (DCE source)	X	X
115	Receiver signal element timing (DCE source)	X	X
118	Transmitted backward channel data	—	X
119	Received backward channel data	—	X
120	Transmit backward channel line signal	—	X
121	Backward channel ready	—	X
122	Backward channel received line signal detector	—	X

[a] May be excluded if so required by local safety regulations.

[b] Not essential for 4-wire full-duplex continuous carrier operation.

7. *Threshold and response times of circuit 109*

A fall in level of the incoming line signal to −31 dBm or lower for more than 10 ± 5 ms will cause circuit 109 to be turned OFF. An increase in level to −26 ± 1 dBm or higher will turn this circuit ON after a delay of

a) 13 ± 3 ms for fast operations,

b) 100 ms to 1200 ms for slow operation,

where the choice of the delay for slow operation depends upon the application. Delays within the range of b) may be provided for 4-wire full-duplex continuous carrier operation.

8. *Timing arrangements*

Clocks should be included in the modem to provide the data terminal equipment with transmitter signal element timing (Recommendation V.24, circuit 114) and receiver signal element timing (Recommendation V.24, circuit 115). Alternatively, the transmitter signal element timing may be originated in the data terminal equipment and be transferred to the modem via the appropriate interchange circuit (Recommendation V.24, circuit 113).

9. The following information is provided to assist equipment manufacturers:

- the data modem should have no adjustment for send level or receive sensitivity under the control of the operator;
- no fall-back rate had been included because the convenient rate would be 3200 bit/s, not a permitted rate;
- circuit 108/2 had not been included in the list of interchange circuits because it was considered the modem would not be suitable for switched network use until an automatic equalizer had been recommended.

10. *Synchronizing signal*

During the interval between the OFF to ON transition of circuit 105 and the OFF to ON transition of circuit 106, synchronizing signals for properly conditioning the receiving modem must be generated by the transmitting modem. These signals are defined as

a) signals to establish basic demodulator requirements;

b) signals to establish scrambler synchronization.

The actual composition of the synchronization signals is continuous 180 degrees phase reversals on line for 9 ± 1 ms followed by continuous 1's at the input to the transmit scrambler for b). Condition b) shall be sustained until the OFF to ON transition of circuit 106.

11. *Response time for circuit 106*

The time between the OFF to ON transition of circuit 105 and the OFF to ON transition of circuit 106 shall be optionally 20 ms $\pm$ 3 ms or 50 ms $\pm$ 20 ms.

12. *Line signal characteristics*

A 50% raised cosine energy spectrum shaping is equally divided between the receiver and transmitter.

13. *Scrambler*

A self-synchronizing scrambler/descrambler having the generating polynomial $1 + x^{-6} + x^{-7}$, with additional guards against repeating patterns of 1, 2, 3, 4, 6, 9 and 12 bits, shall be included in the modem. The Appendix shows a suitable logical arrangement.

At the transmitter the scrambler shall effectively divide the message polynomial, of which the input data sequence represents the coefficients in descending order, by the scrambler generating polynomial, to generate the transmitted sequence, and at the receiver the received polynomial, of which the received data sequence represents the coefficients in descending order, shall be multiplied by the scrambler generating polynomial to recover the message sequence.

The detailed scrambling and descrambling processes are described in the Appendix.

14. *Equalizer*

A manually adjustable equalizer with the capability of compensating for the amplitude and group delay distortion within the limits of Recommendation M.102 shall be provided in the receiver. The transmitter shall be able to send an equalization pattern while the receiver shall incorporate a means of indicating correct adjustment of the equalizer controls. The equalizer pattern is generated by applying continuous 1's to the input of the transmitter scrambler defined above.

Note. — The question whether it is necessary to automatize the process of adjusting the equalizer requires further study.

15. *Alternative equalization and scrambler techniques*

This Recommendation does not preclude the use of alternative equalization techniques, for example:

a) automatic adaptive equalizers, possibly of sufficient speed to permit use in multipoint polled networks;

b) manually adjustable transmit equalizers for use in multi-point polled networks and for point-to-point networks with an unattended location.

These techniques, and their incorporation in the modem, and a new scrambler, should be the subject of further study.

APPENDIX

Detailed scrambling and descrambling processes

1. *Scrambling*

The message polynomial is divided by the generating polynomial $1 + x^{-6} + x^{-7}$. (See Figure 1/V.27.)

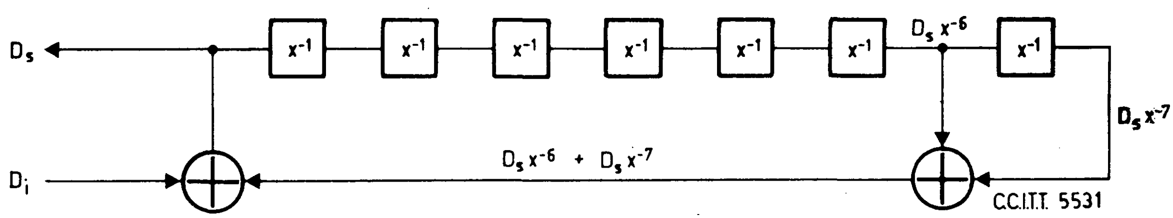
The coefficients of the quotient of this division taken in descending order form the data sequence to be transmitted.

The transmitted bit sequence is continuously searched over a span of 45 bits for sequences of the form

$$p\ (x) = \sum_{i=0}^{32} a_i x^i$$

where $a_i = 1$ or 0 and $a_i = a_{i+9}$ or a_{i+12}

If such a sequence occurs, the bit immediately following the sequence is inverted before transmission.



$$D_s = D_i + D_s x^{-6} + D_s x^{-7}$$

$$D_i = D_s (1 + x^{-6} + x^{-7})$$

FIGURE 1/V.27

2. *Descrambling*

At the receiver the incoming bit sequence is continuously searched over a span of 45 bits for sequences of the form $p\ (x)$.

If such a sequence occurs, the bit immediately following the sequence is inverted.

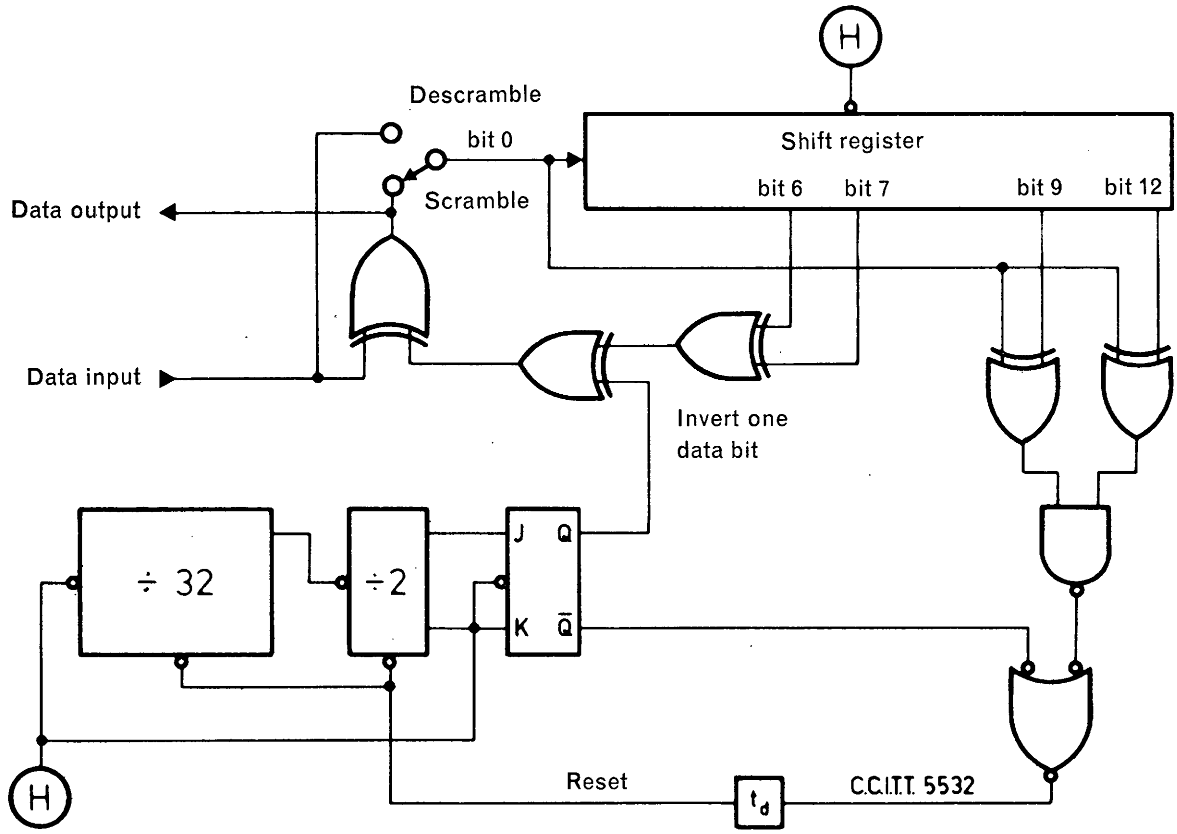
The polynomial represented by the resultant sequence is then multiplied by the generating polynomial $1 + x^{-6} + x^{-7}$ to form the recovered message polynomial. The coefficients of the recovered polynomial, taken in descending order, form the output data sequence.

3. *Elements of scrambling process*

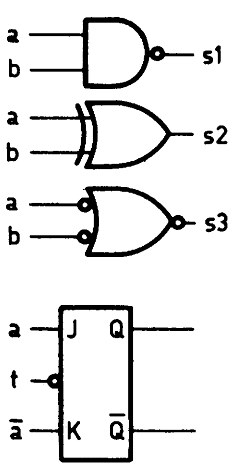
The factor $1 + x^{-6} + x^{-7}$ randomizes the transmitted data over a sequence length of 127 bits.

The equality $a_i = a_{i+9}$ in the guard polynomial $p\ (x)$ prevents repeated patterns of 1, 3 and 9 bits from occurring for more than 42 successive bits.

The equality $a_i = a_{i+12}$ in $p\ (x)$ prevents repeated patterns of 2, 4, 6 and 12 bits from occurring for more than 45 successive bits.



Symbols



Truth tables

a	b	s1	s2	s3
1	0	1	1	0
1	1	0	0	1
0	0	1	0	0
0	1	1	1	0

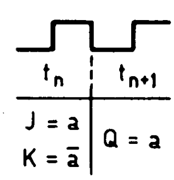


FIGURE 2/V.27

Notes:

1. — *H* represents the clock signal. The negative going transition is the active transition.
2. — There is a delay time, due to physical circuits, between a negative going transition of *H* and the end of the "0" state represented by t_d on the non-RESET wire; therefore the first coincidence between bit 0 and bit 9 or bit 12 is not taken into account by the counter.
3. — The same voltage convention is used for data signals and logical circuits on the diagram.

ELECTRICAL CHARACTERISTICS FOR UNBALANCED DOUBLE-CURRENT INTERCHANGE CIRCUITS

(Geneva, 1972)

1. *Scope*

The electrical characteristics specified in this Recommendation apply generally to interchange circuits operating with data signalling rates below the limit of 20 000 bits per second.

2. *Interchange equivalent circuit*

Figure 1/V.28 shows the interchange equivalent circuit with the electrical parameters, which are defined in this section.

This equivalent circuit is independent of whether the generator is located in the data circuit-terminating equipment and the load in the data terminal equipment or vice versa.

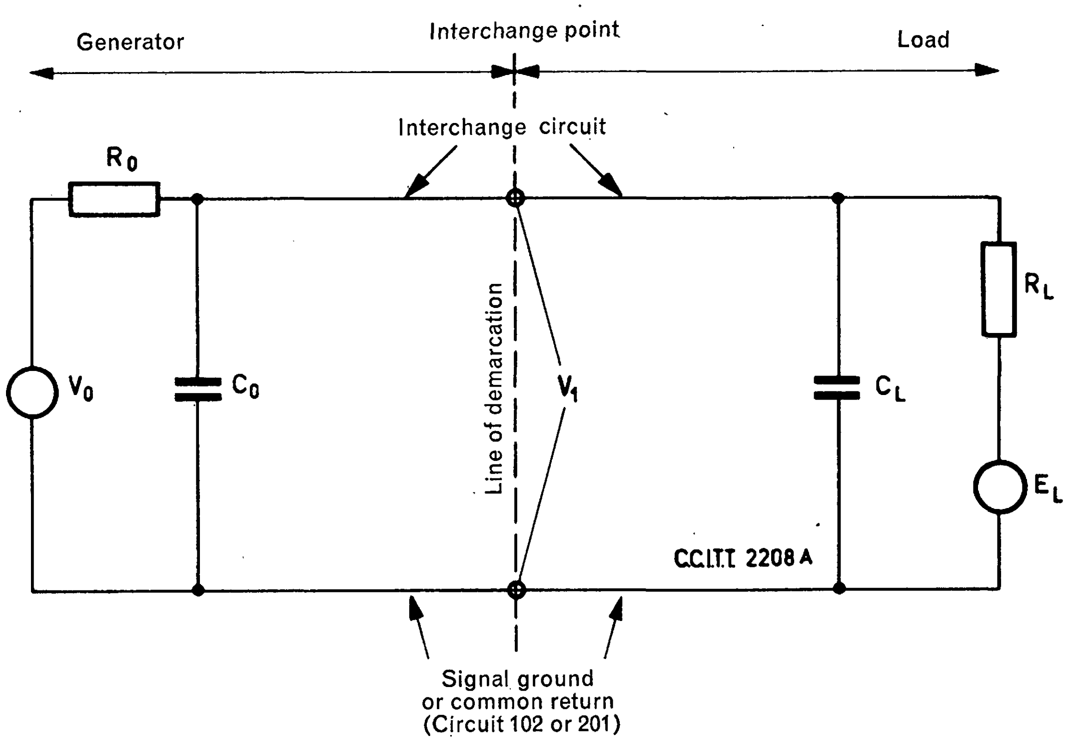


FIGURE 1/V.28. — **Interchange equivalent circuit**

The impedance associated with the generator (load) includes any cable impedance on the generator (load) side of the interchange point.

V_0 is the open-circuit generator voltage.

R_0 is the total effective d.c. resistance associated with the generator, measured at the interchange point.

C_0 is the total effective capacitance associated with the generator, measured at the interchange point.

V_1 is the voltage at the interchange point with respect to signal ground or common return.

C_L is the total effective capacitance associated with the load, measured at the interchange point.

R_L is the total effective d.c. resistance associated with the load, measured at the interchange point.

E_L is the open-circuit load voltage (bias).

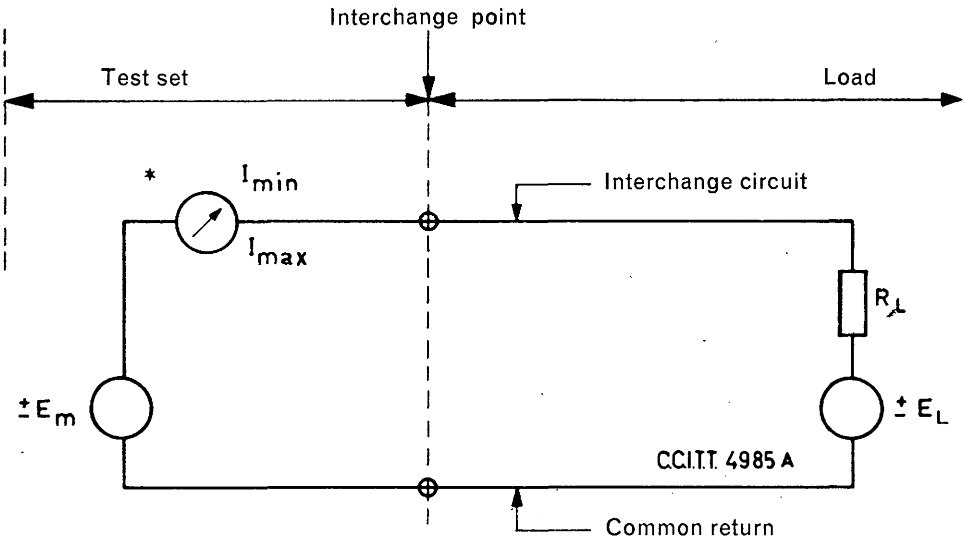
3. *Load*

The test conditions for measuring the load impedance are shown in Figure 2/V.28.

The impedance on the load side of an interchange circuit shall have a d.c. resistance (R_L) neither less than 3000 ohms nor more than 7000 ohms. With an applied voltage (E_m), 3 to 15 volts in magnitude, the measured input current (I) shall be within the following limits:

$$I_{\text{min, max}} = \left| \frac{E_m \pm E_{L\ \text{max}}}{R_{L\ \text{max, min}}} \right|$$

The open-circuit load voltage (E_L) shall not exceed 2 volts.



* *Note*. — The internal resistance of the ammeter shall be much less than the load resistance (R_L).

FIGURE 2/V.28 — **Equivalent test circuit**

The effective shunt capacitance (C_L) of the load, measured at the interchange point, shall not exceed 2500 picofarads.

To avoid inducing voltage surges on interchange circuits the reactive component of the load impedance shall not be inductive.

Note. — This is subject to further study.

The load on an interchange circuit shall not prejudice continuous operation with any input signals within the voltage limits specified in paragraph 4.

4. *Generator*

The generator on an interchange circuit shall withstand an open circuit and a short circuit between itself and any other interchange circuit (including generators and loads) without sustaining damage to itself or its associated equipment.

The open-circuit generator voltage (V_0) on any interchange circuit shall not exceed 25 volts in magnitude. The impedance (R_0 and C_0) on the generator side of an interchange circuit is not specified; however, the combination of V_0 and R_0 shall be selected so that a short circuit between any two interchange circuits shall not result in any case in a current in excess of one-half ampere.

Additionally, when the load open-circuit voltage (E_L) is zero, the voltage (V_1) at the interchange point shall not be less than 5 volts and not more than 15 volts in magnitude (either positive or negative polarity), for any load resistance (R_L) in the range between 3000 ohms and 7000 ohms.

The effective shunt capacitance (C_0) at the generator side of an interchange circuit is not specified. However, the generator shall be capable of driving all of the capacitance at the generator side (C_0), plus a load capacitance (C_L) of 2500 picofarads.

Note. — Relay or switch contacts may be used to generate signals on an interchange circuit, with appropriate measures to ensure that signals so generated comply with the applicable clauses of paragraph 6.

5. *Significant levels (V_1)*

For data interchange circuits, the signal shall be considered in the binary 1 condition when the voltage (V_1) on the interchange circuit measured at the interchange point is more negative than minus 3 volts. The signal shall be considered in the binary 0 condition when the voltage (V_1) is more positive than plus 3 volts.

For control and timing interchange circuits, the circuit shall be considered ON when the voltage (V_1) on the interchange circuit is more positive than plus 3 volts, and shall be considered OFF when the voltage (V_1) is more negative than minus 3 volts.

$V_1 < -3$ volts	$V_1 > +3$ volts
1	0
OFF	ON

FIGURE 3/V.28. — **Correlation table**

Note. — In certain countries, in the case of direct connection to d.c. telegraph-type circuits only, the voltage polarities in Figure 3/V.28 may be reversed.

The region between plus 3 volts and minus 3 volts is defined as the transition region. The signal state or circuit condition is not uniquely defined when voltage (V_1) is in the transition region. For an exception to this, see paragraph 7.

6. *Signal characteristics*

The following limitations to the characteristics of signals transmitted across the interchange point, exclusive of external interference, shall be met at the interchange point when the interchange circuit is loaded with any receiving circuit which meets the characteristics specified in paragraph 3.

These limitations apply to all (data, control and timing) interchange signals unless otherwise specified.

1) All interchange signals entering into the transition region shall proceed through this region to the opposite signal state and shall not re-enter this region until the next significant change of signal condition, except as indicated in 6) below.
2) There shall be no reversal of the direction of voltage change while the signal is in the transition region, except as indicated in 6) below.
3) For control interchange circuits, the time required for the signal to pass through the transition region during a change in state shall not exceed one millisecond.
4) For data and timing interchange circuits, the time required for the signal to pass through the transition region during a change in state shall not exceed 1 millisecond or 3 per cent of the nominal element period on the interchange circuit, whichever is the lesser.
5) To reduce crosstalk between interchange circuits the maximum instantaneous rate of voltage change will be limited. A provisional limit will be 30 volts per microsecond.
6) When electromechanical devices are used on interchange circuits, points 1) and 2) above do not apply to data interchange circuits.

7. *Circuit failures*

The following interchange circuits, where implemented, shall be used to detect either a power-off condition in the equipment connected through the interface or the disconnection of the interconnecting cable:

Circuit 105 (request to send)

Circuit 107 (data set ready)

Circuit 108.1/108.2 (connect data set to line/data terminal ready)

Circuit 120 (transmit backward channel line signal)

Circuit 202 (call request)

Circuit 213 (power indication).

The power-off impedance of the generator side of these circuits shall not be less than 300 ohms when measured with an applied voltage (either positive or negative polarity) not greater than 2 volts in magnitude referenced to signal ground or common return.

The load for these circuits shall interpret the power-off condition or the disconnection of the interconnecting cable as an OFF condition on these circuits.

Recommendation V.30

PARALLEL DATA TRANSMISSION MODEMS STANDARDIZED FOR UNIVERSAL USE IN THE GENERAL SWITCHED TELEPHONE NETWORK

(Mar del Plata, 1968, amended at Geneva, 1972)

There is a need for one-way data transmission systems where a large number of low-cost sending stations (outstations) transmit to a central receiving station (instation) over the switched telephone network.

The following systems are desired:

a) transmitting 16-character combinations;

b) transmitting 64-character combinations;

c) transmitting 256-character combinations.

In most cases a character signalling rate of 20 characters per second will be sufficient; 40 characters per second may be required for some applications of the 16-character combination system.

The transmission from the instation to the outstations is limited either to simple acknowledgement signals (data collection systems) or to analogue signals (voice-answering systems).

The use of normal push-button telephone sets in the outstation for some of these applications may be of advantage for the user. However, it is recognized that for the time being on some telephone systems there exist certain limitations in the frequency band 600 to 900 Hz. This is due to the characteristics of the telecommunication path, such as signalling frequencies and metering pulses. Therefore, for a universal system the frequency band of the data channel is 900 to 2000 Hz, which excludes the use of the normal push-button telephone set.

A so-called parallel data-transmission system using two or three times one out of four frequencies can fulfil the above requirements.

For these reasons, the C.C.I.T.T. *unanimously declares the following view*:

1. Parallel data-transmission systems can be used economically when a large number of low-cost sending stations (outstations) wish to transmit to a central receiving station (instation) over the switched telephone network (or on leased telephone circuits).

Apart from the possibility of the use, on a restricted scale, of a system that is compatible with multifrequency push-button telephone signalling devices, the following system is recommended as a universally applicable system for the switched telephone circuits.

2. *Facilities*

2.1 *Data channel*

The basic system has a maximum of 16-character combinations and a modulation rate of up to 40 bauds. This permits a character signalling rate of up to 20 characters per second when an inter-character rest condition is used, or up to 40 characters per second with the use of a binary timing channel. This basic system consists of two groups of four frequencies, one frequency from each group being transmitted simultaneously (two times one out of four).

The basic system includes provision for expansion up to 64-character combinations by the addition of a third four-frequency group (three times one out of four). No use is foreseen for the system with 64-character combinations at character signalling rates above 20 characters per second, within this class of inexpensive parallel transmission equipment.

An expansion of the basic system to cater for 256 characters (up to 20 characters per second) is achieved by using only two groups for the conveyance of data, each character being transmitted in two sequential parts. The two half characters are positively identified by the two different conditions of a binary channel. The timing channel mentioned above is recommended to be used for this purpose.

Where an inter-character rest condition is required the full number of frequency combinations in the modem will not be available to the user as character combinations:

a) with the 16-frequency combination system, only 15 characters will be available unless a timing channel is used from frequency group B;

b) with the 64-frequency combination system only 63 characters are available.

These recommended systems have an inherent transmission error-detecting capability.

2.2 *Backward channel*

Provision is made for the following facilities:

a) a speech channel non-simultaneous with forward data;

b) a backward channel for audible signalling;

c) a backward channel for electrical signalling purposes.

Facilities b) and c) are provided, either non-simultaneous or optionally simultaneous with the forward data channels.

A loudspeaker will be provided in the outstation modem. On an optional basis a d.c. signalling output will be provided. If national regulations permit, a voice-answering output will also be provided on an optional basis.

3. *Frequency allocations*

3.1 *Data channels*

The following frequency allocations and designations are recommended:

TABLE 1

Channel No. / Group	1	2	3	4
A	920 Hz	1000 Hz	1080 Hz	1160 Hz
B	1320 Hz	1400 Hz	1480 Hz	1560 Hz
C	1720 Hz	1800 Hz	1880 Hz	1960 Hz

For the basic 16-character system only groups A and C are used.

If an inter-character rest condition is used, during the time no imput data circuits are operated, rest frequencies are sent to line. The highest frequency in each group is recommended to be the rest frequency.

3.2 *Timing channel*

If a timing channel is provided in the 16-character system this should consist of a selected pair of group B frequencies. The recommended frequencies are F_{B2} = 1400 Hz and F_{B3} = 1480 Hz.

In the case where this timing channel will be used to identify the two halves of the character in the 256-character system, the higher frequency is transmitted simultaneously with the first half of the character.

No timing channel is provided in the 64-character combination system.

3.3 *Backward channel*

The frequency of the backward channel for audible and electrical signalling shall be 420 Hz. This tone may be amplitude modulated at rates up to, say, 5 bauds.

A frequency modulated backward channel which is similar to that of V.23 modem can also be used simultaneously with the forward data frequencies, use of this channel being optional.

3.4 *Tolerances*

The tolerances on both data and backward frequencies should be ± 4 Hz.

The receiver should cater for ± 6 Hz difference due to carrier systems in addition to the transmitter tolerance of ± 4 Hz.

4. *Power levels*

Based on Recommendation V.2 the following maximum power levels measured at the zero relative level point are recommended for each transmitted frequency:

4.1 *Data and timing channels*

4.1.1 16-character system without timing channel and with a non-simultaneous backward channel: −13 dBm0.

4.1.2 All other cases: −16 dBm0.

4.2 *Backward channel*

4.2.1 Non-simultaneous: −10 dBm0.

4.2.2 Simultaneous: −16 dBm0.

In systems where either the simultaneous or the non-simultaneous backward channel is used, all power levels should be −16 dBm0.

The maximum difference between any data tone at the transmitter terminal should be 1 dB.

5. *Threshold levels of the data channel received signal detector*

When the level of the received signal in group C exceeds −49 dBm, circuit 109 shall be ON. When the level of this received signal is less than −54 dBm, circuit 109 shall be OFF. The detector circuit which causes circuit 109 to turn ON or OFF shall exhibit a hysteresis action such that the level at which the OFF to ON transition occurs shall be at least 2 dB greater than that for the ON to OFF transition.

Group C was chosen for this purpose because it is the most critical from a received level point of view.

6. *Minimum level of received signal on the backward channel*

The expected minimum level is −45 dBm for the 420-Hz tone. This information is provided to assist equipment manufacturers.

7. *Instation modem interface*

The functional characteristics of interchange circuits comply with Recommendation V.24.

7.1 *List of essential interchange circuits:*

101 Protective ground (Note 1)

102 Signal ground or common return

104 Received data (12 or 8 circuits depending on whether Group B is provided or not. These received data circuits are designated A1, A2 ... C4, each corresponding to its relevant frequency (see Table 1))

105 Request to send (Note 3)

107 Data set ready

108/1 Connect data set to line (Note 2)

108/2 Data terminal ready (Note 2)

109 Data channel received line signal detector

125 Calling indicator

130 Transmit backward tone

191 Transmitted voice answer (Note 3).

The following optional interchange circuits may be provided:

110 Data signal quality detector

124 Select frequency groups

131 Received character timing.

Note 1. — May be excluded if so required by local safety regulations.

Note 2. — This circuit shall be capable of use as circuit 108/1 " connect data set to line " or circuit 108/2 " data terminal ready ", depending upon its use. For automatic calling it shall be used as 108/2 only.

Note 3. — These circuits are required if the speech channel facility is provided in the modem. The electrical characteristics of interchange circuits 191 and 192 are left for further study.

7.2 The electrical characteristics of the interchange circuits comply with Recommendation V.28.

Data circuits: when the frequency corresponding to the circuit is ON, the appropriate interchange circuit will be negative. When the frequency in this channel is OFF, the interchange circuit will be positive.

For timing purposes in the 256-character system, a single interchange circuit is selected from group B so that positive polarity indicates the first half of the character period and a negative polarity indicates the second half of the character.

8. *Outstation modem interface*

The functional characteristics of interchange circuits comply with Recommendation V.24.

8.1 *List of essential interchange circuits:*

101 Protective ground (Note 1)

102 Signal ground or common return (Note 3)

103 Transmitted data (nine or six circuits depending on whether Group B is provided or not. These circuits are designated A1, A2 ... C3, each corresponding to its relevant frequency (see Table 1))

105 Request to send

129 Request to receive.

8.2 The following optional interchange circuits may be provided:

107 Data set ready

119 Received backward channel data

192 Received voice answer (Note 2).

When the optional timing channel is used then the appropriate data circuits are operated.

Note 1. — May be excluded if so required by local safety regulations.

Note 2. — See Section 7.1, Note 3.

Note 3. — The transmitted data circuits (103) will all use the same common return (102). The control circuits may operate each on their own return circuit.

8.3 *Electrical characteristics*

The data and control interchange circuits at the outstation will be operated by the opening or closing of contacts carrying only direct current. The electrical characteristics of interchange circuits comply with Recommendation V.31.

9. *Table of correspondence for each group*

TABLE 2

At outstation closing of circuit	Number of the channel on line	At instation negative polarity on circuit
1	1	1
2	2	2
3	3	3
None	4	4

Not more than one circuit per group may be closed at a time.

10. *Character set*

This Recommendation includes the allocation of transmission frequencies to the interchange circuits.

The allocation of interchange circuits to the code combinations to be transmitted, i.e. definition of a character set, must conform to the conditions defined in this Recommendation and must take into account the application requirements and the type of input media (paper tape, punched cards, keyboards, etc.).

For this reason the recommendation for a character set is primarily for I.S.O. in collaboration with C.C.I.T.T.

Note. — Examples of Alphabets and coding methods are given in Supplements Nos. 20 and 21 to the *White Book,* Volume VIII, and in Supplements Nos. 56 and 57 to the *Blue Book*, Volume VIII.

Recommendation V.31

ELECTRICAL CHARACTERISTICS FOR SINGLE-CURRENT INTERCHANGE CIRCUITS CONTROLLED BY CONTACT CLOSURE

(Geneva, 1972)

1. *General*

In general, the electrical characteristics specified in this Recommendation apply to interchange circuits operating at data signalling rates up to 75 bit/s.

Each interchange circuit consists of two conductors (go and return leads) which are electrically insulated from each other and from all other interchange circuits. A common return lead can be assigned to several interchange circuits of a group.

2. *Equivalent circuit of interface*

Figure 1/V.31 shows the equivalent interchange circuit, together with the electrical characteristics laid down in this Recommendation. Some electrical characteristics vary depending upon whether the signal receive side is located in the data circuit-terminating equipment or in the data terminal equipment. This fact is specially referred to in the relevant sections.

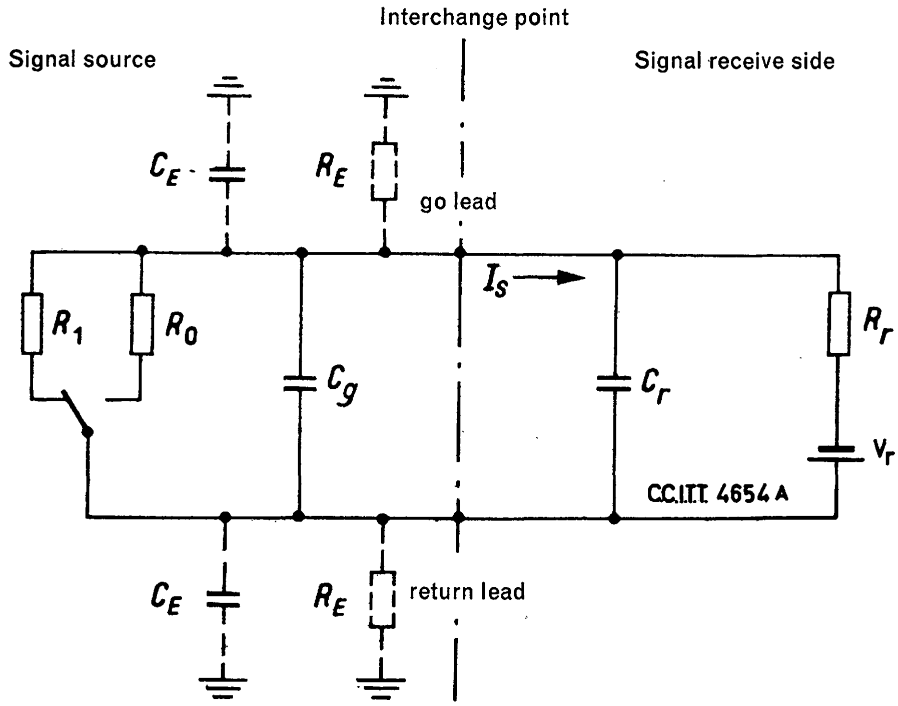


FIGURE 1/V.31. — **Equivalent circuit of interface**

Legend

R_1 Internal resistance of the signal source in the closed contact condition
R_0 Internal resistance of the signal source in the open contact condition
C_g Capacitance of signal source
C_r Capacitance of signal receive side
V_r Open circuit voltage of signal receive side
I_s Current in interchange circuit
R_r Internal resistance of signal receive side
R_E Insulation resistance of signal source if the latter is in the data terminal equipment
C_E Ground capacitance of signal source if the latter is in the data terminal equipment

3. *Signal source*

The signal source must be isolated from ground or earth irrespective of whether it is located within the data circuit-terminating equipment or within the data terminal equipment.

If the signal receive side is in the data circuit-terminating equipment, the open-contact insulation resistance measured from either leg to ground or to any other interchange circuit shall not fall below 5 megohms and the capacitance measured between the same points shall not exceed 1000 picofarads.

Irrespective of the above, the following specifications apply to the signal source.

3.1 *Internal resistance of signal source* R_1, R_0

The d.c. resistance of the closed contact R_1, including the resistance of the interface cable, measured at the interface (see Figure 1/V.31), should not exceed 10 ohms within the current and voltage ranges of the signal receive side.

The d.c. resistance of the open contact R_0 including the insulation resistance of the interface cable should not fall below 250 kilohms when measured at the interface (see Figure 1/V.31) within the voltage range of the signal receive side.

3.2 *Capacitance of signal source* C_g

The capacitance of the signal source C_g including that of the interface cable, measured at the interface (see Figure 1/V.31), should not exceed 2500 picofarads.

4. *Signal receive side*

4.1 *Signal receive side in the data circuit-terminating equipment*

The signal receive side in the data circuit-terminating equipment can be floating or connected to ground at any single point.

4.1.1 *Open circuit voltage of the signal receive side* V_r

The open circuit voltage V_r on the signal receive side of the data circuit-terminating equipment, measured at the interface (see Figure 1/V.31), should not fall below 3 volts and should not exceed 12 volts.

4.1.2 *Current at interface* I_S

The current I_S supplied by the signal receive side in the data circuit-terminating equipment should not fall below 0.1 milliamp and should not exceed 15 milliamps, when measured at the interface (see Figure 1/V.31) in the closed contact condition, i.e. with an internal resistance of the signal source of $R_1 \leqslant 10$ ohms.

Note. — Irrespective of the current I_S in the closed contact conditions, i.e. with an internal resistance of the signal source of $R_1 \leqslant 10$ ohms, the voltage at the interface should not exceed 150 millivolts, when measured between go and return leads.

4.1.3 *Internal resistance of signal receive side* R_r

The internal resistance R_r of the signal receive side of the data circuit-terminating equipment results from the limits for the open-circuit voltage V_r of the signal receive side and the current I_S at the interface, which are specified under 4.1.1 and 4.1.2 above.

Even if R_r has an inductive component, the voltage at the interface should not exceed the maximum of 12 volts specified under 4.1.1 above.

Note. — This item is subject to further study.

4.1.4 *Capacitance of signal receive side C_r*

The capacitance C_r of the signal receive side in the data circuit-terminating equipment, including the capacitance of the cable up to the interface (see Figure 1/V.31), is not specified. It is only necessary to ensure that the signal receive side works satisfactorily, allowing for the capacitance of the signal source C_g.

4.2 *Signal receive side in the data terminal equipment*

The signal receive side in the data terminal equipment can be connected to ground at any single point.

4.2.1 *Open circuit voltage of the signal receive side V_r*

The open circuit voltage V_r of the signal receive side of the data terminal equipment, measured at the interface (see Figure 1/V.31), should not fall below 3 volts and should not exceed 52.8 volts.

4.2.2 *Current at the interface I_S*

The current I_S, supplied by the signal receive side in the data terminal equipment, should not fall below 10 milliamps and not exceed 50 milliamps, when measured at the interface (see Figure 1/V.31) in the closed contact condition, i.e. with an internal resistance of the signal source of $R_1 \leq 10$ ohms.

4.2.3 *Internal resistance of signal receive side R_r*

The internal resistance R_r of the signal receive side in the data terminal equipment is obtained from the limits for the open circuit voltage V_r of the signal receive side and the current I_S at the interface, which are specified under 4.2.1 and 4.2.2 above.

Even if R_r has an inductive component, the voltage at the interface should not exceed the maximum of 52.8 volts, specified under 4.2.1.

Note.—This item is subject to further study.

4.2.4 *Capacitance of signal receive side C_r*

The capacitance of C_r of the signal receive side in the data terminal equipment including the capacitance of the cable is not specified. It is only necessary to ensure that the signal receive side works satisfactorily, allowing for the capacitance of the signal source C_g.

5. *Signal allocation*

For data, control and timing circuits the following allocations for the digital signals apply:

	Closed contact $R_1 \leqslant 10\ \Omega$	Open contact $R_0 \geqslant 250\ \mathrm{k}\Omega$
Data circuits	" 1 " condition	" 0 " condition
Control and timing circuits	" ON " condition	" OFF " condition

Recommendation V.35

DATA TRANSMISSION AT 48 KILOBITS PER SECOND USING 60- TO 108-kHz GROUP BAND CIRCUITS

(Mar del Plata, 1968, amended at Geneva, 1972)

On leased circuits, considering that there exist and will come into being other modems with features designed to meet the requirements of the Administrations and users, this Recommendation in no way restricts the use of any other modems.

This is a particular system using a group reference pilot at 104.080 kHz.

Principal recommended characteristics to be used for simultaneous both-way operation are the following:

1. *Input/output*

Rectangular polar serial binary data.

2. *Transmission rates*

Preferred mode is synchronous at 48 000 $\pm$ 1 bit/s, with the following exceptions permissible:

a) Synchronous at 40 800 $\pm$ 1 bit/s when it is an operational necessity, or

b) Non-synchronous transmission of essentially random binary facsimile with element durations in the range 21 microseconds to 200 milliseconds.

Note.— Operation at half data signalling rate shall be possible when the line characteristics do not permit the above data signalling rates.

3. *Encoding/decoding*

Synchronous data should be encoded to avoid restrictions on the data input format. Such restrictions would be imposed by the need to have sufficient transitions for receiver clock stability, without short repetitive sequences of data signals which would result in high level discrete frequency components in the line signal. Synchronous data should be encoded and decoded by means of the logical arrangements described in Appendix 1.

4. *Modulation technique*

The baseband signal (see section 5) should be translated to the 60- to 104-kHz band as an asymmetric sideband suppressed carrier AM signal with a carrier frequency of 100 kHz. A pilot carrier will be necessary to permit homochronous demodulation. To simplify the problem of recovery of the pilot carrier for demodulation the serial binary data signal should be modified as stated in section 5. The transmitted signal should correspond with the following:

a) The data carrier frequency should be 100 000 $\pm$ 2 Hz.

b) The nominal level of a frequency translated suppressed carrier 48 kbit/s encoded data baseband signal in the 60- to 104-kHz band should be equivalent to -5 dBm0.

c) A pilot carrier at -9 ± 0.5 dB relative to the nominal level of the signal in 4 b) above should be added such that the pilot carrier would be in phase, to within $\pm$ 0.04 radian, with a frequency translated continuous binary 1 input to the modulator.

d) The modulator should be linear, and the characteristics of the transmit bandpass filter should be such that the relative attenuation distortion and the relative envelope delay distortion in the range 64 to 101.5 kHz are less than 0.2 dB and 4 microseconds respectively.

5. *Baseband signal*

a) The encoded synchronous or random non-synchronous serial binary data signal should be modified by the following transform:

$$\frac{pT_1}{1+pT_1}, \text{ to remove the low-frequency components,}$$

where p is the complex frequency operator, and

$$T_1 \text{ is } \frac{25}{2\pi} \text{ times the minimum binary element duration, i.e. 83 microseconds.}$$

The value of T_1 shall have an accuracy of $\pm 2\%$.

In this form the signal is referred to as the baseband signal.

b) The baseband signal resulting from the transformation should not suffer impairment greater than that resulting from relative attenuation distortion or relative envelope delay distortion of 1.5 dB or 4 microseconds respectively, *and*

i) distortion due to modification of the baseband signal by the transform

$$\frac{pT_2}{1+pT_2}$$

where T_2 is 3.18 milliseconds; *or*

ii) distortion due to modification of the baseband signal by the transform

$$\left[\frac{pT_3}{1+pT_3}\right]^2$$

where T_3 is 6.36 milliseconds.

c) Paragraphs 5 a) and 5 b) should apply in the range 0 to 36 kHz.

6. *Voice channel*

A service speech channel provided as an integral part of this system should correspond to channel 1 of a 12-channel system, i.e. as a lower sideband SSB signal in the 104- to 108-kHz band.

a) The characteristics of this channel may be less stringent than those of a telephone circuit in accordance with Recommendation G.232.

b) This voice channel is optional.

7. *Group reference pilots*

a) Means should be provided to facilitate the injection of a group reference pilot at 104.080 kHz.

b) The sections of Recommendation G.232 which refer to interference with and from supergroup reference pilots apply to the group reference pilots used with this equipment.

8. *Adjacent channel interference*

a) When transmitting encoded synchronous serial binary data at 48 kbit/s on the data channel, the out-of-band energy in a 3-kHz band centred at any frequency in the range 1.5 to 58.5 kHz or 105.5 to 178.5 kHz should not exceed −60 dBm0. Additionally, the crosstalk produced in the range 103.680 to 104.480 kHz should not exceed the levels stated in Appendix 2.

b) When a signal at 0 dBm0 at any frequency in the range 0 to 60 or 104 to 180 kHz is applied to the carrier input terminals, the resulting crosstalk measured in the demodulated data baseband should not exceed a level equivalent to −40 dBm0.

9. *Line characteristics*

The characteristics of a channel over which this equipment can be expected to operate satisfactorily are given in Appendix 3.

10. *Interface*

a) The interchange circuits should be as follows:

No.	Function
101 (Note 1)	Protective ground or earth
102	Signal ground or common return
103 ∅	Transmitted data
104 ∅	Received data
105	Request to send
106	Ready for sending
107	Data set ready
109	Data channel receive line signal detector
114 ∅	Transmitter signal element timing
115 ∅	Receiver signal element timing

Note 1. — May be excluded if so required by local safety regulations.

b) The electrical characteristics of the interchange circuits marked ∅ should be as described in Appendix 4; the circuits not marked should conform to Recommendation V.28.

APPENDIX 1

Encoding process

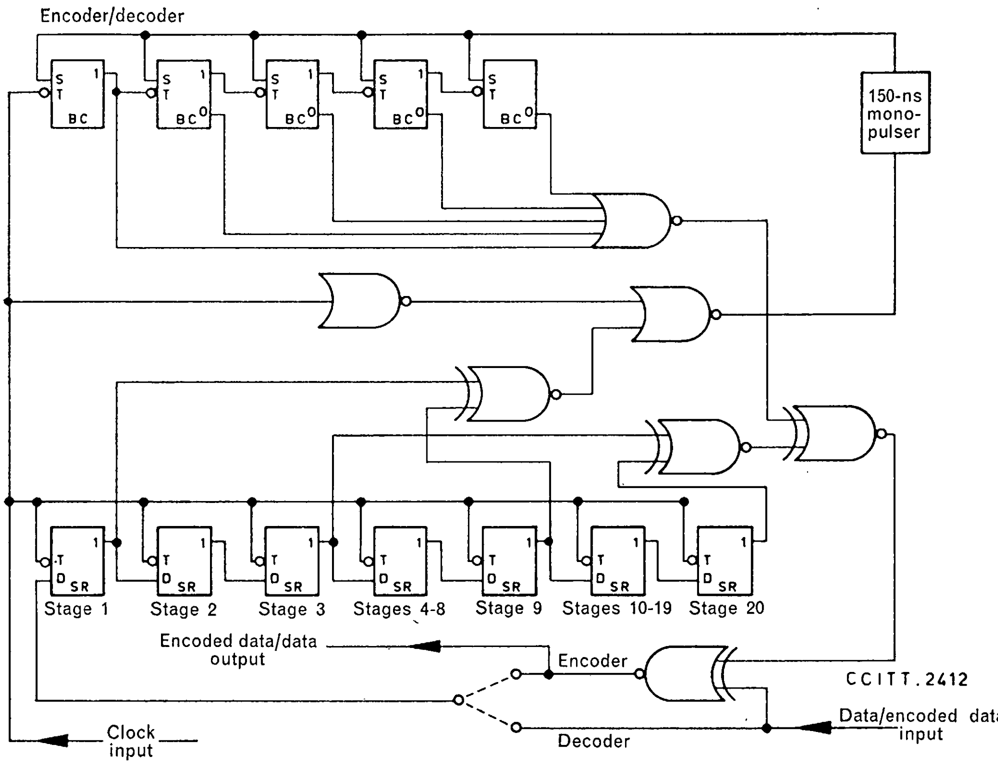
1. *Definitions*

i) The Applied Data Bit: The data bit which has been applied to the encoder but has not affected the transmission at the time of consideration.

ii) The Next Transmitted Bit: The bit which will be transmitted as a result of encoding the applied data bit.

iii) The Earlier Transmitted Bits: Those bits which have been transmitted earlier than the next transmitted bit. They are numbered sequentially in reverse time order, i.e. the first earlier transmitted bit is that immediately preceding the next transmitted bit.

iv) Adverse State: The presence of any one of certain repetitive patterns in the earlier transmitted bits.



Symbol truth tables

Or — Or - Not

A	B	C
0	0	1
0	1	0
1	1	0
1	0	0

Exclusive or - not

A	B	C
0	0	1
0	1	0
1	1	1
1	0	0

Inverter

A	C
1	0
0	1

Shift register

T	D	1 output	0 output
1	Q	—	—
0	—	Q	$\overline{Q}$

Q is either 0 or 1

Binary counter

T	1 output	0 output
1	Q	$\overline{Q}$
0	$\overline{Q}$	Q

S	1 output	0 output
0	Q	$\overline{Q}$
1	1	0

(Reset)

Note 1. — Negative-going transitions of clocks (i.e. 1 to 0 transitions) coincide with data transitions. This is self-synchronizing.

Note 2. — This diagram is given as an indication only, since with another technique this logical arrangement might take another form.

2. *Encoding process*

The binary value of the next transmitted bit shall be such as to produce odd parity when considered together with the twentieth and third earlier transmitted bits and the applied data bit unless an adverse state is apparent, in which case the binary value of the next transmitted bit shall be such as to produce even instead of odd parity.

An adverse state shall be apparent only if the binary values of the p^{th} and $(p + 8)^{th}$ earlier transmitted bits have not differed from one another when p represents all the integers from 1 to q inclusive. The value of q shall be such that, for $p=(q+1)$, the p^{th} and $(p+8)^{th}$ earlier transmitted bits had opposite binary values and $q=(31+32\,r)$, r being 0 or any positive integer.

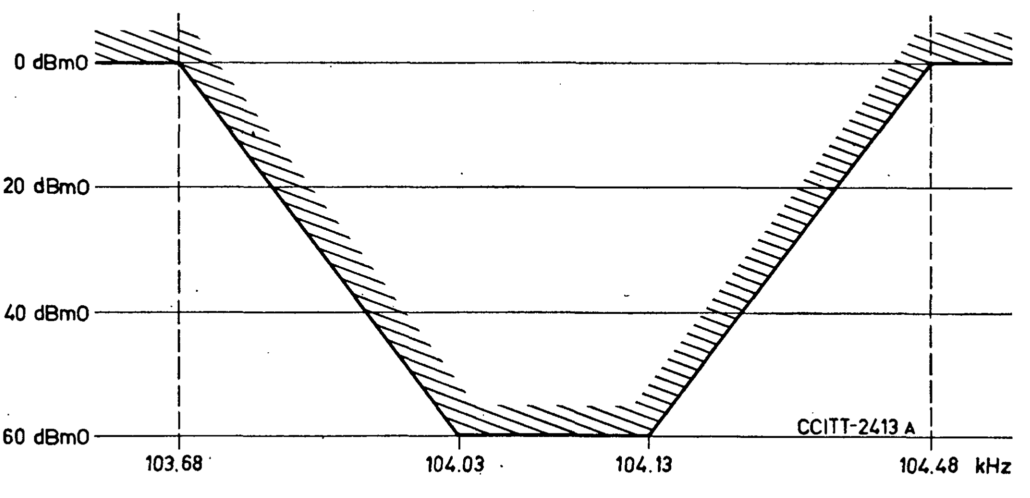
At the time of commencement, i.e. when no earlier bits have been transmitted, an arbitrary 20-bit pattern may be assumed to represent the earlier transmitted bits. At this time also it may be assumed that the p^{th} and $(p + 8)^{th}$ earlier transmitted bits have had the same binary value when p represents all the integers up to any arbitrary value. Similar assumptions may be made for the decoding process at commencement.

Note 1. — From this it can be seen that received data cannot necessarily be decoded correctly until at least 20 bits have been correctly received and any pair of these bits, separated from each other by seven other bits, have differed in binary value from one another.

Note 2. — It is not possible to devise a satisfactory test pattern to check the operation of the Adverse State Detector (ASD) because of the large number of possible states in which the 20-stage shift register can be at the commencement of testing. For those modems in which it is possible to bypass the encoder and the decoder and to strap the encoder to function as a decoder the following method may be used. A 1 : 1 test pattern is transmitted with the ASD of the encoder bypassed. If the ASD of the decoder is functioning correctly the decoded test pattern will contain a single element error every 32 bits, i.e. 90 000 errors per minute for a modem operating at 48 kbit/s indicates that the decoder is functioning correctly. The operation of the ASD of the encoder may be checked in a similar manner with the encoder strapped as a decoder and the decoder bypassed.

APPENDIX 2

Maximum permissible level of interference in the region of the group reference pilot(s)



APPENDIX 3

Extract from Recommendation H.14—Characteristics of group links for the transmission of wide-spectrum signals

B. Characteristics of corrected group links

The characteristics mentioned in paragraphs a) and b) below imply the use of a group pilot at 104.08 kHz. The use of a pilot in the middle of the group band requires different characteristics, which are under study by the C.C.I.T.T.

a) *Group-delay distortion* [1]

The group-delay distortion over the band 68-100 kHz should not exceed $5 + 10\,n$ microseconds with respect to the value of the least group delay within that band. The parameter n is the number of through group connection equipments encountered in the group link.

Note 1. — The following assumptions have been made in order to derive the above formula:

1) The group-delay distortion of through-group connection equipment can be corrected to not exceed 10 μs over the band 68-100 kHz. It should be noted that through-group connection equipment comprises the group demodulating equipment, the through-group filter and the group modulating equipment (see Recommendation G.242).

2) An allowance of 5 μs has been made for the combined effects of the first group modulation equipment and the final group demodulation equipment encountered in the link (together with any group pilot stop filters).[2] Correction may be necessary to achieve this.

3) The distortions 1) and 2) may be expected not to add up adversely.

4) In the case of " delayed transfer " or " multipoint links " an additional pilot suppression of 40 dB is required. Considering the group delay characteristics of existing 104.08 kHz pilot stop filters, and assuming additional group delay equalization, the requirement of 5 μs (see above) in the frequency band 68-100 kHz can be met by this 40 dB-stop filter and the corresponding group translating equipment.

5) To respect these limits it may be necessary to avoid groups 1 and 5.

6) The use of a group containing the supergroup pilot should always be avoided.

Note 2. — In certain cases where disturbing signals outside the basic group band have to be expected, additional filtering has to be provided in the local lines. No group delay distortion caused by such protection filters is included in the formula.

Note 3. — The effect of through-supergroup connection equipment can be significant, particularly for groups 1 and 5. Hence, when supergroup through-connection occurs, the avoidance of these groups (as mentioned in Note 1, 5)) becomes practically essential. If the group section which is made the subject of delay distortion equalization is considered to comprise a group modulating equipment, a line, a group demodulating equipment and a through-group filter, then the effects of the through-supergroup connection equipment can be readily taken into account.

Note 4. — If the group delay distortion limits required for a particular service are stricter than those given by the formulae, the additional equalization should preferably be introduced in the terminating equipments.

b) *Attenuation-frequency distortion*

The attenuation-frequency distortion of the group link with respect to the attenuation at 84 kHz should comply with the limits of Figure 2/H.14.

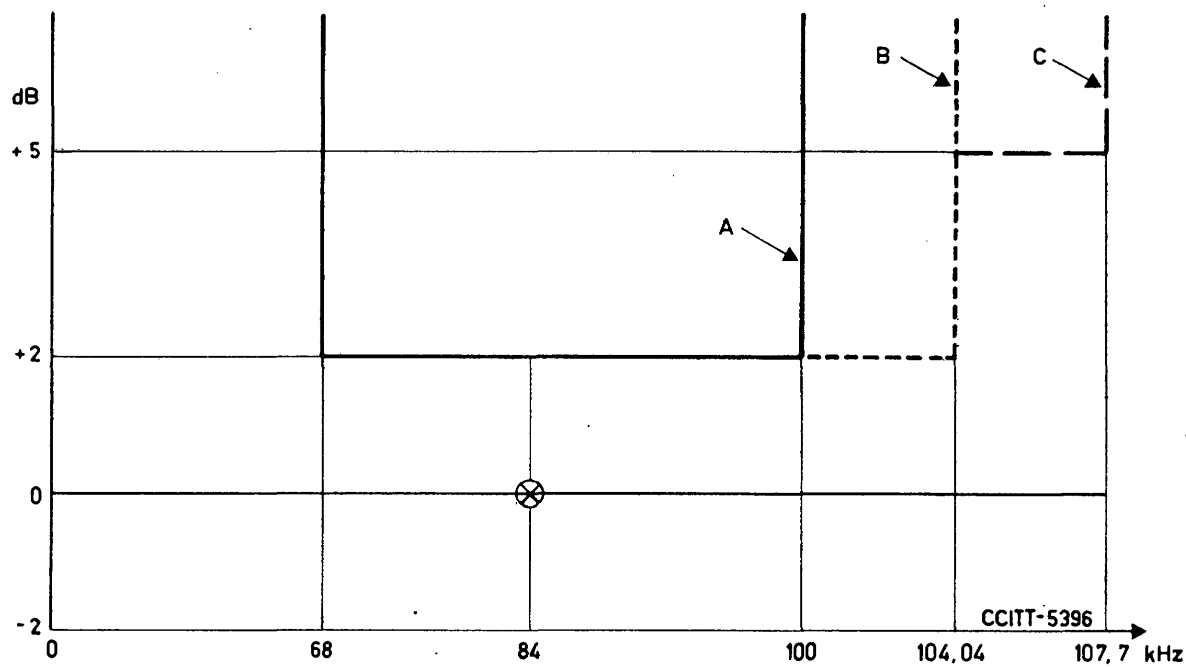
Note 1. — If the service channel is provided, additional equalization may be needed and there will be no possibility of employing simplified through-group filters.

Note 2. — 84 kHz is the reference frequency for the purposes of specifying and measuring attenuation distortion. The group reference pilot at 104.08 kHz may still be used as the regulating pilot, however, as required.

---

[1] The specification of group delay distortion in terms of slope, sag, ripple and number of peaks is still under study.

[2] Group pilot blocking filters for this purpose have to be chosen carefully with respect to the group delay characteristic. Filters which are similar with regard to the loss frequency characteristic may, depending on the design, be very different with regard to group delay distortion.



A = These limits apply if the group reference pilot (104.08 kHz) is injected at an intermediate point on the link (e.g. the terminal national centre).

B = These limits apply if the group reference pilot is transmitted throughout the link (e.g. if it is injected by the terminal equipment).

C = These limits apply if the service channel is provided.

Note. — This diagram of limits applies whatever the conditions of the link, including, for example, the use of an equalizer, if necessary (see Recommendation M.46).

FIGURE 2/H.14. — **Limits for attenuation-frequency distortion**

c) *Carrier leaks*

The leak from any carrier in the 60-108 kHz band shall not exceed —40 dBm0.

Note. — Older types of equipment may need special treatment in order to achieve this limit.

d) *Level variations*

Group link regulation will conform to Recommendation M.18. Insofar as the pilot is injected at the sending terminal equipment and is used for regulation at the receiving terminal equipment (see notes to Figure 2/H.14 above), equivalent overall performance should be obtained.

e) *Background noise*

This can be expected to be substantially uniformly distributed over the group band, and to have a value calculated in accordance with Recommendations G.222 and G.223, paragraph 4. For an actual link, a margin should be allowed as indicated in Recommendation G.226.

f) *Impulsive noise*

(Under study) [1]

g) *Frequency error*

Maximum frequency error shall not exceed 5 Hz.

Note. — According to Recommendation G.225, this condition should readily be met in practice.

h) *Phase changes with time*

(Under study) [1]

i) *Power handling capability*

Applied signals should be within the limits given in Recommendation H.52.

C. Characteristics of non-corrected group links

(Under study) [1]

[1] Under Questions 28/XV and 1/A—point AG.

APPENDIX 4

Electrical characteristics for balanced double-current interchange circuits

1. *Scope*

The electrical characteristics specified here apply only to interchange circuits to Recommendation V.35.

2. *Cable*

The interface cable should be a balanced twisted multi-pair type with a characteristic impedance between 80 and 120 ohms at the fundamental frequency of the timing waveform at the associated terminator.

3. *Generator*

This circuit should comply with the following requirements:

a) source impedance in the range 50 to 150 ohms;

b) resistance between short-circuited terminals and circuit 102: 150 $\pm$ 15 ohms (the tolerance is subject to further study);

c) when terminated by a 100-ohm resistive load the terminal to terminal voltage should be 0.55 volt $\pm$ 20% so that the A terminal is positive to the B terminal when binary 0 is transmitted, and the conditions are reversed to transmit binary 1;

d) the rise time between the 10% and 90% points of any change of state when terminated as in 3 c) should be less than 1% of the nominal duration of a signal element or 40 nanoseconds, whichever is the greater;

e) the arithmetic mean of the voltage of the A terminal with respect to circuit 102, and the B terminal with respect to circuit 102 (d.c. line offset), should not exceed 0.6 volt when terminated as in 3 c) above.

4. *Load*

The load should comply with the following:

a) input impedance in the range 100 $\pm$ 10 ohms, substantial resistive in the frequency range of operation;

b) resistance to circuit 102 of 150 $\pm$ 15 ohms, measured from short-circuited terminals (the tolerance on this resistance is subject to further study).

5. *Electrical safety*

A generator or load should not be damaged by connection to earth potential, short-circuiting, or cross-connection to other interchange circuits.

6. *Performance in the presence of noise*

A generator, as in section 3 above, connected via a cable as in section 2 to a load, as in section 4 above, should operate without error in the presence of longitudinal noise or d.c. common return potential differences (circuit 102 offset) as follows:

a) with $\pm$ 2 volts (peak) noise present longitudinally, i.e. algebraically added to both load input terminals simultaneously with respect to the common return, or

b) with $\pm$ 4 volts circuit 102 offset;

c) if circuit 102 offset and longitudinal noise are present simultaneously, satisfactory operation should be achieved when:

$$\frac{\text{circuit 102 offset}}{2} + \text{longitudinal noise (peak)} = 2 \text{ volts or less.}$$

Note. — It has been proposed to perform a test under inclusion of a cable length corresponding to the actual operation. This point is for further study.

Recommendation V.40

ERROR INDICATION WITH ELECTROMECHANICAL EQUIPMENT

(Mar del Plata, 1968)

If use is made of a code providing for the introduction into each character signal of an extra unit for the parity check, it is possible with electromechanical equipment to detect errors not only in the transmission channel but also in part of the mechanical translation or transmission equipment.

It might be possible therefore, when an error is detected in a character signal, to arrange for an error indication to be given on the position where the error is found.

This indication could take the form of an extra perforation in the tapes of the perforated tape equipment or a special printout with direct printing equipment.

Such devices would however be either very costly or only partially effective (for example, many character signals of the No. 5 Alphabet do not correspond to any printout so that for these characters the normal sign cannot be replaced by an " error " sign).

For these reasons, the C.C.I.T.T. *unanimously recommends*

that use of an alarm or error-counting device is the best method if a local indication is required for an error detected in a character signal.

Recommendation V.41

CODE-INDEPENDENT ERROR CONTROL SYSTEM

(Mar del Plata, 1968, amended at Geneva, 1972)

1. *General*

This Recommendation is primarily intended for error control when implemented as an intermediate equipment which may be provided either with the data terminal equipment or with the data circuit-terminating equipment. The appropriate interfaces are shown in Figures 1/V.41 and 2/V.41. The system is not primarily intended for use with multi-access computing systems. The Recommendation does not exclude the use of any other error-control system that may be better adapted to special needs.

The modems used must provide simultaneous forward and backward channels. The system uses synchronous transmission on the forward channel and asynchronous transmission on the backward channel. When modems to Recommendation V.23 are used with data signalling rates of 1200 or 600 bit/s in the general switched telephone network, Recommendation V.22 applies, the error-control equipment being classed as communication equipment. The margin of the synchronous receiver should be at least $\pm 45\%$.

The system employs block transmission of information in fixed units of 240, 480, 960 or 3840 [1] bits and is therefore most suited to the transmission of medium or long data messages, but a fast starting procedure is incorporated to improve the transmission efficiency for shorter messages.

Error control is achieved by means of automatic repetition of a block upon request (ARQ) from the data receiver. If storage is provided at the receiver, detected errors can be removed before the system output (clean copy). Storage for at least two data blocks must be provided at the transmitter.

The forward bit stream is divided into blocks each consisting of four service bits, the information bits, and 16 error-detection (or check) bits in that order, the check bits being generated in a cyclic encoder. Thus each block transmitted to line contains 260, 500, 980 or 3860 [1] bits.

[1] *Note.* — This block length is suitable for circuits provided by means of geo-stationary orbit satellites.

The system will detect:

a) all odd numbers of errors within a block;

b) any error burst not exceeding 16 bits in length and a large percentage of other error patterns.

Assuming a distribution of errors as recorded in *Blue Book*, Volume VIII, Supplement No. 22, the error-rate improvement factor has been indicated by a computer simulation to be of the order of 50 000 for a block size of 260 bits.

The fixed block system employed limits the use of the system to those lines having a loop propagation time not greater than the figures given in Table 1. Allowances of 40 ms for total modem delay and 50 ms for the detection of the RQ signal have been made.

TABLE 1

MAXIMUM PERMISSIBLE LINE LOOP PROPAGATION TIMES (ms)

Block size (bits) \ Data signalling rate (bit/s)	200	600	1200	2400	3600	4800
260	1210	343	127	18	—	—
500	2410	743	327	118	49	14
980	4810	1543	727	318	182	114
3860	19210	6343	3127	1518	982	714

2. *Encoding and checking process*

The service bits and information bits, taken in conjunction, correspond to the coefficients of a message polynomial having terms from x^{n-1} (n = total number of bits in a block or sequence) down to x^{16}. This polynomial is divided, modulo 2, by the generating polynomial $x^{16} + x^{12} + x^5 + 1$. The check bits correspond to the coefficients of the terms from x^{15} to x^0 in the remainder polynomial found at the completion of this division. The complete block, consisting of the service and information bits followed by the check bits, corresponds to the coefficients of a polynomial which is integrally divisible in modulo 2 fashion by the generating polynomial.

At the transmitter the service bits and information bits are subjected to an encoding process equivalent to a division by the generator polynomial. The resulting remainder is transmitted to line immediately after the information bits, commencing with the highest order bits.

At the receiver, the incoming block is subjected to a decoding process equivalent to a division by the generator polynomial which in the absence of errors will result in a zero remainder. If the division results in other than a zero remainder, errors are indicated.

The above processes may conveniently be carried out by a 16-stage cyclic shift register with appropriate feedback gates (see Figures 3/V.41 and 4/V.41) which is set to the all 0 position before starting to process each block; at the receiver the all 0 condition after processing a block indicates error-free reception.

Use of scramblers: Where self-synchronizing scramblers (i.e. scramblers which effectively divide the message polynomial by the scrambler polynomial at the transmitter and multiply the received polynomial by the scrambler polynomial at the receiver) are used, in order to ensure satisfactory performance of the error-detecting system, the scrambler polynomial and the Recommendation V.41 generating polynomial must have no common factors. Where this condition cannot be maintained, the scrambling process must precede the error detection encoding process and the descrambler process must follow the error detection decoding process. Where additive (i.e. non-self-synchronizing) scramblers are used, this precaution need not be observed.

3. *The service bits*

3.1 *Block sequence indication*

The four service bits at the beginning of each block transmitted to the line indicate the block sequence and convey control information external to the message information. One of these control functions is to ensure that the information block order can be checked during repetitions, thus ensuring that information is not lost, gained or transposed. Three block sequence indicators A, B and C are used cyclically in that order.

Once a sequence indicator has been attached to an information block it remains with that block until the block is received correctly. Examination of the sequence indication is an additional part of the checking process.

3.2 *Allocation of service bits*

The allocation of the 16 possible combinations of the four service bits is given in Tables 2 and 3. Table 2 lists essential and therefore mandatory combinations and Table 3 optional combinations.

TABLE 2

ESSENTIAL COMBINATIONS

Note. — The digit on the left occurs first.

Group	Combination	Function
a	0011	Block A sequence indicator
b	1001	Block B sequence indicator
c	1100	Block C sequence indicator
d	0101	Synchronizing sequence prefix

TABLE 3

OPTIONAL COMBINATIONS

Group	Combination	Function
e	0110	Hold block
f	1000	End of transmission (this block contains no data)
g	0001	Start of message 1 (five-unit codes)
h	1010	Start of message 2 (six-unit codes)
j	1011	Start of message 3 (seven-unit codes)
k	0010	Start of message 4 (eight-unit codes)
l	0100	End of message (this block contains no data)
m	0111	Data link escape (general control block)
n	1101	To be allocated by bilateral agreement
p	1110	To be allocated by bilateral agreement
q	1111	To be allocated by bilateral agreement
r	0000	To be allocated by bilateral agreement

3.3 *Control functions*

Synchronization is the only essential control function catered for in the service bits.

The optional data link escape (general control) block contains data which are special in some way agreed by the users.

Additional optional functions are start of message 1 (or for five-unit codes), start of message 2 (or for six-unit codes), start of message 3 (or for seven-unit codes), start of message 4 (or for eight-unit codes), end of message, and end of transmission.

Four additional service bit combinations are available for allocation by bilateral agreement.

The message information part of the non-data blocks (hold, end of transmission and end of message) is of no significance, but such blocks will still be checked at the receiver.

When the optional facilities groups g to k are not used, the first data block following the OFF to ON transition of " ready for sending " is automatically prefixed block A sequence indicator, group a. Data blocks BCABC etc. then follow sequentially unless one (or more) of the other types of block are inserted.

When the optional facilities groups g to k are used, the first data block is prefixed by one of the start of message indicators 1, 2, 3 or 4 (groups g to k), depending on the number of bits per character which will be used during transmission. Data blocks ABCAB etc. then follow. Should an interruption to a leased type connection occur during transmission or should an operator interrupt the transmission to change on to the speech mode, the transmission will be resumed with the sequence indicator following that of the last block to be accepted before the interruption. A start of message indicator should not be used after such an interruption.

In the case of switched connections special measures may be necessary to ensure that an interrupted message is not continued by a new message without appropriate indication.

4. *Correction procedure*

A binary 1 condition on the backward channel (the supervisory channel) indicates the need for repetition of information (RQ). Conversely, a binary 0 implies acceptance of the transmitted information. The rules governing the transmission and reception of these conditions are given below and in sections 5 and 6.

4.1 *Data transmitter sequence*

Starting and resynchronizing conditions are given in sections 5 and 6, this section dealing only with normal operations.

Data are transmitted block by block, but the contents of each transmitted block together with its service bits are held in store at the transmitter until correct reception has been ensured. Storage for at least two blocks must be provided.

During transmission of a block the condition of the backward channel (circuit 119) is monitored for a period of 45-50 milliseconds immediately prior to transmission of the last check bit. If any RQ is found within this period the block is rendered invalid by inverting this last bit. The transmitter then recommences transmission from the beginning of the previous block by reference to the store. During the retransmission of the block which follows the detection of the RQ signal, the state of the backward channel is ignored.

4.2 *Receiver procedure*

In normal operation a binary 0 is maintained on the backward channel as long as blocks are received with correct check bits and permissible service combinations. Any data contained in these blocks are passed to the receiver output. If a " clean copy " output is required, data storage for at least one block should be provided since a block cannot be checked until it has been completely received.

When a block has been received which does not meet the error check condition, binary 1 is transmitted on the backward channel and the expected service bit combination is noted in the receiver.

Usually, the first received data block in the repetition cycle having correct check bits also will have an acceptable service bit combination and any data within it will be processed. Occasionally the first block which checks correctly may bear an abnormal service bit combination due to a line transmission error in the backward channel (causing either a mutilated or imitated binary 0 signal). In either case the data in this first block are discarded. In the case that the block checks correctly but the service bit combination indicates the block preceding the expected block, a binary 0 should be applied to the backward channel.

If the next block checks correctly and bears an acceptable service bit combination, its data should be processed and normal operation resumed. In the case that the service bit combination indicates an invalid block, a binary 1 should be applied; moreover, if the service bit combination indicates the block following the expected block, it is implied that a binary 0 has been imitated for the whole of the 45 ms period specified in sub-section 4.1 and an alarm must be given since it is not possible to recover from this (rare) condition automatically.

5. *Starting procedures*

5.1 *Transmitter procedures and synchronizing pattern*

During the delay between " request to send " and " ready for sending ", line idle conditions (binary 1) are emitted by the modem. The first data signals, after the modem is ready for sending, are the synchronizing sequence prefix (0101) followed by the synchronizing filler followed by the synchronizing pattern. The filler may be of any length provided it includes at least 28 transitions and does not include the synchronizing pattern. The synchronizing pattern is 0101000010100101 starting from the left-hand digit (see Appendix for possible derivation). The 28 transitions are provided for bit synchronization purposes. These synchronizing signals are followed by block A or a start of message block (groups g to k in Table 3). During the whole of this sequence from the beginning of the synchronizing prefix the transmitter ignores the condition of the backward channel, acting as though binary 0 were present. The condition of the backward channel then assumes its normal significance (see section 4). Should this be binary 1 during the examination period of the second block, this block must be completed with the last bit inverted and the starting procedure must be recommenced from the beginning of the synchronizing sequence prefix.

5.2 *Receiver procedures*

Binary 1 is emitted on the backward channel at the receiving terminal until the synchronizing pattern (0101000010100101) is detected, at which time binary 0 is emitted and block timing is established. The only acceptable service bit combinations to follow the synchronizing pattern are the block A sequence indicator or a start of message indicator (when used). If other service bit combinations are received, binary 1 is returned and the search for the synchronizing pattern is resumed.

6. *Resynchronization procedure*

6.1 *Recovery of synchronization*

Should the receiver fail to recognize an acceptable block within a reasonable time, then it must examine the incoming bit stream continuously to find the synchronization pattern. When this pattern is found, block timing is re-established and the binary 0 condition applied to the backward channel; the procedure is identical to the starting procedure except that the expected service bit combination is that following the last sequence indicator to have been accepted.

6.2 *Emission of synchronization pattern*

If the normal repetition cycle has continued for a number of times consecutively (typically 4 or 8) the transmitter must assume that resynchronization is necessary. The normal repetition cycle is replaced by a three-block cycle including a synchronization block and the two blocks previously repeated. The synchronization " block " contains the synchronization sequence prefix, filler and pattern as described in paragraph 5.1.

Note. — A short filler should result in quicker resynchronization, particularly when long blocks are used. However, the short filler has the disadvantage that correct synchronization can be lost if the prefix is imitated or disturbed by noise or should the synchronization pattern be disturbed. The use of the longer filler, making the block the same length as the data block, overcomes this difficulty. There is the option to choose either length, both lengths being compatible.

6.3 *Use of synchronization block for delay in transmission*

The information flow may be suspended by the insertion of a synchronizing " block ". In the case of the short filler it is essential that the receiving terminal should recognize the synchronizing prefix and change itself immediately into the synchronizing search mode, otherwise synchronization will be lost. In the case of the filler which produces a normal block length it is desirable to change into the search mode without abandoning block timing, a backward binary 0 being returned at the end of the block if the prefix is recognized and the check bits correspond to the synchronization pattern.

It may happen that the transmitter emits a resynchronization cycle before the receiver has changed into the synchronization search condition. The procedure at the receiver is identical to that just described for the use of a synchronization block for suspending the information flow.

7. *Interfaces*

7.1 *Modem interfaces*

In the normal case where the modems are not an integral part of the data terminal, the modem interfaces are as shown at points A-A in Figures 1/V.41 and 2/V.41. Where synchronous modems are employed, the appropriate signal element timing circuits will also be included in these interfaces.

7.2 *Data terminal interfaces*

Where the error control equipment (including stores) is not an integral part of the data terminal, the error control equipments are interposed between the data terminals and the modem. The data terminal interfaces are then as indicated at B-B and C-C in Figures 1/V.41 and 2/V.41 respectively. A signal element timing circuit is included in each of these interfaces.

7.2.1 In the case of the transmitting terminal all the interchange circuits perform their usual functions but " ready for sending " also takes advantage of the final paragraph of its definition in Recommendation V.24 and performs in the following manner:

Ready-for-sending circuit (see Figure 1/V.41)

This circuit, in conjunction with the signal element timing circuit, will inform the data terminal equipment when data are required in response to the request-to-send circuit. The ready-for-sending circuit will go to the ON condition when data are required and to the OFF condition when data are not required (in general this will be during the service and check bit transmissions and any repetition). This circuit will not go to the ON condition until the request-to-send circuit has gone to the ON condition. All transitions of this circuit will coincide with the signal element timing transition from ON to OFF. The transition from ON to OFF will thus coincide with the signal element timing transition from ON to OFF during the 240th, 480th, 960th or 3840th bit of the information within a block, as appropriate.

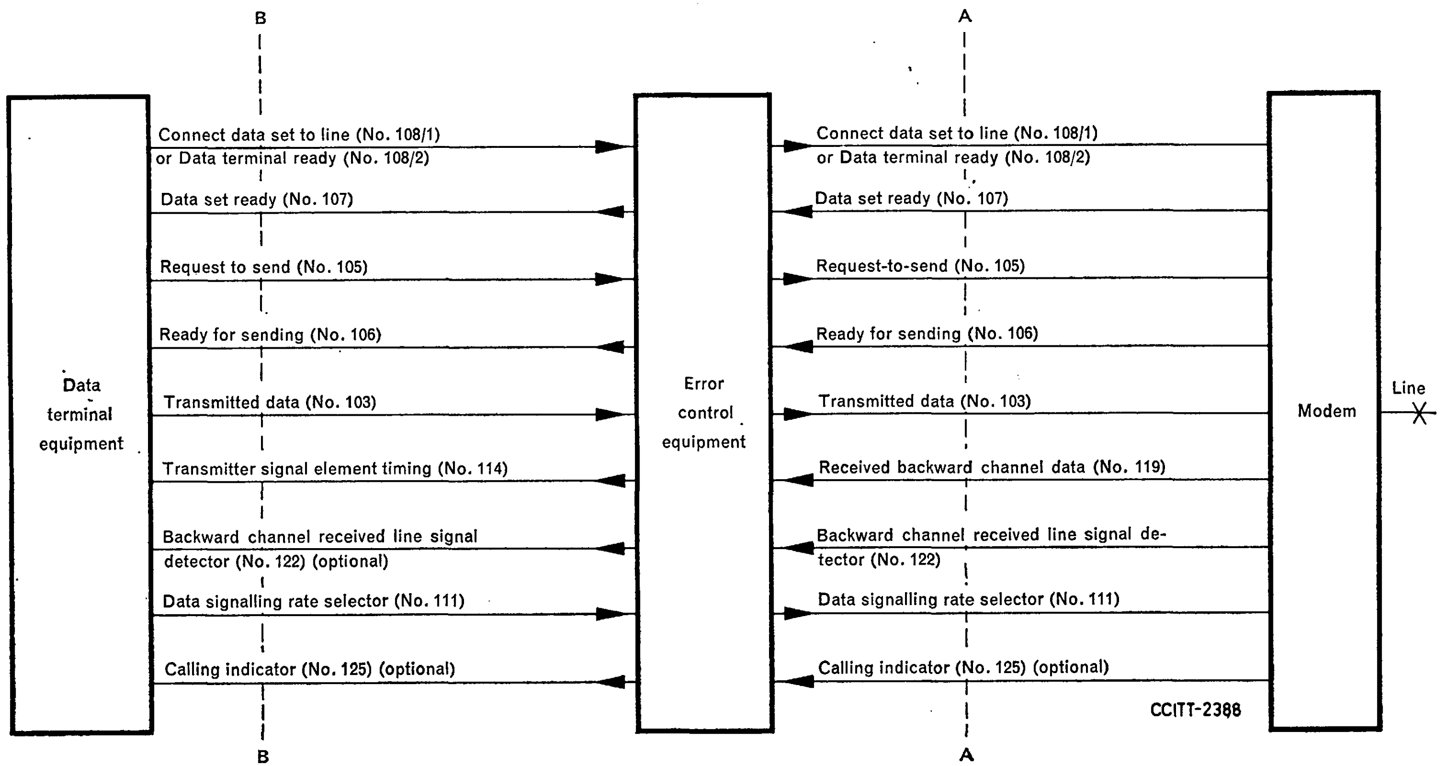


FIGURE 1/V.41. — **Interchange circuits—Transmitting terminal**

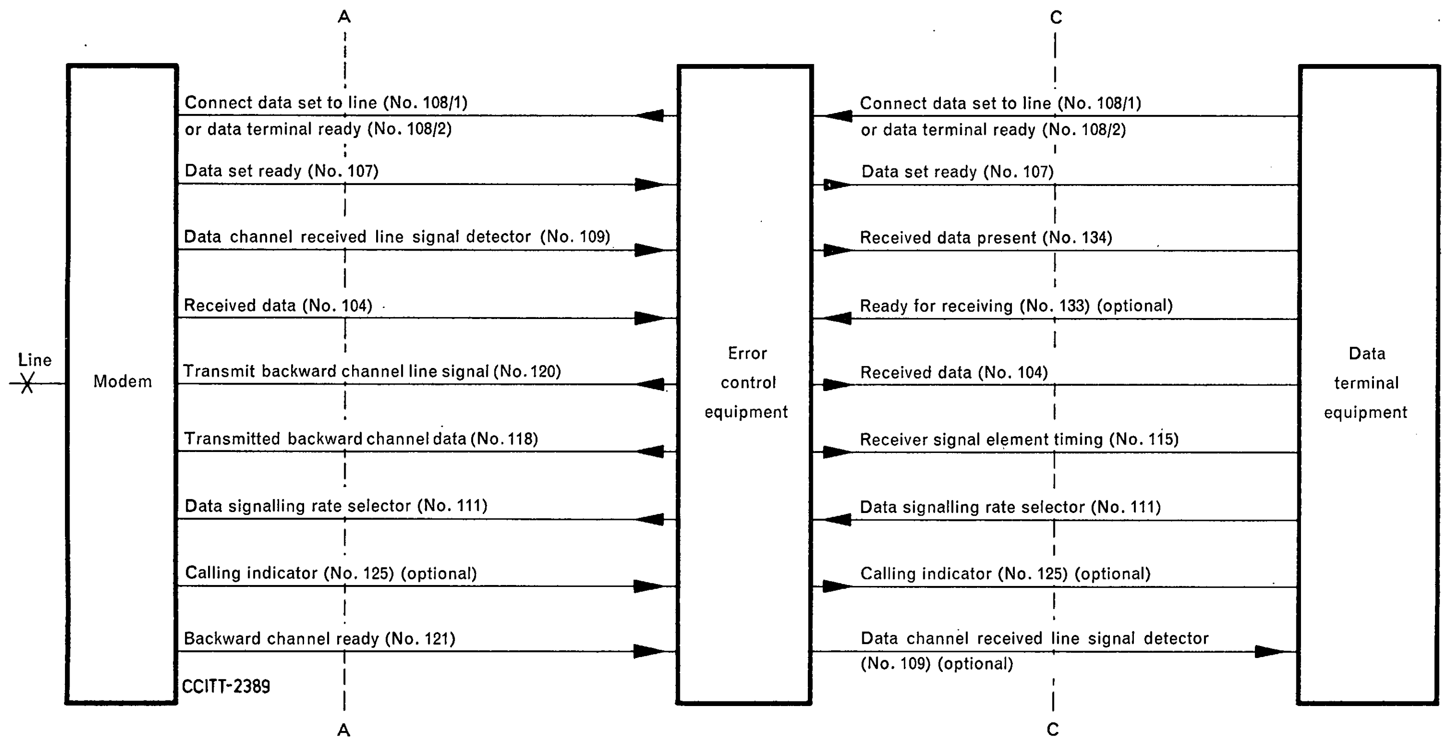


FIGURE 2/V.41. — **Interchange circuits—Receiving terminal**

7.2.2 In the case of the receiving terminal two new circuits are introduced, but since two (or more) of the modem interface circuits are not used in this interface, the number of circuits is not increased. Circuit 118 (transmitted backward channel data) is not available at this interface.

A " ready-for-receiving " function must be provided to inform the error control equipment of the status of the data terminal. This function may be performed by circuit 108, in which case a connection on the switched telephone network will be released when the circuit goes from ON to OFF. Alternatively, a separate function control circuit may be provided in order to retain the line connection for short periods when the data terminal is unable to accept data. This new circuit may be assumed to take the place of circuit 120 and functions in the following manner:

Ready-for-receiving (see Figure 2/V.41)

Direction: to error control equipment from data terminal equipment

The data terminal equipment shall maintain the ON condition on this circuit when the data terminal equipment is ready to receive data. Since the error control equipment will receive data in blocks, the data terminal equipment must be capable of receiving data also in blocks. Therefore, the data terminal equipment shall change this circuit to the ON condition only if the data terminal equipment is capable of accepting a block of data (240, 480, 960 or 3840 elements) and shall return to the OFF condition if the data terminal equipment cannot accept another block within 15 element intervals after the end of the previous block of transferred data.

Note. — If this ready-for-receiving circuit is OFF at the end of this 15-element period, an RQ condition will be generated.

The other new circuit performs the function of responding to the ready-for-receiving function and is therefore analogous to circuit 121 (backward channel ready). This new circuit functions as below:

Received data present (see Figure 2/V.41)

Direction: from error control equipment to data terminal equipment

This circuit, in conjunction with the signal element timing circuit, will inform the data terminal equipment when data are going to be output in response to the receive data terminal's connect data set to line (and separate ready-for-receiving circuit when provided) and the incoming data from the distant end being adjudged correct. The received data present circuit will go to the ON condition when data are going to be output and to the OFF condition at all other times. All transitions of this circuit will coincide with the signal element timing transition from ON to OFF. The transition from ON to OFF will thus coincide with the signal element timing transition from ON to OFF during the 240th, 480th, 960th or 3840th bit of the information within a block as appropriate.

7.2.3 Additional interchange circuits may be provided at the data terminal interface by bilateral agreement of the users. These additional circuits may be used to introduce service bit control functions other than those provided as a basic necessity. Such circuits should not interfere with the operation of the recommended circuits.

8. *Use of service functions*

Data link escape is included in Table 3 as an optional indicator and its use is left to be agreed between operators. It may, for instance, be used to signal to a receiving station that the sending station wishes to speak over the connection. In this case the receiving equipment would operate a bell or similar calling device and transfer the line from the modem to a telephone. Alternatively, it may cause a short message to be printed on a teleprinter for the attention of an operator.

End of transmission is envisaged as giving a positive indication to the receiver that the transmission has ended and that the connection may be released. This is an alternative to the data terminal equipment interpreting the received data to know when to release the connection.

The optional start of message indicators together with the end of message indicator may be used to route messages to different destinations or terminal equipment at the receiving end, which may include the selection of equipment appropriate to the code used.

The hold block need not be used at a transmitter since synchronization sequences may be used as packing between data blocks in the event of data not being ready at the transmitting data terminal equipment, but if required a hold block may be used for this purpose.

APPENDIX

(to Recommendation V.41)

Encoding and decoding realization for cyclic code system

1. *Encoding*

Figure 3/V.41 shows an arrangement for encoding using the shift register. To encode, the storage stages are set to zero, gates A and B are enabled, gate C is inhibited and k service and information bits are clocked into the input. They will appear simultaneously at the output.

After the bits have been entered, gates A and B are inhibited and gate C enabled, and the register is clocked a further 16 counts. During these counts the required check bits will appear in succession at the output.

Generation of the synchronizing pattern may be achieved by making $k = 4$, the four bits being 0101. Clocking is suspended for the duration of the synchronizing filler.

2. *Decoding*

Figure 4/V.41 shows an arrangement for decoding using the shift register. To decode, gates A, B and E are enabled, gate D is inhibited and the storage stages are set to zero.

The k information or prefix bits are then clocked into the input and after k counts gate B is inhibited, the 16 check bits are then clocked into the input and the contents of the storage stages are then examined. For an error-free block the contents will be zero. A non-zero content indicates an erroneous block.

3. *Synchronizing at receiver*

For block synchronizing gate D is enabled (Figure 4/V.41) and gates A, B and E are inhibited and the register is examined in successive bit intervals for the required 16-bit pattern. When the pattern is recognized the register and bit counter are set to zero and decoding proceeds normally.

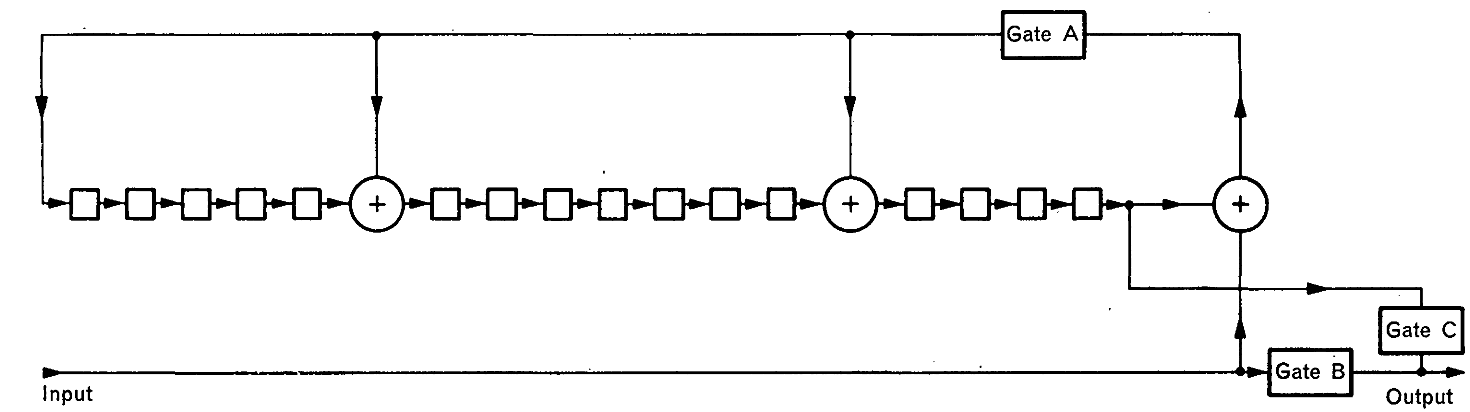


FIGURE 3/V.41. — **Encoder**

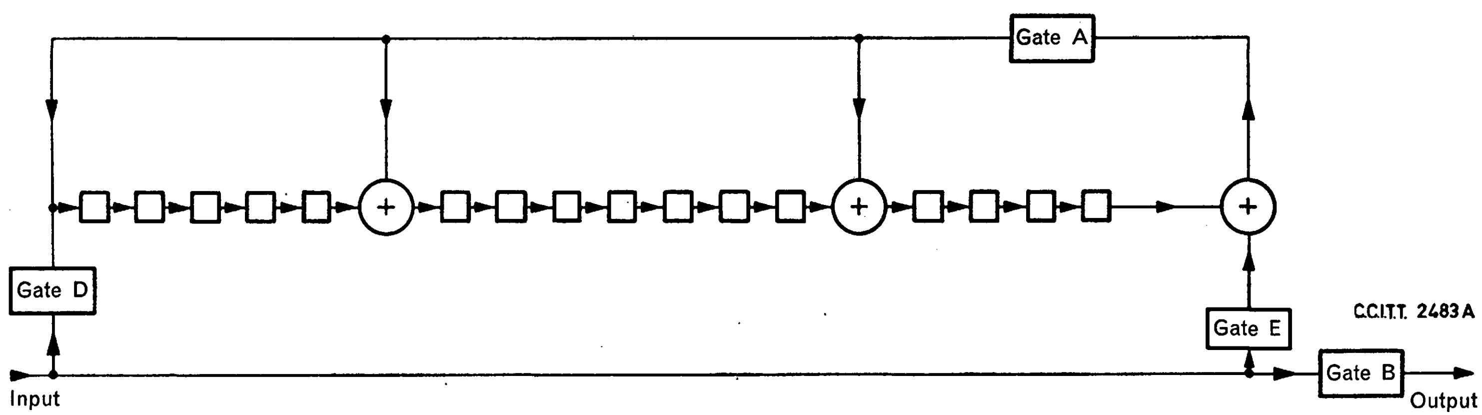


FIGURE 4/V.41. — **Decoder**

Recommendation V.50

STANDARD LIMITS FOR TRANSMISSION QUALITY OF DATA TRANSMISSION

(Mar del Plata, 1968)

One of the most important factors affecting data transmission quality—similarly to telegraph transmission quality—is the distortion in time of the significant instants (known as " telegraph distortion ": Definition 33.04 of the *List of Definitions*); the degree of signal distortion must be kept within certain limits, the ultimate objective being that the degree of distortion on received signals should be compatible with the margin of the receiving equipment.

This distortion on received signals arises from the composition of:

a) the sending distortion;

b) the distortion introduced by the transmission channel.

Hence, limits must be fixed for the degree of sending distortion and for the degree of distortion due to the transmission channel.

The limits contemplated for the transmission channel are specified in Recommendation V.53; these limits, which are not yet final, are recalled below:

Channel with modem V.21	: 20-25%
Channels with modem V.23	
600 bauds—leased circuits	: 20-30%
1200 bauds—leased circuits	: 25-35%
600 bauds—switched circuit	: 25-30%
1200 bauds—switched circuit (when this mode of operation is possible)	: 30-35%

These figures are expressed provisionally in maximum degrees of individual distortion and apply to the circuit including the modems.

The limits for the degree of sending distortion must be fixed so that a reasonable margin is left for the receiving equipment, making allowance for the distortion introduced by the circuit.

In view of the foregoing, the C.C.I.T.T. *unanimously issues the recommendation that:*

1. With regard to the *quality of transmission signals* (signals at point A—Recommendation V.51), it is preferable, given the wide range of possible modulation rates, to adopt a single standard for each type of modem.
2. When a V.21 modem is used, the duration of a unit element should be at least 90% of the duration of the unit element at 200 bauds (i.e. $\frac{1}{200} \times \frac{90}{100}$ second, or 4.5 milliseconds).
3. When a V.23 modem is used, the duration of a unit element should be at least 95% of the duration of the unit element either at 1200 bauds ($\frac{1}{1200} \times \frac{95}{100}$ second, or 0.791 millisecond) or at 600 bauds ($\frac{1}{600} \times \frac{95}{100}$ second, or 1.583 millisecond).
4. If a system sends signals of which the sending distortion is systematically well below the limits specified above for the category concerned, the permissible margin for receivers of that system may be reduced.
5. The values indicated above could be revised when a more accurate plan for transmission quality has been drawn up.

Note. — The receive margin limits will be studied in liaison with the I.S.O.

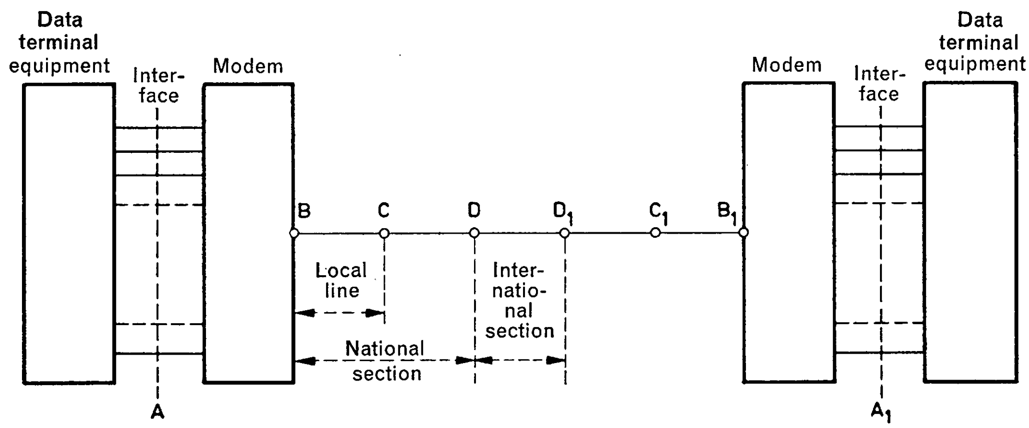
Recommendation V.51

ORGANIZATION OF THE MAINTENANCE OF INTERNATIONAL TELEPHONE-TYPE CIRCUITS USED FOR DATA TRANSMISSION

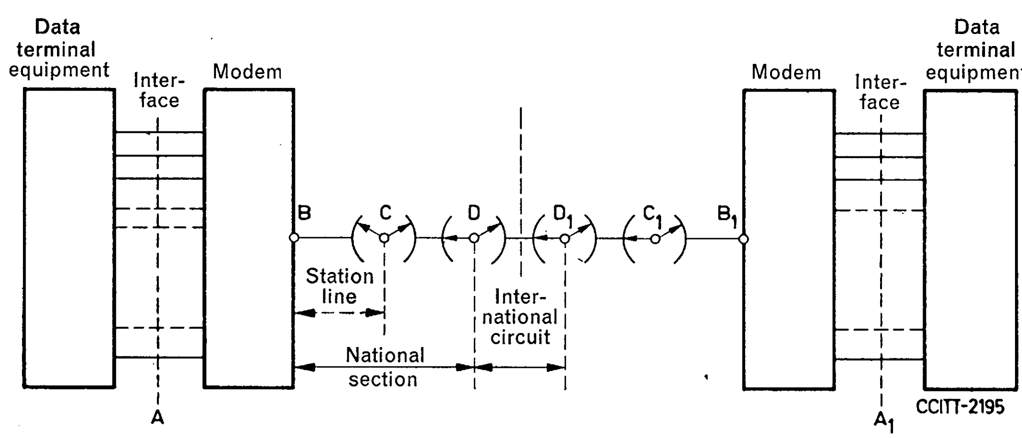
(Mar del Plata, 1968)

In order to ensure satisfactory co-operation between Administrations interested in the maintenance of international telephone-type circuits used for data transmission, and in order to ensure the maintenance of satisfactory data communication, it is necessary to unify the essential action to be taken for the establishment and maintenance of leased and switched telephone-type circuits used for data transmission.

The composition of a data transmission connection is as follows:



i) Leased circuit



ii) Switched connection

Taking into account these considerations, the C.C.I.T.T. *unanimously declares the view:*

1. That maintenance measurements should consist of:

a) *Telegraph maintenance measurements;*

b) *Telephone maintenance measurements.*

2. *Telegraph maintenance measurements*

Telegraph maintenance measurements consist of:

a) measuring the degree of distortion in time of significant instants;

b) measuring error rates.

2.a)1 *Maintenance method by measurements of significant instants distortion in time* (known as " Telegraph distortion ": Definition 33.04 of the *List of Definitions*)

Provisionally, the distortion of significant instants should be evaluated by measuring the degree of isochronous distortion in the absence of any appreciable disturbance which might produce error bursts.

Note 1. — This measurement should be made by evaluating the degrees of early and late individual distortion, the degree of isochronous distortion being the sum, in absolute terms, of the maximum degrees of early and late individual distortion.

Note 2. — It is recognized that measurements of isochronous and individual distortion are both quite important, but that for lack of an exact definition of the ideal reference instant, the non-uniformity of individual distortion measurements makes them difficult to apply in an agreed manner.

2.a)2 Measurements of distortion should be made using the apparatus recommended in Recommendation V.52 placed at points A and A_1.

2.a)3 The duration of the measurement should be 20 seconds.

2.b) *Maintenance method by measurement of the error rate*

2.b)1 Measurements should be taken of the error rate on the bits and the error rate on the blocks (or sequence); the measurements should be made with the apparatus described in Recommendation V.52 using the pseudo-random sequence at the appropriate signalling rate. The apparatus should be placed at points A and A_1.

2.b)2 The duration of the measurements shall be 15 minutes. Every measurement shall be a gross measurement, i.e. without any deduction of errors and without stopping the measurements if there is, for any reason, a brief period of high error-rate. However, if an incident of appreciable importance (e.g. prolonged interruption of the circuit or loss of synchronization on several pseudo-random sequences) upsets the measurement, the measurement should be started again.

3. *Telephone maintenance methods*

3.1 Telephone maintenance methods consist of:

i) measurement of the attenuation at 800 Hz;

ii) measurement of the attenuation distortion as a function of the frequency;

iii) measurement of the delay/frequency distortion;

iv) measurement of noise with the psophometer;

v) measurement of impulsive noise using the instrument described in Recommendation V.55.

3.2 Impulsive noise levels should be expressed in dBm0 because a) the difference between the various national transmission plans is taken into account and b) the level value is related to the value of data signal level to a close degree.

3.3 Bearing in mind the following two points,

— that Recommendation V.2 demands a maximum data signal level of −10 dBm0 for a simplex transmission and −13 dBm0 for duplex transmission,

— that there has been considerable experience of using the threshold −18 dBm0 and −22 dBm0, the threshold settings should be −18 dBm0 and −21 dBm0 respectively for the ordinary and special quality circuits mentioned in Recommendation M.102, the standard measuring instrument being adjustable to thresholds 3 dB apart.

Owing to lack of experience, no external filter should be used for present maintenance purposes.

3.4 At the time of measurement the line should be terminated at both ends on impedances of 600 ohms each. The modem may be used for this purpose if it complies with this impedance.

4. *Maintenance procedures* should be carried out as follows:

4.1 *Maintenance measurements before a leased circuit is put into service*

Before a circuit is put into service the following measurements should be made:

i) *between points B and B_1:*

telephone measurements as specified in section 3;

ii) *between points A and A_1:*

telegraph measurements as specified in section 2.a;

iii) so far as possible, these measurements should be made at peak periods;

iv) on the modems, modem test measurements.

For this purpose the modems must be equipped, if possible, with looping devices on interface or line sides, so that the loop test can be performed either from the data terminal equipment or from a test centre.

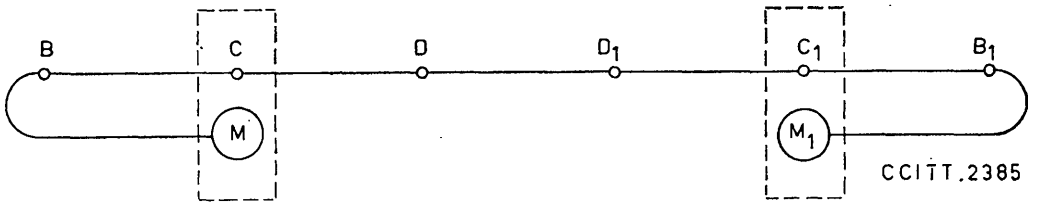
The design of these loops and the tests to be made for modem checks cannot be specified for general application since the deciding factors for these tests are the type of modem and the type of interface signal.

4.2 *Routine maintenance of leased circuits*

On a leased point-to-point connection, maintenance of the B-B_1 circuit is organized in the same way as prescribed for leased telephone circuits, which follows as closely as possible the organization prescribed for the maintenance of circuits in the general telephone service; on each international group of circuits there is, in each country, an *international maintenance centre* (I.M.C.) and one of them is the controlling centre. Circuit information is kept in each I.M.C. An I.M.C. has to inform the controlling I.M.C. of any intervention or incident on the circuit.

4.3 Telegraph measurements requiring restitution of the characteristic instants are practical only between the interfaces.

On the other hand, by using a supplementary telephone pair between B and C and between B_1 and C_1, it might be possible to take " telephone " measurements from the connecting centres, on the lines of the following diagram:



CCITT.2385

It is not recommended that measurements between M and M_1 be substituted for those to be made between B and B_1; however, this change in the measuring point might be acceptable when the measurements made from M to M_1 can be regarded as representative of the measurements from B to B_1. This is a question of local circumstances.

4.4 *Maintenance measurements before data transmission equipment for use on the switched network is put into service*

It is recommended that data test centres be set up in one or more countries; each subscriber to the switched data service should come under one of these centres. Before putting into service, this centre should be called and, once the connection has been set up, telegraph-type measurements only should be taken (distortion, error rate).

4.5 *Routine maintenance measurements for switched connections*

Between C and C_1, the circuit should receive the routine maintenance for telephone circuits, in accordance with the Recommendations in the *Green Book*, Volume IV.

Since means are available to the users for checking the quality of data transmissions:

— it is unnecessary to arrange for routine telephone-type maintenance measurements between B and B_1;

— it is unnecessary to arrange for routine telegraph-type maintenance measurements between A and A_1.

However, when there are signs of trouble developing, preventive maintenance measurements should be taken, but they will not be routine or systematic.

Administrations should be in a position to carry out modem tests.

5. *Fault location and clearance* should be effected as follows:

In each country an *international data co-ordinating centre* (I.D.C.C.) shall be set up.

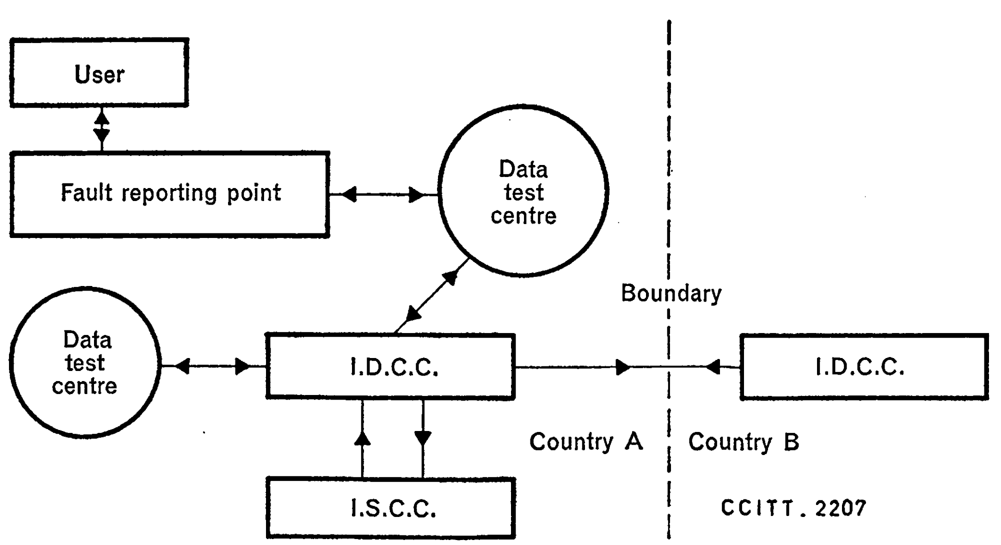
This centre:

— shall keep a record of international data transmission links (by leased circuit or switching);

— shall direct operations for putting international links for data transmission into service;

— shall act as a liaison point between countries for locating faults.

This centre is not a test centre, but it orders and co-ordinates the operation of test centres. It has no direct contact with users.



International service co-ordination centre

The diagram shows the links between the various services which may take part in locating and clearing faults on an international link.

The procedure for reporting and clearing faults would thus be as follows:

a) The user tests the line by telephone with the user at the other end, if the data transmission system permits;

b) the user checks that the equipment for which he is responsible is in normal working order;

c) the user reports the fault to his fault-reporting point according to the instructions issued by his Administration;

d) tests are made on the national network with the intervention, if necessary, of the data test centre;

e) if these tests are abortive, the I.D.C.C. is informed; this I.D.C.C. contacts the I.D.C.C. in the other country;

f) the I.D.C.C.s guide the search for the fault and, if necessary, call on the services of the maintenance centres on the international circuits involved.

If there is no data test centre in a country, the data test centres of a neighbouring country may be used with the consent of the Administrations concerned.

By agreement between the Administrations concerned, a user in country A may carry out tests with the aid of a data test centre in country B, and vice versa.

Recommendation V.52

CHARACTERISTICS OF DISTORTION AND ERROR-RATE MEASURING APPARATUS FOR DATA TRANSMISSION

(Mar del Plata, 1968, amended at Geneva, 1972)

Considering

that distortion and error rate measurements are of interest in data transmission and that measuring instruments must have compatible characteristics for international inter-operation,

the C.C.I.T.T. *unanimously declares the view that*:

1. *Modulation rates*

a) The nominal *modulation rates* of the measuring apparatus to be used in the tests are:

50, 75, 100, 200, 600, 1200, 1800, 2000, 2400, 3000, 3600 and 4800 bauds.

b) The accuracy of these rates should in no case deviate from the nominal value by more than $\pm 0.01\%$.

c) To obtain these rates a time-base external to the instrument may be used.

2. *Emission of test signals*

a) In order to test circuits for data transmission on an international basis it is necessary to standardize the test patterns to be used. Such a pattern should be a pseudo-random one having the following characteristics:

— it should contain all or at least the majority of eight-bit sequences likely to be met in the transmission of actual data;

— it should contain sequences of zeros and ones as long as possible compatible with ease of generation;

— the pattern should be of sufficient length such that at modulation rates higher than 1200 bauds its duration is significant compared with line noise disturbances.

Accordingly a 511-bit test pattern is recommended. The pattern may be generated in a nine-stage shift-register whose fifth and ninth stage outputs are added together in a modulo-two addition stage, and the result is fed back to the input of the first stage. The modulo-two adder would be such that the output produces a 0 output when the two inputs are similar and 1 output when the two inputs are dissimilar.

The following table shows the state of each stage of such a shift register during the transmission of the first 15 bits. The pattern over a longer period is as under:

11111111100000111101111100010111001100 etc.

SHIFT REGISTER STAGES DURING PSEUDO-RANDOM PATTERN GENERATION

↓ 1	2	3	4	↑ 5	6	7	8	9 ↑	Output
1	1	1	1	1	1	1	1	1	1
0	1	1	1	1	1	1	1	1	1
0	0	1	1	1	1	1	1	1	1
0	0	0	1	1	1	1	1	1	1
0	0	0	0	1	1	1	1	1	1
0	0	0	0	0	1	1	1	1	1
1	0	0	0	0	0	1	1	1	1
1	1	0	0	0	0	0	1	1	1
1	1	1	0	0	0	0	0	1	1
1	1	1	1	0	0	0	0	0	0
0	1	1	1	1	0	0	0	0	0
1	0	1	1	1	1	0	0	0	0
1	1	0	1	1	1	1	0	0	0
1	1	1	0	1	1	1	1	0	0
1	1	1	1	0	1	1	1	1	1

It is clear from the table that this pattern is the sequence of bits in stage 9 of the shift register but it also represents the sequence in any other stage shifted in time. The choice of stage to be connected to the output is therefore a matter of circuit convenience.

b) Other test signals recommended are: permanent space, permanent mark, 1:1, 3:1, 1:3, 7:1 and 1: 7, all of which may be sent over the line for an unlimited time.

c) A tolerance of $\pm 1\%$ is the maximum permissible for the transmitter distortion of the test signals.

d) The form of signals shall be as prescribed in Recommendation V.28.

3. *Synchronization of transmitting with receiving apparatus*

The receiving measuring set shall be synchronized with the transitions of the test signals received; these signals to be the recommended 511-bit sequence.

4. *Measurement of distortion*

a) The apparatus should measure the degrees of early and late individual distortion.

b) The receiver should measure bias distortion on reversals (1: 1 signals), with a $\pm 2\%$ measurement accuracy.

c) The tolerance of the measurement of the individual distortion of pseudo-random signals shall be $\pm 3\%$.

d) The impedance of the receiving apparatus shall be as recommended in Recommendation V.28.

e) Provisionally, the margin of the measuring receiver should be measured in terms of the " margin of a synchronous receiver " (Definition 34.091), under the following measurement conditions: the signals entering the receiving measuring set shall be those defined in paragraph 2 above, with the transitions in one direction only subject to a delay equal to $\Delta\%$ of the theoretical duration of a significant unit. The modulation rate may be fixed at the nominal value, and at a value in the range: nominal value $\pm 0.01\%$. The receiving measuring set should not indicate any error after the synchronizing period as long as Δ is less than 90%; this applies to both directions of the transitions subject to the delay Δ. Under these conditions the margin of the measuring apparatus shall be said to be over 90%.

5. *Measurement of error rate*

Both bit error rate and block error rate measurements should be possible with the apparatus.

Information on the error rate for sequences of 511 bits should be given in a form similar to that for the bit error rate, the two measurements being made simultaneously.

Recommendation V.53

LIMITS FOR THE MAINTENANCE OF TELEPHONE-TYPE CIRCUITS USED FOR DATA TRANSMISSION

(Mar del Plata, 1968)

For data transmission maintenance purposes, the following limits are recommended for the essential parameters indicating the quality of a transmission channel.

1. *Telegraph distortion limits*

Limits for the *degree of distortion on a transmission channel* between the interfaces (i.e. including the modems) vary with the data transmission system. The following values are recommended, these same limits applying to the backward channel:

System with modem V.21	: 20-25%
Systems with modem V.23	
600 bauds—leased circuits	: 20-30%
1200 bauds—leased circuits	: 25-35%
600 bauds—switched circuit	: 25-30%
1200 bauds—switched circuit (when this mode of operation is possible).	: 30-35%

These figures express provisionally maximum degrees of individual distortion. They will be converted into degrees of isochronous distortion once a method for determining the reference ideal instant has been studied, specifying a synchronization procedure for the distortion-measuring receiver.

2. *Limits for error rates*

2.1 *Bit error rate*

The following limits are recommended; when they are exceeded the maintenance services should consider the transmission channel defective:

Modulation rate (bauds)	*Connection*	*Maximum bit error rate*
1200	switched (when possible)	10^{-3}
1200	leased	$5 \cdot 10^{-5}$
600	switched	10^{-3}
600	leased	$5 \cdot 10^{-5}$
200	switched	10^{-4}
200	leased	$5 \cdot 10^{-5}$

the period of measurement being about 15 minutes (more precisely, the period corresponding to the transmission of the total number of sequences which is closest to 15 minutes).

Note. — These values are not intended for use in planning circuits, but for the information of maintenance services.

2.2 *Block error rate*

Information on the error rate for sequences of 511 bits would be given in a form similar to that for the bit error rate, the two measurements being made simultaneously. However, no limit for the sequence error-rate can be recommended for the time being.

Note. — To enable Administrations to appreciate the value of sequence error rate measurement, the following table shows the *maximum and minimum theoretic values* of error rates for sequences of 511 bits corresponding to different values of bit error rate.

These theoretic values do not depend on the modulation rate. For the purposes of this table, a modulation rate of 1200 bauds has been taken as an example.

Modulation rate	: 1200 bauds
Period of measurement	: 15 minutes = 900 seconds
Number of bits transmitted	: 1 080 000
Length of sequence	: 511 bits
Number of sequences transmitted	: 2113

Bit error rate	Number of erroneous bits	Erroneous sequences			
		Maximum number	Maximum rate in %	Minimum number	Minimum rate in %
1	2	3	4	5	6
$2 \cdot 10^{-3}$	2160	2113	100	5	0.24
10^{-3}	1080	1080	51.1	3	0.15
$5 \cdot 10^{-4}$	540	540	25.5	2	0.10
10^{-4}	108	108	5.1	1	0.05
$5 \cdot 10^{-5}$	54	54	2.5	1	0.05

Note 1. — The *maximum* number of erroneous sequences given in column 3 corresponds to a *uniform* distribution of erroneous bits (one bit per sequence).

Note 2. — The *minimum* number of erroneous sequences given in column 5 corresponds to a *grouped* distribution of erroneous bits (sets of 511 bits affecting the sequences).

Note 3. — It will be seen that for a bit error rate of 10^{-3}, the sequence error rate can vary between 0.15 % and 51.1 %. (This shows the value of sequence error rate measurement, not only for users, but also for Administrations, which can thus obtain useful information on the causes of bit and sequence error.)

3. *Limit of uniform-spectrum random noise*

See Recommendation G.153 (*Green Book*, Volume III).

4. *Limits for impulsive noise*

4.1 Since the number of noise impulses is counted with the instrument in the flat bandwidth condition, the following limit is recommended:

On a leased circuit the admissible limit is 70 impulse counts per hour; but in view of the fact that error rate measurements are conducted for periods of 15 minutes each, the recommended maintenance limit is 18 counts in 15 minutes for leased circuits. The measurements should be made during peak hours.

Note. — These values are given as an indication. The question of the duration of the measurement and permissible maximum standards for impulsive noise forms the subject of future studies.

4.2 For the general switched telephone network, no maintenance limits are recommended for impulse counts, although it is recognized that measurements of impulsive noise are useful as a diagnostic aid at the discretion of the Administration. This is because the impulse count results taken on any one connection vary considerably with time and even greater differences appear between various connections.

Recommendation V.55

IMPULSIVE NOISE MEASURING INSTRUMENT FOR DATA TRANSMISSION

(Mar del Plata, 1968)

Considering

that impulsive noise is of interest to data transmission and that first consideration should be given to a simple pulse counter suitable for field use, the C.C.I.T.T. *unanimously declares the view*:

that the instrument for impulsive noise measurement should have the following characteristics:

a) it should register a count whenever the voltage applied at the input exceeds an adjustable threshold;

b) it should operate independently of the sense (or polarity) of the applied impulse;

c) the nominal input impedance should be 600 ohms within the range of 200 to 3400 Hz or a switchable high impedance giving a bridging loss not exceeding 0.1 dB. The input circuit should be balanced in relation to earth, with a degree of balance such that a pulse whose level is 60 dB higher than the threshold, applied between the mid-point of the source impedance and the earth terminal of the instrument, should not operate it;

d) the threshold should be adjustable in steps of 3 dB (with a tolerance of $\pm$ 0.5 dB) from -50 dB to 0 dB with respect to 1.1 volt, which is the peak voltage of a sine wave having a power of 1 mW in 600 ohms.

The thresholds for the two polarities should be within 0.5 dB of each other.

e) after the instrument has been calibrated against a 1000-Hz sine wave signal at a level of 0 dBm and with the weighting control network in the " flat " condition, rectangular pulses of either polarity, of 50 milliseconds duration having a peak amplitude of 1.1 volt, and with an interval between pulses in excess of the operating time of the counter (dead-time, see f)), shall be applied to the input of the instrument and cause the counter to operate at the correct rate. When the operating level control is set at -1 dBm, and the duration of these pulses is gradually reduced, the counter shall count at the correct rate when the pulses have a duration of 50 microseconds but shall not count when the pulses have a duration of 20 microseconds;

f) dead-time is defined as the time after which the counter is ready to register another pulse after the start of the preceding pulse. Several values for this dead-time have been proposed. Whatever range of values may be adopted for a particular instrument, the value of 125 $\pm$ 25 milliseconds should be provided in all cases;

g) in the flat bandwidth condition, the response should be within $\pm$ 1 dB in the frequency range 275 Hz to 3250 Hz. Outside this range, the response curve should be compatible with the sensitivity requirement in clause e) above;

h) the instrument may provide other optional bandwidths;

to enable the instrument to be used for other than maintenance measurements, it should be so designed that external filters may be added.

One of these filters shall have the following characteristics:

3 dB points at 600 Hz and 3000 Hz;

Characteristic from 750 Hz to 2300 Hz flat to within $\pm$ 1 dB;

Response falling off at about 18 dB per octave:

— below 600 Hz,

— above 3000 Hz.

i) calibration should be possible from the peaks of a 1-mW standard test tone;

j) a built-in timer, continuously adjustable from 5 to 60 minutes, should be provided. Significant testing intervals will be 5, 15, 30 and 60 minutes;

k) all the preceding clauses shall be satisfied when the ambient temperature varies between $+10°$ C and $+40°$ C;

l) the capacity of the counter shall be at least 999.

ANNEX

(to Recommendation V.55)

Use of the impulsive noise counter for data transmission

1. Levels should be expressed in dBm0, because a) the difference between the various national transmission plans is taken into account and b) the level value is related to the value of data signal level to a close degree.

Bearing in mind the following two points:

— that Recommendation V.2 demands a maximum data signal level of −10 dBm0 for a simplex transmission; and −13 dBm0 for duplex transmission;

— that there has been considerable experience of using the threshold −18 dBm0 and −22 dBm0;

the threshold settings should be −18 dBm0 for telephone type circuits and −21 dBm0 for the special quality circuits mentioned in Recommendation M.102, the standard measuring instrument being adjustable to thresholds 3 dB apart.

Owing to lack of experience, no external filter should be used for present maintenance purposes.

However, the study of the use of external filters should continue; one of these filters should be the one described in point h) of Recommendation V.55; the United Kingdom Post Office uses an impulse counter that also includes a filter having the following characteristics:

3 dB points at 300 Hz and 500 Hz;

Response falling off at about 18 dB per octave:

— below 300 Hz,

— above 500 Hz.

At the time of measurement the line should be terminated at both ends by impedances of 600 ohms. The modem may be used for this purpose if it complies with this impedance.

2. For counting the number of impulses, the instrument shall be used in the " flat " bandwidth condition.

On a leased circuit, the admissible limit should be 70 impulse counts per hour; but in realizing that error rate measurements are conducted for periods of 15 minutes each, the recommended maintenance limit should be 18 counts in 15 minutes for leased circuits. The measurements should be made during peak hours.

3. For the general switched telephone network, there should be no recommended maintenance limits for impulse counts, but the instrument might be useful as a diagnostic aid at the discretion of the Administrations. This is because the impulse count results taken on any one connection vary considerably with time and even greater differences appear between various connections.

4. The correlation between the bit error rate and the number of impulse counts thus determined has not yet been established.

Recommendation V.56

COMPARATIVE TESTS OF MODEMS FOR USE OVER TELEPHONE-TYPE CIRCUITS

(Geneva, 1972)

To facilitate the work of Administrations in making comparative tests of modems for use over telephone-type circuits offered by different manufacturers, it is recommended that the tests should be made in the laboratory under the following operating conditions:

1. *List of test parameters*

TABLE 1

Ref. No.	Parameter	Four-wire point-to-point	Two-wire switched network	
			Serial modems	Parallel modems
1	Total attenuation or receiving signal level	X	X	
2	Attenuation distortion	X	X	
3	Envelope or group delay distortion	X	X	
4	Frequency shift (or offset)	X	X	
5	Sudden changes of attenuation	X	X	
6	Interruptions	X	X	
7	Phase hits	X	X	
8	Phase jitter	X	X	
9	Harmonic distortion	X	X	X
10	Listener echo		X	
11	" White " noise	X	X	
12	Impulsive noise	X	X	
13	Single tone interference		X	

2. *Block diagram for standard test measuring set-up*

It is proposed that comparative tests be made using either all or parts of the measuring set-up shown in Figure 1/V.56.

3. *Test parameters*

3.1. Parameters of the line characteristics simulator (Note).

a) Symmetric line distortions

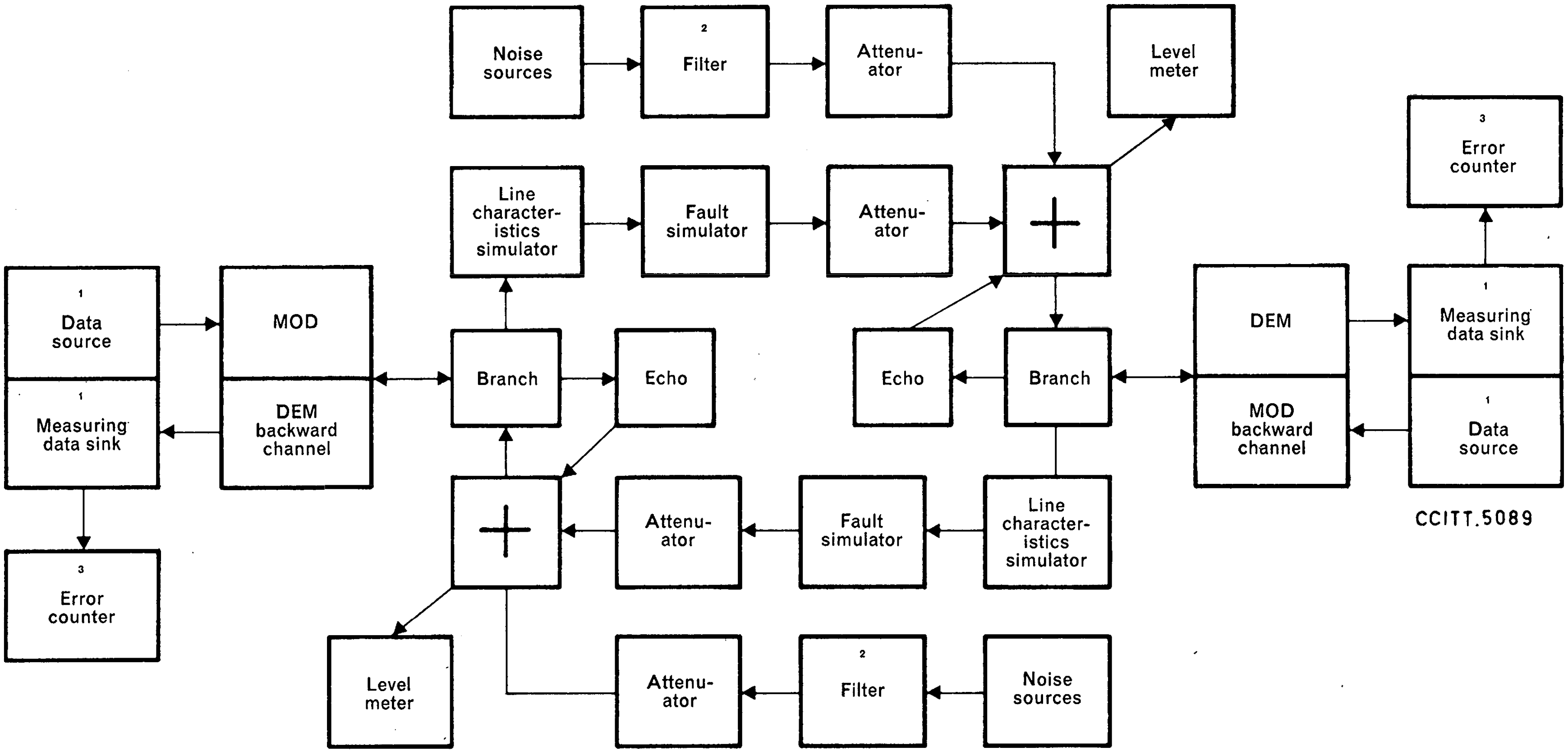
Attenuation distortion in dB

Frequency (Hz)	Mode 1	Mode 2
300	6	12
500	2	3
1000	0	0
2800	4	6
3000	5	8

Group delay distortion in ms

Frequency (Hz)	Mode 1	Mode 2
500	3	6
1000	1	2
2000	0	0
2500	0.12	0.23
2800	0.5	1

Tolerances for all values: ± 10%



[1] 511-bit pseudo random text.
[2] 300-3400-Hz band pass filter; the filter is left out if impulsive noise in the form of a square wave is used.
[3] For bit and block error count, see Recommendation V.52.

FIGURE 1/V.56. — **Measuring set-up for the standard tests of modems**

b) Asymmetric line distortions

Attenuation distortion in dB

Frequency (Hz)	Mode 1	Mode 2
300	0.15	0
1000	0.5	0
2500	unspecified	4
2800	3	>40
3000	6	∞

Group delay distortion in ms

Frequency (Hz)	Mode 1	Mode 2
500	0	0
1000	0.1	0.2
2000	0.5	1
2500	1	2
2800	1.5	3

Tolerances for all values: ± 10%

Note.— The above figures and tolerances are provisional.

3.2 *Parameters of the fault simulator*

a) Phase hits: with external control of timing (e.g. 0.25; 1; 100 Hz) adjustable continuously or in steps up to 165 degrees.

b) Frequency shifts e.g. ± 5 Hz, ± 6 Hz or ± 10 Hz by means of channel converters.

c) Peak-to-peak phase jitter from 0.2 degree to 30 degrees continuously from 50 to 300 Hz— sinusoidal waveform.

d) Sudden changes of attenuation and interruption: this point is referred for further study as agreement could not be reached on the repetition period and duration of these changes.

3.3 *Noise sources* (this subject needs further study)

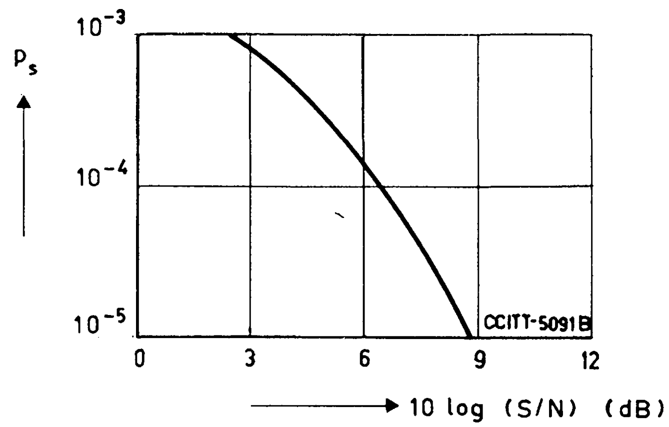
a) White noise.

b) Impulsive noise by symmetric square wave signal with defined duration and repetition rate.

c) Statistically distributed noise by recording or by simulation (e.g. as proposed in Supplement No. 26 of the present volume) which is information to assist in standardizing a " Random noise simulator " which would encourage the utilization of block error counts.

4. *Measuring procedure*

4.1 Measurement of the bit error rate (p_S) as a function of the signal-noise ratio (S/N) in the case of white noise. The receiving level at the summation point should be −30 dBm for switched line comparisons and −20 dBm for leased line comparisons.



$$p_S = f(S/N) = \frac{\text{error bits}}{\text{transmitted bits}}$$

S = signal level

N = noise level

FIGURE 2/V.56 (example). — **Bit error rate as a function of the signal-noise ratio**

4.2 Measurement of the number of the bit errors per second as a function of a sudden change of attenuation (a_S) or of phase (φ_S). The receiving level at the summation point should be −30 dBm for switched line comparisons and −20 dBm for leased line comparisons.

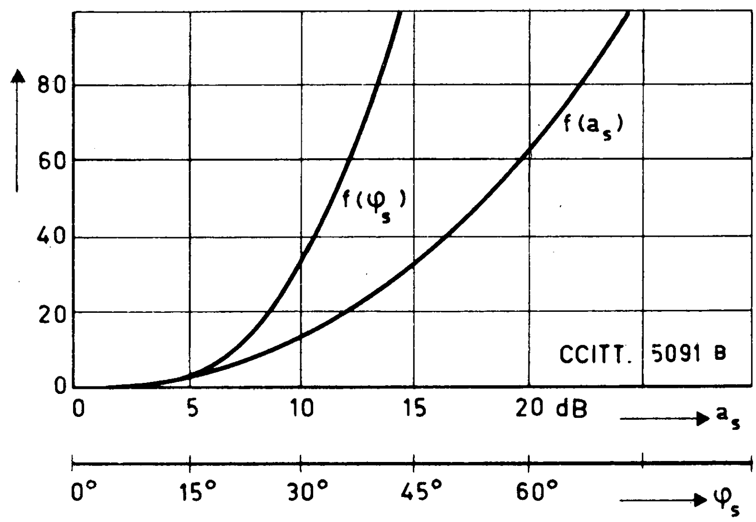


FIGURE 3/V.56 (example). — **Bit error as a function of the value of sudden changes of attenuation or phase**

5. *Comparative tests of modems*

TABLE 2

NINE SELECTED TESTS ACCORDING TO SECTIONS 1, 2, 3 AND 4

Test	A	B	C	D	E	F	G	H	J
Measuring procedure according to point	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.2	4.2
Test parameters according to point	—	3.1a mode 1	3.1a mode 2	3.1b mode 1	3.1b mode 2	3.1a mode 1	3.1a mode 2	3.1a mode 1	3.1a mode 2
Frequency shift	—	—	—	—	—	± 6 Hz	±10 Hz	—	—
Test parameters according to Table 1	1, 11	1, 2, 3, 11	1, 2, 3, 11	1, 2, 3, 11	1, 2, 3, 11	1, 2, 3, 4, 11	1, 2, 3, 4, 11	1, 2, 3, 5, 6, 7	1, 2, 3, 5, 6, 7

The above typical tests were accepted as an interim selection but it is realized that further study is needed to arrive at a more realistic selection of tests for the comparison of modems that operate on leased and switched channels. Administrations and manufacturers are asked for further information to assist in solving this question.

Recommendation V.57

COMPREHENSIVE DATA TEST SET FOR HIGH DATA SIGNALLING RATES

(Geneva, 1972)

The C.C.I.T.T.,

considering

that the characteristics for measuring instruments recommended in V.52 are not suitable for use with modems conforming with V.35 and that distortion and error rate measurements are of interest in data transmission when these modems are used,

unanimously declares the view that for tests at high data signalling rates the following provisions shall apply:

1. *Data signalling rates*

a) The nominal data signalling rates of the measuring apparatus shall be 20 400, 24 000, 40 800 and 48 000 bit/s.

b) The accuracy of these rates shall be $\pm$ 0.002% if timing is not derived from the modem under test or that recommended in V.35 if timing is derived from the modem under test.

c) To obtain these rates a time-base external to the instrument may be used. To accommodate higher rates, which may be standardized in the future, it should be possible for error measurements to be made at rates up to 2 Mbit/s using timing derived from the system under test.

2. *Emission of test signals*

a) In order to test circuits for data transmission on an international basis it is necessary to standardize the test patterns to be used. The test signals recommended are those recommended in V.52 plus an additional pseudo-random pattern having the following characteristics:

— it should contain the majority of bit sequences likely to be met in the transmission of actual data;

— it should contain long sequences of zeros and ones compatible with ease of generation;

— it should be possible to generate the pattern as a line signal with the coder of a V.35 modem by applying a steady state, binary 1, to its input.

b) A tolerance of $\pm$ 1% is the maximum permissible for the transmitter distortion (Definition 33.059) of the test signals.

c) The form of the signals shall be as prescribed in Recommendation V.35.

Accordingly a 1 048 575-bit test pattern is recommended. This pattern may be generated in a 20-stage shift register of which the 20th and 3rd stage outputs are modulo-two added together and fed back to the input of the first stage.

3. *Synchronization of the receiving measuring apparatus*

Two modes shall be possible:

a) Synchronization by means of a timing signal derived from the modem when the modem is working in the synchronous mode.

b) Synchronization from the transitions of the test signals received when the modem is operating in the non-synchronous mode.

4. *Measurement of distortion*

a) The apparatus should measure the degrees of early and late individual distortion when operating in the mode in which its synchronizing is derived from transitions in the received test signals.

b) The tolerance of measurement of individual distortion of pseudo-random signals should be $\pm 3\%$.

c) The apparatus should measure bias distortion of received reversal (1: 1) signals with $\pm 2\%$ accuracy.

d) The characteristics of the receiving circuit of the apparatus shall be as prescribed in Recommendation V.35.

e) The margin of the apparatus should be measured in terms of the " margin of a synchronous receiver " (Definition 34.091), under the following measurement conditions: The signals entering the receiving measuring set should be those defined in paragraph 2 above, with the transitions in one direction only subject to a delay equal to $\Delta\,\%$ of the theoretical duration of a significant interval. The modulation rate may be fixed at the nominal value, and a value in the range: nominal value $\pm$ 0.002%. The receiving measuring set should not indicate any data error after the synchronizing period as long as $\Delta\,\%$ is less than 90%; this applies to both directions of the transitions subject to the delay Δ. Under these conditions the margin of the measuring apparatus shall be said to be over 90%.

5. *Measurement of error rate*

Both bit error rate and block error rate measurements should be possible with the apparatus simultaneously.

For the purpose of block error measurements a block length of 32 768 (i.e. 2^{15}) should be used.

Note. — Designers of testing apparatus may find it convenient also to incorporate means for using a block length equal to a full pseudo-random pattern of 1 048 575 bits. This longer block length might be more suitable for testing systems operating at higher rates than recommended in V.35.

SERIES X RECOMMENDATIONS

Data transmission over public data networks

SECTION 1

SERVICES AND FACILITIES

Recommendation X.1

USER CLASSES OF SERVICE FOR PUBLIC DATA NETWORKS

(Geneva, 1972)

The establishment in various countries of public networks for data transmission creates a need to standardize user data signalling rates, terminal operating modes, address selection and service signals; such standardization facilitates international interworking, bearing in mind that in the data mode the network should be code-independent.

Recommendations in the V series already standardize data signalling rates for synchronous data transmission in the general telephone network and modulation rates for modems. These rates are, however, not necessarily most suitable for networks devoted entirely to data transmission and this leads to the requirement for an additional standard.

Bearing in mind:

the desirability of providing sufficient data signalling rates to meet users' needs;

the requirement to optimize terminal, transmission and switching costs to provide an overall economic service to the user;

the interaction between users' requirements and tariff structure,

the C.C.I.T.T. *unanimously declares the following view*:

1) users' data transmission requirements via public data networks may best be served by defined user classes of service;

2) these user classes of service are shown in Table 1; they cater for two particular types of users' data terminals, namely terminals operating in the start-stop mode (as typified by teleprinters used for message transfer) in classes 1 and 2 and terminals operating in a synchronous mode in classes 3 to 6.

TABLE 1

USER CLASSES OF SERVICE FOR PUBLIC DATA NETWORKS

Class	User classes of service	Address selection and service signals
1	200 bit/s, 11 [a] units/ char. start-stop	200 bit/s, Alphabet No. 5
2	50-200 bit/s, 7.5-12 units/ char. start-stop	200 bit/s, Alphabet No. 5
3	600 bit/s, synchronous	600 bit/s, Alphabet No. 5
4	2 400 bit/s, synchronous	2 400 bit/s, Alphabet No. 5
5	9 600 bit/s, synchronous	9 600 bit/s, Alphabet No. 5
6	48 000 bit/s, synchronous	48 000 bit/s, Alphabet No. 5

[a] Usage in accordance with Recommendation V.4.

Notes.

1. There is no user class of service for the data signalling rate of 50 bit/s, the transmission mode of 7.5 units/character start-stop and address selection and service signals at 50 bit/s, Alphabet No. 2. However, several Administrations have indicated that their telex service (both the 50-baud service and any higher speed service that may be agreed internationally) will be provided as one of the many services carried by their public data network.

2. Although it is recognized that start-stop data terminals operating on a character-by-character basis will continue to exist for a long time, it is expected that their long-range development direction is towards the use of synchronous mode of transmission at the DCE-DTE interface.

3. The user data signalling rates shown in classes 3-6 are the maximum possible user information transfer rates; users may also operate at particular compatible lower rates, for example, half the rates quoted. The ways in which this is to be accomplished are for further study.

4. Both burst isochronous and continuous isochronous transmission modes are possible for classes 3 to 6.

5. Class 2 will provide, for example, for operation at the following speeds and code structures:

75 bauds	(7.5 units/character)
100 bauds	(7.5 and 10 units/character)
110 bauds	(11 units/character)
134.5 bauds	(9 units/character)

6. For class 2, it shall be noted that the networks may not be able to prevent two terminals working at different speeds and code structures from being connected to each other.

7. Further study as indicated in Question 1/VII—point A is required.

Recommendation X.2

RECOMMENDED USER FACILITIES AVAILABLE IN PUBLIC DATA NETWORKS

(Geneva, 1972)

The user facilities to be made available in public data networks are under study within the C.C.I.T.T.[1] The following table summarizes the outcome of the study to date.

USER FACILITIES IN PUBLIC DATA NETWORKS

Title of facility	*Availability*
Symmetrical duplex	P
Bit sequence independence	N (User classes of service Nos. 1-2) P (User classes of service Nos. 3-6)
Manual and automatic calling and answering	P
Direct call	E
Abbreviated address	E
Closed user group	E
Closed user group with outgoing access	O [a]
Remote terminal identification	O [a]
Multi-address	O
Delayed delivery	O (User class of service No. 1) N (User classes of service Nos. 2-6)

Note. — P = A facility supplied as part of the user class of service.
E = A facility recommended to be available to the user in public data networks.
O = A facility which may be provided in public data networks.
N = Not required.
[a] Further study is required in conjunction with I.S.O.

[1] See Question 1/VII—point B.

SECTION 2

DATA TERMINAL EQUIPMENT AND INTERFACES

Recommendation X.20

INTERFACE BETWEEN DATA TERMINAL EQUIPMENT AND DATA CIRCUIT-TERMINATING EQUIPMENT FOR START-STOP SERVICES IN USER CLASSES 1 AND 2 ON PUBLIC DATA NETWORKS

(Geneva, 1972)

1. Scope.
2. Line of demarcation.
3. Definitions of interchange circuits.
4. Electrical characteristics of interchange circuits.
5. Interface procedures.

Many data terminal equipments are in use which are equipped with interfaces recommended for existing networks such as Recommendation V.21 for duplex working over telephone networks. For a period of time, data networks will also provide similar interfaces for start-stop operation.

For the long term a new simpler interface is recommended and described below.

1. *Scope*

1.1 This Recommendation applies to the interconnecting circuits, being called interchange circuits, between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for the transfer of binary data and control signals.

1.2 This DCE provides all signal conversions between the DTE and the line. It may or may not be a specific or separate piece of equipment.

1.3 The interchange circuits defined in this Recommendation are applicable to DTE of the user-classes 1 and 2 (see Recommendation X.1) where short interconnecting cables are used between the DTE and the DCE (see Section 4).

2. *Line of demarcation*

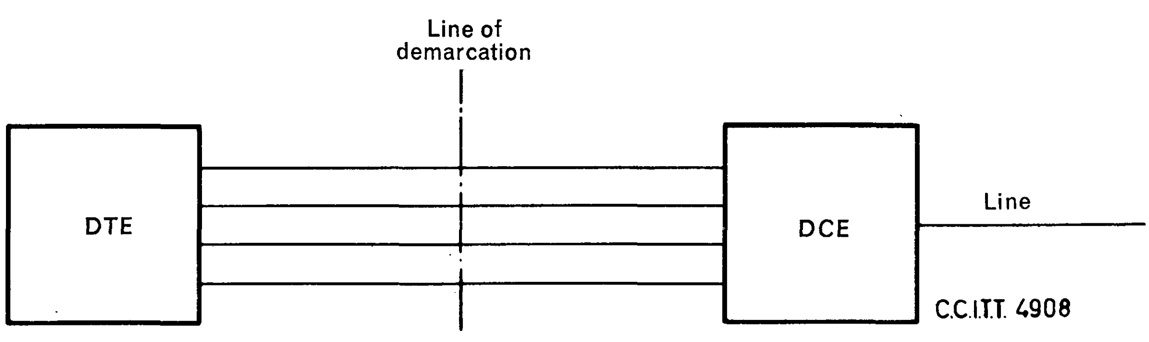


FIGURE 1/X.20. — **Illustration of the layout of DTE and DCE**

The interface between DTE and DCE is located at a connector which is the interchange point between these two classes of equipment.

An interconnecting cable or cables will normally be provided with the DTE. The use of short cables is recommended with the length solely limited by the load capacitance and other electrical characteristics, specified in Section 4.

3. *Definitions of interchange circuits*

General application

A list of these interchange circuits is presented in tabular form in Table 1.

Circuit 101—Protective ground or earth

This conductor shall be electrically bonded to the machine or equipment frame. It may be further connected to external grounds as required by applicable regulations.

Circuit 102—Signal ground or common return

This conductor establishes the signal common reference potential for unbalanced interchange circuits in the 100 series. Within the DCE, this circuit shall be brought to one point, and it shall be possible to connect this point to circuit 101 by means of a metallic strap within the equipment. This metallic strap can be connected or removed at installation, as may be required to meet applicable regulations or to minimize the introduction of noise into electronic circuitry.

Circuit 103 A—Transmitted data
Direction: To DCE

The data signals originated by the DTE to be transmitted via the data channel to one or more remote data stations are transferred on this circuit to the DCE.

Moreover, all data signals produced by the DTE during the call establishment and the disconnection and being required by the network to establish and clear connections are transmitted via this circuit. The operational conditions indicated to the data network are also included (see Section 5).

During an established connection and the setting-up phase of a call as well as during all intervals between the signals, the DTE shall keep the circuit " transmitted data " in Z-polarity.

Circuit 104 A—Received data
Direction: From DCE

The data signals generated by a remote DTE and transmitted via the data network are passed on this circuit to the DTE.

Furthermore, all data signals generated by the data network during call establishment and the clearing and being required by the DTE to establish and clear connections are transmitted via this circuit.

TABLE 1

INTERCHANGE CIRCUITS

Interchange circuit No.	Interchange circuit name	Ground	Data	
			to DCE	from DCE
101	Protective ground or earth	X		
102	Signal ground or common return	X		
103 A	Transmitted data		X	
104 A	Received data			X

4. *Electrical characteristics of interchange circuits*

The electrical values given in Recommendation V.28 shall apply.

TABLE 2

CORRELATION TABLE

$V_1 < -3$ volts 1 OFF Z-polarity	$V_1 > +3$ volts 0 ON A-polarity

5. *Interface procedures*

Figure 2/X.20 " Sequence of signals at the interface " shows the procedures at the interface during the setting-up of a call, the data transfer-phase, and the clearing of a call including the busy and failure conditions.

5.1 *Call establishment*

5.1.1 *Free line condition*

The circuits 103 A and 104 A have A-polarity.

5.1.2 *Outgoing call*

The circuit 103 A is changed by the DTE to Z-polarity.

5.1.3 *Proceed-to-select signal*

The circuit 104 A is changed by the network to Z-polarity.

5.1.4 *Selection*

The selection signals including the end-of-selection signal are transmitted by the DTE on the circuit 103 A.

Selection signals shall be in International Alphabet No. 5 at 200 bit/s in accordance with Recommendation V.4. Selection shall commence within 6 s after the proceed-to-select signal and shall be completed within 30 s from commencement of selection.

The maximum permissible interval between the individual selection signals should not exceed 6 s.

5.1.5 *Remote terminal identification (optional)*

The remote terminal identification sent by the network is received on the circuit 104 A and shall be in International Alphabet No. 5 at 200 bit/s in accordance with Recommendation V.4.

5.1.6 *Connect-through signal*

This signal is the receipt by the DTE of the character ACK (combination 0/6 of International Alphabet No. 5) on the circuit 104 A.

5.1.7 *Data transfer*

After the reception of the connect-through signal, the calling DTE as well as the called DTE can start with the data transfer at least 10 ms after the receipt of the connect-through signal.

5.1.8 *Clearing*

5.1.8.1 *Clearing by DTE*

The circuit 103 A is changed to permanent A-polarity by either DTE when it wishes to clear.

5.1.8.2 *Clear confirmation*

For clear confirmation, the circuit 104 A is changed to permanent A-polarity by the network regardless of whether the remote DTE has been cleared.

After a guard delay the DTE shall be completely released and ready to receive a new call.

5.1.8.3 *Clear confirmation by cleared DTE*

If, immediately following an operating condition where the circuit 103 A as well as the circuit 104 A have Z-polarity, permanent A-polarity is received on the circuit 104 A, the DTE has to recognize this reversal of polarity as clearing and has to transmit permanent A-polarity within a period in the range of 280-490 ms for clear confirmation on the circuit 103 A. Not later than 490 ms (guard delay) after the clear confirmation, the DTE must be ready to receive a new call.

Note (applicable to 5.1.8.2 and 5.1.8.3). — The indicated times apply only to DTE of the user class 1. They are still to be specified for DTE of the user class 2.

5.1.9 *Incoming call*

The circuit 104 A is changed to Z-polarity by the network.

5.1.9.1 *Call confirmation*

DTE changes the circuit 103 A to Z-polarity.

50 ms after the change to Z-polarity the DTE transmits the character ACK (combination 0/6 of International Alphabet No. 5) on the circuit 103 A.

Note 1. — This is a provisional figure, subject to further study and the specification of tolerances. The possibility of using different call-confirmation characters to indicate terminal status is left for further study.

Note 2. — After reception of the call, the call confirmation at those DTE which, due to their technique, require a speed-up time has to be transmitted within a time of ≤ 600 ms. In the case of all other DTE, the time required for the call confirmation should be considerably less than the times mentioned above and should approach ≤ 10 ms. The latter remains still to be determined.

5.2 *Unsuccessful call*

If a call is not successful, the network may indicate this fact and its reason to the calling DTE by means of service signals. Afterwards, the connection is released.

The service signals comprise the conditions set up by Recommendation X.70, and will consist of a prefix and of the character NAK (International Alphabet No. 5).

Note. — The prefixes are subject to further study.

5.3 *Faults*

5.3.1 *No selection by the DTE*

If, within a guard time of > 6 s, no selection has been started by the DTE, the network will reverse the circuit 104 A to permanent A-polarity after this period of time.

If, after that, the circuit 103 A changes to permanent A-polarity, the DTE will again be ready for operation after the expiration of the guard delay (see point 5.1.8.3).

5.3.2 *Circuit 103 A (transmitted data) in undefined state*

If the circuit 103 A is in an undefined state which may be caused by a power-off condition, short-circuit or interruption, the DCE shall in any case and in every operating condition interpret the faults by transmitting to the exchange the electrical criterion corresponding to A-polarity on the subscriber loop. Thus, it is secured that a possibly existing connection is released (see Figure 2/X.20, point 5.3.2).

5.3.3 *Circuit 104 A (received data) in undefined state*

If an undefined state occurs on the circuit 104 A which is caused by reasons mentioned in point 5.3.2, the DTE interprets the fault as A-polarity. Thus, it is secured that a possibly existing connection is released (see Figure 2/X.20, point 5.3.3). In all other cases, the fault is discovered as soon as the DTE is calling or called. An additional control device (optional) of the circuit 104 A may indicate the fault visually or acoustically.

5.3.4 *No proceed-to-select*

If the DTE does not receive a proceed-to-select signal on the circuit 104 A, it shall cancel the call after 6 s by switching the circuit 103 A to A-polarity.

5.3.5 *No connect-through signal*

Sixty seconds after the selection has been completed, the DTE should switch the circuit 103 A to A-polarity which is interpreted by the network as clearing. After that, the network will transmit the clear confirmation.

5.4 *Head-on collision*

If an incoming call occurs in conjunction with an outgoing call, the network will not receive the call confirmation character and will start the busy procedure for the remote calling DTE. The near calling DTE interprets the reversal of the circuit 104 A to Z-polarity as proceed-to-select signal and will transmit the selection signals (see Figure 2/X.20).

If the exchange cannot accept the selection signals it may send the clearing signal to the near calling DTE.

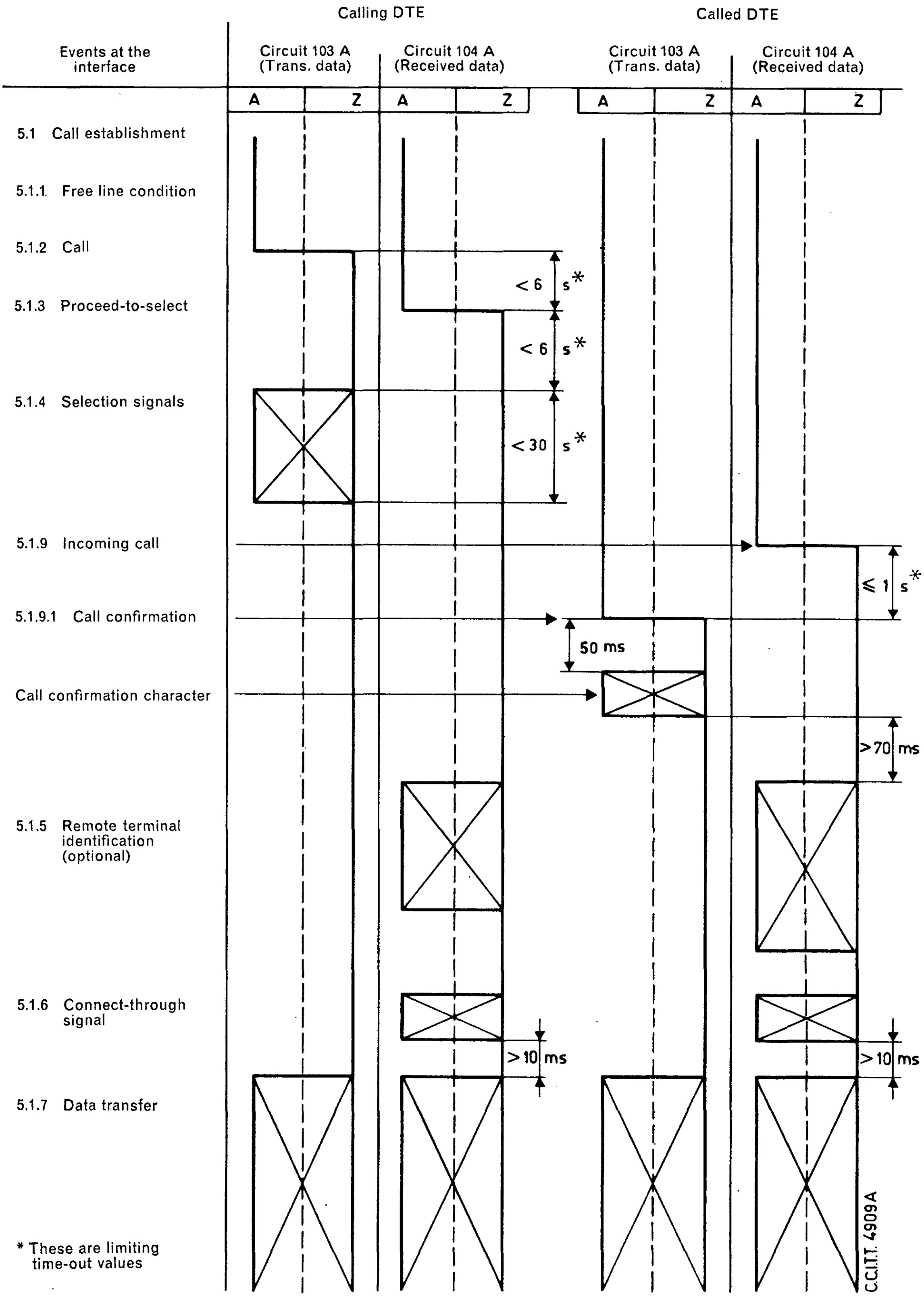


FIGURE 2/X.20. — **Interface signalling scheme**

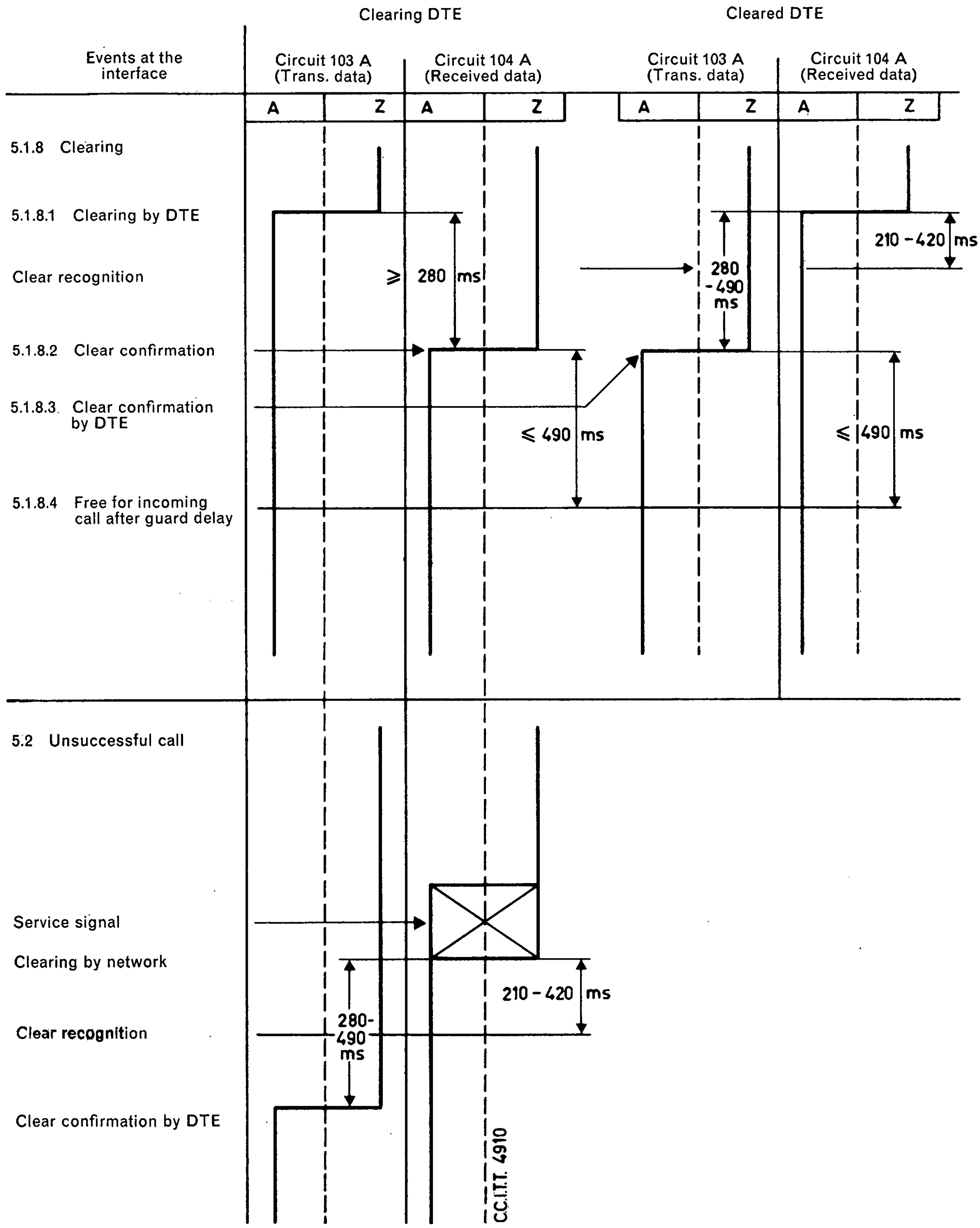


FIGURE 2/X.20 (continued). — **Interface signalling scheme**

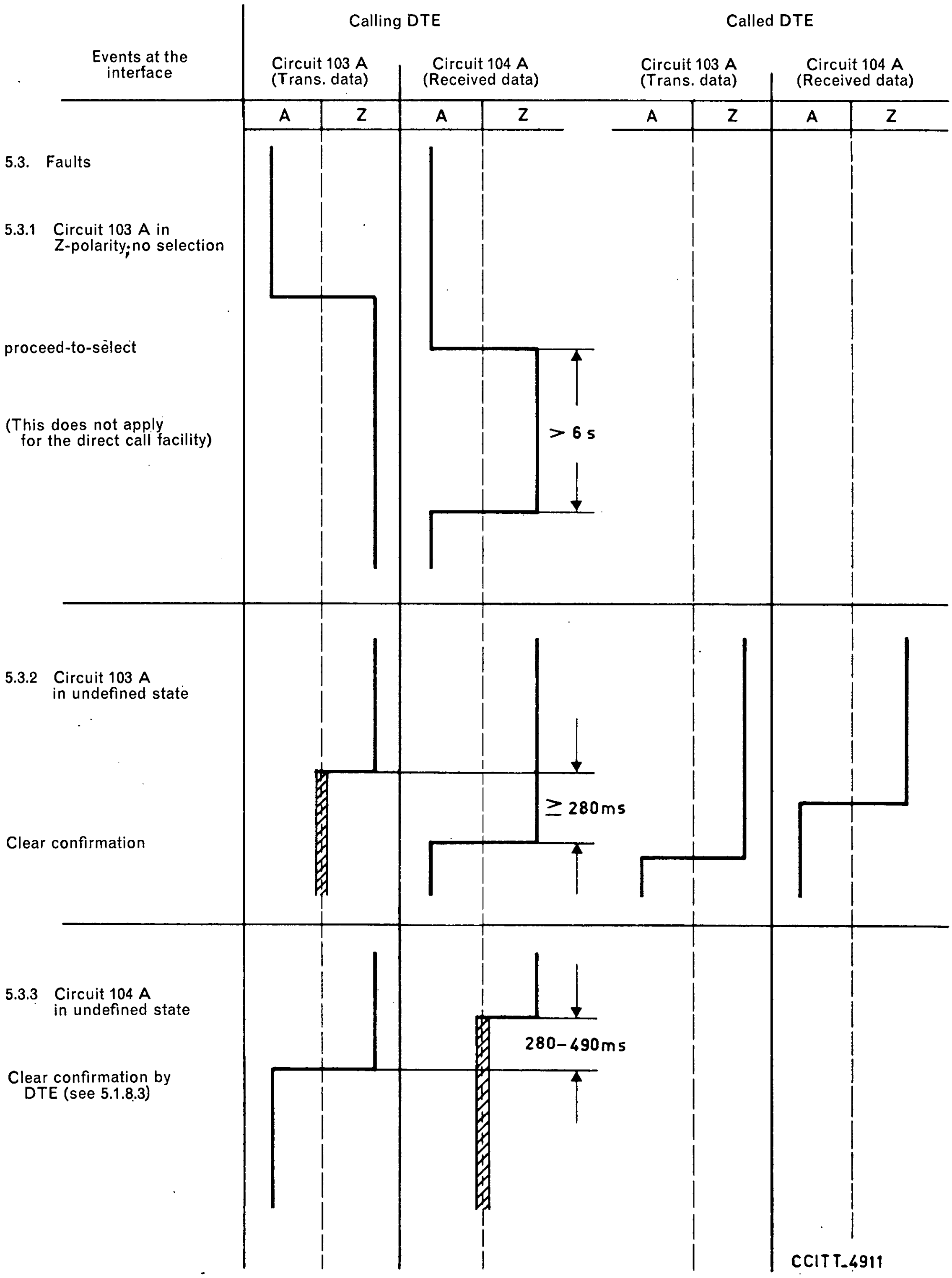


FIGURE 2/X.20 (concluded). — **Interface signalling scheme**

Note 1. — The numbering refers to Section 5 " Interface procedures ".

Note 2. — The times recommended in points 5.1.8, 5.2, 5.3.2 and 5.3.3 are target figures to meet the clear-down times suggested. They are subject to review during the continuing study of public switched data networks.

Recommendation X.21

INTERFACE BETWEEN DATA TERMINAL EQUIPMENT [1] AND DATA CIRCUIT-TERMINATING EQUIPMENT [1] FOR SYNCHRONOUS OPERATION ON PUBLIC DATA NETWORKS

(Geneva, 1972)

Scope

This Recommendation is the basis of and defines the important parameters for a general-purpose interface for synchronous operation on public data networks.

Content

1. The interchange circuits used.
2. The interface signalling scheme.
3. The method of character alignment between the DTE and the network.

1. *Interchange circuits used*

Protective ground or earth

Signal ground or common return

Transmitted data

Received data

Control DTE source

Control DCE source

Signal element timing DCE source

Byte timing DCE source (where provided).

Additional study is required to prepare definitions of these circuits where these are not given in Recommendation V.24.

2. *Interface signalling scheme*

The procedures and the conditions on the interchange circuits (except timing circuits) for various stages in the progress of a call are given in Table 1. The precise timing relationships between the changes of state on the various interchange circuits is not yet defined and is subject to further study.

[1] In this Recommendation the terms " data terminal equipment " and " data circuit-terminating equipment " are indicated by DTE and DCE respectively.

TABLE 1

INTERFACE SIGNALLING SCHEME

Call phase	DTE	Event	Interchange circuits			
			Transmitted data	Received data	Control DTE source	Control DCE source
Establishment	Calling	Free line	0	0	OFF	OFF
		Call request	1	0	ON	OFF
		Proceed to select	1	Ch	ON	OFF
		Selection signals	Ch	1	ON	OFF
		Selection acknowledgement	1	Ch	ON	OFF
		Waiting	1	1	ON	OFF
		Connect through or call progress signals	1	Ch	ON	OFF
		Data transfer	Data	Data	ON	ON
	Called	Free line	0	0	OFF	OFF
		Incoming call	0	1	OFF	OFF
		Call confirmation	Ch	1	ON	OFF
		Connect through	1	Ch	ON	OFF
		Data transfer	Data	Data	ON	ON
Data	Both		Data	Data	ON	ON
Disconnection	Clearing	Data transfer	Data	Data	ON	ON
		Clear request	0	Data	OFF	ON
		Clear confirmation	0	0	OFF	OFF
		Free line	0	0	OFF	OFF
	Cleared	Data transfer	Data	Data	ON	ON
		Clear indication	Data	0	ON	OFF
		Clear confirmation	0	0	OFF	OFF
		Free line	0	0	OFF	OFF
Control signalling after entering data phase	Station initiating control	Data transfer	Data	Data	ON	ON
		Control request	Ch	Data	OFF	ON
		Control response	1	Ch	ON	OFF
		Continue data	Data	Data	ON	ON
	Other station		To be defined			

NOTES

Data: Information generated by the DTE and can be any bit sequence.

States of interchange circuits:

0 = Continuous binary 0
1 = Continuous binary 1
ON = Continuous ON condition (binary 0)
OFF = Continuous OFF condition (binary 1)
Ch = Characters used for call progressing, selection and control signalling selected from International Alphabet No. 5 to Recommendations V.3 and V.4 (7 bits + odd parity). The choice of characters is not yet specified.

Signal element timing is provided continuously by the DCE.

Byte timing is provided continuously by the DCE where this is required by the national network (see Section 3).

Selection address will be terminated by an end-of-selection character.

Data phase commences when the control DCE source interchange circuit turns ON and terminates when this circuit turns OFF.

Head-on collision may be detected by DTE as Proceed to Select will be a different character from incoming call. DTE may decide to accept incoming call by returning call confirmation character instead of selection signals. If call confirmation is not sent by DTE then data switch will return busy to original caller and attempt to respond to new call demand. If the data switch is unable to proceed with call then it will send clear. Some Administrations may find it an advantage as an interim message (except on user class of service 6) to use the all 1's condition as the proceed-to-select signal leaving the resolution of collision entirely to the switch.

Connect-through: The connect-through signal is to be generated by the network and when received by the DTEs data transmission and reception can commence. This signal will indicate that all bits sent by either terminal after the connect-through indication is received shall be delivered to the corresponding terminal after the receipt of the connect-through signal at that corresponding terminal.

Note. — At the local station, the connect-through indication may be followed by either bits originated in the distant DTE or in the network. If generated in the network, the maximum duration and pattern of these bits shall be specified after further study.

Clearing: Data bits delivered to the network before the clearing signal is applied from the same DTE must be delivered to the distant DTE before the clear signal arrives at that DTE. This may require safeguards in the signalling system, e.g. centralized system.

Note. — During the clear-down process, bits generated by the network may be received by the DTEs. The maximum duration and pattern of such bits shall be specified after further study.

Remote terminal identification if provided by the network will occur before the connect-through signal.

3. *Character alignment*

Two methods of providing character alignment between the DTE and the data network are defined:

a) No byte timing interchange circuit is provided and all control character sequences to and from the network are preceded by " n " SYN characters, where the number " n " is left for further study.

b) A byte timing interchange circuit is provided. This circuit will define continuous 8-bit sequences, e.g. one International Alphabet No. 5 character. All control characters to and from the network shall be properly aligned with the indications on the byte timing circuit (see Note 4). SYN characters are not required and may not be provided by the network or by the DTE.

Note 1 — Alphabet for control signalling between DTE and a data network

An agreed coded character set is necessary to permit exchange of control information both for call set-up and call progress purposes. This is solely for control signalling between DTE and the network and may not be applicable for signalling between data signalling exchanges.

International Alphabet No. 5 has already been standardized and is therefore an attractive solution since its use avoids the work involved in developing a new alphabet. However, the use of this alphabet has been criticized on the grounds that the number of code combinations exceeds those required for network control purposes.

Examination of the structure of the code table in Recommendation V.3 shows that the allocation of characters to the various columns is such that various network proposals require characters from at least 5 columns, e.g. alpha characters from columns 4 and 5, numericals from column 3 and control characters from columns 0 and 1. A subset of International Alphabet No. 5 is not therefore readily possible for all purposes. The use of International Alphabet No. 5 in total permits characters to be chosen which are most appropriate for the various functions. It is not expected that all 128 code combinations will be necessary for data network control signalling and indeed may not be suitable, e.g. those left for national options.

In summary the use of International Alphabet No. 5 gives the needed flexibility without the need for a new standard.

Note 2. — A basic or simple binary interface with minimum or no logic in the NTU is the subject of further study.

Note 3. — Interfaces similar to those in the V series Recommendations may be provided by some Administrations.

Note 4. — See Supplement No. 29 to this Volume VIII.

Note 5. — Further studies as indicated in Question 1/VII—point Q are required.

Recommendation X.30

STANDARDIZATION OF BASIC MODEL PAGE-PRINTING MACHINE IN ACCORDANCE WITH INTERNATIONAL ALPHABET No. 5

(Geneva, 1972)

The C.C.I.T.T.,

considering

that the basic model page-printing machine is defined as having certain basic features for receiving (including printing) and/or transmitting;

Recommendations V.3 and V.4 of the C.C.I.T.T.;

unanimously declares the view

1) the sets of graphics to be used should be either:

one set of 95 characters consisting of columns 2 to 7 in the code table of International Alphabet No. 5 excluding the character DEL; or

one smaller set of 64 characters consisting of columns 2 to 5 of the code table of International Alphabet No. 5;

if the machine is designed only for the smaller set of characters, the logic of the machine must be such that it prints the appropriate capital letters even when it receives a code combination for small letters;

Note. — The interpretation, by 64-character machines, of other than alphabetic characters in columns 6 and 7 of the code table is at the discretion of Administrations for the time being.

2) the number of characters which the line of text of the basic model page-printing machine may contain should be fixed at 80;

3) for direct printing machines at speeds up to 20 characters per second the carriage return time (operation effected by the format effector CR, position 0/13 in the code table of International Alphabet No. 5) should not exceed the duration of 4 characters. At 30 characters per second operation, this time should not exceed the duration of 6 characters;

4) the time elapsing between the application of power to the motor of a machine and the machine's running up to speed and being ready to receive or send characters should not exceed 600 ms. In the case where the machine is used in a switched network, this elapsed time shall start from the instant when an incoming call is received at the interface.

Note. — Manufacturers should endeavour to minimize this time.

Recommendation X.31

CHARACTERISTICS, FROM THE TRANSMISSION POINT OF VIEW, AT THE INTERCHANGE POINT BETWEEN DATA TERMINAL EQUIPMENT AND DATA CIRCUIT-TERMINATING EQUIPMENT WHEN A 200-BAUD START-STOP DATA TERMINAL EQUIPMENT IN ACCORDANCE WITH INTERNATIONAL ALPHABET No. 5 IS USED

(Geneva, 1972)

Taking into account Recommendations V.3 and V.4 of the C.C.I.T.T., this Recommendation applies, except where otherwise specified, to " start-stop apparatus ", in the wide sense of the term as defined in 34.14 of the *List of Definitions*, Part I, and that it covers also reperforators, service signals sent by the switching equipments, the signals of answer-back units, automatic transmitters, etc.

The characteristics laid down below are those which should be evident in service conditions at the interchange point between data terminal equipment and data circuit-terminating equipment.

The C.C.I.T.T. *unanimously declares the view:*

Equipment characteristics

1. The nominal modulation rate should be 200 bauds.

2. The difference between the real mean modulation rate of the signals when in service and the nominal rate should not exceed $\pm$ 0.1 %.

3. The nominal duration of the transmitting cycle should be at least 11 units, the stop element lasting for at least 2 units.

4. The receiver must be able to translate correctly in service the signals coming from a transmitter with a nominal transmitting cycle of 10 units (see Recommendation V.4).

Transmitter characteristics

5. The degree of gross start-stop distortion of transmitted signals, measured at the interchange point between data terminal equipment and data circuit-terminating equipment, must not exceed 5 %. This value applies to all working conditions of the equipment under consideration encountered during normal service, whether the signals are transmitted separately or whether they succeed one another at the maximum rate compatible with the modulation speed.

It is recommended that the measurement should be made with a start-stop distortion measuring set for two consecutive periods, each of them corresponding to the transmission of about 1200 transitions (i.e. about 15 s), early distortion being observed during one period and late distortion during the other.

Receiver characteristics

6. The effective net margin measured at the interchange point between data terminal equipment and data circuit-terminating equipment should not be less than 40 % for signals sent by a transmitter having a nominal cycle equal to or greater than 10 units.

It is recommended that the measurement should be made under the following conditions, in service:

— 11-unit cycle for the signals transmitted by the measuring apparatus;

— use of one of the signal trains specified in Recommendation X.33;

— first test with an identical distortion rate on all transitions of the signal train, obtained by lengthening the start element;

— a second test with the same rate of identical distortion on all the transitions of the signal train, but obtained in this case by shortening the start element;

— reading the margin when one error per test sentence is obtained. (The margin is the lesser of the two values of the degree of distortion obtained from the two measurements.)

The length of the start element must in no case be less than 50% of the unit element [1].
The length of the unit element must in no case be less than 50% of the unit element [1].

Note. — It will be up to Administrations using some other measuring method to work out for their own use figures to give equivalent results to those which would have been obtained by the recommended method.

Recommendation X.32

ANSWER-BACK UNITS FOR 200-BAUD START-STOP MACHINES IN ACCORDANCE WITH INTERNATIONAL ALPHABET No. 5

(Geneva, 1972)

The C.C.I.T.T.,

considering

that start-stop machines are capable of receiving communications without the aid of an operator;

that it may be necessary to verify the correct functioning of the line and of the distant terminal equipment,

unanimously declares the view

that if the use of an automatic answer-back unit is requested, it would be advisable:

1. to effect the operation of the code transmitter by the control character ENQ, position 0/5 in the code table of International Alphabet No. 5 (Recommendation V.3);

2. to compose the code-emission by a series of 20 signals, as follows:

1 CR (position 0/13 in the code table),

1 LF (position 0/10 in the code table),

2 non-printing, non-carriage moving signals (but which may include CR),

16 signals chosen for the subscriber comprising the identification of the apparatus;

3. when the code signal does not comprise 16 characters, to distribute them by inserting at the beginning as many fill signals (such as DEL or NUL) as are necessary to make up the total of 16 signals;

4. that the answer-back signals follow Recommendations V.4 and X.31;

5. that the delay between the reception of the beginning of the start unit of control character ENQ and the beginning of the start unit of the first signal of the answer-back sent by the machine should lie between one and four character periods.

[1] Provisional value to be made definitive in the light of future experience.

Recommendation X.33

STANDARDIZATION OF AN INTERNATIONAL TEXT FOR THE MEASUREMENT OF THE MARGIN OF START-STOP MACHINES IN ACCORDANCE WITH INTERNATIONAL ALPHABET No. 5

(Geneva, 1972)

The C.C.I.T.T. *unanimously declares the views:*

1) that it is not necessary to standardize a single international text for the measurement of the margin of a teleprinter;

2) that nevertheless it would be of interest to recommend to the operating Administrations the use of one or other of the following texts (based on the international reference version of Alphabet No. 5):

a) in case of application of the 95 characters set (columns 2 to 7 in the code table)

VoyeZ Le BricK GéanT QuE J'ExaminE PrèS Du WharF 123 456 7890 + – × : = ¤ %()

ThE QuicK BrowN FoX JumpS OveR ThE LazY DoG 123 456 7890 + – × : = ¤ %()

b) in case of application of the 64 characters set (columns 2 to 5 in the code table)

VOYEZ LE BRICK GEANT QUE J'EXAMINE PRES DU WHARF 123 456 7890 + – × : = ¤ %()

THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 123 456 7890 + – × : = ¤ %()

SECTION 3

TRANSMISSION, SIGNALLING AND SWITCHING

Recommendation X.40

STANDARDIZATION OF FREQUENCY SHIFT MODULATED TRANSMISSION SYSTEMS FOR THE PROVISION OF TELEGRAPH AND DATA CHANNELS BY FREQUENCY DIVISION OF A PRIMARY GROUP

(Geneva, 1972)

The C.C.I.T.T.,

considering

1. That some Administrations are planning the introduction of public data networks;

2. That, to facilitate interworking between some networks, it is desirable to standardize the characteristics of transmission systems for the provision of channels for certain maximum modulation rates;

3. That interest has been expressed in deriving channels by frequency division of a primary group;

4. That Recommendation X.1 defines the user classes of service for public data networks;

5. That Recommendation X.1 includes user classes 3, 4 and 5 which correspond to maximum user data signalling rates of 600 bit/s, 2400 bit/s and 9600 bit/s, the transmission channels for which can be economically provided by frequency division of a primary group;

Note. — In the case of synchronously operated terminals a method of keeping synchronism between the subscribers is necessary. This implies the need for a method to provide bit sequence independency in accordance with Recommendation X.2, e.g. a scrambler. This is provided external to this system but forms part of the network.

6. That, for the present, no interest has been shown in providing separate channels for 600 bauds;

7. That standardization of channels for modulation rates less than 600 bauds, for example 200 bauds, is the subject of other Recommendations (e.g. R.38 A and R.38 B);

8. That there could be economic advantages in providing 2400- and 9600-baud channels (and possibly, in due course, 600-baud) in the one system;

unanimously declares the following view:

1. A primary group will be used as a bearer circuit;

2. The nominal modulation rates should be standardized at 2400 bauds and 9600 bauds;

3. For the 2400-baud channels the nominal mean frequencies are: (110-4n) kHz, where n = 1, 2, . . ., 12 (Figure 1/X.40).

For the 9600-baud channels the nominal mean frequencies are 96 kHz for channel 1 and 72 kHz for channel 2 (Figure 1/X.40).

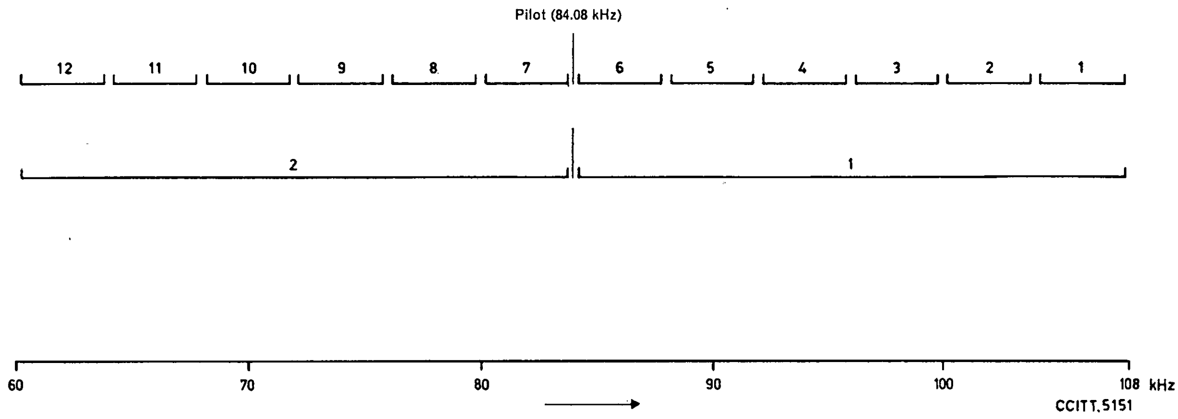


FIGURE 1/X.40. — **Division of the primary group into data channels for 2400 bauds and 9600 bauds**

The mean frequency F_0 is defined as the half-sum of the characteristic frequencies corresponding to the start polarity (F_A) and the stop polarity (F_Z).

4. The mean frequencies at the sending end should not deviate by more than $\pm$ 20 Hz for both 2400-baud channels and 9600-baud channels.

5. The difference between the two characteristic frequencies in the same channel is fixed at:

2 kHz in the case of 2400-baud channels;

8 kHz in the case of 9600-baud channels.

6. The maximum tolerance of this difference is $\pm$ 10% for both 2400-baud channels and 9600-baud channels.

7. The total average power transmitted to the primary group is limited to —4 dBm0 (400 µW at a point of zero relative level). This sets, for the average power of a derived channel, the limit of

—15 dBm0 for the 2400-baud channels,

—7 dBm0 for the 9600-baud channels,

in a fully equipped system.

Note Recommendation H.52, which in section a) 2 says:

" In order to limit cross-modulation effects in wideband systems, the power level of any individual spectral component in the band 60-108 kHz should not exceed —10 dBm0 (except for the environment of the pilot for which a separate recommendation exists)."

" With regard to its effect on non-telephone type signals, a discrete component is defined as a signal of sinusoidal form with a minimum duration of about 100 ms."

To meet this requirement at 9600 bauds, a data scrambler may be used external to the system.

8. The in-service levels of the permanent " start " polarity and permanent " stop " polarity signals must not differ by more than 1.5 dB and the higher of these two signal levels must comply with those of paragraph 7.

9. The " start " polarity frequency is the lower of the two characteristic frequencies in the primary basic group and the " stop " polarity frequency is the higher one.

10. In the case of 9600 bauds where scramblers are used external to the system to comply with paragraph 7, it will also be necessary to drop the continuous —7 dBm0 " start " polarity signal to —10 dBm0 in the absence of channel modulator control.

11. The receiving equipment should operate satisfactorily when the receiving level falls to 6 dB below the nominal level. The receiving equipment should have been restored to start polarity when the receiving level has fallen to 12 dB below the nominal level.

The alarm-control level is left to the choice of each Administration.

12. The maximum degree of isochronous distortion on standardized text is provisionally fixed at 8% in the whole receiver level range (± 6 dB from nominal level) for closed circuit measurements.

13. Systems should be designed in such a manner that the combined use of 6 channels for 2400 bauds and 1 channel for 9600 bauds is possible.

14. As an optional facility it should be possible to replace any 2400-baud channel, in particular channels No. 1 and No. 12, by a channel translating equipment which enables the insertion of a VFT system according to Recommendations R.35, R.35 bis, R.36, R.37, R.38 A or R.38 B.

Recommendation X.50

FUNDAMENTAL PARAMETERS OF A MULTIPLEXING SCHEME FOR THE INTERNATIONAL INTERFACE BETWEEN SYNCHRONOUS DATA NETWORKS

(Geneva, 1972)

The establishment in various countries of public synchronous data networks creates a need to standardize a multiplexing scheme to be used on international links between these countries.

Considering

that the resolution of the fundamental parameters of a multiplexing scheme is urgently needed for the design of data networks;

The C.C.I.T.T. *unanimously declares the following view:*

1. The multiplex aggregate bit rate of 64 kbit/s should be standardized for international links and framing information for the channels should be contained within the 64 kbit/s capability.

2. For the basic multiplexing of information bearer channels, the following applies:

i) both structures suitable for handling homogeneous (with respect to bearer rates) mixes of bearer channels and structures suitable for handling heterogeneous mixes of bearer channels are required,

ii) the signal elements of each individual channel should be assembled in octets,

iii) the status bits should be included in the octets and should be allocated to the last bit position in the octets (see note below),

iv) an octet interleaved structure should be used,

v) a distributed framing pattern should be used with the framing bits occupying the first bit position in consecutive octets (see note below),

vi) these interleaved octets will appear on the 64 kbit/s bearer as follows:

12.8 kbit/s channels will repeat every 5th octet;
3.2 kbit/s channels will repeat every 20th octet;
800 bit/s channels will repeat every 80th octet.

Note. — Further studies as indicated in Question 1/VII—point S are required.

3. A multiframe will be provided and will be based on a 4-octet grouping in each channel, thus giving a sequence of 32 bits of which 24 are information bits.

4. When links containing a multiframe are connected in tandem to provide a trunk, multiframe integrity shall be maintained across the connection.

5. When either end of an international circuit terminates in a national network operating with multiframing, the international circuit shall use multiframing.

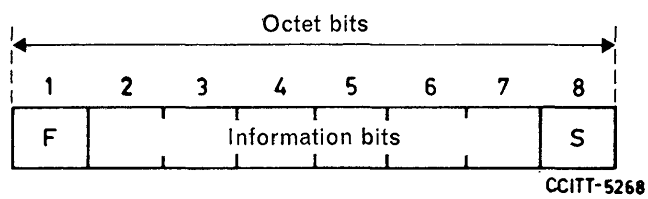
In the case where one of the national networks does not provide multiframing, there is no relationship between the multiframe and any character structure in the data outgoing from that network.

6. When neither end of an international circuit terminates in a national network operating with multiframing, only those items in paragraphs 1 and 2 above apply.

7. In transit switching multiframe integrity shall be retained.

Explanatory notes

1. The basic channel structure is the octet, in which bit 1 is reserved for multiplex framing purposes, bits 2-7 are information bits for the channel, and bit 8 is a status bit:



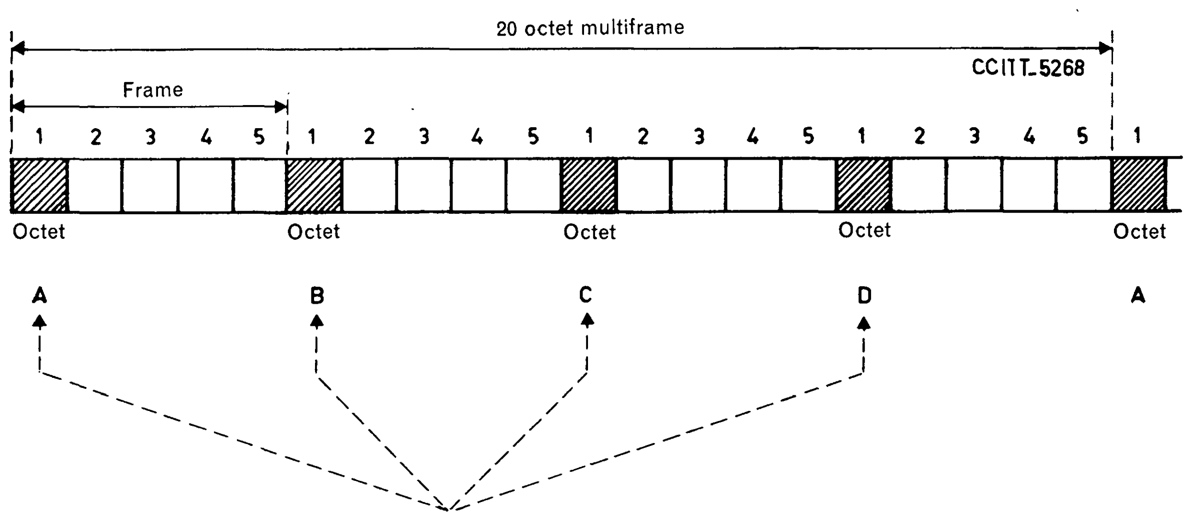
2. The addition of framing and status bits results in a 33% increase in bit rate, so that channel bearer rates are:

12.8 kbit/s for the 9.6 kbit/s user rate;
3.2 kbit/s for the 2.4 kbit/s user rate;
800 bit/s for the 600 bit/s user rate.

3. Octets for each bearer channel are assembled on the 64 kbit/s stream in an octet interleaved basis as follows:

12.8 kbit/s channels repeat every 5th octet;
3.2 kbit/s channels repeat every 20th octet;
800 bit/s channels repeat every 80th octet.

4. Four successive octets of each channel form a group consisting of 32 bits, structured by a multiframe. Thus, for example, for the 12.8 kbit/s bearer channel, the 4-octet group recurs after every 20 octets.



5. The 4-octet group is reassembled on a single channel as a 32-bit group providing 24 information bits. This gives the possibility of accommodating three 8-bit characters, e.g. P, Q, R, as in the following table:

F	P1	P2	P3	P4	P5	P6	S	Octet A
F	P7	P8	Q1	Q2	Q3	Q4	S	Octet B
F	Q5	Q6	Q7	Q8	R1	R2	S	Octet C
F	R3	R4	R5	R6	R7	R8	S	Octet D

6. Similar structures apply to the lower bearer speeds of 3.2 kbit/s and 800 bit/s.

Recommendation X.70

TERMINAL AND TRANSIT CONTROL SIGNALLING SYSTEM FOR START-STOP SERVICES ON INTERNATIONAL CIRCUITS BETWEEN ANISOCHRONOUS DATA NETWORKS

(Geneva, 1972)

With the appearance of public data networks in various countries it becomes necessary to establish the appropriate international control signalling schemes for interworking in order to facilitate the introduction of such networks as much as possible. The main objective of public data networks is to offer to the user a great range of data signalling rates with a minimum of restrictions, very short call set-up and clear-down times and a variety of new service facilities. These requirements can be fulfilled only by a specially conceived signalling system which caters for all foreseeable needs and which is flexible enough to provide also for new, not yet defined, services.

For these reasons, the C.C.I.T.T. unanimously declares the view that for interworking between anisochronous data networks the following control signalling scheme should be used on international circuits:

Note 1. — The start-stop user classes of service are specified in Recommendation X.1.

Note 2. — The signalling for synchronous user classes of service provided on anisochronous networks is the subject of further study.

Note 3. — The signalling on links between synchronous and anisochronous networks is the subject of further study.

1. *General switching and signalling principles*

1.1 The control signalling should be at the maximum data signalling rate of the links for each user class of service. The two classes which are considered applicable to anisochronous types of data network each require a control signalling rate of 200 bit/s. Telex service based upon 50-baud trunks does not form part of this Recommendation.

1.2 Decentralized signalling will apply, the same channel being used for control signalling and data transmission.

1.3 Both terminal and transit operation will be required. Due to the inclusion of transit operation, link-by-link signalling control of calls will be adopted.

Transit and incoming terminal centres will commence onward selection as soon as sufficient routing information is available from the received signals (overlapping of selection signals).

Selection signals will be transmitted in a single block at automatic speed by the originating country, in which case the end-of-selection signal may be omitted. Alternatively, selection signals may be converted (see section 2, Note 4) and retransmitted as they are received from a terminal and in this case an end-of-selection signal will be included. Only one of these alternatives will apply on a route. The incoming country will decide which method will apply.

1.4 The schedule of telex destination codes laid down in Recommendation F.69 will apply also to data networks of the anisochronous type.

Note. — This conclusion is provisional and Question 1/VII—point E provides for further study of this matter and possible alternatives.

1.5 Alternative routing will be permitted. The principle of a few high-usage circuits will be adopted, with overflow on to adequately provided routes between main centres. Overflow on to higher speed circuits will not be permitted.

In order to prevent repeated alternative routing causing traffic to circulate back to the originating point, alternative routing will be restricted to once per call.

1.6 Both-way operation will be assumed and inverse order testing of circuits on both-way routes or a close approximation to it by testing the route in small groups in fixed order always starting the search from the same position will be specified in order to minimize head-on collisions.

1.7 The accounting principle, described in Recommendation F.68, that in all cases, including that of transit switching, the originating country will be responsible for recording accounting information, will apply to public data networks of anisochronous type.

1.8 The grade of service to apply for the provision of circuits for fully-automatic telex service, namely one lost call in 50, would also apply to links between public data networks of anisochronous type which carry traffic overflowed from other routes, or from which overflow was not permitted.

For high-usage direct links circuits would be provided at a grade of service of one lost call in 10.

1.9 Sufficient switching equipment will be provided to ensure that congestion will not be signalled on more than 0.4% of calls in the busy hour, and only then when congestion has been positively identified.

1.10 The characters identifying transit countries will be those of the telex destination codes.

1.11 The target setting-up time for the user classes of service applicable to these types of data networks will be one second.

2. *Specific signalling characteristics*

Notes applicable to this section:

Note 1. — X denotes the international centre which originates the call under consideration on the international link concerned. Y denotes the international centre which receives the call under consideration on the international link.

Note 2. — Timings shown are within the exchange concerned with no allowance being made for propagation and other delays, such as slow sending of selection signals from the originating terminal.

Note 3. — In the signalling description, periods of continuous start (A) polarity or stop (Z) polarity are related to character length rather than time, in case higher rates are to be provided at any time, when the need to change most individual timing intervals will be avoided.

Note 4. — The 4-unit code with one parity bit and single-unit start and stop element used in this control signalling system is listed in Table 8. The parity unit of the signal should correspond to the even parity with regard to elements of Z polarity. The individual bits should be transmitted at the nominal modulation rate with the low order bit (i.e. b_1) first and completed by the parity bit (b_5).

2.1 The signalling system between two data networks of anisochronous type will be as described in Table 1.

2.2 The incoming equipment may release the connection if the calling signal exceeds the maximum period of two characters. Start polarity will be maintained on the backward signalling path from centre Y to centre X.

2.3 The first forward path signal following the calling signal (class-of-traffic signal) is distinctive from the first backward path signal to provide a guard against head-on collisions in the case of both-way operation.

A head-on collision is detected by the fact that centre X receives a first class-of-traffic character instead of the reception confirmation or reception congestion signal.

When a head-on collision is detected, the switching equipment at each end of the circuit should make another attempt to select a free circuit, either on the same group of circuits or on a group of overflow circuits, if they exist. In the event of a further head-on collision on the recall, or on the call attempt via the overflow route, no further recall will be made and the call will be cleared down. In the case of a transit centre, the NC service signal (combination No. 2) followed immediately by the clearing signal, will be returned to the preceding centre after the reception confirmation signal and the country identification code.

2.4 Failure to receive the reception confirmation or reception congestion within 2 seconds from the start of the calling signal, or if the received signal is spurious, as indicated by a character other than a first class-of-traffic character, or the combination of the reception confirmation or reception congestion signal, should initiate the automatic re-test signal on the circuit concerned.

In the case of the failure to receive the correct reception confirmation or reception congestion signal, another attempt to select a circuit should be made (once only). In the case of transit calls, if the second attempt is unsuccessful, the NC service signal (combination No. 2) followed by the clearing signal, will be returned to the preceding centre after the reception confirmation signal and the country identification code.

2.5 Selection signals can be divided into two parts. The first part, designated as the network selection signals, contains information regarding network and user requirements and may be composed of one to seven possible characters (see Tables 2, 3, 4 and 5). The second part comprises the address signals (the called subscriber number which is preceded by the destination code in the case of a transit call).

The network selection signals used in the forward direction (see also Appendix 1 to this Recommendation) are further sub-divided and assembled as follows for signalling purposes. Note that the term " user class of service " has been abbreviated in the following sections to " user class ".

1) *First class-of-traffic character* (see Table 2)

The calling signal is always followed by at least one class-of-traffic character. The bit functions of this character were so chosen that no further characters are needed for most connections.

If there is a need for indication of further requirements, a second class-of-traffic character may be used. Whether the second class-of-traffic and user class characters follow or not, will be indicated by the bits b_3 and b_4 of the first class-of-traffic character.

2) *User class character (Indication of speed and code)* (see Table 3)

This character, if used, will follow the first class-of-traffic character and will be required when, for example, this information cannot be derived from the incoming line.

When eight user class characters in Table 3 are not sufficient, a second user class character may be added by means of an escape character. Whether a second class-of-traffic character follows or not, it will be indicated by the bit b_4 of the first user class character.

3) *Second and further class-of-traffic characters* (see Table 4)

These characters follow any user class characters required.

The number of these class-of-traffic characters depends on the number of user facilities available.

The bit b_4 of the second class-of-traffic character will indicate whether a third class-of-traffic character follows or not.

4) *Closed user group character* [1] (see Table 5)

These characters are only used in conjunction with the second and possibly subsequent class-of-traffic signals which may follow.

Eight different closed user groups can be specified by Table 5.

If there is a need for further possibilities, a second closed user group character may be used. This character will be indicated by the bit b_4 of the first closed user group character. Similarly, a third closed user group character may be added, if necessary.

The numerical characters used for the second part of the selection signals are shown in Table 6. When the first class-of-traffic character indicates a terminal call, the Recommendation F.69 telex destination code will be omitted.

2.6 The incoming equipment should maintain start polarity on the backward signalling path by releasing the connection if the first received character is spurious, as indicated by a character other than a first class-of-traffic signal. This procedure prevents the possibility of regarding a second selection signal as a first class-of-traffic character and provides a further safeguard against false calls.

In the case of receipt of a spurious signal as indicated by a character other than a selection signal (with the exception of the first class-of-traffic signal), the incoming equipment should return the NC signal to the preceding centre (after the reception confirmation, and possibly the country identification code), followed by the clearing signal.

The incoming equipment may release the connection if any of the selection signals are not completely received within a period of 15 s.

2.7 The maximum number of digits to be expected in the sum of the destination code and national number is 12.

2.8 In the case of receipt of the reception congestion signal at a transit centre, the NC service signal (combination No. 2) should be returned to the preceding centre (after the reception confirmation and possibly the country identification in the case of a transit centre) and followed by the clearing signal.

2.9 The country identification code shall be sent following the reception confirmation signal in all cases of transit calls but not for terminal calls. However, when a service signal is returned from the destination network for reasons other than failure or congestion of the called subscriber line, or the called number is spare, it should be followed immediately by the country identification code.

If several transit countries are involved in setting up a call, the calling network will receive the country identifications one after the other.

This information could be useful for retracing the route followed by a call (for traffic statistics, international accounts, analyses of unsuccessful calls and the clearing of faults).

It is possible for a transit centre to receive backward path signals, such as country identification codes, call-connected signal or service signals, from subsequent centres whilst the backward path signals originated locally are still being sent. It is necessary for the transit centre to ensure that the received signals are retransmitted to the preceding centre without mutilation or loss.

2.10 The backward path signals indicating effective and ineffective call conditions are scheduled in Tables 7 and 7a.

---

[1] See Definition 52.48.

2.11 If at the first transit centre the call-connected or service signal is not received within 60 s from the end of selection then the NC signal will be returned to the preceding centre.

Note. — The need of this signal and its timing are subject to further study.

2.12 If the called station is not able to receive data information immediately, the connect-through signal and possibly the call-connected signal should be delayed accordingly.

2.13 The connect-through signal confirms that the identification of calling or called subscriber has been completely received by the terminating or originating exchange respectively and converted and retransmitted to the subscriber as explained in the following Table A.

TABLE A

USE OF THE CONNECT-THROUGH SIGNAL [a]

		The identification of the called subscriber is required by the originating exchange (signalled on the forward path) and sent by the terminating exchange (backward path)	
		no	yes
The identification of the calling subscriber is required by the terminating exchange (signalled on the backward path) and sent by the originating exchange (forward path)	no	— —[b]	forward path —[b]
	yes	— backward path	forward path backward path

[a] See also Appendix 2.

[b] In these cases the call-connected signal additionally serves the purpose of the connect-through signal.

2.14 The guard period on clearing should be a period of 14 characters measured from the appearance of start polarity on both signalling paths. The equipment at the incoming end shall be completely released and ready to receive a new call after a maximum period of 14 characters.

2.15 The automatic re-test signal will be initiated as indicated in paragraph 2.4.

The circuit should be tested five times and a check made to confirm the receipt of the reception confirmation signal in response to each test. When the reception confirmation signal is received, the circuit should be returned to service. If no reception confirmation is received on any of the five test cycles, it should be permanently taken out of service for outgoing traffic and an alarm should be given.

In order to cater for the possibility that a faulty circuit may be seized at both ends, the automatic re-test equipment should be arranged to allow an incoming call to be received during the interval between tests. The intervals between the tests at the two ends of the trunk circuit should be made different to be sure that successive retests do not overlap at both ends. When a circuit is still faulty after five tests it should be busied-out for outgoing traffic but incoming calls should be accepted.

The use of a special first class-of-traffic character for retest permits the incoming centre to be informed about re-tests on its incoming circuits.

2.16 If at the receiving end parity does not check during the establishment of the connection, provisionally the connection should be cleared down unless otherwise specified. However, the possibility of different actions remains open for further study.

TABLE 1

SIGNALLING BETWEEN ANISOCHRONOUS DATA NETWORKS

Note. — For the combination numbers mentioned refer to Table 8.

Signal or function	Forward path (X towards Y)	Backward path (Y towards X)	Remarks
Free line	Start polarity (polarity A)	Start polarity (polarity A)	
Call	Stop polarity (polarity Z) for a minimum period of one character and a maximum period of two characters and then followed immediately by selection signals.		The equipment at centre Y must be connected and ready to receive selection signals within one character period. The minimum and consequently the maximum periods will be lengthened at the request of the incoming country Y. (*Note.* — The duration of the calling signal may require review in the light of false calling signals).
Reception confirmation		Stop polarity followed by combination No. 14.	Stop polarity returned within one character period after the end of receipt of the first class of traffic signal. The return of combination No. 14 shall be commenced within one to two character periods after the inversion to stop polarity. The reception confirmation signal will have to be absorbed by the switching equipment of X and should not be able to go through that equipment to arrive at the preceding centre.
Selection signals	At least one (first class-of-traffic signal only) and possibly several network selection signals depending on the network requirement (see Appendix 1), the two or three digits of the F.69 telex destination code of the called country, the digits of the called terminal number and (possibly) an end-of-selection signal (combination No. 11).		These signals are transmitted immediately after the calling signal without awaiting the reception at X of the reception confirmation signal. The selection signals are transmitted according to the control signalling code at the appropriate data signalling rate for the user class of service concerned, and at automatic speed in which case no end-of-selection signal is employed. The destination code will be omitted for terminal calls.
Country identification		Combination No. 12 followed by the F.69 telex destination code.	For transit calls the combination No. 12 follows the reception confirmation signal at automatic speed within one to two character periods. These signals must go through centre X and arrive at the originating country. For terminal calls, the combination No. 12 follows the service signal character(s), when specified, at automatic speed within one or two character periods.

TABLE 1

SIGNALLING BETWEEN ANISOCHRONOUS DATA NETWORKS *(continued)*

Signal or function	Forward path (X towards Y)	Backward path (Y towards X)	Remarks
Reception congestion		Stop polarity for a period of one or two characters followed by the clearing signal.	This signal is returned within one character period after receipt of the calling signal when the selection signals cannot be received. This signal should be absorbed by centre X and not allowed to be received by a preceding country.
Call connected		One combination of the control signalling code (see Table 7).	See Appendix 2.
Subscriber identification (if required)	Combinations of the calling subscriber's identification code transmitted within one to two character periods of receipt of the call connected signal.	Combinations of the called subscriber's identification code transmitted within one to two character periods of the transmission of the call connected signal.	The combination(s) of the subscriber's identification code comprise the F.69 code (for an international call) followed by the digits of the subscriber's number.
Connect-through (if required)	Combination No. 13 sent after identification has been completely received and retransmitted to the user.	Combination No. 13 sent after identification has been completely received and retransmitted to the user.	See Appendix 2.
Service signals		One or two combinations of the control signalling code (see Table 7), possibly followed by the country identification signals (see para. 2.9) followed by clearing signal.	
Idle circuit	Stop polarity.	Stop polarity.	
Clearing	Inversion to start polarity in the direction of clearing. The minimum recognition time is 6 characters and the maximum time is 12 characters.		
Clear confirmation	Inversion to continuous start polarity in the opposite direction after a minimum duration of 8 characters of clearing signal and a maximum duration of 14 characters.		

TABLE 1

SIGNALLING BETWEEN ANISOCHRONOUS DATA NETWORKS *(concluded)*

Signal or function	Forward path (X towards Y)	Backward path (Y towards X)	Remarks
Guard delay	Period of 14 characters, measured from the appearance of start polarity on both signalling paths.		Equipment at the incoming end shall be completely released and ready to receive a new call after this period.
Automatic re-test	Stop polarity for 1-2 character periods followed by combination No. 13, stop polarity for 1 second and then start polarity for 30 or 36 seconds repeated.		30 seconds of start polarity for one centre and 36 seconds of start polarity for the other centre.
Backward busy	Continuous stop polarity for a maximum of 5 minutes.		

TABLE 2

CODE OF SIGNALS OF THE FIRST CLASS-OF-TRAFFIC CHARACTER

Combination				Condition signalled
b_4	b_3	b_2	b_1	
A	A			No further network selection signals follow
A	Z			Second class-of-traffic character follows without any user class character
Z	A			User class character follows and possibly a second class-of-traffic character
			A	Transit traffic
			Z	Terminal traffic
		A		Alternative routing not allowed
		Z		Alternative routing allowed
Z	Z	A	A	Re-test signal
Z	Z	A	Z	Not allowed (used for reception confirmation on the backward path)
Z	Z	Z	A	Reserved for national use
Z	Z	Z	Z	Reserved for national use

TABLE 3

CODE OF SIGNALS OF THE USER CLASSES (*indication of speed and code*) [a]

Combination				Condition signalled	
b_4	b_3	b_2	b_1	speed (bit/s)	code length (units/char.)
A				No second class-of-traffic character follows	
Z				A second class-of-traffic character follows	
	A	A	A	200	11
	A	A	Z	50-200	7.5-12
	A	Z	A	[b]	
	A	Z	Z	[b]	
	Z	A	A	[b]	
	Z	A	Z	[b]	
	Z	Z	A	[c] Reserve	
	Z	Z	Z	Escape character when a second user-class character follows	

[a] The user class character may be omitted if, for example, the information can be derived from the incoming line.
[b] Used in telegraph networks (see Recommendation U.12).
[c] Additional signalling rates and structures may be specified further.

TABLE 4

CODE OF SIGNALS OF THE SECOND CLASS-OF-TRAFFIC CHARACTER

Combination				Condition signalled
b_4	b_3	b_2	b_1	
A				No third class-of-traffic character follows
Z				Third class-of-traffic character follows [a]
	A			No closed user-group character follows
	Z			Closed user-group character follows
		A		Identification of the called terminal not required
		Z		Identification of the called terminal required
			A	Reserve
			Z	Reserve

[a] Reserve for future needs.

TABLE 5

CODE OF CLOSED USER-GROUP CHARACTERS

Combination				Condition signalled
b_4	b_3	b_2	b_1	
A				No further closed user-group character follows
Z				Further closed user-group character follows
	A	A	A	0 Octal digit of closed user group
	A	A	Z	1
	A	Z	A	2
	A	Z	Z	3
	Z	A	A	4
	Z	A	Z	5
	Z	Z	A	6
	Z	Z	Z	7

TABLE 6

TABLE OF DECIMAL DIGITS AND MISCELLANEOUS SIGNALS

Combination				Condition signalled
b_4	b_3	b_2	b_1	
A	A	A	A	digit 0 Used to express destination code, country identification code, called terminal number and terminal identification
A	A	A	Z	,, 1
A	A	Z	A	,, 2
A	A	Z	Z	,, 3
A	Z	A	A	,, 4
A	Z	A	Z	,, 5
A	Z	Z	A	,, 6
A	Z	Z	Z	,, 7
Z	A	A	A	,, 8
Z	A	A	Z	,, 9
Z	A	Z	A	End-of-selection signal
Z	A	Z	Z	Reserve
Z	Z	A	A	Connect-through signal
Z	Z	A	Z	Not allowed (used for reception confirmation on the backward path)
Z	Z	Z	A	Reserve
Z	Z	Z	Z	Reserve

TABLE 7

CODE OF SIGNALS FOLLOWING THE RECEPTION-CONFIRMATION SIGNAL

Combination				Condition signalled
b_4	b_3	b_2	b_1	
A	A	A	A	OCC
A	A	A	Z	NC
A	A	Z	A	DER
A	A	Z	Z	ABS
A	Z	A	A	NA
A	Z	A	Z	NP
A	Z	Z	A	NCH
A	Z	Z	Z	Escape character for further service signals [a]
Z	A	A	A	„ „ „ „ call-connected signals [b]
Z	A	A	Z	Reserve
Z	A	Z	A	Reserve
Z	A	Z	Z	Start of country identification code
Z	Z			Call-connected signal
			A	„ „ „ call metering
			Z	„ „ „ no call metering
		A		„ „ „ no identification of the calling terminal required
		Z		„ „ „ identification of the calling terminal required

[a] See Table 7 a.

[b] This extension is not yet specified. It will be necessary to define expanded ranges of call-connected facility when they are known.

TABLE 7 a

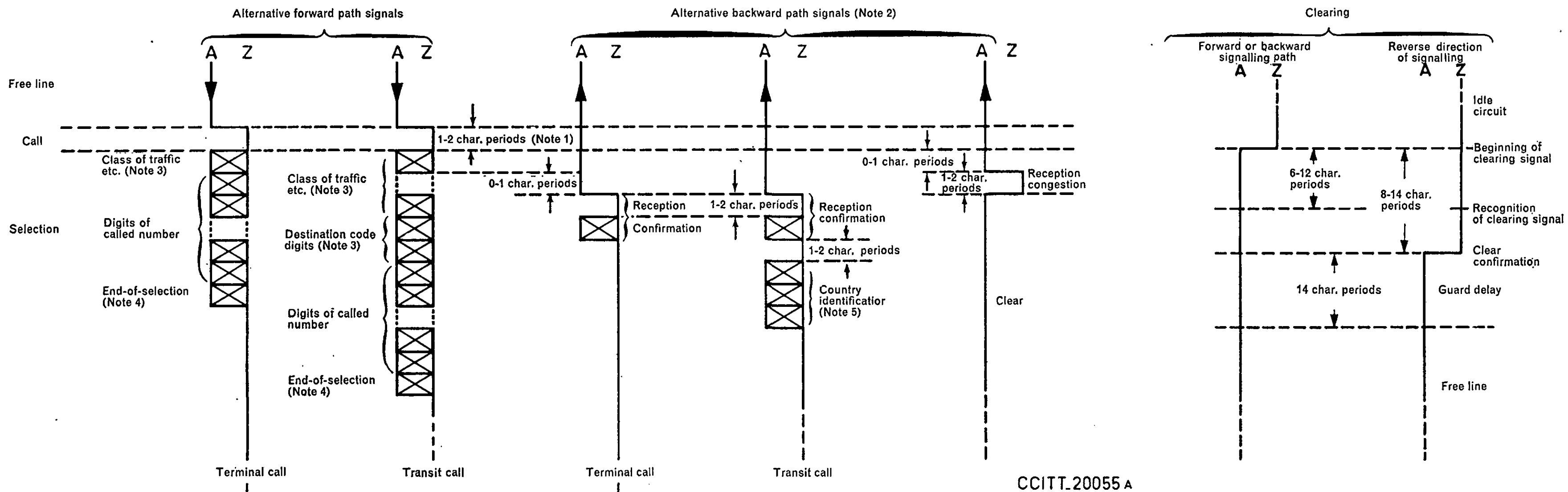
CODE OF SIGNALS FOLLOWING THE ESCAPE CHARACTER AZZZ (see Table 7)

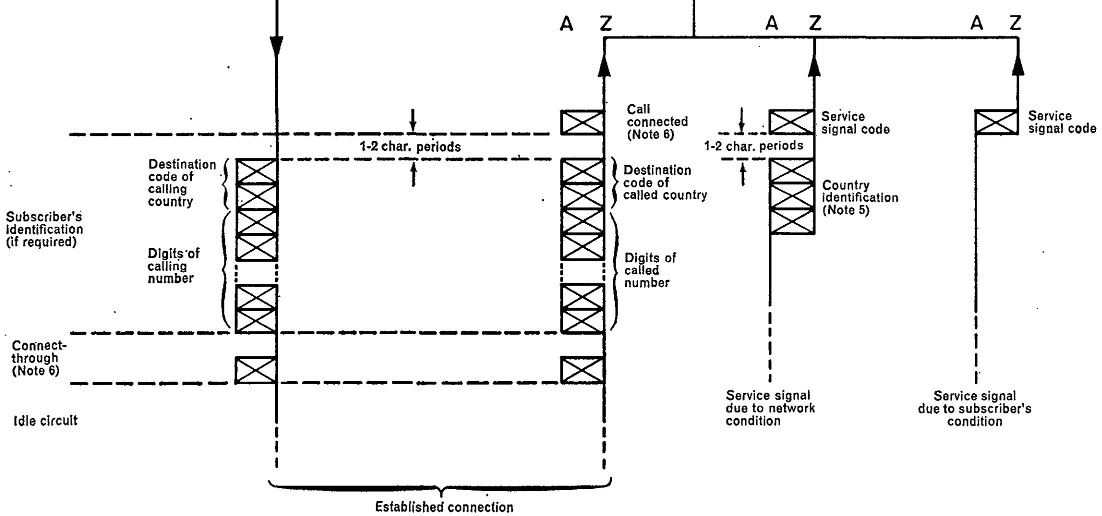
Combination				Condition signalled
b_4	b_3	b_2	b_1	
A	A	A	A	INF
A	A	A	Z	Reserve for international purposes
A	A	Z	A	
A	A	Z	Z	
A	Z	A	A	
A	Z	A	Z	
A	Z	Z	A	
A	Z	Z	Z	
Z	A	A	A	Reserve for national purposes
Z	A	A	Z	
Z	A	Z	A	
Z	A	Z	Z	
Z	Z	A	A	
Z	Z	A	Z	
Z	Z	Z	A	
Z	Z	Z	Z	

TABLE 8

TABLE OF THE CONTROL SIGNALLING
CODE USED FOR INTERWORKING BETWEEN ANISOCHRONOUS DATA NETWORKS

No.	Combination			
	b_4	b_3	b_2	b_1
1	A	A	A	A
2	A	A	A	Z
3	A	A	Z	A
4	A	A	Z	Z
5	A	Z	A	A
6	A	Z	A	Z
7	A	Z	Z	A
8	A	Z	Z	Z
9	Z	A	A	A
10	Z	A	A	Z
11	Z	A	Z	A
12	Z	A	Z	Z
13	Z	Z	A	A
14	Z	Z	A	Z
15	Z	Z	Z	A
16	Z	Z	Z	Z





Notes :

1. Timings are shown as character periods of the 4 (+ 1 parity) bit code and are therefore applicable at all control signalling rates. Switching and propagation delay are not included.
2. Forward path signals may also appear on the backward path indicating a head-on collision on bothway circuits.
3. Network selection signals (class of traffic, user class signals, etc.): see Tables 2-5. Destination codes may comprise 2 or 3 digits.
4. Selection signals may be always sent as a single block by the originating country when there will be no end of selection signal or they may be sent as received from the caller, but then the end of selection signal must be included.
5. The country identification comprises a distinctive character followed by the destination code of the country concerned.
6. For additional information regarding call-connected and connect-through signal, see Appendix 2.

FIGURE 1/X.70. — Signalling between data networks of anisochronous type

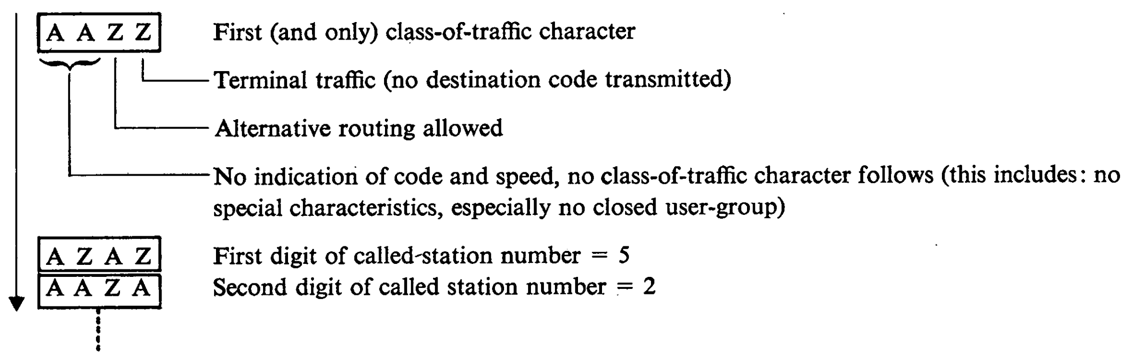
APPENDIX 1

(to Recommendation X.70)

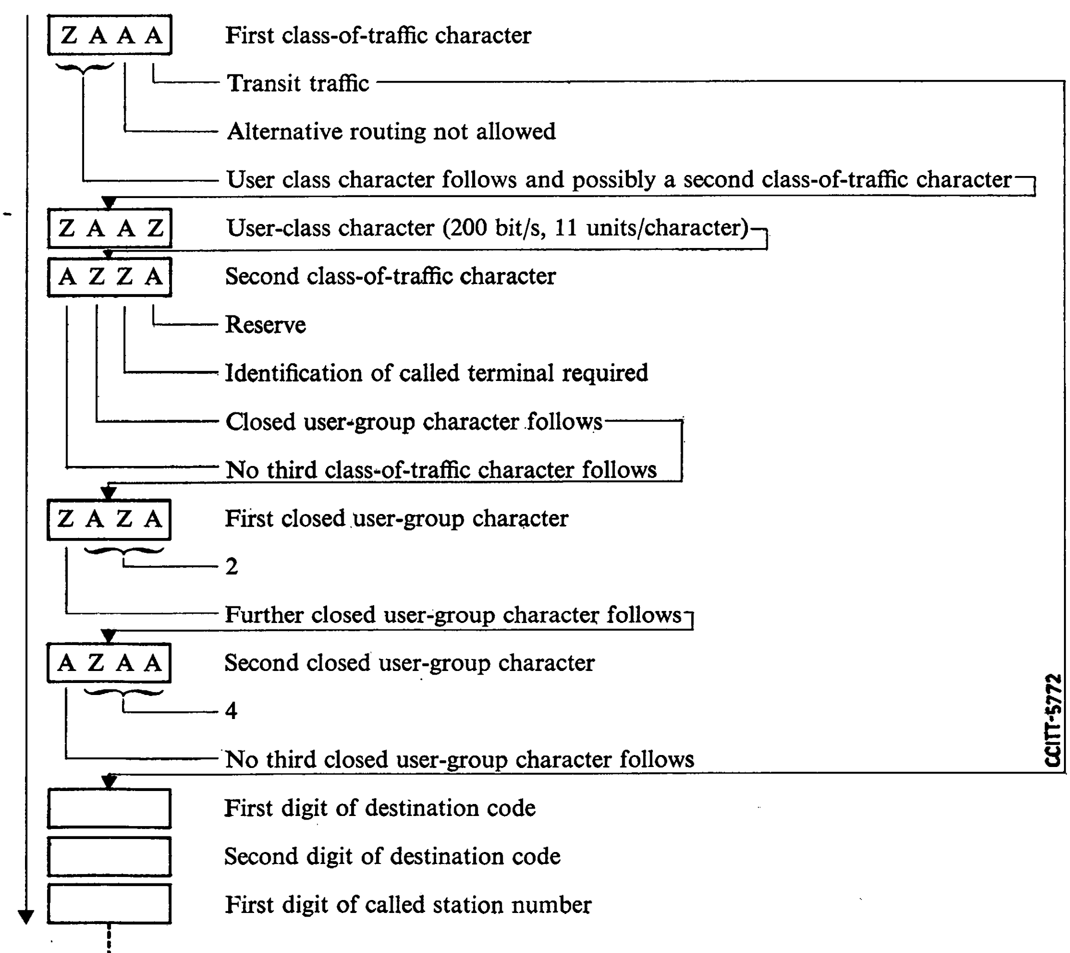
Example of network selection signals

1. *First example (minimum sequence of network selection signals)*

This example shows a sequence of minimal length. (The preceding calling signal, start and stop elements and the parity bit are not shown. The bits are shown in the order of b_4, b_3, b_2 and b_1).



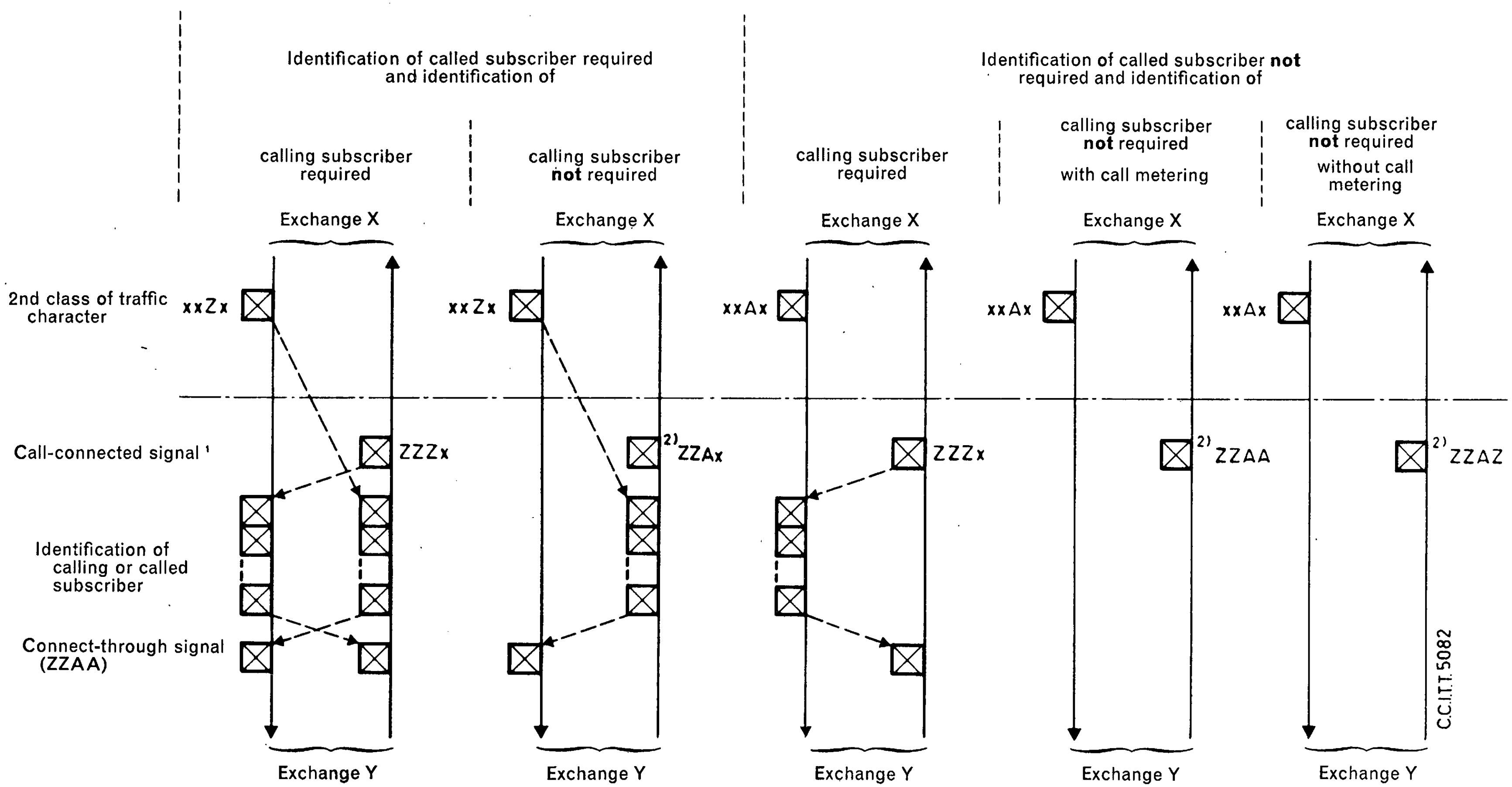
2. *Second example (a sequence of network selection signals including closed user-group characters)*



APPENDIX 2

(to Recommendation X.70)

Use of connect-through signal



¹ Escape character for further call-connected signals (see Table 7) is not considered here.

² In these cases the call-connected signal additionally serves the purpose of the connect-through signal.

PAGE INTENTIONALLY LEFT BLANK

PAGE LAISSEE EN BLANC INTENTIONNELLEMENT

QUESTION ON DATA TRANSMISSION ENTRUSTED TO SPECIAL STUDY GROUP A FOR THE PERIOD 1973-1976

Chairman : Mr. V. N. VAUGHAN (United States of America - American Telephone and Telegraph Company)

Vice-Chairmen : Mr. G. D. ALLERY (United Kingdom Post Office)

Mr. H. BIEHLER (Federal Republic of Germany)

Mr. G. DENNERY (France)

Question 1/A — Data transmission

(continuation of Question 43 of Study Groups 1 and 8, 1957-1960, amended at Geneva, 1964, at Mar del Plata, 1968, and at Geneva, 1972)

What general characteristics should be standardized to permit international data transmission over telephone or telex networks ?

ANNEX

(to Question 1/A)

Study programme for further study of the Question:
Points for special study and recommendations on the test to be made

Note. — An asterisk (*) indicates an urgent study point.

Point	Title	Remarks
B	Supplement to the vocabulary for data transmission	
C	Complement to standardization of International Alphabet No. 5	Concerns also Study Groups I (Question 6/I) and VIII (Question 9/VIII)

Point	Title	Remarks
J	Use of leased telephone-type circuit for the simultaneous transmission of: 1) data and speech; 2) data and facsimile signals	To be examined by Joint Working Party LTG
L	Tests for data transmission systems on telephone-type circuits	Concerns also Study Group IV
O *	Modem for data signalling rates above 1200 bits per second on the general switched telephone network and 2400 bits per second on telephone-type leased circuits	
Q	Further study of parallel data transmission for universal use on telephone circuits	
Q *bis* *	Study of parallel data transmission systems using the push-button telephone signalling frequencies	
R *	Error control in the general telephone network	
S + T	Measurement of phase distortion and transmission loss between subscribers	Concerns also Study Groups IV and XIV
U	Specification of characteristics of circuits leased for data transmission; measuring techniques to check these characteristics	Concerns also Study Group IV
V	Specification of impulsive noise limits for data transmission over switched telephone circuits	Concerns also Study Group IV
W *	Maintenance methods	Concerns also Study Groups IV and VIII
Y	Automatic originating and answering of calls in the telephone network	
Z *	Data transmission over 48-kHz and 240-kHz circuits	Concerns also Joint Working Party LTG (Questions 28 and 29/XV)
AB	Use of digital transmission (or pulse code modulation)	To be examined by Special Study Group D
AC	Use of circuits established by means of satellite	
AD	Comparative tests of modems for use over telephone-type circuits	
AE *	Interchange circuits	
AG	Transmission constraints on wideband data system	Concerns also Joint Working Party LTG (Questions 28 and 29/XV)
AH	Modems for transmission of medical analogue data	
AI	Transmission of data over intercontinental telephone-type circuits	
BA *	Duplex modems	
BB	Tests for data transmission systems on wideband circuits	
BC	Revision of the existing V series Recommendations	

Question 1/A - point B — Supplement to the vocabulary for data transmission

(continuation of point B of the study programme 1964-1968, amended at Mar del Plata, 1968, and at Geneva, 1972)

This study should be pursued, bearing in mind:

— definitions included in the *List of definitions of essential telecommunication terms*—2nd edition, 1961, and in the first and second Supplements to this List.
— definitions included in the list of definitions published in the *Green Book*, volume VIII.
— study of definitions for p.c.m. terms by Special Study Group D.
— study of definitions of terms for public data networks by Study Group VII.

Question 1/A - point C — Complement to standardization of International Alphabet No. 5

(continuation of point C of the study programme 1964-1968, amended at Mar del Plata, 1968)

1. Study of points arising from the implementation of Recommendations V.3 (International Alphabet No. 5) and V.4 (General structure of signals of International Alphabet No. 5 code).

2. Further study of the definitions and use of certain control characters such as " shift-out ", " shift-in ", ESC (Escape), DLE (Data link escape), etc.

Note 1. — This point is concerned with Question 6/I (Study Group I) and Question 9/VIII (Study Group VIII).
Note 2. — The study should be pursued in co-operation with the I.S.O.

Question 1/A - point J — Use of leased telephone-type circuit for the simultaneous transmission of: 1) Data and speech; 2) Data and facsimile signals

(continuation of point J of the study programme 1964-1968, amended at Mar del Plata, 1968, and at Geneva, 1972)

Note 1. — This point is to be examined by the Joint Working Party LTG.

Note 2. — This point is concerned with Question 6/XIV (Study Group XIV) and Question 24/XV (GM/LTG).

Question 1/A - point L — Tests for data transmission systems on telephone-type circuits

(continuation of point L of the study programme 1964-1968, amended at Mar del Plata, 1968, and at Geneva, 1972)

It would be difficult and probably undesirable to establish a rigid test specification, but nevertheless some guiding principles can be given for further tests.

1. *Preliminary laboratory tests*

The recommendations given below apply to systems which have already been subjected to the normal laboratory tests applied to new transmission systems.

2. *Arrangement of the test connection*

It is possible to set up the test connection on a point-to-point basis or in the form of a loop. The former arrangement most closely resembles the practical case but there are serious difficulties involved in transporting equipment and personnel.

A satisfactory form of loop testing can be achieved by connecting the transmitting apparatus to a distant point by means of a high-quality circuit producing no noise or attenuation in the test conditions. The return circuit to the receiving apparatus can be set up in a variety of ways as detailed later.

3. *Data signalling rate*

It is recommended that a data signalling rate be selected from those which are preferred or permitted by Special Study Group A (see also Recommendations V.22 and V.22 *bis*).

Special Study Group A expressed the opinion that three preferred rates can be stated, namely 2400 bit/s, 1200 bit/s and 600 bit/s, for use over telephone connections established on the switched network.

Special Study Group A would also like tests to be made at other rates, namely 200, 1800 and 3000 bit/s or more.

On point-to-point circuits, the preferred rates would be 600, 1200, 2400 and 4800 bit/s and tests asked for data signalling rates of 3600, 7200 and 9600 bit/s.

4. *Signal level*

It is recommended that the tests should be made at the signal level which is proposed in Recommendation V.2. Additional tests should be carried out at levels 6 dB above and below the level proposed. In the event that no particular value of signal level is recommended, systems should be tested on the basis of a signal level of −10 dBm0 with auxiliary tests at levels 6 dB above and below this value. Tests at 6 dB above the recommended levels should be made only if they do not cause interference with other circuits.

5. *Sampling of test circuits*

The system performance tests using the 511-bit pseudo-random test pattern standardized in Recommendation V.52 should be carried out on a selection of samples totalling not less than the quantities shown in the following table:

Data-signalling rate	Leased circuits	Switched circuits
600	2×10^7 bits	4×10^7 bits
1200	4×10^7 bits	8×10^7 bits
1800 and above	8×10^7 bits	2×10^8 bits

For the leased circuits, the samples chosen should be representative of the facilities likely to be frequently used in practice.

For the switched circuits, the tests should include at least 25 different connections which are representative of the facilities likely to be experienced in practice.

The tests should be restricted to the business hours of normal working days and the samples should be representative both of the working day and the different attenuation conditions which may be experienced in practice.

Tests should also be made on long and complicated circuits.

No special maintenance should be carried out on circuits.

6. *Error record*

It was agreed that there are two possible forms in which the error statistics might be recorded:

i) A complete fault statement including the exact position of all faults. Such raw material could be used for a variety of statistical studies necessary for the overall design of a data transmission system.

ii) A simplified fault record indicating totals for a number of predetermined parameters which could be easily obtained during the testing process.

It was agreed that the complete fault statement was preferable for general assessment and essential for the evaluation of the error detection part of the system. The simplified record will be valuable for the comparison of different data transmission systems and line facilities.

7. *Presentation of results*

It is recommended that for all tests the following statistics should be recorded:

i) block-error rate for given block sizes;

ii) number of erroneous bits within erroneous blocks;

iii) error burst length (a burst being regarded as constituted by errors separated by 10 or more error-free elements);

iv) structure of error bursts or error distribution;

v) average element-error rate.

8. *Information concerning connections used for test*

It is desirable that characteristics of the connection used for data tests should be obtained by monitoring and by measurement. For example, if the transmission of data causes any unwanted operation of signalling equipment with a consequential adverse effect on the stability of the connection, this should be recorded. Similarly it should be recorded if the reception of the test message is adversely influenced by warning tones, metering signals, etc. The presence and extent of switch noise, dial impulses and random impulse noise should be noted. The level of the signals at the receiving apparatus, the level of white noise and, if possible, noise bursts, attenuation distortion and phase distortion, should also be recorded.

9. *Statistics of the public switched telephone network*

In the study of the data transmission characteristics to be standardized for data signalling rates in excess of 1200 bit/s on the general switched telephone network it is desirable that the results should be capable of application in the maximum number of situations.

In order to achieve this, Special Study Group A should be in possession of as much information as possible concerning the properties and technical limitations of public switched telephone networks and international links. Therefore, it would be very helpful if Administrations could obtain and submit as a contribution as many statistics as possible in order to further the studies. Much of this information will be valuable in studying other points of Question 1/A.

Subjects on which information would be of interest are enumerated below. Many relevant contributions on specific subjects have been made previously to either Special A or other Study Groups in which case it will only be necessary to give the appropriate reference. Information on the following would be useful:

1) inband signalling systems, their limitations and percentage usage. If any obsolescent systems are to be replaced in the future, such information would be useful;

2) presence of echo suppressors within a country and any disabling features they contain. Possibilities of simultaneous backward channel operation;

3) subscriber-to-subscriber loss over as much as possible of the available bandwidth. The information might be relative to the loss at 800 or 1000 Hz plus the slope over the frequency

band, or the actual loss at a number of discrete frequencies covering the band, the latter being preferable as the former can give pessimistic results;

4) phase distortion between subscribers;

5) phase jitter;

6) presence of sudden changes of phase or amplitude or short line breaks and the frequency of occurrence;

7) impulsive noises not included in 6 above;

8) signal/listener echo ratios;

9) signal/background noise ratios including information about special noise sources, e.g. p.c.m. systems;

10) any non-linearity giving rise to harmonics and intermodulation products;

11) probability of successful connections with regard to data transfer considering the limits set for the error rate and distortion (e.g. Recommendation V.50).

It is appreciated that the above list of subjects is a formidable one but any information that can be obtained on any of the aspects will be useful.

10. *Interruption of the connection used for the test*

It was agreed that in the event of the connection used for the test being interrupted for a period exceeding 300 milliseconds, it should be considered that the connection was " out of service " during such an interval; such periods are to be ignored when the test results are evaluated, but will be indicated in the test record (duration, time of occurrence, and, if possible, the cause).

11. *System description*

It is recommended that the performance results should be accompanied by a brief description of the basic characteristics of the data transmission system undergoing test. In addition, a short explanation of the method of testing used would be advisable.

12. The results of this test are of interest for Study Group IV (Maintenance on the general telecommunication network), which is to be kept informed by the C.C.I.T.T. Secretariat.

Note. — See Supplements Nos. 1 to 11 of this volume.

Question 1/A - point O* — Modem for data signalling rates above 1200 bits per second on the general switched telephone network and 2400 bits per second on telephone-type leased circuits

(continuation of point O of the study programme 1964-1968, amended at Mar del Plata, 1968, and at Geneva, 1972)

1. Study of points arising from the implementation of Recommendations V.26, V.26 *bis* and V.27.

2. Further study of modems of more advanced design which would provide a higher reliability of transmission at 2400 bit/s or even at a higher rate on the general switched telephone network.

Considering that Recommendation V.26 *bis* defined the characteristics of a modem which can provide limited 2400 bit/s operation on the general switched telephone network, the following points should be considered for a modem to achieve a high probability of satisfactory operation on international connections:

— type of modulation;

— synchronization;

— necessary bandwidth;
— equalization technique;
— possibility of higher speed operation and control of this function;
— possibility of some degree of compatibility with Recommendation V.26 *bis*;
— backward channel.

3. Study of 4800 bit/s modems used on leased circuits other than those recommended in Recommendation M.102 (for example: increased noise level and greater frequency distortion over long circuits).

4. Study of modems for data signalling rates in excess of 4800 bit/s on leased point-to-point and multipoint circuits, e.g. 7200, 9600 bit/s.

In considering the relative merits of the above data signalling rates the cost effectiveness of the implementation of each rate should be studied with a view to minimizing the numbers of recommended rates and modems.

For the rates in question consideration should be given to:
— type of modulation;
— synchronization;
— necessary bandwidth;
— possibility of reduced speed operation;
— ability to transmit all bit sequences;
— ability to establish synchronism quickly;
— ability to adapt the data signalling rate to line quality;
— compatibility of recommended error control equipment with any scramblers used (see Recommendation V.41, section 2).

Note. — See Supplements Nos. 1 and 4 to 10 of this volume.

ANNEX

(to Point O)

FURTHER POINTS OF STUDY ON RECOMMENDATION V.26

(Extract from the reply by Special Study Group A, December 1972)

1) A " New Synch " circuit would have particular use when V.26 modems are configured in a multipoint network. It was noted that interface circuit 108 may still be required in such systems. The study of this circuit and its operation needs further clarification and amplification.

2) No agreement could be reached regarding " receiver holdover time ", or the period for which the receiver will maintain bit synchronism after the loss of carrier. The study of this point will be continued.

Question 1/A - point Q — Further study of parallel data transmission for universal use on telephone circuits (see Recommendation V.30)

(continuation of point Q of the study programme 1964-1968, amended at Mar del Plata, 1968, and at Geneva, 1972)

1. There is the need to study the question of the allocation of code combinations to the transmission frequencies (channel numbers). Is there a need to standardize the method of coding or should it be left to the user to allocate codes?

2. Is there a requirement for dibit control of the outstation transmitter and dibit decoding at the instation?

3. The subject of operating procedures needs further study.

4. Characteristics of the Data Signal Quality Detector, when used in parallel systems, requires careful study.

5. The methods of deriving timing requires study. Timing can be recovered from the received data channels and from the timing channel when it is used.

Question 1/A - point Q *bis — Study of parallel data transmission systems using the push-button telephone signalling frequencies**

(Mar del Plata, 1968)

1. *Definition of the nature of the data transmission signals*

a) Characteristics of the generated signals:
— frequency allocation and tolerances for other than push-button telephone frequencies;
— level;
— timing.

b) Transmission channel characteristics:
— loss;
— carrier frequency drift;
— attenuation/frequency distortion.

c) Interference characteristics:
— voice;
— echoes;
— noise.

2. *Instation terminals*

a) Specify the operation of data communication equipment for the demodulation of signals generated by a push-button telephone dial or a compatible parallel modulator (see section 3 b below):

1) Origination and answering of calls—automatic and/or manual.

2) Optional station arrangements, e.g. compatibility with line hunting or call distributing arrangements.

3) Non-simultaneous backward channels and their characteristics:
— tones;
— voice;
— data channel input;
— other.

4) Signal demodulation and error control:
— sensitivity;
— dynamic range;
— response times for signal detection circuits;
— response times for interference protection circuits;
— error performance.

b) Specify the interchange circuits:

1) Functional characteristics of interchange circuits:

a) Definition of forward channel data interchange circuits:
— two times one-out-of-four;
— two times one-out-of-five;
— four lead parallel binary;
— serial.

b) Definition of backward channel interchange circuits.

c) Definition of control interchange circuits.

2) Electrical characteristics of interchange circuits:
   — digital circuits;
   — voice interchange circuits.

3) Response times of interchange circuits.

3. *Outstation terminals*

a) Characterization of push-button telephone sets and/or dials used for data transmission:
   — hand-operated dials;
   — card-operated dials;
   — repertory dials.

b) Parallel data modulators employing push-button signalling frequencies:
   — two-frequency group systems;
   — three-frequency group systems;
   — amplitude or frequency modulation;
   — use of rest tones;
   — character signalling rates;
   — interface and procedures.

c) Backward channels (simultaneous or non-simultaneous):
   — low-speed channels, e.g. 0-20 bauds;
   — high-speed channels, e.g. V.23 data channel.

Note. — See Supplements Nos. 12 and 13 of this volume.

ANNEX

(to point Q *bis*)

DATA TRANSMISSION USING THE PUSH-BUTTON TELEPHONE SIGNALLING FREQUENCIES

(Contribution COM Sp. A-No. 200, June 1968, American Telephone and Telegraph Company)

This paper discusses the American Telephone and Telegraph Company's push-button dialling system when it is used for data applications. It covers coding, the keyboard, error performance, the technical aspects of the receiving data set, equipment, interfaces, operational requirements, and typical systems.

Figure 1 shows the frequency plan of the audio-frequency tones utilized in the service [1]. Fundamentally, the eight frequencies are arranged in two groups of four frequencies, one low group and one high group. Each character or digit is represented by two frequencies, one from each group as shown in Figure 1. Twelve such symbols are presently assigned *for use in North America*, leaving four for future use (this as opposed to C.C.I.T.T., which designates six spares).

Many factors were considered in the selection of frequencies. Among these factors were transmission characteristics of a typical telephone line, avoidance of certain combinations of frequencies that occur frequently in speech, and the selection of frequencies not harmonically related.

In dialling service a receiver is needed at the central office to detect the frequency combinations and initiate switching functions. These receivers are not adequate for use in end-to-end signalling. A new data set receiver was developed with added sensitivity, wider bandwidths, echo protection, talk-off protection, answer-back channels, line control functions, and facilities for interfacing with a large variety of business machines.

[1] The frequencies of this plan have been adopted for international use by the C.C.I.T.T. (Recommendation Q.23, *Green Book*—Volume VI).

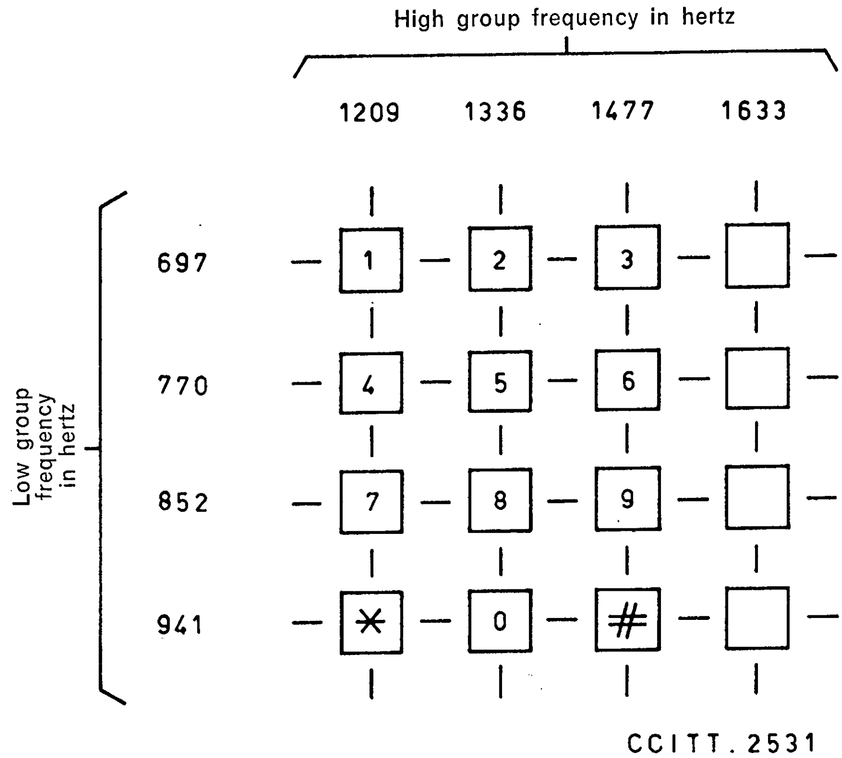


FIGURE 1. — **Frequency assignments**

Description of data set receiver

The receiver responds to multifrequency signals generated by the push-button telephone of 40 ms in duration with an interpulse time of 45 ms and whose total power may vary over a range of 40 dB. The receiver is capable of operating at an overall power level sensitivity of −46.0 dBm. The channel bandwidths of the receiver are $\pm(0.017 f_0 + 15 \text{ Hz})$, where f_0 is the nominal signalling frequency and the 15 Hz is allowance for carrier offset.

The receiver delivers output indications (data) to the business machine for approximately 37 ms, regardless of input signal duration in excess of 40 ms. A data carrier detector (DCD) indication is delivered 2 to 3 ms after the data indication. The DCD is reset by the disappearance of the input signal or the end of the timed data output whichever occurs last.

The receiver is capable of differentiating between valid signals and speech, noise or echo signals. Worst case echoes are expected with delays of 40 ms at an amplitude 14 dB below the amplitude of the signal.

The data set has three different answer-back channels available to communicate with the transmitting location. These include an input port for pre-recorded voice signals, a three-state oscillator for tone generation, and a high-speed data input port.

Control functions for automatic operation are provided. The data set has a telephone line terminating impedance of 600 or 900 ohms. It has its own protection against lightning surges on the telephone line. It has a return loss of greater than 20 dB within the signalling band of 600 to 2100 Hz.

The data set operates from a 117-V to 60-Hz power source over an ambient temperature range of 4° to 49° C (40° F to 120° F) and relative humidity of 20 to 90%.

Data set receiver operation

The data set as shown in block diagram form in Figure 2 is divided into two parts, the basic receiver and an interface coupler. The basic receiver may be functionally broken down into three sections: 1) line control circuits, 2) receiver channel, and 3) answer-back channels.

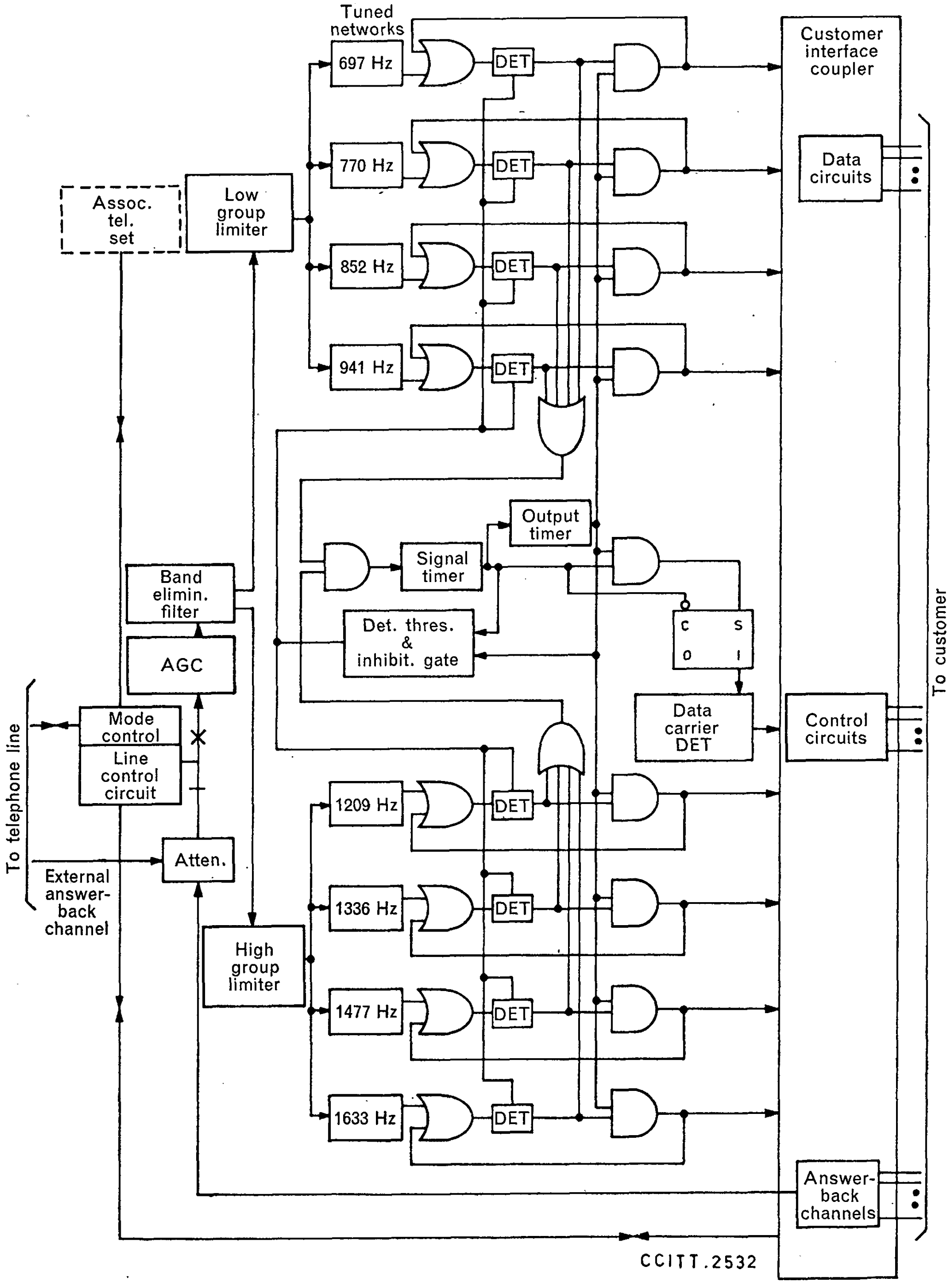


FIGURE 2. — **Block diagram of data set**

Line control circuit

Figure 3 shows a simplified block diagram of the line control circuit in the basic receiver. The 20-Hz ringing signal from the central office is detected by the ring detection circuit. This signal is rectified and then operates a relay R (not shown). If the customer has signalled the data set on the data terminal ready lead that he is ready to accept incoming calls, the C relay will operate; this permits line current to flow through the input transformer, causing the 20-Hz ringing signal to be removed from the line by the central office. The line holding relay H will be operated by the C relay and hold the C relay operated after the R relay releases.

When the R relay operates, it resets the interval timer. When the relay releases, the timer is started. At the end of a 1.1-second timer interval, the 2025-Hz oscillator is operated. This signals the calling party that the data set has been enabled. The 0.57-second timer resets the SC flip-flop which turns off the 2025-Hz oscillator and operates the data set ready (DSR) relay which indicates that the data set has answered an incoming call and is ready to receive or transmit data. Indication of the original ringing signal is transmitted to the customer during the period that the 20-Hz ringing signal is present.

Receive channel

The data set is placed in the receive mode by an ON condition on the data receive lead which operates the DR relay in Figure 3. When the data receive lead is OFF, the data set is in the answer-back mode. The constituent parts of the receive channel are the AGC amplifier, band-elimination filters, limiters, detectors, signal and output timers, and the data carrier detector (Figure 2).

AGC amplifier

The input signal to the data receiver is amplified to a fixed level by the AGC amplifier. This circuit compensates for transmission loss variations of different connections through the switched telephone network. For an input signal variation of 41 dB, the output varies $\pm$ 1.0 dB. The AGC has an attack time of 2 to 4 ms and a long release time. The sensitivity of the receiver is controlled mainly by the AGC and is 0 to -41 dBm. The slow release characteristic of the AGC is used to provide protection against digit simulation due to echo signals.

Band-elimination filter and channel limiters

The band-elimination filter, which is driven by the AGC amplifier, separates the received signals into their respective high and low groups. The signals are then passed to the group channel limiters. Also, any noise received which is outside both the signalling groups will be passed to both group channel limiters.

The limiters supply a constant output square wave, provided the input is above a design threshold. The threshold circuit is used in conjunction with the slow release time characteristic of the AGC to provide protection against duplication of input information caused by echo signals. In addition, through the instantaneous limiter action, some immunity is provided against digit simulation by voice signals. Equalization is also provided in the limiters to compensate for the uneven attenuation characteristic of the telephone plant.

Channel detectors, signal and output timers, and data carrier detector

The output of each channel limiter goes to a group of four series-tuned networks used for recognition of the signal frequencies. Each tuned network output connects to a detector whose operating threshold is approximately 2.5 dB below the peak output from the tuned networks. This threshold ensures that one and only one detector in each group will operate. Once the detector operates, it will remain operated for as long as the signal is present at the detector. An AND gate is used to verify that one detector is operated in each group. This is verified for a timed interval of 40 ms. Next, the output timer is turned on, which in turn operates and holds the correct output driver in each group for 37 $\pm$ 2 ms. The data carrier detector is operated 2 to 3 ms after the data output driver, with an indication passed through the interface coupler. The data carrier detector will be reset by the signal timer at the end of its timing transition or by the ending input data signal, whichever occurs last. Feedback from the output drivers to the operated detectors causes the detectors to remain operated should the input data signal disappear during the

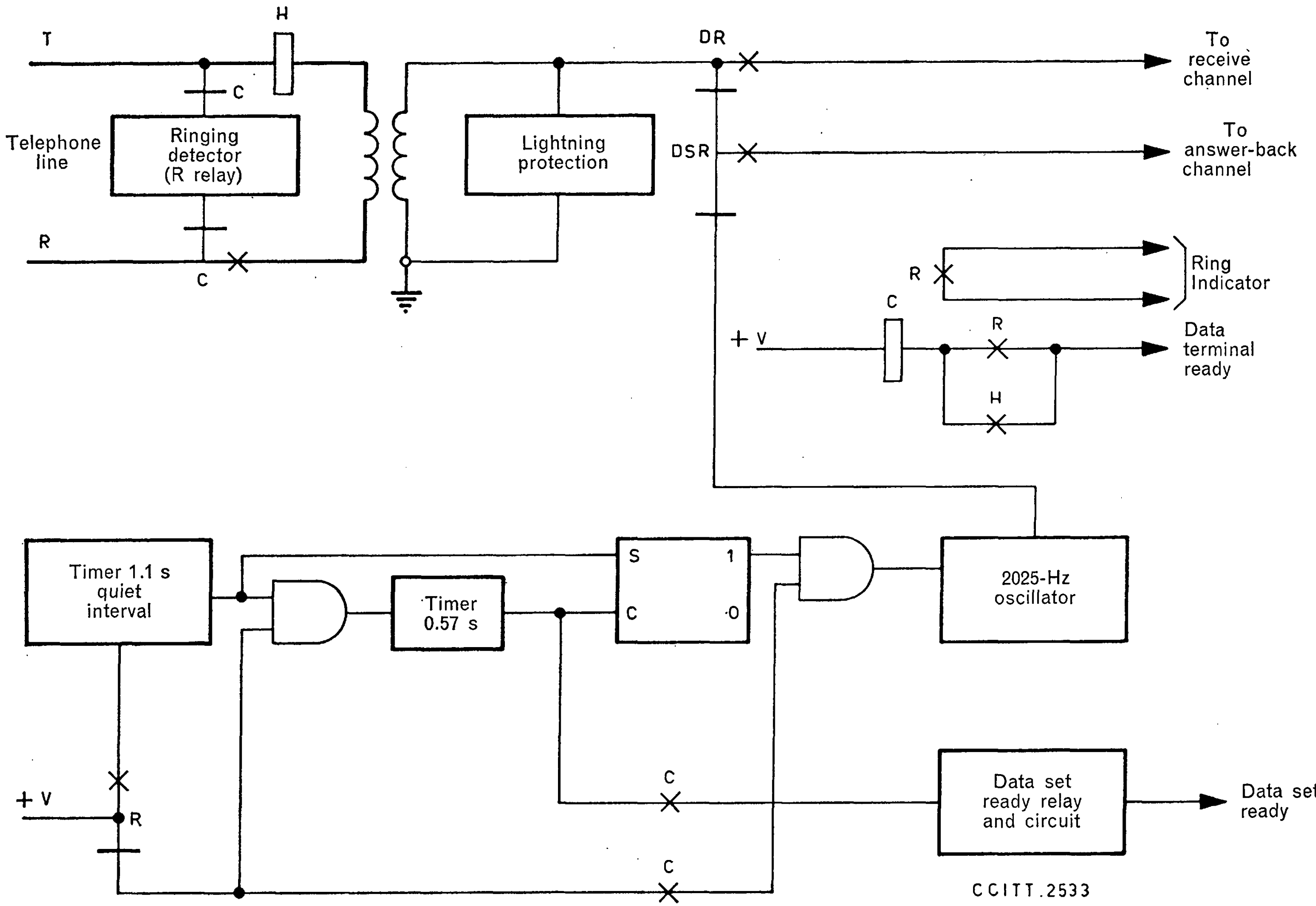


FIGURE 3. — **Block diagram of line control circuit**

37 ms output period. To prevent the operation of the other detectors, the threshold level is raised 1 dB above the tuned network outputs.

Answer-back channels

Communication from the answer-back channel may take the form of pre-recorded voice signals, tone signalling, or high-speed data exchange. For the exchange of high-speed data, the calling station must have a data set capable of communicating at the speeds in question in addition to the telephone set.

A voice frequency input port is available to the customer to couple pre-recorded or machine-generated voice signals to the telephone line. These signals are limited before they are passed to the telephone line. When a signal is 10 dB above the recommended transmission level of 0 dBm from the connecting business machine, it is peak limited. The input impedance to the port is 600 ohms balanced. Figure 4 shows the input power to the data set from the connecting business machine to the maximum output power level to the telephone line. This curve may be shifted down 3 or 6 dB to match allowable transmission levels.

The answer-back tone transmitter will transmit three different frequencies by manipulation of interface leads A and B as shown:

Leads	Transmitted frequencies (Hz)
AB′	1017
.AB	1785
A′B	2025

Operation of the answer-back transmitter leads pre-empts the voice answer-back channel. The answer-back transmitter may be operated in a frequency shift keying (FSK) mode at a rate of 40 bauds. The answer-back attenuator in Figure 2 is adjusted during installation to ensure that the answer-back signals enter the connecting central office at acceptable level.

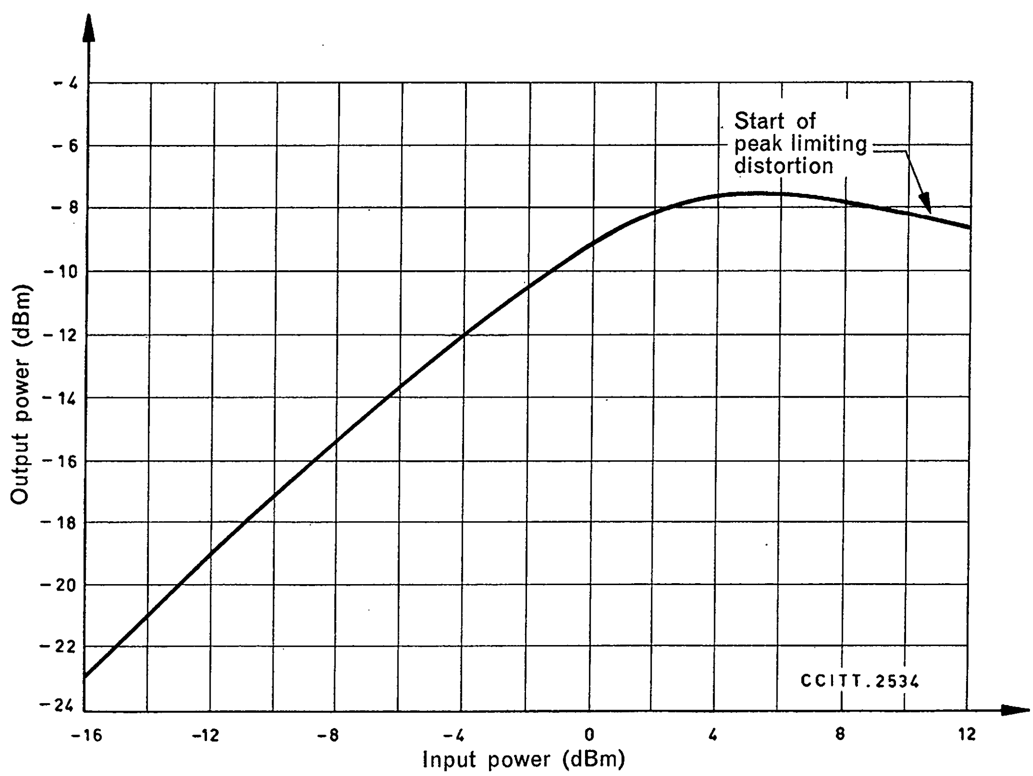


FIGURE 4. — **Power transfer characteristics of voice answer-back limiter**

Interface

Three interface couplers have been designed and are subsequently described.

Relay contact interface coupler

Each detector in the relay contact interface (Figure 5) causes an output driver to operate a dry-reed type relay. The output to the connecting business machine is a two-out-of-eight code (one relay contact closure in each group) for data indications and a data carrier detector closure to signal ground for sampling and timing indications. Each of the data contacts is protected by a series RC network of 470 ohms and 0.1 microfarad.

The following control functions are contained in this coupler:

1) Ring indicator: a ground indication is transmitted to the connecting business machine whenever 20-Hz ringing voltage appears at the input to the data set.
2) Data set ready: a ground indication is passed to the connecting business machine whenever the data set has answered a call and is ready to receive or transmit data.
3) Data terminal ready: a ground indication is received by the data set indicating that the business machine is ready to receive data calls.
4) Attendant: a ground indication is received by the data set from the business machine when a data call should be intercepted by an attendant at the receiving location.
5) Out-of-service: the presence or absence (installer option) of a ground indication on this lead will make the data set appear busy to incoming calls.
6) Data receive: the connecting business machine transmits a ground indication on this lead to transfer the data set to the receive mode or removes the ground indication to transfer the data set to the answer-back mode.

Binary coded matrix voltage interface coupler

To eliminate costly and complex translating equipment between the data set and a central processor, a coupler with a voltage interface using a special four-level binary code was designed. For simplicity, this code will be referred to as a BCM (binary coded matrix) code. This code resulted from considering the push-button dial matrix and assigning a code to the matrix in such a way as to minimize the cost of translation and the cost of connecting processing equipment. This code assignment is shown in Figure 7.

The data carrier detector function in the data set becomes very important when using this code. The data carrier detector indication is transmitted after the data indications and may be used to sample the data leads permitting the detection of 0000.

A block diagram of the BCM coupler is shown in Figure 6. It contains voltage drivers for the control and data functions, the voice answer-back limiter, the answer-back transmitter, and remote test circuitry. The interface is voltage controlled (except for the voice answer-back channel which is a 600-ohm balance input). The interface functions available, along with terminal assignments, are shown in Figure 8. These functions, except functions RD1, RD2, RD3 and RD4 are the same as those explained in the previous section except that ground indications are replaced by the appropriate voltage indications as shown in Figure 8. Electrical characteristics of the interface leads conform substantially to C.C.I.T.T. Recommendation V.28.

ASCII [1] voltage interface coupler

This interface (Figure 9) is intended for use with terminal equipment accepting serial data input and having minimal logic capabilities. Characters representing the digits 0-9 are coded by the receiver as the corresponding ASCII characters 0-9. The frequencies corresponding to the 11th and 12th buttons (* and # keytops, respectively) are coded by the installer to be any character in the first four columns of the ASCII code. The interface unit is capable of detecting a sequence of two successive depressions of the twelfth button. The translation of the first and second depressions can be different. Again, the coding for the second depression can be any code in the first four columns of the ASCII code. If desired, the unit can be arranged to disconnect the call when two consecutive receptions of the twelfth button frequencies are detected. Also, if desired, the unit can be arranged to provide automatic disconnect after a 15-second or 45-second period of inactivity. To ensure message separation, the installer

---

[1] American Standard Code for Information Interchange: Equivalent Reference International Alphabet No. 5.

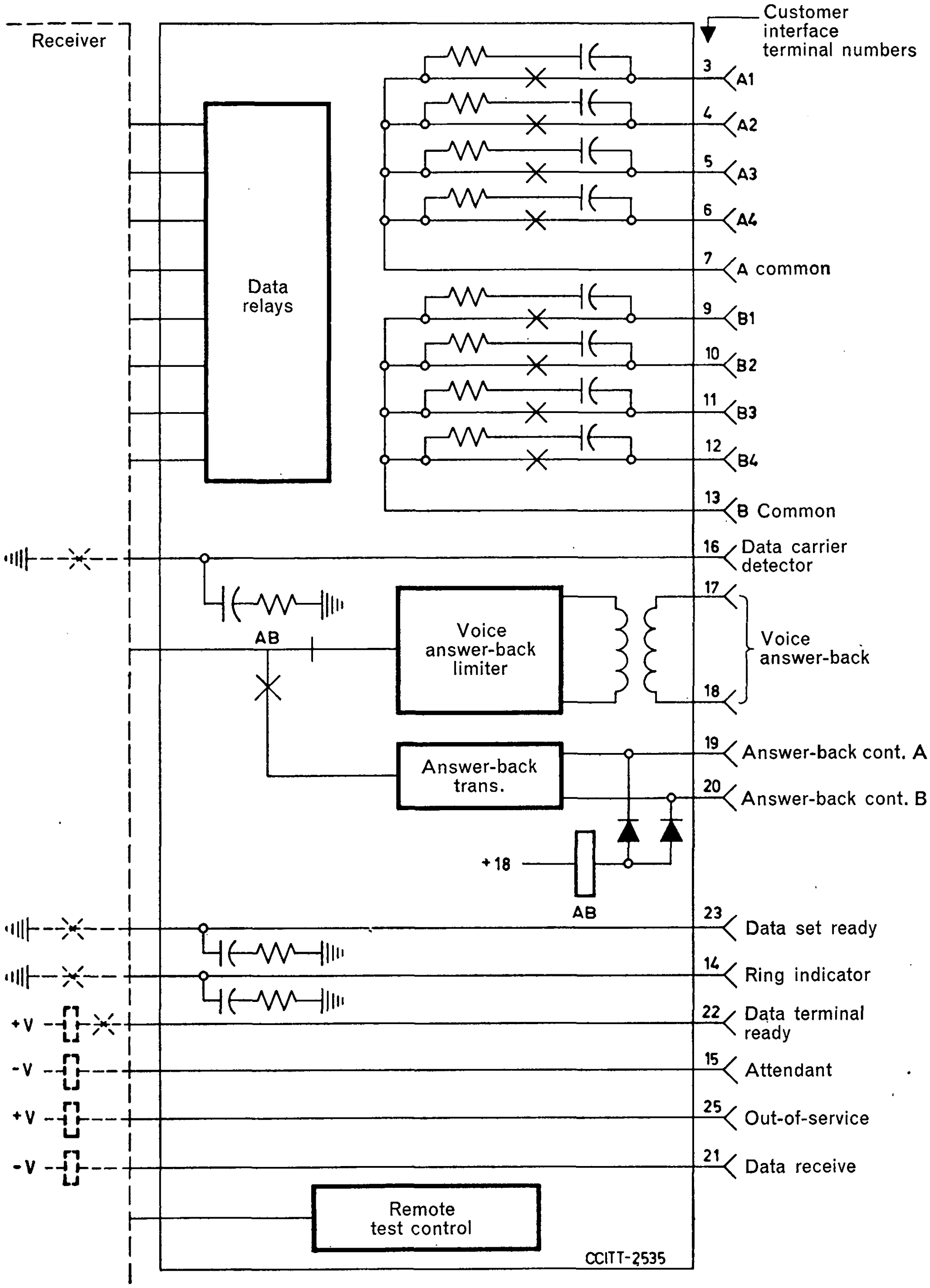


FIGURE 5. — Customer interface coupler—Relay contact interface

can arrange the interface unit to generate automatically the ASCII character selected for the second depression of the 12th key at the beginning of each call. The proper even-parity bit is added to each 7-bit ASCII code to form an 8-bit character.

Echo protection

The telephone transmission plant, like many other transmission media, contains many discontinuities which manifest themselves as generating echo signals. These echo signals (called listener echoes in this application) directly affect the performance of the data set since they may appear as legitimate data signals or mask successive data signals. Hence, the requirement is imposed on the data set to ignore echo signals and to pass on to the connecting business machine only those signals it believes to be legitimate data information. This discrimination is performed by the AGC amplifier and the channel limiters.

Digit simulation

The digit simulation (talk-off) performance of the data set is affected by many variables: exposure time, noise, type of talker (male or female), characteristics of the transmission channel, etc. The more important variable is exposure time; the shorter the exposure time, the lower the probability of error per call due to digit simulations.

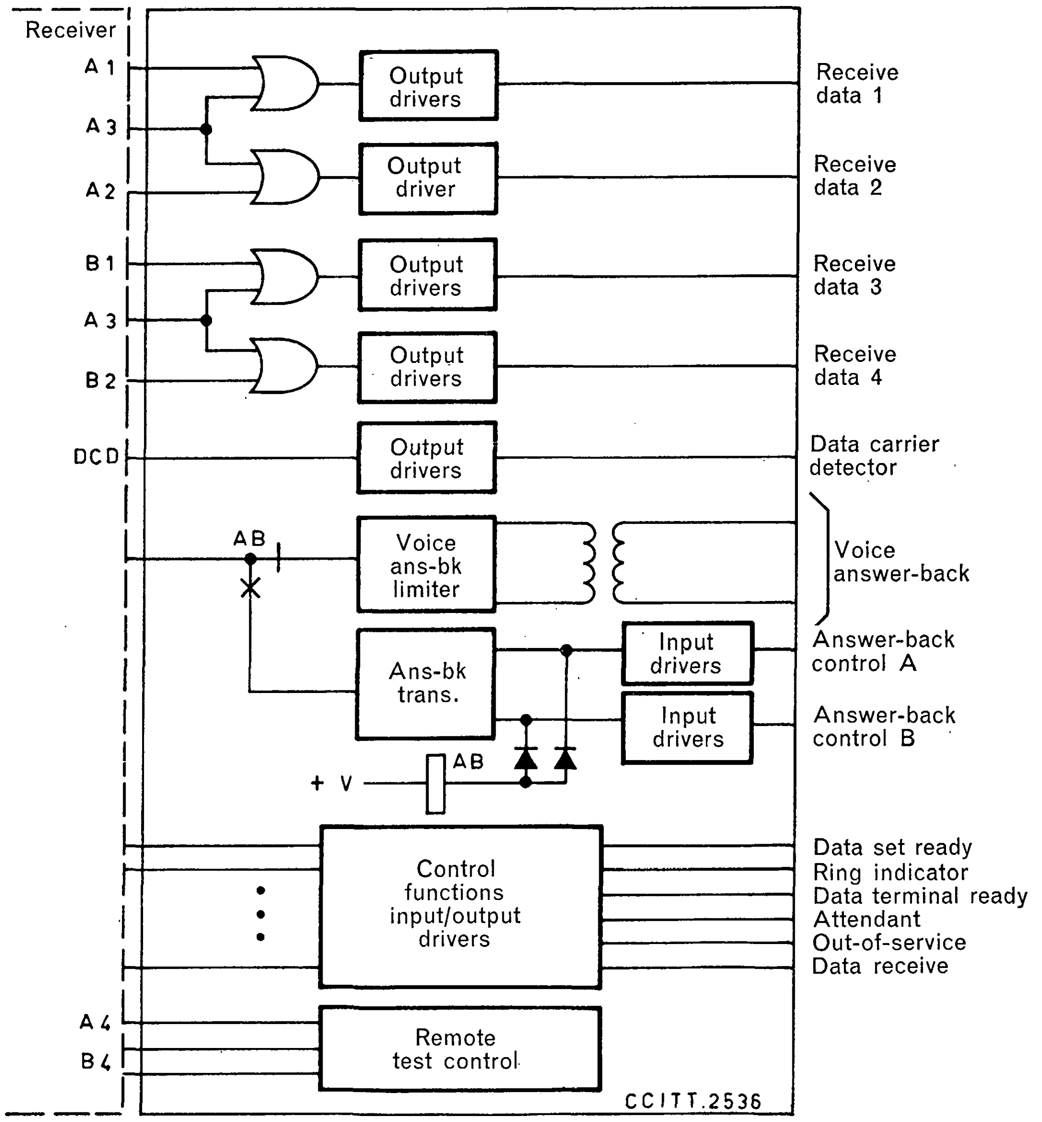
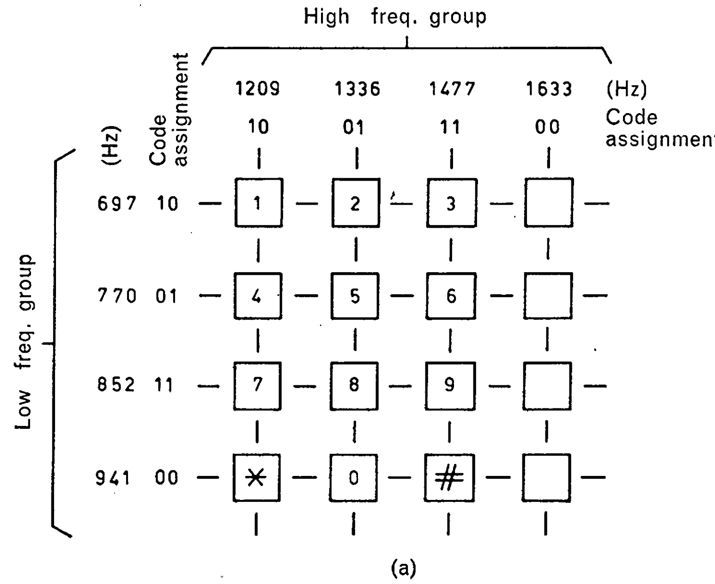


FIGURE 6. — **Customer interface coupler—Binary coded matrix voltage interface**



B.C.M. code table

Digit	Receive data leads			
	RD1	RD2	RD3	RD0
1	1	0	1	0
2	1	0	0	1
3	1	0	1	1
4	0	1	1	0
5	0	1	0	1
6	0	1	1	1
7	1	1	1	0
8	1	1	0	1
9	1	1	1	1
0	0	0	0	1
*	0	0	1	0
#	0	0	1	1
Unassigned	1	0	0	0
	0	1	0	0
	1	1	0	0
	0	0	0	0

(b) CCITT.2537

FIGURE 7. — **(a) Arrangement of dial showing code assignment of the BCM voltage interface coupler; (b) BCM code table**

Type of circuit	Function	Terminal number	Interface terms		
Data	Receive data 1 Receive data 2 Receive data 3 Receive data 4 Data carrier detector	3 4 5 6 16	*Binary state :* *Signal condition :* *Voltage :* *Paper tape :*	one marking negative hole	zero spacing positive no hole
Control	Ring indicator Data set ready Data receive Data terminal ready Out-of-service Attendant Answer-back control A Answer-back control B	14 23 21 22 25 15 19 20	*Control function :* *Voltage :*	on positive	off negative
Ground	Signal ground Protective ground	24 1	See EIA standard RS-232-B		
	Voice answer-back A Voice answer-back B	17 18	600-ohm balanced pair Maximum input level 0 dBm		

FIGURE 8. — **Binary coded matrix (BCM) voltage interface**

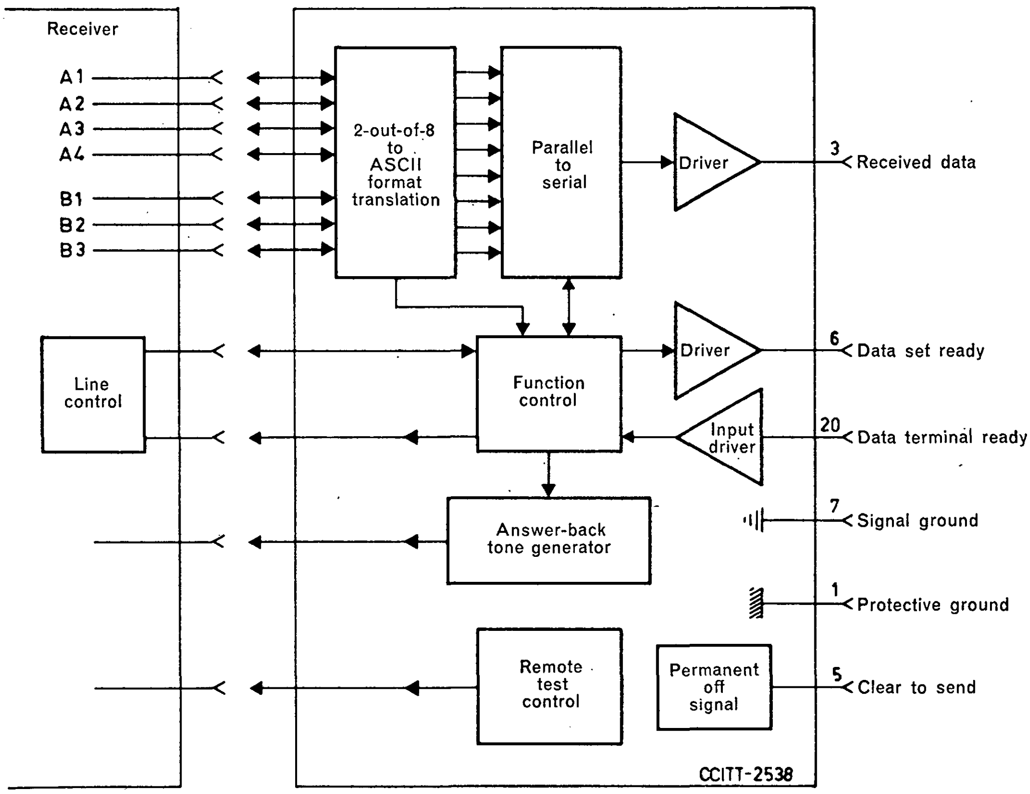


FIGURE 9. — **Customer interface coupler-serial – ASCII voltage interface**

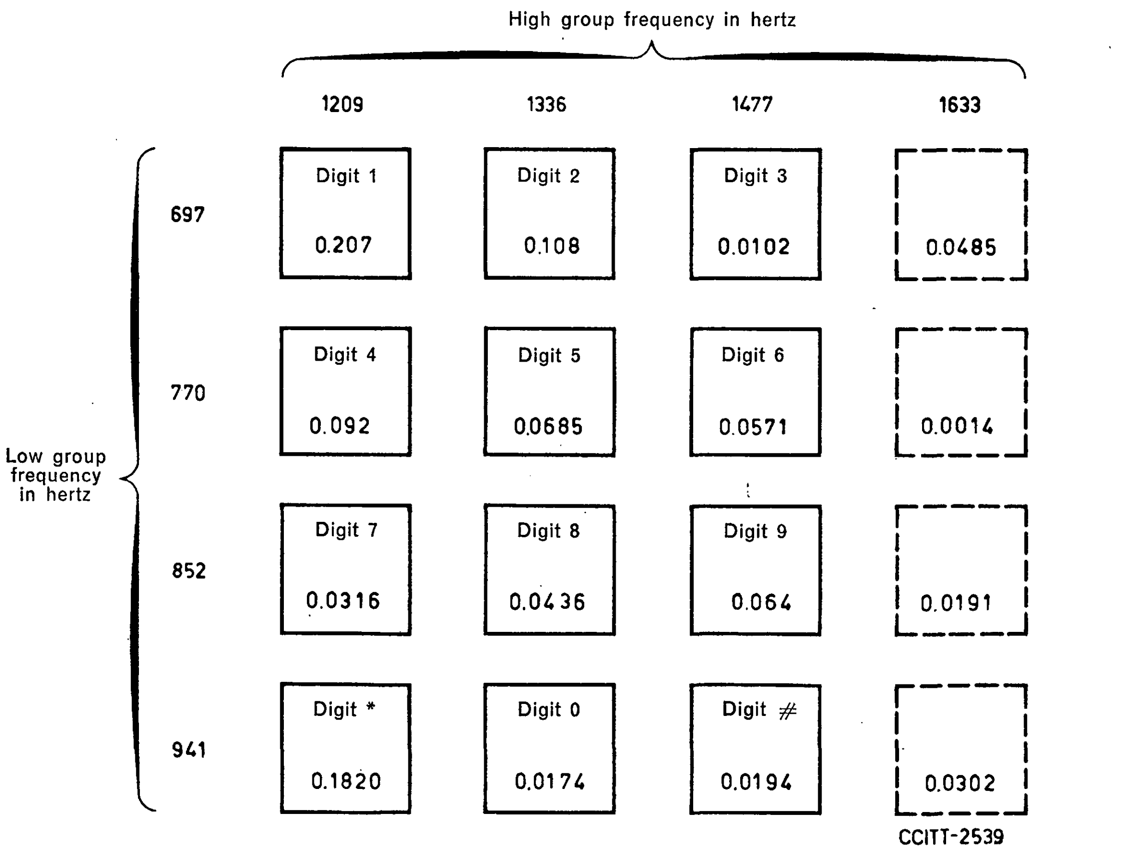


FIGURE 10. — **Probability of simulation of frequency pairs due to noise coupled through the telephone handset for data set 403D**

The receiver was tested by exposing it to continuous speech and noise from 40 000 telephone connections for a period exceeding 1600 hours. The distribution of digit simulations among the 16 total available combinations is shown in Figure 10. This figure thus shows the conditional probability of simulation of each of the 16 digits, given that a digit simulation has occurred.

What error rate due to speech and noise may one expect when using the receiver in a system with push-button type telephone sets? A sample of users of this system indicates that the input information will be in blocks of 15 characters or less and will be entered manually. The time to enter 15 characters varies with the user, the grouping of the characters, the environment of the user, etc. Tests indicate that the receiver will have an error rate of one digit simulation per 12.97 hours of exposure time for the 10-decimal digits, one digit simulation per 9.51 hours of exposure for the 10-decimal digits plus * and #, and one digit simulation per 8.56 hours of exposure for the complete 16 digits.

The data set is vulnerable to being talked off only when a call has been answered, and the data receiver is connected to the telephone line. This time normally starts at the end of the 2025-Hz tone which is transmitted to the calling station and ends when the customer leaves the data receive mode. This time will be referred to as access time.

The real exposure time of the receiver is:

$$E(t) = A(t) - [ND \cdot C(t)]$$

where

$E(t)$ = exposure time;

$A(t)$ = access time;

ND = number of digits dialled;

$C(t)$ = average time per digit the carbon microphone is disabled in the telephone handset.

Consider an example which shows the access time $A(t)$ for a 15-digit number to be 12 seconds. From the tests performed, the mean time to dial a digit has been found to be 180 ms with a standard deviation of 115 ms. The carbon microphone in the telephone handset is disabled approximately 10 ms before the tones are transmitted to the telephone line and is enabled 10 ms after the tones have ended. Therefore, the mean time the carbon microphone is disabled is 200 ms.

The exposure time is then:

$$E(t) = 12 - (15 \cdot 0.2),$$

$$E(t) = 9.0 \text{ seconds},$$

and the calls per digit simulation (ds), or error rate ER, is then:

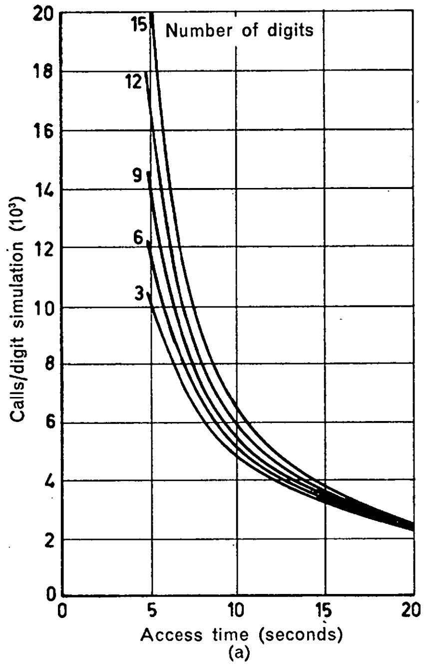
$$ER = 12.97 \, \frac{\text{hours}}{ds} \cdot \frac{3600 \text{ seconds}}{\text{hour}} \cdot \frac{1 \text{ call}}{9 \text{ seconds}}$$

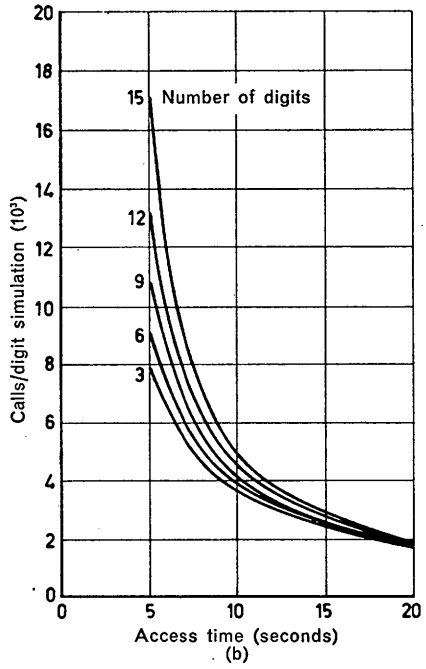
$$ER = 5188 \text{ calls}/ds$$

for the 10-decimal digits.

Since the digital simulation rate is a function of the access time and of the number of digits (total pulse time), a family of curves may be constructed to determine the error rate for any particular system. Using the previous information of error rate and also the mean time $C(t)$ that the carbon microphone is disabled in the telephone handset, the curves in Figure 11 are constructed for hand-pulsed information only. These curves may be adjusted for different values of $C(t)$. For example, suppose we have an application in which the access time is 12 seconds and the number of manually entered digits is 9; a performance rate of 4500 calls per digit simulation is read from the ordinate axis of Figure 11 a.

These curves apply only for systems where there is one inquiry. For multiple access calls these curves must be adjusted accordingly.





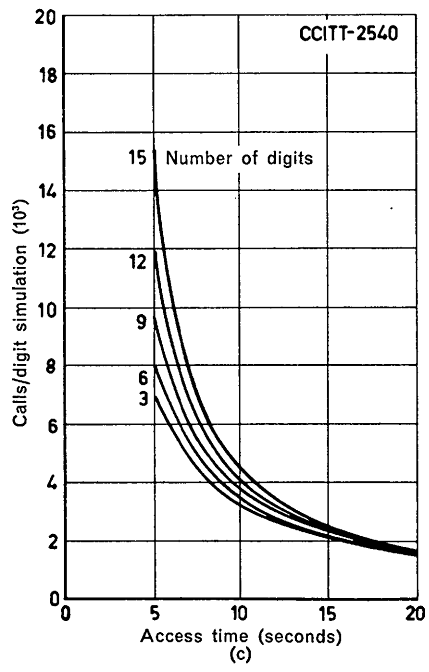


FIGURE 11. — **Performance of data set 403D for hand-entered digits when (a) the 10-decimal digits, (b) the 10-decimal digits plus * and #, and (c) the full 16 digits are sampled**

Question 1/A - point R* — Error control in the general telephone network

(continuation of point R of the study programme 1964-1968, amended at Mar del Plata, 1968)

Which characteristics should be recommended for systems of error control in data transmission on general telephone network at:

a) 200 bauds

b) 600/1200 bauds

c) higher modulation rates?

The following points should be examined:

i) character by character error-control system;

ii) small data block error-control system;

iii) efficiency of data signal quality detector;

iv) error control system based on data signal quality detector.

Question 1/A - point S + T — Measurement of phase distortion and transmission loss between subscribers

(continuation of points S and T in the study programme 1964-1968, amended at Mar del Plata, 1968, and at Geneva, 1972)

(concerns Study Groups IV and XIV)

1. *Phase distortion*

Measurement of phase distortion between subscriber and subscriber is desirable, and Administrations are encouraged to report any such tests that are made.

It would be very helpful to the designers of data modems to have statistical information on overall subscriber-to-subscriber phase distortion. The results of any test the Administrations are able to make would be a help in the future study of this problem.

On the other hand, Recommendation G.114 specifies the propagation time between subscribers, and Recommendation G.133 on limits of the phase distortion on a chain of international circuits.

2. *Transmission loss*

A nominal range of losses in subscriber-to-subscriber connections might be 5 to 30 dB at the reference frequency (800 or 1000 Hz), perhaps assuming up to 35 dB loss at the carrier and characteristic frequencies recommended. Studies and, where necessary, tests should be made from which statistical conclusions could be drawn for national, international and intercontinental connections. These might be expressed in terms of the loss at the reference frequency, plus the slope over the frequency band of interest, and would form the basis of a study on equalization.

Note. — See Supplements Nos. 14 to 17 of this volume.

Question 1/A - point U — Specification of characteristics of circuits leased for data transmission; measuring techniques to check these characteristics

(continuation of point U of the study programme 1964-1968, amended at Geneva, 1972)

(concerns Study Group IV)

The following line parameters should be studied from the data transmission point of view:

— attenuation distortion;

— group delay distortion;

— circuit noise:
  random noise,
  quantizing noise,
  impulsive noise,
  single tone interference;
— frequency error;
— harmonic distortion;
— phase jitter;
— phase hit;
— others.

Notes. — 1. See Recommendation M.102 and certain O series Recommendations (Specifications of measuring equipment) in Volume IV.

2. See Supplements Nos. 10 and 18 of this volume.

ANNEX

(to point U)

SPECIFICATION OF PRIVATE MULTI-TERMINAL CIRCUITS FOR DATA TRANSMISSION AT 2400 BIT/S AND ABOVE

(Extract from the report by Special Study Group A, December 1972)

There are two types of multi-terminal network:

— multi-terminal radial networks in which the link between the central station and each of the outlying stations must conform to Recommendation M.102;
— multi-terminal conference networks in which the link between any two stations must conform to Recommendation M.102.

Both types of network were considered. In the case of multi-terminal conference networks, each section of the network must be corrected. The transmission characteristics to be obtained for each of these sections obviously depend on the number of sections encountered in the most complex link. The Study Group thinks that it is already relatively easy to establish such networks if there are no more than three sections in tandem, even using compromise fixed equalizers. However, it would be desirable to have the opinion of Study Group IV as to how many links in an omnibus or conference multi-terminal circuit may be connected in tandem within the overall characteristics specified in Recommendation M.102. In the case of multi-terminal radial networks, a different equalization method may be envisaged. This consists in equalizing each of the links between the central station and the outlying stations by placing equalizers on the outlying station side in both directions of transmission. In this case the question of tandem connected links does not arise.

The United States of America proposes for elements of a multipoint circuit new limits which, for group delay, amount to one-fifth of those in Recommendation M.102. However, in accordance with what has already been said above, it would seem already a relatively easy matter to establish circuits with limits amounting to one-third of the group delay distortion limits in Recommendation M.102. These new limits could be taken as a basis for subsequent studies. The studies would be assisted by the views of Study Group IV as to the most stringent characteristics which are possible to achieve and maintain on point-to-point circuits.

If the studies of Study Group IV showed that the limits of an nth ($n>3$) of those in Recommendation M.102 were practicable, multi-terminal networks consisting of up to n sections could be envisaged for data transmission.

Attenuation distortion should take a half of those in Recommendation M.102 as a basis for further study.

Question 1/A - point V — Specification of impulsive noise limits for data transmission over switched telephone circuits

(continuation of point V of the study programme 1964-1968)
(concerns Study Group IV)

Note 1. — See point 3 of the annex to Recommendation V.55.
Note 2. — See Supplements Nos. 16 to 18 of this volume.

Question 1/A - point W* — Maintenance methods

(continuation of point W of the study programme 1964-1968, amended at Mar del Plata, 1968)
(concerns Study Groups IV and VIII)

What binary-digital maintenance testing methods can be recommended for data communication over telephone-type circuits?

In particular, supplementary study of Recommendations V.50, V.51, V.52, V.53 and V.55 should be continued.

ANNEX
(to point W)

REPORT ON LOOP TEST DEVICES

(Mr. J. M. GAUTHIER — *Rapporteur on loop test devices, November 1972*)

1. *Introduction*

At its meeting from 15 to 19 May 1972, Special Study Group A decided to set up a working party by correspondence on loop test devices. The name of the rapporteur appointed on this occasion was also notified to I.S.O. at the meeting held in Berlin in June. In view of the mutual interest of these two international organizations in the question, documents from both were used in the preparation of the report.

Particular consideration was given to the following documents:[1]

COM Sp. A—No. 155 (U.K.P.O.)
COM Sp. A—No. 190 (" Maintenance " Working Party)
COM Sp. A—No. 254 (P.T.T., France)
COM Sp. A—No. 264 (Sp.A)
COM Sp. A—No. 274 (Sp.A)
ISO/TC 97/SC 6 588 (U.S.A.) and 435 (E.C.M.A.)
Japanese Comments on ISO/TC 97/SC 6 N588 and N600 (Japanese National Committee).

The rapporteur also received three letters from the United Kingdom and the German and Netherlands Standards Committees containing statements of principle.

2. *General*

The documents published to date reveal a very substantial agreement on the four types of maintenance loops shown below:

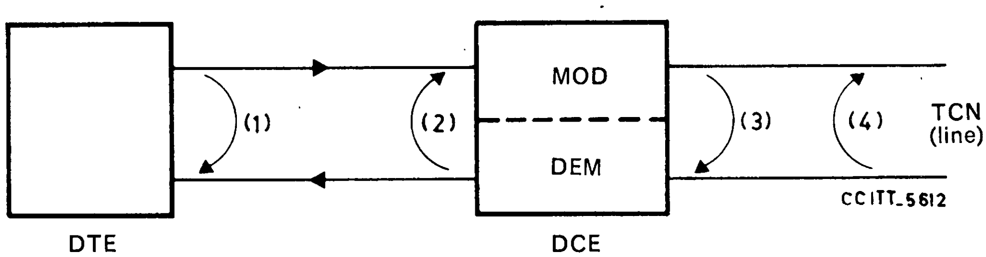


FIGURE 1

DTE = Data terminal equipment.
DCE = Data circuit-terminating equipment.
TCN = Telecommunication network.

[1] Documents published during the period 1968-1972.

The difficulties encountered relate to the following points:

1) Type of loop control—manual or automatic;

2) Definition of the interface wires for automatic control and interworking with the other circuits (manual or automatic control);

3) Divergences caused by the type of medium used (2 or 4 wires) and modem (full duplex, half-duplex, etc.);

4) Precautions required to prevent interference to network operation (loops (3) and (4) in particular);

5) Determination of precise looping procedure in order to identify the defective element in a circuit.

Points 1, 2 and 5 concern I.S.O. and the C.C.I.T.T., whereas points 3 and 4 would appear to concern the C.C.I.T.T. alone. Consequently, one possible solution might be to deal with the following three questions in turn:

— definition of interface wires used for loop control, as an addition to Recommendation V.24;

— looping procedures in the modems, laid down in the Recommendations for each type of modem;

— definition of a maintenance procedure.

Only the first of these three questions, on which various contributions have been submitted, will be covered fully in this report.

3. *Proposed addition to revised Recommendation V.24*

3.1 *General remarks*

There is some ambiguity with regard to loop (1), at least for that part of the equipment which it can be used to test. It appeared to us that there was no point in discussing here a loop which only involves the terminal. On the other hand, if this loop calls for any action in the modem, thus making it possible to check the operation of the cable and possibly of the interface circuits, it should be taken into account.

Further, loop (4) seems to require special precautions, at least so far as the levels are concerned, and should only be used with the authorization or even at the request of the Administrations. We therefore felt that it should not be put at the automatic disposal of terminals, and we left it out of account in the definition of circuits XXX and YYY.

Finally, the only possibilities considered were those shown in Figure 2.

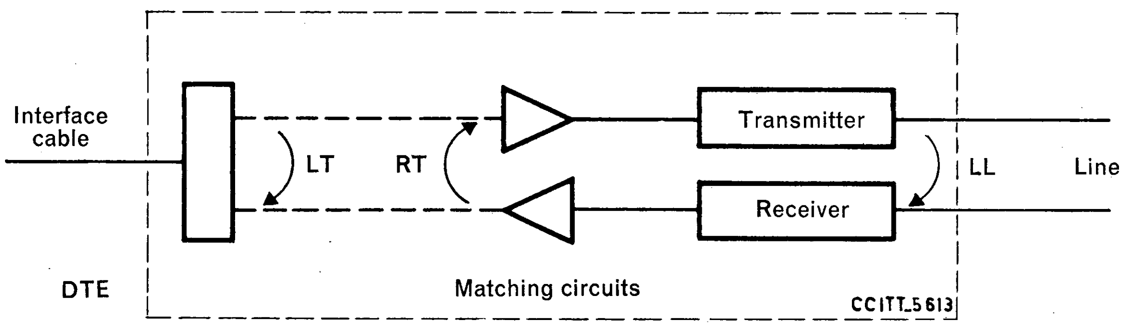


FIGURE 2

These are:

— normal operation;

— remote test terminal (RT);

— local test terminal (LT);

— local test line (LL).

The RT and LT tests can be carried out on either side of the matching circuits. It is also clear that the remote tests (return of information to the remote source) and the local tests (return to the local terminal) can be distinguished.

Two interchange circuits are sufficient for loop control.

There is no provision for modem response to the terminal, mainly to economize on the number of plugs employed for this purpose, but also because it must be possible in many cases to signal any non-availability of the modem by other means (107, 106 . . .).

During the (local) LT and LL tests, calling indicator (125) facilities should be maintained.

The interface circuits might be:

1. Control circuit for looping at the interface;
2. Control circuit for local test.

The functions carried out are those shown in the table below:

TABLE 1

Circuit 1	Circuit 2	Operation
OFF	OFF	Normal operation
ON	OFF	Remote test terminal (RT)
ON	ON	Local test terminal (LT)
OFF	ON	Local test line (LL)

Note. — The LL loop can still be controlled if the circuit 1 does not exist.

3.2 *Proposed amendment to Recommendation V.24*

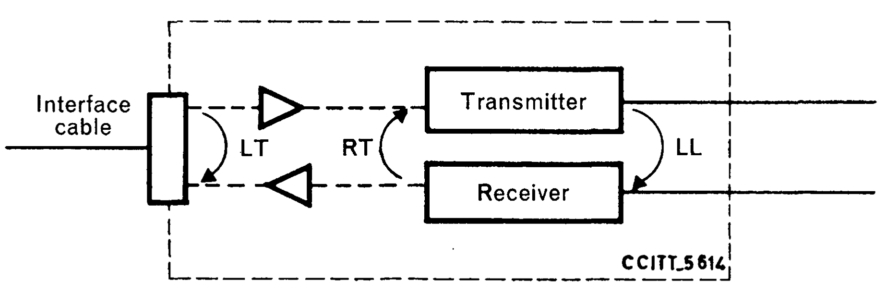
To facilitate automatic localization of faults among the components of a data transmission channel, two interchange circuits can be employed:

Circuit XXX: Loop control circuit at the interface (to the modem).

The ON condition causes the circuit to loop interchange circuits 103 and 104 and the other circuits specified in the recommendations concerning the various modems to allow a maintenance operation to be carried out. The function performed is connected with the condition of circuit YYY according to Figure 3 and Table 2 below.

Circuit YYY: Control circuit for local test (to the modem).

The ON position causes this circuit to return the information to the local terminal. Its operation, also when it is in the OFF position, is connected with the condition of circuit XXX according to Figure 3 and Table 2 below:



Note. — Loops LT and RT can be established either side of the interface matchings units.

FIGURE 3

TABLE 2

Circuit XXX	Circuit YYY	Function
OFF	OFF	Normal operation
OFF	ON	LL loop
ON	OFF	RT loop
ON	ON	LT loop

Note. — If one of the circuits is not used, it will be considered as being in the OFF position.

4. *Relations with the other interchange circuits*

It is important for each of the loops (whether established manually or automatically) to specify the state of the interchange circuits other than XXX and YYY. Although differences may arise according to the type of modem envisaged, it would seem feasible to apply common principles. It should be noted, however, that the " abnormal " situation of the terminal installation during testing will call for particular directives to be added to those of paragraph IV of Recommendation V.24.

The rapporteur submits the following tentative proposals.

LT

If they exist, circuits 103 and 104, 113 or 114 and 115 are combined in the modem. Circuit 108/2 should be OFF. Circuit 125 should operate normally in the case of a DCE on a switched network.

RT

Circuits 103 and 104, 113 and 115 are combined in the modem.

Circuit 107 should be kept OFF.

Circuit 109 should control circuit 105.

Circuit 125 need not be considered, since the line is considered as occupied.

LL

All circuits operate normally at the interface. Circuit 125 should continue to operate.

The line should be terminated by appropriate impedances according to the national regulations and can in no case be simply disconnected from the modem.

5.[1] *Special features of the types of line and terminal*

The Japanese contribution referred to above draws attention to the difficulties likely to arise from the fact that loops in half-duplex systems can only be rendered effective by measures which may prove costly.

Table 3 sums up the situation, taking account of the three system components.

It will be noted that some loops are particularly delicate to establish, particularly the LL test for a duplex modem on a 2-wire line (200 bauds), and the LL and (4) tests in a 4-wire line requiring an equalizer at reception.

These test procedures should be precisely defined in the Recommendations on modems.

[1] Paragraphs 5 and 6 should be regarded as tentative solutions.

TABLE 3

DTE	DCE	TCN	Loop			
			LT	RT	LL	(4)
full duplex	full duplex	2 wires 4 wires	yes yes	yes yes	yes [a] yes [c]	yes [b] yes [c]
half duplex	full duplex	2 wires 4 wires	no no	yes yes	yes [a d] yes [c d]	yes [b] yes [c]
half duplex	half duplex	2 wires	no	yes [e]	yes [d f]	yes [b]

[a] Provision must be made for frequency conversion, signal shaping or level regulation.
[b] This line test is only carried out in d.c. It can only be considered as test (4) by stretching the definition.
[c] These tests can be conducted with or without equalizer; difficulties arise in both cases.
[d] The test is carried out by an equipment which replaces the terminal.
[e] Requires storage in DCE.
[f] Calls for looping ahead of the line transformer or a simple unbalance of the differential transformer (modification proposed by the rapporteur).

6.[1] *Diagnostic procedure*

Two complementary approaches can be adopted:

1. The administrative or legal approach, whereby the problem is considered from the standpoint of sharing responsibilities among the (different) suppliers of the transmission medium, the modems and the terminals.

2. The technical approach, whereby attention is focused on the precise localization of the fault in the data transmission channel. It would seem that this second, more complete, approach should be adopted for the study.

However, Table 4 reflects the standpoint of the National Japanese Committee for Group ISO/TC 97 with regard to 1 above.

TABLE 4

DTE	DCE	TCN	Test			
			LT	RT	LL	(4)
S_1	S_2	Ad	N	N	N	N
	S		O	O	O	O
S	Ad		N	N	O	O

S = supplier Ad = Administration N = necessary O = optional

[1] Paragraphs 5 and 6 should be regarded as tentative solutions.

Detection of fault

One possible procedure which might be accepted is proposed in Document ISO/TC 97/SC 6/588 (U.S.A.). It is described below for the following circuit.

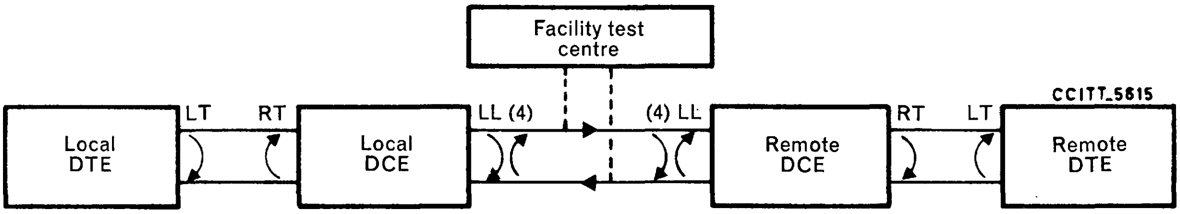


FIGURE 4

It is assumed that the DTE delivers a suitable data test signal and that it is capable of providing an indication of the received signal quality. Otherwise, a test set will be substituted for the terminal.

When the DTE encounters difficulty in communicating with the remote station it should be subjected to local testing by the LT loop. If the test is satisfactory, then the LL test condition should be activated, which makes it possible to check the operation of the complete terminal installation. If the local station is found to be satisfactory, the next step is to activate test condition RT in the remote DCE. If this test result is satisfactory, the fault condition is isolated to the remote terminal. Otherwise, the fault is isolated to the transmission facilities or the remote DCE. Test loop (4) can be used to determine whether the TCN or the remote DCE is at fault. Should the fault be in the TCN, it can be detected with greater accuracy if a facility test centre activating loop (4) at each end is available.

Such a sequential diagnosis permits rapid fault detection in the defective section and referral to the responsible supplier.

7. *Conclusions*

The various loops which can be used for maintenance are well known. They can be established either manually or automatically; the consequences for the state of the normal interface circuits and the precise operations carried out on the modems must be the same in both cases.

It is proposed that:

1) Recommendation V.24 should be supplemented by two loop control circuits by the terminals.

2) The effects of the loops on the other interface wires should be specified.

3) The procedure for setting up the loops envisaged should be specified for each type of modem in the light of the type of network (line) employed (2 or 4 wires, leased or switched).

4) A procedure should be specified for the use of the tests thus defined for the diagnosis of the faulty component in a circuit.

A full proposal is given for point 1. An outline is given for the study of points 2, 3 and 4.

Question 1/A - point Y — Automatic originating and answering of calls in the telephone network

(continuation of point Y of the study programme 1964-1968, amended at Mar del Plata, 1968, and at Geneva, 1972)

The following points should be considered:

1. Consideration in respect to operation with any modems recommended for use over the general switched telephone network.

2. Automatic calling equipment (ACE) for multiline operation.

Bearing in mind that the ACE is only required during the call establishment period and is idle during the information transfer period, the additional hardware for interfacing the ACE serves for only a small percentage of the time if it is used on a one ACE to one line basis.

The sharing of ACEs among a group of lines in both the telegraph and telephone cases should therefore be examined.

In the study on a procedure for the multiple channel ACE the following considerations should be included:

i) the principle of operation shall be compatible with that of the existing Recommendation V.25 whenever possible;

ii) specific use of the 2100-Hz answering tone as specified in Recommendation V.25 to identify the called party as appropriate DCE;

iii) specific use of interchange circuit 108/2 " Data terminal ready " for controlling switching to data condition on either station.

iv) for switching of the ACE to the data channel on which connection establishment is to be performed, the DTE shall place a selection character in front of the dialling information;

v) alterations of the 200 series interchange circuit definitions in Recommendation V.24 must be avoided. Necessary complementary definitions should be part of both, the future explanatory note chapter of Recommendation V.24 and the new Recommendation on the multiple channel ACE.

Question 1/A - point Z* — Data transmission over 48-kHz and 240-kHz circuits

(continuation of point Z of the study programme 1964-1968, amended at Mar del Plata, 1968, and at Geneva, 1972)

(concerns Joint Working Party LTG; Questions 28/XV and 29/XV)

1. Study of points arising from the implementation of Recommendation V.35 (modems for 48 kilobit/s).

2. Further study of synchronous modems for the 48-kHz band including specification of characteristics and line signals for:

a) 48 kilobit/s transmission;

b) data signalling rates above 48 kilobit/s.

The study to take account of digital techniques (see Annex 1) and multi-condition modulation (see Annex 2) which gives information on a 72-kilobit/s modem.

3. Study of characteristics to be standardized for data transmission over 240-kHz channels.

4. Study of methods of comparative tests of wideband modems.

Notes. — 1. See Recommendations H.14 and H.15 in the *Green Book*, Vol. III.
2. See Supplements Nos. 19 to 23 of this volume.

ANNEX 1

(to point Z)

COMMENTS ON RECOMMENDATION V.35

(Extract from the contribution by the Netherlands Administration; Mar del Plata, September 1968)

1. *General considerations*

In general the Netherlands Administration is in favour of recommending a line signal for 48 kilobit/s data transmission, as far as this may facilitate the exchange of data across the national frontiers. In establishing such recommendations, however, one should try to leave open as many possibilities of implementation as possible, at the sending side as well as at the receiving side, in order to be able to choose the most economical solution depending on the circumstances and on the use made of the transmission link. This point is extremely important, especially in view of the fast-developing digital techniques.

In this light it seems to us that the wording of sections 4 and 5 of Recommendation V.35 had better be changed to the extent that only the line signal characteristics are described, without reference being made to a particular method of implementation. As such, the modulation technique should not be prescribed explicitly, as the same line signal can be realized with different methods. For example, with the synchronous mode of operation a line signal with the same characteristics as a vestigial sideband signal can be made by:

a.1) Vestigial sideband modulation with suppressed carrier;

b.1) Splitting the signal into two sequences, which are modulated in quadrature double sideband technique with suppressed carrier;

c.1) Using duobinary frequency modulation, combined with proper encoding (Bennett and Davey, *Data Transmission*, McGraw-Hill 1965, section 11.6).

These signals, no matter in which way they have been realized, can all be detected by the use of one of the following demodulation methods, combined with proper decoding:

a.2) Coherent demodulation with the (virtual) carrier frequency at the edge of the frequency band;

b.2) Coherent demodulation with a frequency at the centre of the band (quadrature demodulation, resulting in two sequences which have to be interleaved);

c.2) *Duobinary f.m.-detection*

The equivalence of the line signals for the cases a), b) and c) with the synchronous mode of operation disappears in the asynchronous mode of operation. However, asynchronous operation is still possible, with minor changes, in the combinations a.1)-a.2), b.1)-b.2) and c.1)-c.2). In the synchronous mode of operation especially the methods b) and c) offer extra possibilities compared with the vestigial sideband mode of operation: in the case of b.1) at the sending side and b.2) at the receiving side the use of the system as two separate 24 kbit/s channels is easily achieved; method c.2) at the receiving side is of interest for those cases where transmission quality gives rise to no problems, in which case a cheap duobinary f.m.-receiver can give quite a satisfactory performance.

The use of a certain method of modulation for 48 kilobit/s synchronous data transmission does not imply that the corresponding demodulation method has to be used. However, duobinary f.m.-detection is not consistent with the use of a carrier pilot nor is it consistent with a frequency gap around the carrier frequency as proposed in Recommendation V.35. In section 4 of this Recommendation it is stated that a pilot carrier will be necessary to permit homochronous demodulation. However, it is clear that the above-mentioned duobinary f.m.-demodulation does not require transmission of a pilot for the demodulation purpose. Another method of detection could be homochronous demodulation with the centre frequency of the signal (e.g. 84 kHz), which may be recovered in a similar way to the reference phase for a four-phase signal demodulator. This method has as an additional advantage that due to the position of the centre-frequency the influence of delay distortion is small compared with the vestigial sideband mode of operation where the virtual carrier lies at the edge of the group band.

The quadrature method of operation can have the same performance as a vestigial sideband system as far as signal-to-noise ratio is concerned (Bennett and Davey, section 11.1, table 11-1 at the bottom).

Still another method of operation is given in Bennett and Davey, section 13.2. In this section a carrier recovery method for a vestigial sideband system, permitting the transmission of the complete spectrum, is described. This system, using a carrier pilot in quadrature with the suppressed carrier, is given some preference over the method of carrier recovery with the aid of a frequency gap. The latter method also requires dc-restoration, especially when used for facsimile in the asynchronous mode.

In view of the above considerations the Netherlands Administration is in favour of recommending line signal characteristics, which are applicable in the duobinary f.m.-detection mode and the quadrature sending and receiving mode, as well as in the vestigial sideband mode of operation. As a consequence, the Netherlands Administration would like the recommendation of the frequency gap around the carrier frequency to be deleted, this frequency gap not being essential and even annoying for some modes of operation (especially for the duobinary f.m. mode of detection).

As homochronous demodulation in a pilot may be required, the Netherlands Administration suggests that a carrier pilot be recommended, as an optional feature, without at the same time a frequency gap around this pilot being recommended, as this gap is not essential and might give some difficulties in digital implementations of the modulator. As far as asynchronous operation of the system is concerned, it would be possible:

1) to recommend one of the given modes of operation for asynchronous use;

2) to make the mode of operation subject to bilateral agreement.

The Netherlands Administration is not in a position to judge which of the two possibilities seems to be the better, or even whether there should not be a separate recommendation for facsimile use. In the latter case, in our opinion, it is no longer a problem to be dealt with in Special Study Group A.

2. *Specific points*

2.1 *Carrier frequencies*

To avoid the exclusion of digital modulation techniques, it is necessary or at least advantageous to choose carrier frequencies equal to a multiple of 1/4 of the data signalling rate, the modem being used synchronously. With the preferred data signalling rate of 48 kilobit/s the (virtual) carrier frequency for the vestigial sideband mode should be 96 kHz (or 72 kHz at the lower edge of the band) rather than 100 kHz. The (virtual) carrier frequency at midband according to the quadrature mode will then be 84 kHz. Moreover, this choice results in a better spacing between the data-signal frequency band and the voice band 104-108 kHz. A shaping factor up to 0.66 is attainable in the proposed configuration of the frequency spectrum. See Figure 1.

2.2 *Signal spectrum*

In general, successive pulse signals can be detected without intersymbol interference when the amplitude spectrum of the pulses shows odd symmetry (on a linear scale) about the frequency equal to half the maximum signalling rate. With a 48-kilobit/s signal this frequency is 24 kHz for the baseband signal. Translated to the primary group in the vestigial sideband mode with a carrier frequency of 96 kHz, this frequency is 96 − 24 kHz = 72 kHz (see Figure 2). With an asymmetric sideband signal, the same rule of odd symmetry, but not about the carrier frequency, can ensure the absence of intersymbol interference due to low frequencies in the baseband signal (see Figure 3). The above-mentioned rules should lead to 6 dB-down points in the spectral density of the pulse signals at 72 kHz and 96 kHz. Analogous reasoning can be followed for the other modes of modulation, leading to the same results. These 6 dB-down points at 72 kHz and 96 kHz include:

i) pulse shaping and filtering at the sending side;

ii) filtering at the receiving side in the 60-104-kHz band and possibly some filtering after demodulation, but before detection has taken place.

To avoid intersymbol interference it does not matter whether the above-mentioned measures are all taken at the sending side, partly at the sending side and partly at the receiving side, or all at the receiving side. So one should not expect any consequence of this reasoning in the specification of the line signal characteristics. However, there is a connection between the foregoing and the signal-to-noise ratio. With regard to noise entering on the transmission path, which has essentially a flat frequency response, the optimum signal-to-noise ratio and hence the optimum security in the detection of the signal will be reached when the effects of the measures i) and ii) mentioned above are evenly divided. Consequently, this means that the spectral density of the signal at the sending side should have 3 dB points at 72 kHz and 96 kHz and odd symmetry in the *power* spectrum instead of the amplitude spectrum. When this characteristic is not met, signal power is spoiled, which results in signal-to-noise ratios worse than can be realized in the optimum situation.

Of course, when a gap should be used in the spectral density at a carrier frequency the optimum situation is intentionally abandoned as far as the low-frequency content of the signal is concerned. In view of the foregoing considerations the Netherlands Administration suggests that the shape of the spectral power density of the signal be prescribed in the above-mentioned sense.

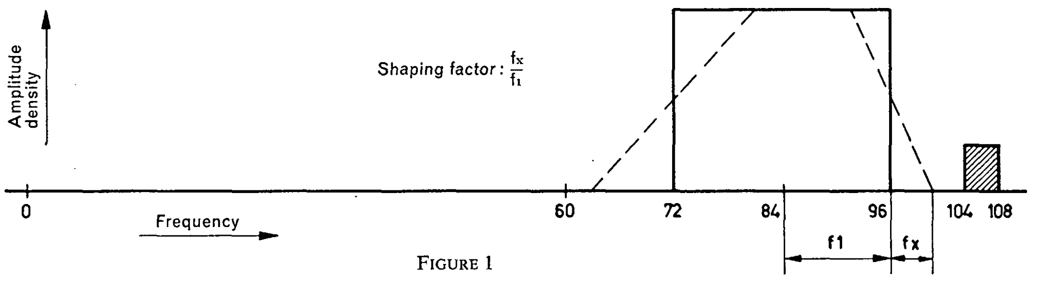


FIGURE 1

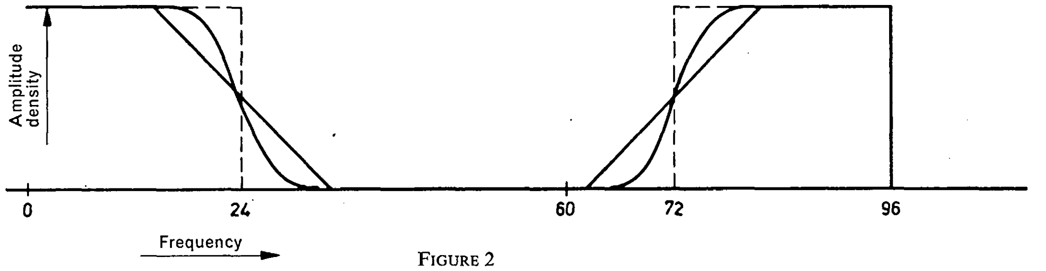


FIGURE 2

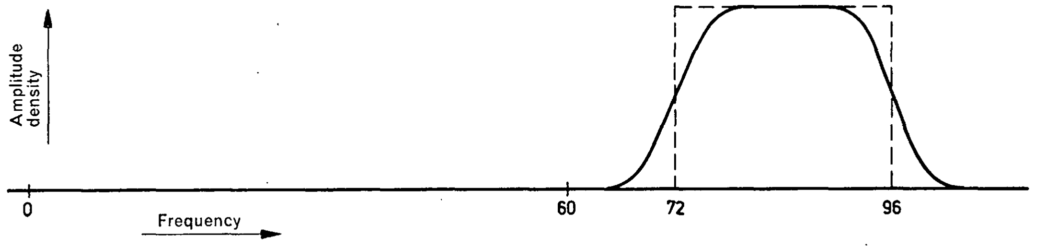


FIGURE 3

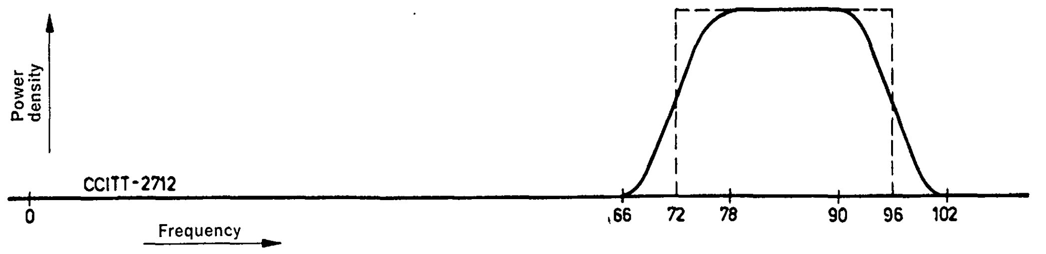


FIGURE 4

ANNEX 2

(to point Z)

USE OF WIDE-BAND CIRCUITS

(Contribution COM. Sp. A—No. 143—U.S.S.R., October 1967)

General considerations

It is common practice to divide all data-transmission systems on the network of the Soviet Union into three groups according to the type of communication channel used and transmission rate:

1. Low-speed systems operating over telegraph channels with transmission rates more than 200-300 bauds.

2. Average-speed systems operating over telephone channels with transmission rates not more than 10 000 bauds.

3. High-speed systems operating over wide-band channels set up on the multi-channel links of modern carrier systems.

The design problem of high-speed data-transmission systems may be expediently divided into two parts:

1. Design of standard wide-band channels of different width on the basis of multi-channel links of modern carrier systems. It seems that this problem must be primarily studied by Study Group XV. It is also advisable to raise this question before this Study Group.

2. Design of standardized high-speed data-transmission equipment; this part of the problem relates to the research field of Special Study Group A.

Wide-band channel design

It is advisable to standardize:

— pre-group wide-band channel on the pre-group basis (three telephone channels),

— group wide-band channel on the group basis (12 channels),

— super-group wide-band channel on the super-group basis (60 channels),

— master-group wide-band channel on the master-group basis (300 channels).

In future a need to study data transmission over channels using wider bands and over standardized video channels may arise.

To set up a wide-band channel on the group link basis, for example, it is necessary to add to standard carrier equipment:

— channel translating equipment which is connected at the ends of the channel and which contains channel filters, frequency characteristic equalizers, suppression filters for pilots and amplifiers;

— transit equipment which is connected at intermediate points where the through connection of group links is provided; this equipment contains through-connection filters, frequency characteristic equalizers and suppression filters for line pilots.

Wide-band channels must be provided with means of frequency characteristic equalization. This is necessary because considerable phase distortions may cause inadmissible signal distortion which cannot be equalized at the channel end. Phase distortion should be equalized in each through-connection equipment.

Precision equalization devices can be provided in data-transmission equipment for final equalization of the wide-band channel together with the local line.

Group wide-band channel requirements

Requirements for group wide-band channel designed for data transmission can be formulated in the following way:

1. channel type: four-wire, non-switched;

2. nominal frequency band of 60 to 108 kHz;

3. nominal transmission test level (in power) must be equal to −39 dB at the input and −5.2 dB at the output;

4. data-transmission signal level at the input (at the test level point −39 dB) must not exceed −43.5 dB in average power and −39 dB in maximum power;

5. nominal value of input and output channel impedances must not exceed 150 ohms. The reflection coefficient relative to the nominal value must not exceed 15%;

6. irregularity of amplitude/frequency characteristic must not exceed 1.7 dB ($\pm$ 0.85 dB) in the frequency range of 65-103 kHz with channel up to 12 500 km (with the number of through connections within the group link up to 19 and within the super-group link up to 15) excluding the band 83.7 to 84.6 kHz;

7. irregularity of envelope delay/frequency characteristic in the range of 66-102 kHz must not exceed 30 microseconds with channel up to 12 500 km;

8. noise level at the point of test level -5.2 dB should not exceed -40 dB at the output of the channel having the length of 2500 km;

9. the level of selective noise introduced by carrier and pilot leaks at the output of the channel having the length of 2500 km should not exceed -48.5 dB at the point of test level -5.2 dB;

10. smooth changes of the test signal level in time at the output of the channel having the length of 2500 km should not exceed $\pm$ 0.85 dB relative to the nominal level;

11. abrupt changes of signal level exceeding $\pm$ 1.7 dB (but not more than $\pm$ 6 dB) should not appear more than once within the period of 30 seconds in the channel having the length up to 12 500 km;

12. relative time period during which the impulse noise measured with the help of a device having the integration time of 10 microseconds exceeds 100 mV at the point -5.2 dB should not be above 5×10^{-5} within a one-hour period in the channel having the length up to 2500 km;

13. relative time during which the pilot level is reduced by 17.4 dB and more (within the period of more than 30 microseconds) should not be more than 8×10^{-6} within a one-hour period in the channel up to 12 500 km;

14. abrupt phase changes of the transmitted signal exceeding 30° should not appear more frequently than once within a two-hour period in the channel up to 12 500 km;

15. bit error rate in the speed range of 12-72 kilobauds should not exceed 5×10^{-5} in the channel up to 12 500 km;

16. in the first stage special selection and preparation of multi-channel links can be admitted for setting up wide-band channels designed for high-speed digital information transmission.

These requirements were formulated without taking into account the local lines. Perhaps they could be extended to comprise the whole channel including the local lines.

The requirements can be considered, naturally, only as provisional data to be used in raising this question before Study Group XV.

Reference pilots

It is not expedient to divide the wide-band channel into two parts because such a division causes frequency band losses and reduces total transmission speed. Using the whole frequency band of 60-108 kHz without division into sub-channels reduces the amount of data-transmission terminal equipment, makes it possible to obtain the highest data-transmission rate in a costly wide-band channel.

In order to eliminate the influence of the data-transmission signal on group reference pilot of about 84 kHz and the influence of this reference pilot on the data receiver, it is necessary to insert narrow-band rejection filters both at the beginning and at the end of the wide-band channel (in channel translating equipment).

The rejection filter causes adverse influence on data-transmission in two ways:

1. by cutting out a part of energy of a useful data signal;

2. by introducing into the surrounding medium a considerable phase distortion which cannot be corrected.

The first adverse factor is studied in the Annex to this contribution. This theoretical study shows that the presence of a rejection filter leads to the appearance of adverse impulses. The amplitude of these impulses is in most cases extremely small, therefore the influence of the impulses may not be taken into account. Carrier frequency and transmission rate must be chosen in such a way that main spectrum components of a signal do not fall in the stop-band of the rejection filter.

Experiments in data transmission over real group links were carried out. Mid-band frequency of the rejection filter was 84.14 kHz, the bandwidth at the level of 6 dB was approximately equal to 80 Hz and the attenuation at the mid-band frequency was about 30 dB. The data-signal carrier frequency was 84.00 kHz. Measurements were made by using frequency modulation, four-phase and eight-phase modulation methods. Transmission rates were 24-

36 kilobauds, 48-60 kilobauds and 60-72 kilobauds, respectively. With the insertion of two or three rejection filters the impairment of stability to fluctuation noise (with the error rate of 10^{-5}) did not exceed 2 dB.

Therefore, in the near future with the use of modern modulation methods employing transmission rates of up to 72 kilobauds the influence of rejection filters may be neglected. There are no reasons to shift the group reference pilot.

In future, when it will be necessary to obtain even higher transmission rates and to use more perfect equalizers and more elaborate modulation methods, situations will possibly arise when the use of rejection filters in the middle of the passband will lead to considerable impairment of noise immunity. With this in mind, it is advisable to continue (in conjunction with Study Group XV) the study of the question concerning the shift of pilots and rejection filters beyond the passband of the wide-band channel or, at least, to the passband edges.

The second approach to the problem is possible, namely, cutting off group pilot and rejection filters when using the channel for data transmission. The possibility of such an approach can be determined when this question is studied jointly by Special Study Group A and Study Group XV.

Switched wide-band channels

In the Soviet Union, high-speed data-transmission systems are supposed to be used in the near future only over leased circuits.

Transmission rates

The rule 600×2^n does not favour the creation of optimal systems. For example, for the channel of 48 kHz bandwidth the rates of 19 200, 38 400 and 76 800 bauds can be considered. The first two transmission rates do not ensure the use of all the channel possibilities, whereas the introduction of the third rate will result in considerable complication of the equipment.

The use of $600 \times \sqrt{2^n}$ rule adds intermediate rates of 27 072 and 54 144 bauds to the three rates mentioned above. This eases the situation but not to a great extent.

The adoption of the $600 \times m$ rule would mean, in fact, the refusal of the standardization of high rates. For example, 119 standard rates are obtained in the range of 12 000 to 84 000 bauds.

It is proposed to limit the number of standard rates by the new rule $12\,000 \times n$, adopting the $600 \times m$ rule as the basis. For example, the rates of 36 000, 48 000, 60 000 and 72 000 bauds obtained are very good for the 48-kHz channel.

Supervisory channel

The cost of a wide-band channel is, as a rule, high, therefore it is necessary to use the channel in the best way. It is proposed to use the whole frequency-band of the wide-band channel for data transmission without assigning a part of it (in the order of 4 kHz) for the supervisory channel. It is advisable to provide the possibility of establishing a supervisory speech connection instead of high-speed data transmission.

Such a solution is expedient at least for 12- and 48-kHz channels. In channels with wider bands, where the loss of 4 kHz will be negligible, the setting-up of a permanent supervisory channel might not reduce the possibilities of transmission.

If a customer urgently needs a permanent supervisory channel (for average-speed data transmission alternately with speech), it can be set up over a separate ordinary telephone channel.

Modulation method

When choosing a modulation method for a high-speed modem, it is necessary to take into account the considerably higher cost of a wide-band channel in comparison with that of a telephone channel. From the economical point of view it is advisable to use a more complicated data-transmission equipment in order to achieve the greatest possible rate.

Various modulation methods were tested on real channels:

— frequency modulation;

— amplitude modulation with a vestigial sideband;

— phase modulation with a vestigial sideband;

— four-phase differential modulation;

— eight-phase differential modulation.

It is proposed to use in data-transmission equipment the last method: eight-phase differential modulation. It ensures the highest transmission rate with normal error rate and good stability in operation. The 84-kilobaud rate was achieved. For the practical operation conditions, however, the lower rate of 72 kilobauds is recommended.

Description of eight-phase differential modulation modem

The block diagram of an eight-phase modulation modem transmitter is shown in Figure 1. The modem employs the ordinary digital principle of generating a phase-shift-keyed signal based on addition or inhibition of pulses in the process of frequency division in the frequency divider by eight. From a master oscillator the frequency of 672 kHz is fed to the divider input (672 kHz = 84 kHz $\times$ 8, where 84 kHz is a carrier frequency). From the divider output rectangular pulses are fed through the amplifier to the band-pass filter with the passband of 60-108 kHz. At the band-pass filter output the phase-keyed signal of 84-kHz carrier frequency is obtained.

From the transmitter input transmitted information is fed through the amplifier to the distributing circuit where binary signal elements are distributed among three sub-channels 1, 2 and 3. Data of three information signal elements are stored in triggers 1, 2 and 3. Then a coder generates three signals which control addition or inhibition of pulses in the divider by eight.

A " matching " circuit matches pulse trains of timing and carrier frequencies.

The output signal of the transmitter has eight possible phase shifts:

Sub-channels			Phase shift
1	2	3	
0	1	0	0
0	1	1	45°
0	0	1	90°
0	0	0	135°
1	0	0	180°
1	0	1	225°
1	1	1	270°
1	1	0	315°

The modulation code indicated above will give an error only in one sub-channel, if an adjacent phase position is received by mistake under the noise influence.

The phase modulation rate is three times less than the operational transmission rate (in the case described it is 72: 3 = 24 kilobauds).

The receiver block-diagram of the 8-phase modulation modem is shown in Figure 2. The received signal passes through the receiving band filter, then it is applied to the input amplifier limiter and to the envelope recovery circuit. As is known, the phase-shift-keyed signal envelope contains timing frequency components to which the local timing frequency is adjusted in the envelope recovery circuit.

The received signal and the local phase-shift-keyed signal with a " rotating " phase, obtained with the help of the divider by eight and coder, in the same way as in the transmitter, are fed to two phase detectors. The local signal repeats the phase positions of the preceding signal element received [1]. Thus, an original " differentially coherent method " is implemented in the receiver. The local signal, however, is free from noise.

[1] The method applied is similar to the reception method described in the article by Kazuo Kawai and others: " A new carrier multiplex telegraph system using phase modulation " (*The Journal of the Institute of Electrical Communication Engineers of Japan*, 1965, Vol. 48, No. 8, pp. 1369-1377).

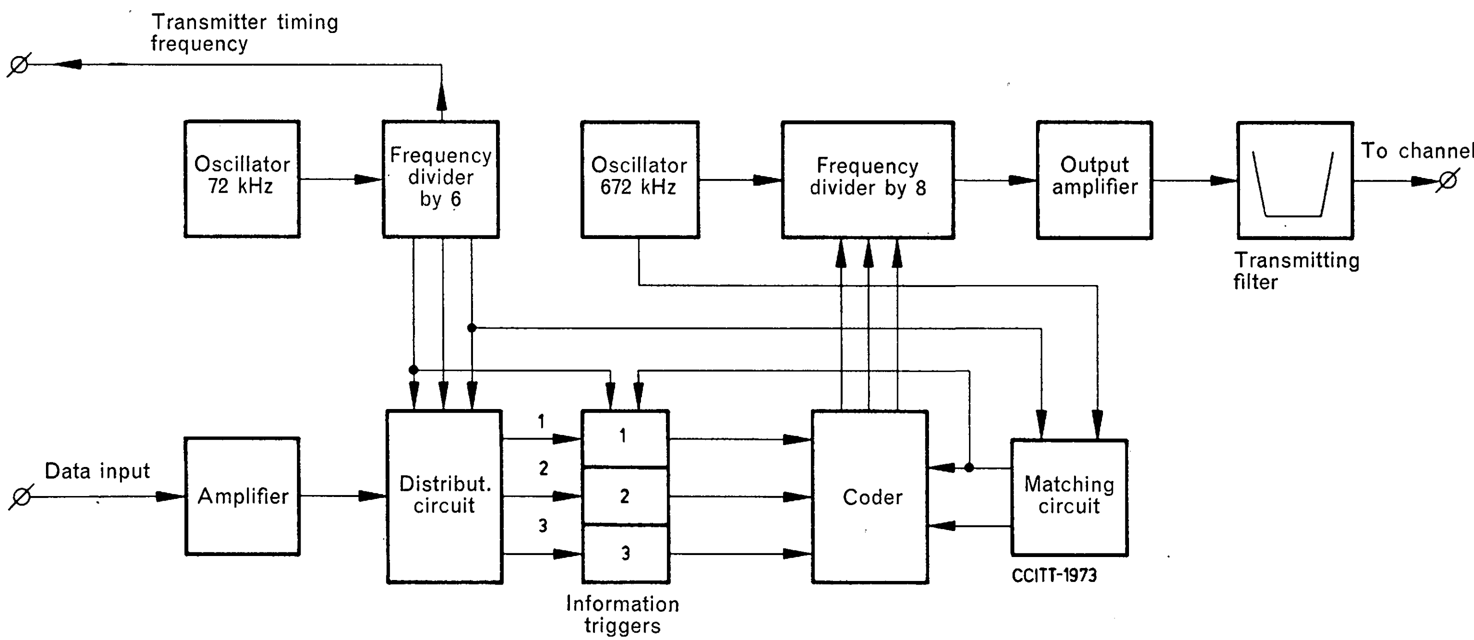


FIGURE 1. — **Transmitter block-diagram (72 kilobit/s)**

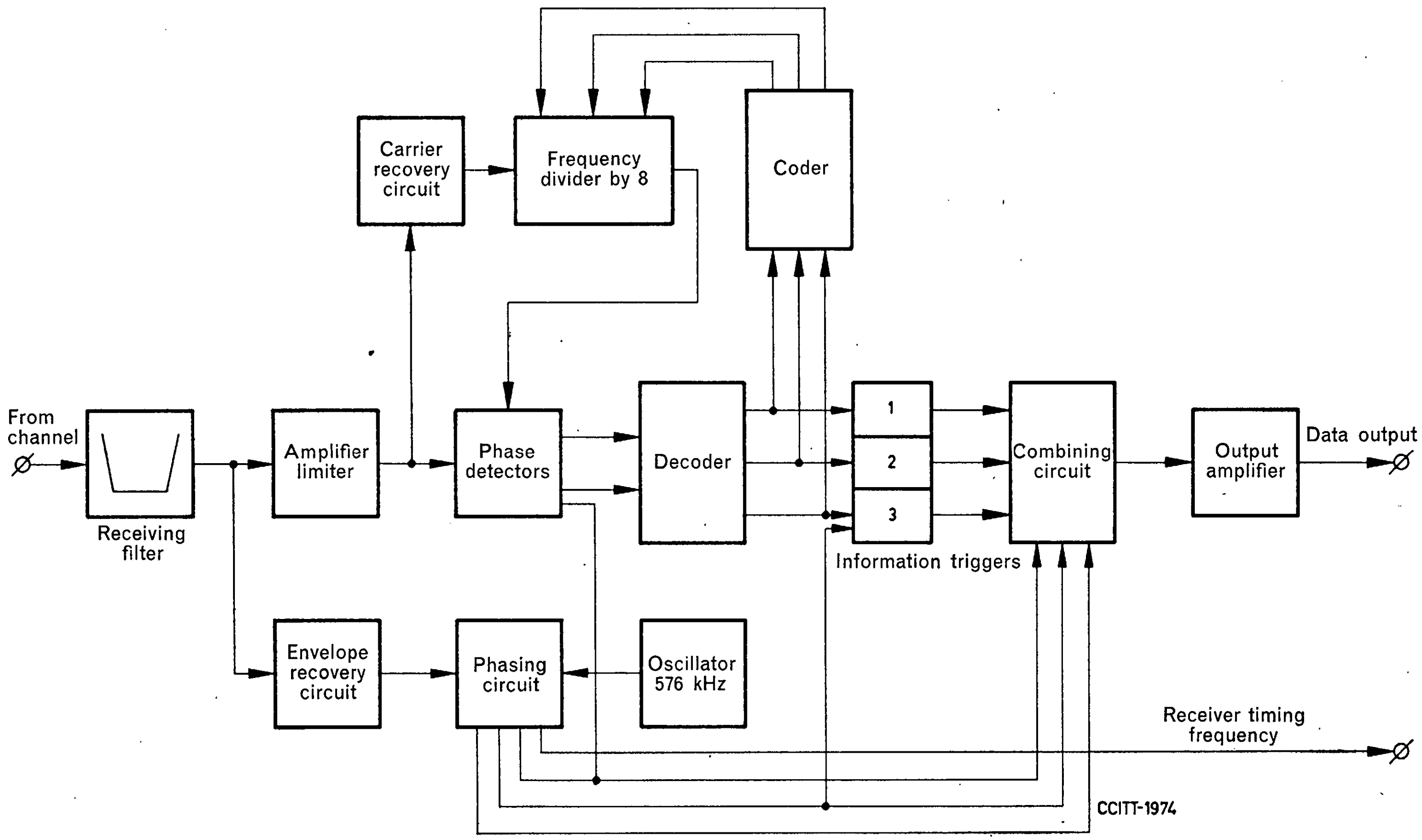


FIGURE 2. — **Receiver block-diagram (72 kilobit/s)**

Detected signals are applied to the decoder which recognizes signal elements in the three sub-channels. The use of the " rotating " phase method considerably simplified the decoder. The elements recorded in the information triggers are alternately fed to the output through the combining circuit.

Modem test results

From the tests carried out on the lines of 1500-3500 km, the following results were obtained:

a) At the rate of 60 kilobauds bit error rate within a 10-minute period did not exceed 1×10^{-5} during 75% of the time and 1×10^{-4} during 98% of the time; total test time was 90 hours, average error rate was 1.8×10^{-5}.

b) At the rate of 72 kilobauds bit error rate within a 17-minute period did not exceed 1×10^{-5} during 60% of the time and 1×10^{-4} during 92% of the time; the total test time was 53 hours, average error rate was 2.5×10^{-5}.

Figure 3 shows interrelation of bit error rate and S/N ratio under the influence of fluctuation noise with the bandwidth of 48 kHz; the interrelation was measured in laboratory conditions.

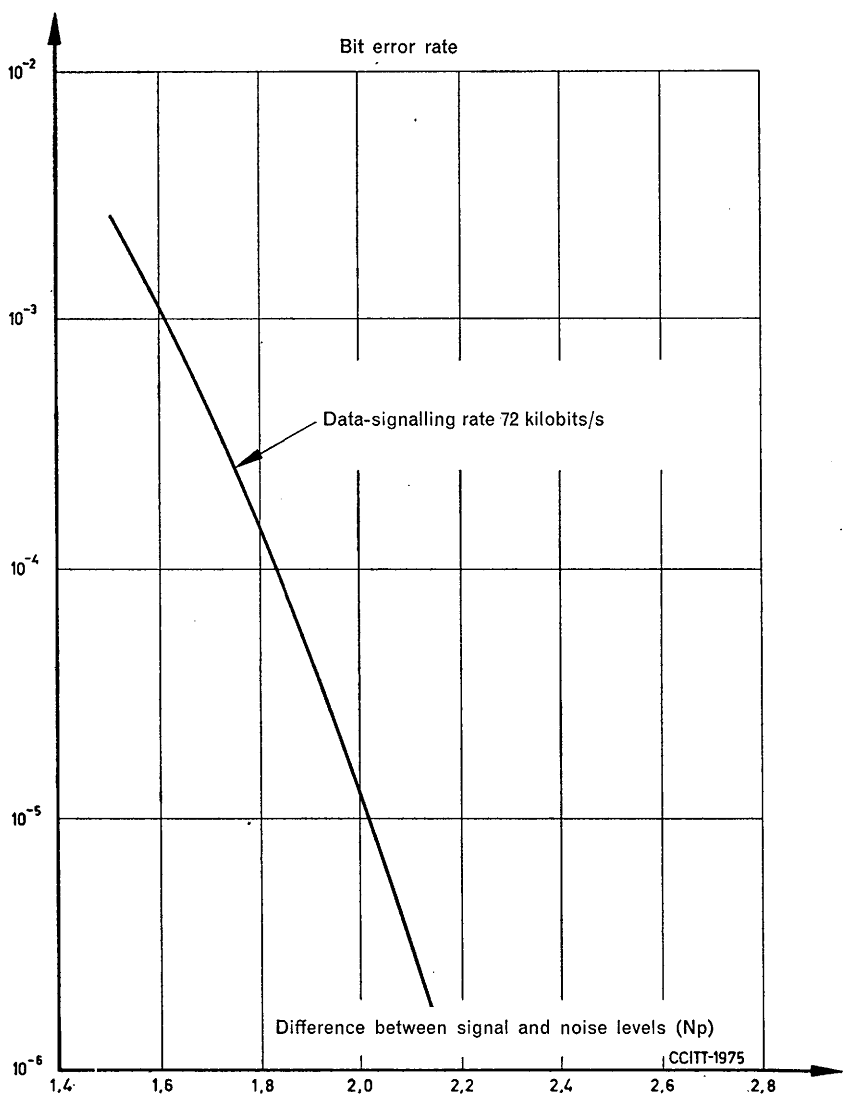


FIGURE 3. — **Interrelation of error rate and difference of signal and fluctuation noise levels**

APPENDIX TO ANNEX 2

Influence of rejection filters on pulse transmission over wide-band circuits

Let us first evaluate theoretically the influence of rejection filters on the transmission of unmodulated signals over a baseband system and then extend the results obtained on the transmission of modulated signals.

The baseband system

Suppose $A_0(\omega)$ is the spectrum of a pulse at the output of a baseband system having the linear phase response $\varphi_0(\omega) = \omega\tau_0$ in the absence of a rejection filter. Let the rejection filter with the midband frequency ω_r be connected in series with the baseband system. The amplitude response (amplitude/frequency characteristic) of this rejection filter is $A_r(\Omega)$ and the phase response is $\varphi_r(\Omega)$, where $\Omega = \omega - \omega_r$. Then the resulting amplitude response $A(\omega)$ and the resulting phase response $\varphi(\omega)$ are

$$A(\omega) = A_0(\omega)\, A_r(\omega - \omega_r) \qquad \varphi(\omega) = \omega\tau_0 + \varphi_r(\omega - \omega_r), \tag{1}$$

Assuming that for the pulse response (i.e. the response of the system to the Dirac's pulse) the stopband of the rejection filter is much narrower than the bandwidth of the channel, we have

$$P(t) = P_0(t) - A_0(\omega_r)\, a(t_0) \cos \omega_r t_0, \tag{2}$$

where

$P_0(t)$ is the pulse response of the system without a rejection filter,

$$a(t_0) = \frac{2}{\pi}\left\{ \Omega_N \frac{\sin \Omega_N t_0}{\Omega_N t_0} - \int_0^{\Omega_N} A_r(\Omega) \cos\left[\Omega t + \varphi_r(\Omega)\right] \mathrm{d}\Omega \right\}, \tag{3}$$

$\Omega_N = |\omega_r - \omega_N|$ is the frequency beyond which the influence of the rejection filter on the frequency response of the baseband system can be neglected;

$t_0 = t - \tau_0$.

Expression (3) shows that in the case of transmission of a single pulse with the spectrum $A_0(\omega)$, the rejection filter having the midband frequency ω_r, causes spurious oscillations at the frequency ω_r. The amplitude of these oscillations depends on the shape of the spectrum of the pulse transmitted and on the relative position occupied by the rejection filter midband frequency in the channel (i.e. ω_r).

The envelope of these oscillations is defined only by the amplitude and phase responses of the rejection filter.

It can be shown [1] that the amplitude response and the phase response of the rejection filters used in the carrier transmission equipment can be approximated by the following expressions:

$$A_r(\Omega) = \frac{\tau\Omega}{\sqrt{1 + (\tau\Omega)^2}} \qquad \varphi_r(\Omega) = \operatorname{arctg} \frac{1}{\tau\Omega} \tag{4}$$

where τ is a constant factor expressed in terms of the time and chosen so as to ensure that the characteristics mentioned above will correspond as nearly as possible to the actual rejection filter. For example, in the case of the 84.14 kHz rejection filter $\tau = 6.4 \times 10^{-3}$ s.

Substituting (4) in (3) and assuming the shape of the signal spectrum at the output of the baseband system to be cosine-squared [2], we have:

$$A_0(\omega) = \cos^2 \frac{\pi\omega}{2\omega_{\max}} \qquad f_{\max} = \frac{\omega_{\max}}{2\pi} > 36 \text{ kHz}$$

Thus for the 84.14 kHz rejection filter we obtain the maximum amplitude values of the interference voltage during transmission of a single pulse as shown in Table 1.

---

[1] B. S. Danilov: The influence of rejection filters on the pulse transmission over a telecommunication circuit (*Proceedings of the Central Research Communication Institute of the U.S.S.R. Ministry of Posts and Telecommunications*, 1963, No. 1).

[2] The frequency band chosen is equivalent to the frequency spectrum of the modulated VSB signal transmitted over the group channel in the range of 60 kHz to 108 kHz at the modulation rate of 36 000 bauds.

TABLE 1

$\frac{\omega_r}{\omega_{max}}$	0	0.25	0.33	0.5	0.75	1.0
The interference voltage amplitude/ undistorted pulse amplitude ratio	0.0087	0.0074	0.0066	0.0044	0.0013	0

Table 1 shows that the influence of the rejection filter on transmission of a single pulse can be neglected since the amplitude of the interference voltage is less than 1 per cent of the pulse amplitude.

The transmission of a random pulse train will result in a voltage being a sum of a great number of components. The ratio of the r.m.s. value of the interference voltage $\bar{U}$ to the undistorted pulse amplitude may be shown to be:

$$\bar{U} = \frac{1}{P_0(0)} \sqrt{\frac{1}{T}\int_{-\infty}^{\infty} (\Delta P)^2 \, dt}, \qquad (5)$$

where $\Delta P = P(t_0) - P_0(t_0)$,

T is the time interval between the pulses transmitted.

For the particular case considered earlier, where $f_{max} = 36$ kHz and $\tau = 6.4 \times 10^{-3}$ s, the values of $\bar{U} = F\frac{(f_r)}{(f_{max})}$ found from (5) are shown in Table 2.

TABLE 2

$\frac{\omega_r}{\omega_{max}}$	0	0.25	0.33	0.5	0.75	1.0
$\bar{U}$	0.066	0.056	0.050	0.033	0.010	0

In the case where the transmission of bidirectional pulses shows a certain regularity, the maximum value of the interference voltage can be calculated by summing up the interfering actions of individual pulses.

For the particular case discussed and for certain periodical pulse combinations the estimated values of the actual voltages are shown in Table 3, where $\frac{\omega r}{\omega_{max}} = 0.5$.

TABLE 3

Pulse train transmitted	Interference voltage	
	for double-current working	for single-current working
1. 1011010011000101 and further repeated	0.099	0.078
2. 1111111111111111	0.005	0.005
3. 1010101010101010	1.000	1.000
4. 1001001001001001	0.003	0.003
5. Random pulse train	0.003 (r.m.s. value)	

From the table one can see that in most cases the effect of the rejection filter during the pulse train transmission is rather small. For some combinations (e.g. 1111 and 1001001) almost complete mutual compensation of interference voltages takes place. In such cases the value of the interference voltage is much lower than the r.m.s. value of the noise.

We must also pay attention, however, to the case of transmission of " dots " (1010 signal). The values of the interference voltages in this case are summed up and the sum may have the same value as the wanted signal.

This has a straightforward physical meaning. In fact, during the transmission of " dots " the rejection filter midband frequency coincides with the first harmonic of the pulse train spectrum, this being the only harmonic for the given channel. In the cases 2 and 4, on the contrary, the rejection filter midband frequency is placed exactly between spectral lines of the pulse train transmitted. Case 1 is a close approximation to the random pulse transmission, therefore the interference voltage is of the same order of magnitude as the r.m.s. value of the voltage in the case of transmission of a random pulse combination.

Thus the ratio of the modulation rate to the channel bandwidth and the midband frequency of the rejection filter must be chosen in such a manner that the main spectrum signal components do not fall in the stopband of the rejection filter.

Transmission of modulated signals

The modulated signal in the phase-modulation systems is described in its most general form by:

$$P\omega\ (t) = R\ (t) \cos\ (\omega_0 t - \varphi_0) + Q\ (t) \sin\ (\omega_0 t - \varphi_0), \tag{6}$$

where $R\ (t)$ is the in-phase component,

$Q\ (t)$ is the quadrature component,

ω_0 is the angular frequency,

φ_0 is the initial phase of the carrier.

a) With the vestigial-sideband transmission of modulated signals and a synchronous detector in the receiver, the latter responds to the in-phase component only. Therefore, the output signal $P\ (t)$ of the receiver will be:

$$P_{\text{out}}\ (t) = R\ (t) = P\ (t),$$

where $P\ (t) = P_0\ (t_0) - A_0\ (\Omega_r)\ a\ (t_0) \cos \Omega_r\ t_0$ is the output signal of the baseband system which is described by (2)

Ω_r is the difference between the rejection filter midband frequency and the carrier frequency.

Thus in the PM/VSB system the effect of the rejection filter is similar to its effect in the baseband system.

b) With the PM/DSB system the rejection filter midband frequency is generally placed to the left or to the right of the carrier frequency, thus affecting the signal spectrum symmetry. From (2) and (6) the envelope of the in-phase component is

$$R\ (t) = 2\ P_0\ (t_0) - A_0\ (\Omega_r)\ a\ (t_0) \cos \Omega_r\ t_0.$$

The quadrature component of the voltage appears as well.

In the case of synchronous demodulation, we have:

$$P_{\text{out}}\ (t) = 2\ P_0\ (t_0) - A_0\ (\Omega_r)\ a\ (t_0) \cos \Omega_r\ t_0,$$

i.e. the effect is half of that in the baseband system.

With the four-phase modulation system, in each of the two quadrature sub-channels the interference voltage comprises two components:

a) a component due to the influence of the rejection filter on transmission of signals over the given sub-channel which is fully identical to the influence of that in PM/DSB system;

b) a component due to the appearance of the quadrature component of the interference voltage during the transmission of signals over another sub-channel.

Supposing the amplitude of the latter component is almost identical to that of the former component, we may conclude that the influence of the rejection filter in the four-phase modulated system is twice as large as in the PM/DSB system and approximately equal to that in the PM/VSB system.

ANNEX 3
(to point Z)

Modem for operation on wideband circuits at data rates above 48 kilobits per second

(Extract from the report of Special Study Group A, December 1972)

1. *Mode of operation*

It was agreed that any modem for higher data rates on 48-kHz circuits should be synchronous.

2. *Data rate*

It was agreed that it would be desirable to have one family of modems for higher data rates. The rates to be considered were 48 kbit/s, 56 kbit/s, 64 kbit/s and 72 kbit/s. There was general agreement that a modem would be required for the new data network, and that Study Groups VII and IX should be asked to state their requirements exactly.

3. *Line signal*

It was agreed that the line signal should be identical with an SSB or a VSB suppressed carrier AM signal with its carrier frequency at 100 kHz.

It was further agreed that some form of digital filtering would be convenient for the suppression of the components around 100 kHz, but it was too early to specify the precise method.

4. *Pilot*

It was agreed that although it would be desirable to retain the group pilot at 84 kHz (and there were in fact methods of suppressing the power in this region at a certain speed), it would nevertheless be impracticable to design a suitable system accommodating a number of different speeds.

It was agreed therefore that the system should be based on the removal of the pilot to 104 kHz.

5. *Code insensitivity*

It was agreed that modems should be completely code-transparent.

6. *Sensitivity to group delay distortion and attenuation distortion*

Unless further information is received on this matter, the modem should be designed for operation on circuits according to the revised Recommendation H.14.

7. *Error rate*

It was agreed that an objective bit error rate of less than 10^{-6} should be established. This would be in the presence of noise limits as set in the relevant C.C.I.T.T. reference circuit recommendations.

8. *Outband signal level*

Further study of this point should be made, taking into consideration Recommendation H.52.

ANNEX 4
(to point Z)

Methods of comparative tests of wideband modems

(Extract from the report of Special Study Group A, December 1972)

1. Both the tests and the conditions under which they were to be carried out were specified so that comparable measurements might be obtained.

In connection with the study of alternative wideband synchronous modems the following indicates the basis on which performance tests of modems should be carried out.

2. *Error rate curve and S/N ratio*

2.1 A minimum of 10 errors should be recorded for each measurement.

2.2 The signal power (S) is the sum of the powers of the data signal and the modem pilots. It does not include the power of the group reference pilot nor that of the service speech channel.

2.3 The white gaussian noise (N) shall be injected and measured after band limiting by a through-group filter (60-108 kHz).

2.4 To get a random signal on line a binary 1 condition shall be applied to the input of the modem when the latter includes a scrambler. When it does not, a scrambler similar to that described in Recommendation V.35 shall be placed in front of the modem.

3. *Data-signalling rate*

Measurements shall be made at at least one of the following data-signalling rates: 48, 72 and 96 kbit/s.

4. *Characteristic curves*

The characteristic curves for attenuation and variation in group delay with frequency should be plotted for each test and given with the corresponding error rate curve.

5. *Group tests*

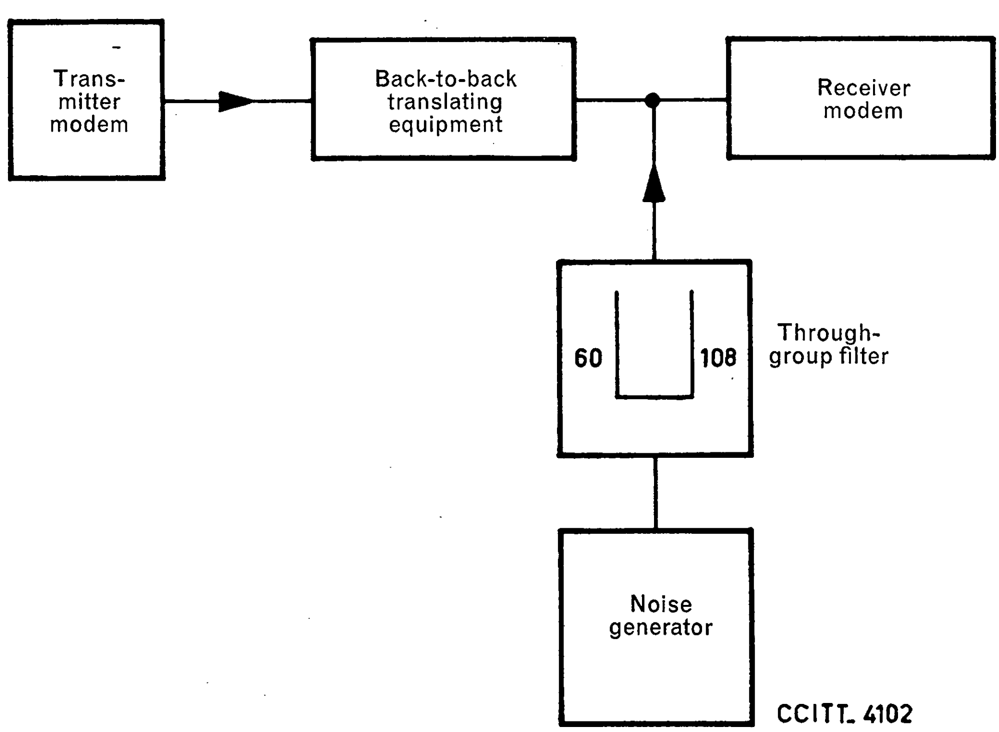
These tests shall be made in the laboratory by inserting between the transmitter and receiver either:

- one respectively two-looped group sections; in this case the neighbouring groups shall not be loaded (see figures in Sections 5.1 and 5.2), or
- an equivalent quadripole with identical characteristics.

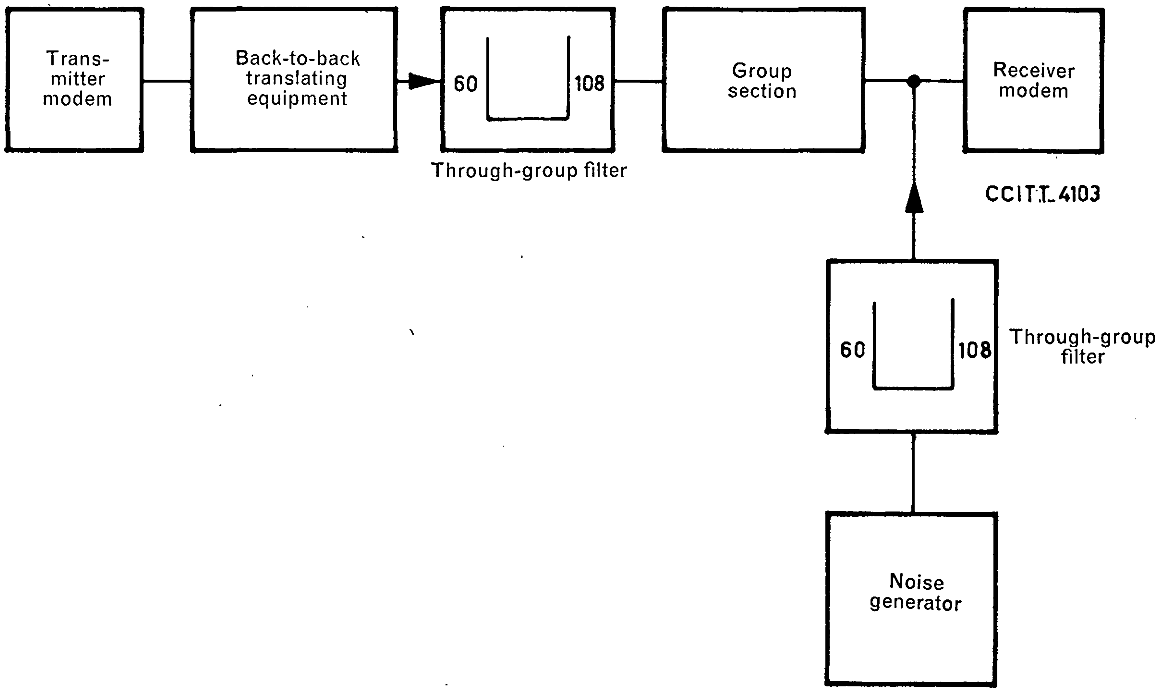
Where appropriate, the frequency of the group reference pilot shall be given.

Two types of group links were taken:

5.1



5.2



6. *Tests on H.14 type circuits*

A test shall be made on a circuit of the type given in Recommendation H.14.

7. *Test path*

A test shall be made on a path approximately 1000 km long.

In addition to the error rate, the level (in dBm0) and the characteristic curves, the following information shall be given:

— the make-up of the circuit (number of sections, group reference pilot frequency, etc.);

— the type of loading on neighbouring groups;

— the noise power (in dBm0) measured at the receiving end across a through-group filter (60-108 kHz);

— the harmonic noise, particularly at 72 and 96 kHz;

— the duration of the tests.

8. *Additional information*

Where possible, test results shall be accompanied by such additional information as:

— the outband level measured per 4-kHz speech channel;

— resistance to amplitude and phase jumps.

Question 1/A - point AB — Use of digital transmission (or pulse-code modulation)

(continuation of point AB of the study programme 1964-1968)
(to be examined by Special Study Group D)

ANNEX
(to point AB)

EXTRACT FROM THE REPORT OF SPECIAL STUDY GROUP A, DECEMBER 1972

1. It was agreed that for the time being only data transmission using a single p.c.m. time slot and non-synchronous with the p.c.m. system should be studied. The bit rate of this data slot considered is 56 kbit/s which can be accepted without code restrictions. The use of 64 kbit/s time slots or a complete digital p.c.m. type link or of part or whole of a standard p.c.m. frame should be studied at a later stage. Nevertheless, the priority order of these various methods of broadening the digital data transmission facilities over and above 7-bit time slot should be studied in order to give guidance to Special Study Group D.

2. The most important items to be investigated regarding non-synchronous heterochronous data transmission using 7 bits per time slot are—not necessarily in order of priority—the following:

a) the services to be provided, i.e. the transmission rates and the detail of the structure of the data to be conveyed;

b) the classes of circuit to be provided, i.e. point-to-point circuits, multipoint circuits not involving breaking into the p.c.m. link, multipoint circuits involving breaking into the p.c.m. link;

c) the general structure of the transmission path, including the relationship of p.c.m. to local lines, modems or other sections of the transmission path;

d) the effect of impairments produced by coding when connecting to non-p.c.m. parts of the circuit, e.g. telegraphic distortion, jitter, frame slip, etc.;

e) the representation of the data stream in the time slot bearing in mind the transmission efficiency, and its cost and flexibility and the need for supervision as provided by the data interface.

3. Special Study Group A is of the opinion that the special problems connected with the use of a pulse code modulated telephone channel for data transmission should be studied in relation with other points of Question 1/A.

4. Special Study Group A agreed to retain this point for the next study period although there was not much study during the current period. It would also be advantageous to be kept informed of the study results from Special Study Group D.

Question 1/A - point AC — Use of circuits established by means of satellite

(continuation of point AC of the study programme 1964-1968, amended at Mar del Plata, 1968)

Satellite links may possess properties different from other links with regard to noise distribution, available bandwidth, and propagation delay. In view of these different properties, it is recommended that the following factors be studied:

a) What general characteristics for error detection and correction should be standardized to enable efficient use to be made of data transmission over circuits involving satellite links (see Recommendation V.41)?

b) What methods should be standardized for the efficient establishment of data connections, especially in the automatic mode over circuits composed, in part, of a satellite link?

Note. — See Supplements Nos. 24 and 25 of this volume.

Question 1/A - point AD — Comparative tests of modems for use over telephone-type circuits

(Mar del Plata, 1968, amended at Geneva, 1972)

1. Study of points arising from the implementation of Recommendation V.56.

2. Points for further study are:

1) Test parameters for symmetric and asymmetric tone attenuation and group delay distortions—these parameters and their tolerances are provisional and require standardization in order to reproduce laboratory comparisons.

2) Of primary importance are the specifications of line simulators and how they are to be manufactured. Suggestions have been made to specify circuit components or poles and zeros so that standard curves with minimum ripple characteristics can be selected that meet the requirements of 1) above. Information is required to realize the best solution.

3) Quantizing noise—additional information is required to substantiate the importance of this parameter to the test set-up for the comparison of modems.

4) Impedance mismatch—same as 3) above.

5) Sudden changes of attenuation and interruptions—information is needed to specify the characteristics of this fault for a test set-up. Administrations are requested to submit test data for live channels relating to the magnitude, duration and repetition of this fault.

6) White noise source—information is needed to specify the characteristic of this source.

7) Echo source—same as 5) above.

8) Selected tests for comparisons—information from all sources are requested to standardize the specific tests and the sequence in which they are performed.

9) As the technology of modems becomes more sophisticated, these devices may be affected by parameters that are not clearly evident today. Information is continuously requested when new problems arise that affect modem operation so that the standard test set-up can be updated.

10) In the testing of modems under simulated conditions, all efforts should be made to operate the modem as if it was on actual lines; for example, if a modem has an adjustable manual equalizer, the equalization procedure should be performed in the same manner as if line traffic was being transmitted. Suggestions for the various methods to improve simulations for actual line conditions are advised.

Note. — See Supplement No. 26 of this volume.

Question 1/A - Point AE * — Interchange circuits

(Mar del Plata, 1968, amended at Geneva, 1972)

1. Study of points arising from the implementation of Recommendations V.24, V.28 and V.31.

2. Further study of the electrical characteristics for balanced double-current interchange circuits.

3. Study of the electrical characteristics for interchange circuits implemented in integrated-circuit technology.

Question 1/A - point AG — Transmission constraints of wideband data system

(Mar del Plata, 1968)
(concerns Joint Working Party LTG; Questions 28/XV and 29/XV)

In wideband data systems, what constraints should be placed on the distribution of data signal (inband and outband) energy with respect to its concentration within a given frequency band and the permissible duration of such concentration?

1. The problems associated with interference to other services is more complex and potentially more serious with wideband than with voiceband data transmission. This is because the total allowable power is greater in the wideband than in the voiceband facility (viz., about 10 dB higher on 48 kHz than on a voice channel). It is desirable for this energy to be uniformly distributed over the entire frequency spectrum.

2. Difficulties and interference are likely if, as a result of the data terminal sending a repeated pattern of bits (repeated character or an idle condition), the total signal power is concentrated in a single frequency or a few frequencies for any extended period of time—viz., 1 second or more.

3. This problem is minimized in Recommendation V.35 by use of an encoder/decoder (i.e. a scrambler) which ensures a random data signal. However, these constraints need defining to aid in future work on standardizing new modems and in cases where non-standardized modems are permitted.

4. Limits should be set on the maximum permissible concentration of signal energy (power) within a portion of the total bandwidth (viz., within any 1 kHz of bandwidth) when this energy is integrated over some specified interval (viz., 1 second). It may be necessary to specify different limits for integration over several different time intervals.

ANNEX
(to point AG)

REPLY TO POINT AG BY SPECIAL STUDY GROUP A, DECEMBER 1972

1. *Introduction*

The point AG is related to three aspects of a data signal:

— maximum permissible inband power;

— maximum permissible outband power;

— distribution of the power in the frequency band.

These aspects are interdependent: either inband or outband power should similarly be constrained to a lower level when discrete components are present in the spectrum. In that case, we ought to define what is meant by " discrete components ". An appropriate definition may be: " a signal of sinusoidal form with a minimum duration of, say, 100 msec ".

2. Recommendations often have the intention:

— of guaranteeing optimal conditions, e.g. to reach as high a signal-to-noise ratio as possible;

— of preventing interference with other services which use the same system.

Both aspects influence the constraints put on a wideband data signal.

3. *Existing recommendations concerning constraints*

3.1 G.241 d gives information about the maximum permissible power of a discrete component in the outband of a data group link, which can disturb the functioning of an automatic group regulator of an adjacent group.

3.2 G.241 f deals with the protection of the group pilot of the data group link. The graph which shows the limiting values of the inband signal is under study. From the context of Recommendation G.241 f this study relates to:

3.2.1 the position of the pilot (84 + d kHz or 104.080 kHz);

3.2.2 the characteristics of a new group regulator with a passband as narrow as possible;

3.2.3 the need of a bandstop filter for the group pilot at the input of a data group link and the characteristics of this filter depending on the spectrum of the data signal;

3.2.4 in addition, the graph gives the impression that the maximum level of a data signal at the pilot frequency should be —65 dBm0, although that figure is not mentioned explicitly.

3.3 G.242 as a whole discusses maximum outband levels in the case of through-group connections. The problem is, however, that the discussion and the figures are based on the use of telephone-type circuits.

3.3.1 G.242 b gives valuable information which, bearing in mind the foregoing remark, states a diminution of the unwanted levels in a speech channel of 70 dB.

3.4 H.52 is a recommendation which, in fact, summarizes problems to be solved. These problems are:

3.4.1 the maximum power of an inband discrete component in the data signal (a value of —14 dBm0 is mentioned as used by at least one Administration);

3.4.2 this recommendation refers to Recommendation G.241 f for constraints on the spectrum of the data signal in the neighbourhood of pilots. As pointed out under 3.2, some problems are yet to be solved;

3.4.3 concerning outband levels, we are referred to Recommendation G.242 b as to the limitation of power by directives similar to that Recommendation. However, the remark made under 3.3 shows that " similar directives " are not yet described adequately.

3.5 Recommendation V.35 gives directives concerning the following points:

- the nominal level should be equivalent to —5 dBm0;
- a pilot with a relative level of —9 dB should be added in phase with the input (the total power level, however, can then reach a value of —3.5 dBm0);
- no information is given about the speech level in the channel that should be provided for. This speech level can result in a higher group level;
- interference of the data group pilot of groups with the supergroup pilot is referred to in Recommendation G.232 M b;
- adjacent channel interference is limited by putting a figure of —60 dBm0. This figure should be in accordance with the attenuation of 70 dB mentioned under 3.3.1 and should also be in accordance with the rule of H.52, pointed out under 3.4.3;
- the " crosstalk " within the band 60 to 108 kHz between data spectrum and the gap for the pilot should be limited as indicated in Appendix 2. This Appendix, however, is not in accordance with the graph mentioned under 3.2;
- interference of signals outside the data band should be limited to —40 dB crosstalk attenuation in the range 0 to 60 kHz and 104 to 180 kHz.

4. *Points to be studied*

As Recommendation V.35 relates to a specific use of a wideband circuit, the study of transmission constraints on wideband data systems should for the time being be confined to Recommendation H.52 and Recommendation G.241 f. We are also in need of an adequate interpretation of Recommendation G.242 b for data systems.

This study can be split up into the following parts:

4.1 A study to be carried out by Special Study Group A on how a signal with an adequately low level of discrete components can be made by means of a scrambler, taking into account as many economical and practical aspects as possible.

4.2 A study to be done by Study Group XV which gives information about acceptable length and levels of discrete components in the outband of a data signal. (See Question 1/A—point AG, paragraph 3.)

4.3 A study to be done by Study Group XV which gives rules on how to apply the values of Recommendation G.242 b, as mentioned under 3.3.1 and 3.4.3.

4.4 To ask Study Group XV which graph should be used—the graph of Recommendation G.241 or the graph of Recommendation V.35.

Should the graph of Recommendation G.241 be used, as may be expected, then the value of the bottom part of the graph should be indicated (−65 dBm0?).

4.5 The problems mentioned under 3.2.1, 3.2.2 and 3.2.3 are already under study by Study Group XV.

Special Study Group A therefore submitted the above comments to Study Group XV for its consideration during the current study period (1968-1972).

Question 1/A - point AH — Modems for transmission of medical analogue data

(Mar del Plata, 1968)

In some countries, use is made of the general telephone network for the transmission of ECG (electrocardiogram) analogue data directly from a patient in his home or a doctor's office to a major medical centre where specialists are available. The transmitting modem may be electrically connected to the subscriber line or may be acoustically coupled to the telephone. A bandwidth of about 100 Hz is used.

Requirements for similar international ECG transmissions are likely to develop.

Additionally, experimental work is under way on systems for the simultaneous transmission of three channels of ECG data from a patient directly to a computer. The medical community, in co-operation with the communication and computing experts, are devising automated diagnostic procedures which hold great promises for mankind.

What are the requirements for the transmission of medical analogue data and what are the characteristics of modems to meet these needs?

Note. — See Supplement No. 27 of this Volume.

Question 1/A - point AI — Transmission of data over intercontinental telephone-type circuits

(Mar del Plata, 1968)

Should use be made of a special signal to distinguish data calls which may involve equipment different from that of normal speech connection?

ANNEX
(to point AI)

Extract from reply to point AI by Special Study Group A, December 1972

Special Study Group A discussed what specific items should be studied under this question and the following points were proposed by certain delegates:

— data transmission over intercontinental telephone-type circuits which make use of a speech concentrator such as TASI. Handshaking procedures and burst types of data transmission should particularly be taken into consideration;

— data transmission over the switched telephone network taking into account the presence of both terrestrial and satellite intercontinental circuits and the wide range of propagation times which could be experienced on resulting connections. Such variations in propagation time are of particular significance with respect to error control arrangements and handshaking procedures at the terminals;

- the conditioning of intercontinental circuits (terrestrial and satellite) in the switched telephone network for data transmission (e.g. provision of equalization in addition to echo-suppressor disablers);
- overall data transmission performance over intercontinental connections on the switched telephone network;
- the need for inter-register information or other signals to identify data calls on the switched telephone network.

Question 1/A - point BA* — Duplex modems

(Geneva, 1972)

1. It is desirable to consider amending Recommendation V.21 to permit operation up to 300 bauds when terminals capable of operating at this higher rate are available at each end of a connection.

2. In view of the trend towards terminals capable of duplex operation at rates in excess of 20 characters per second, it is desirable to standardize modems for operation over public switched telephone networks at rates greater than that permitted by Recommendation V.21.

Points to be considered are:

1) Is compatibility with V.21 modems desirable?

2) Maximum data signalling rate required by new terminals.

3) Synchronous or asynchronous operation.

4) Technical parameters of suitable systems.

Question 1/A - point BB — Tests for data transmission systems on wideband circuits

(Geneva, 1972)

Data transmission tests on wideband circuits should be made, taking account of Recommendation V.57.

Question 1/A - point BC — Revision of the existing V series Recommendations

(Geneva, 1972)

QUESTION ON PUBLIC DATA NETWORKS ENTRUSTED TO STUDY GROUP VII FOR THE PERIOD 1973-1976

Chairman : Mr. V. C. MacDonald (Canada)

Vice-Chairmen : Mr. N. R. Crane (Australia)
Mr. H. Gabler (F.R. of Germany)
Mr. A. E. Serrure (Belgium)

Question 1/VII — Public data networks

(continuation of Questions 9/X, 1/A - point H and 1/A - point AJ, part 2, 1968-1972, amended at Geneva, 1972)

What general characteristics should be standardized to permit international data communication over public data networks?

ANNEX

(to Question 1/VII)

Study programme for further study of the Question

Note. — An asterisk (*) indicates an urgent study point.

Point	Title	Remarks
A	Standardization of user classes of service for public data networks	
B	Standardization of user facilities	
C	Packet-mode operation	
D	Call set-up and clear-down time	
E	What numbering plan should be adopted for public data networks?	
F	Grade of service	
G	Transmission quality	
H	Interworking problems which may arise with the telex service	Concerns Study Group X
I	Standardization of signalling in anisochronous public data networks	Concerns Study Group X
J	Implementation of the user facilities in public data networks	
K *	The provision of features in the DTE-DCE interface for fault identification and isolation	
L	The use on public data networks of DTEs which are designed for interfacing to existing V-series modems	

Point	Title	Remarks
M	Protection of control characters used for signalling at the DTE-DCE interface	
N	The means of operation when the DTE is in a local or non-operating mode	
O	Compatibility between DTE-DCE interfaces used for start-stop and synchronous services	
P *	The interface between DTE and DCE for start-stop services	
Q *	The interface between DTE and DCE for synchronous services	
R	Definition of terms arising during the study of public data networks	
S *	Multiplex structure for international links between synchronous data networks	Concerns Study Groups IX and Special D
T	Timing and synchronization	
U *	Centralized control signalling for international connections between synchronous data networks	
V *	Decentralized control signalling for international connections between synchronous data networks	
W	What are the characteristics of and requirements on the bearer channels over which the 64 kbit/s aggregate multiplex bit rate channels are to be carried?	
X	Error control	
Y	Security in data networks	

Question 1/VII - point A — Standardization of user classes of service for public data networks

1*. Further consideration of the user classes of service applicable to the start-stop mode of transmission as specified in Recommendation X.1.

2*. Further consideration of the user classes of service applicable to the synchronous mode of transmission as detailed in Recommendation X.1.

3. Data rates higher than 48 kilobit/s.

Question 1/VII - point B — Standardization of user facilities

Bearing in mind the user facilities recommended in Recommendation X.2, what additional ones should be recommended? Consideration, for example, could be given to:

1) High-speed multiplex links, which are defined as a means of enabling a DTE to have several access channels to the data network over a single circuit.

   Three possibilities could arise:

   a) bit interleaved;

   b) byte interleaved;

   c) packet interleaved.

Consideration should be given to the overall economic advantage to users of these facilities, and to defining the technical and operational aspects of these facilities.

2) Speed and/or format conversion—possible considerations for study are:

   a) Should the conversion be achieved automatically by the network or,

   b) Should the conversion be achieved only on request by a calling terminal?

3) Code conversion—possible considerations for study are:

   a) Between what codes should conversion be available?

   b) Should the facility be provided by the network or by an add-on device?

   c) Does code conversion also imply speed conversion (refer to 2) above)?

4) Information (Inquiry) services—possible considerations for study are:

   a) What speed and codes should be used to obtain an answer to the inquiry?

   b) Is the facility better provided initially by speech communication over the general telephone network?

5) Repeat call attempts—should there be a restriction placed on the number of automatic attempts and if so what constraints should apply?

6) Polling—possible considerations for study are:

   a) Is polling a feasible method of operation on a switched data network compared with other methods of operation?

   b) Would polling impose a heavy loading on the network?

7) Data collection at users' request—possible considerations for study are:

   a) Should the facility be provided for each user class of service?

   b) What are the storage requirements in the network?

8) Call back when busy line free.

9) Leased circuit facilities—in view of the proposed switched facilities (Recommendation X.2) what leased circuit facilities should be provided?

10) Multiple line (at the same user's address)—points for consideration are:

   a) Should this facility be provided by means of a data multiplexer at user's location?

   b) To what extent is this facility covered by consideration of 1)?

11) Incoming calls barred.

12) Redirection of calls—points to be considered are:

   a) Should redirection be at the user's request?

   b) Should initiation of such a request be permitted by the user using an agreed class of traffic signal?

Note. — The definitions of 3) and 9) are contained in the list of C.C.I.T.T. definitions. The definitions of 1), 4), 6), 7), 8), 10), 11) and 12) are shown in the Annex to Question 1/VII—point R, but are not yet agreed.

Question 1/VII - point C — Packet-mode operation

Should the packet-mode of operation be provided on public data networks and if so how should it be implemented?

Question 1/VII - point D — Call set-up and clear-down time

What objectives should be set for call set-up and clear-down time?

ANNEX 1

(to Question 1/VII - point D)

1. As a guide, a call set-up target figure of 100 ms-200 ms for all user classes of service from 2400 bit/s upwards using a 10-character address should be aimed at for distances of up to 800 km and for connections involving three switching points. At speeds lower than 2400 bit/s, a set-up time figure of up to one second might be acceptable over these distances. The provision or otherwise of a network verification or continuity check could affect the actual values mentioned above.

For these distances a clear-down target figure of 100 ms for user classes of service from 2400 bit/s upwards, and up to 400 ms for lower speeds should be aimed at.

2. Paragraph 1.11 of Recommendation X.70 states that a target setting-up time of one second has been set for the start-stop user classes of service.

ANNEX 2

(to Question 1/VII - point D)

THE NATIONAL NETWORK USED FOR STUDY OF CALL SET-UP AND CLEAR-DOWN DELAYS

(Extract from Document GM/NRD—No. 50—August 1971, United Kingdom Post Office)

The national network used to calculate call set-up and clear-down delays is based on the principles briefly outlined below:

1. *Local network*

Each data switching exchange (DSE) to control a fully synchronous local network employing digital line systems as a transmission medium and multiplexing equipment for combining the data traffic from various sources within the DSE area.

Network control signalling between the customer and the parent DSE would be accomplished by in-channel signalling at the maximum information rate of the bearer channel. The network control signalling codes would be by characters employing a 7 + 1 bit code.

The model assumes automatic calling and network control signalling at the customers' premises and assumes no delay in the customers' data terminal equipment when responding to a network control signal. A ten-character selection sequence has been used. A propagation delay representing 50 miles (80 km) has been included with other buffering delays involved at multiplexing equipment. No traffic concentration in the local network has been assumed.

2. *Data switching exchange*

The model assumes a centralized network control signalling system with a processor delay of about 5 ms at each exchange. A queueing time is included for gaining access to the separate signalling channel.

Digital switching has been assumed in the exchanges and thus an allowance has to be included for slot changing delays where in-channel signals form part of call set-up/clear-down.

3. *Trunk network*

The trunk network has been assumed to consist of two links each of 200 miles (322 km) interconnecting an originating and destination DSE via a tandem DSE. The trunk network employs centralized signalling with a separate network control signalling channel between each DSE. The state of the called terminal (is " Free " or " Busy ") can therefore be tested before physically setting up a circuit switched channel. The capacity of the separate network control signalling channel interconnecting each exchange has been taken as 48 kbit/s.

4. *International link*

The international link has been assumed to be 1000 miles long (1610 km), employing the same network control signalling arrangements as the national trunk network.

TABLE 1

NATIONAL CALL

The national network has been assumed to be that described in paragraph 3, i.e. two links each of 200 miles (322 km) interconnecting the originating and destination data switching exchanges via a tandem data switching exchange.

Type of customer activity	Customer data signalling rate (bit/s)	Pre-selection delay (ms)	Selection delay (ms)	Post-selection delay (ms)	Continuity check (ms)	Total delay (ms)
Hot line call	600	34	—	83	—	117
	2 400	9	—	63	—	72
	9 600	3	—	58	—	61
	48 000	2	—	56	—	58
Call with address selection	600	61	133	83	—	277
	2 400	21	33	63	—	117
	9 600	11	8	58	—	77
	48 000	8	2	56	—	66
Hot line call with a continuity check	600	34	—	83	205	322
	2 400	9	—	63	64	136
	9 600	3	—	58	27	88
	48 000	2	—	56	19	77
Call with address selection and a continuity check	600	61	133	83	205	482
	2 400	21	33	63	64	181
	9 600	11	8	58	27	104
	48 000	8	2	56	19	85
Originator of clear-down	600	—	—	—	—	61
	2 400	—	—	—	—	21
	9 600	—	—	—	—	11
	48 000	—	—	—	—	8
Non-originator of clear-down	600	—	—	—	—	89
	2 400	—	—	—	—	49
	9 600	—	—	—	—	39
	48 000	—	—	—	—	36

Question 1/VII - point E — What numbering plan should be adopted for public data networks?

1) The possible need for interworking between data terminals on a public data network and data terminals on public telex and telephone networks.

2) The provisional conclusion that public data networks adopt the telex destination codes listed in Recommendation F.69.

3) Possible alternatives to 2) above.

Question 1/VII - point F — Grade of service

What should be the overall grade of service in a public data network?

ANNEX
(to Question 1/VII - point F)

Paragraph 1.8 of Recommendation X.70 states:

The grade of service to apply for the provision of circuits for fully automatic telex service, namely, one lost call in 50, would also apply to links between public data networks of anisochronous type which carry traffic overflowed from other routes, or from which overflow was not permitted. For high usage direct links circuits would be provided at a grade of service of one lost call in 10.

Question 1/VII - point G — Transmission quality

To consider the question of transmission quality from both the user and network planning points of view and make Recommendations.

Question 1/VII - point H — Interworking problems which may arise with the telex service

1) When the telex service is provided on synchronous data networks in two countries.

With the emergence of Recommendations for synchronous data networks, the possibility of providing the telex service over such a network is envisaged by some countries. In view of this, study should be made of the problems involved, particularly the signalling between the national data networks concerned.

2) More generally, different methods of providing the telex service may be used in the future, for example, by conventional telex or public data networks. There are many possibilities, including the following, to be taken into account when studying the interworking problems which arise.

a) New public data networks in different countries may be based on synchronous or anisochronous procedures;

b) In some countries these networks will carry the telex service as well as data transmission services;

c) In most cases there will be a transitional period during which the telex service on a new public data network will be required to coexist with telex on an existing network;

d) New " defined " telex services may be introduced at a higher signalling rate than 50 bit/s with the possibility of interworking. (This point is related to Question 1/VII - point B, items 2 and 3);

e) International telex gateway centres for any country may be part of an existing telex network or a public data network or in both during a transitional period;

f) International transit facilities for telex may be required on either public data networks or existing telex networks.

Question 1/VII - point I — Standardization of signalling in anisochronous public data networks

1) Further consideration of Recommendation X.70 in the light of experience or further study.

2) Signalling for the synchronous user classes of service.

Question 1/VII - point J — Implementation of the user facilities in public data networks

The implications of implementing the facilities included in Recommendation X.2 with particular reference to:

a) the interface between DTE and DCE;

b) signalling;

c) operational procedures.

ANNEX

(to Question 1/VII - point J)

Implementation of the multi-address facility requires that the following matters be considered:

1) Should the call be set up by the DTE establishing each connection sequentially by sending an address and awaiting for " connect-through " before sending the next address?

2) Should the call be set up by the DTE giving the network all the called terminals addressed at one time?

3) What is the effect on " connect-through " signals used at interface? Is another signal required?

4) What action should be taken if one terminal is busy? Two alternative actions are:
   - wait till this terminal is free, thus holding up the call completion, or
   - establish the connection with all available terminals and advise the calling terminal of called terminal(s) that are connected.

5) Does multi-address require replies from the called terminals as data or text, or as control messages for error protection?

6) If error protection of the data is required, are the necessary procedures available to the users in national or international standards?

7) Is multi-address feasible with the proposed signalling systems?

Question 1/VII - point K* — The provision of features in the DTE-DCE interface for fault identification and isolation

1) What are the requirements for fault identification?

2) What facilities are required in the network to meet these requirements?

3) What features are required in the DTE-DCE interface to meet these requirements?

4) What should be provided in the DTE-DCE interface to isolate identified faults so as to reduce or prevent faulty operation in the network?

Question 1/VII - point L — The use on public data networks of DTEs which are designed for interfacing to existing V series modems

1) Is this possible due to the differing characteristics of the telephone network and public data networks?

2) What modifications need to be made to the existing interfaces of the V series, for use with public data networks? Can such revised interfaces provide working with DTEs designed for use with existing V series DCEs? Such new Recommendations for modified interfaces based upon V series DCEs must consider the protocol used with DCEs used on the telephone network and that used or proposed for public data networks. The study of this point requires consideration of the various interface functions which must be implemented.

Question 1/VII - point M — Protection of control characters used for signalling at the DTE-DCE interface

Some of the network control functions at the DTE-DCE interface appear in a serial binary form between the DCE and the network. Consideration, for example, should therefore be given to:

1) Is there a requirement to protect such control sequences against errors caused for example by equipment malfunction, transmission impairments in the local loop, etc.?

2) If so, what means should be specified?

Question 1/VII - point N — The means of operation when the DTE is in a local or non-operating mode

A DTE may be in a local mode or may be unable to accept incoming calls; for example, it may be engaged in a data processing operation which cannot be interrupted. To determine how an incoming call should be handled the following possibilities should be considered:

1) The DTE to advise the data switching exchange whether it can accept calls, or if it is in a local or other non-operating mode. This will enable the exchange to decide if a call should be offered to the DTE, or if the call should be rejected because the DTE is not in an operating mode.

2) Offer all calls to the DTE which can then accept or reject them. Is there need in this case for the DTE to indicate why the call is being rejected?

3) Redirect the call to another DTE.

The method of implementing these procedures requires study.

Question 1/VII - point O — Compatibility between DTE-DCE interfaces used for start-stop and synchronous services

Is compatibility between start-stop and synchronous interfaces important?

If so, what adaptations are required to the Recommendations for interfaces for start-stop and synchronous working compatibility taking into account the need to provide efficient working in each user-class of service?

Question 1/VII - point P* — The interface between DTE and DCE for start-stop services

Further consideration of Recommendation X.20 in the light of experience and, in addition, consideration of the following points to complete the Recommendation.

a) Timings used in the clearing process require study to determine whether changes in them can lead to reduced clear-down times.

b) When the multi-address facilities are further defined, their impact on the interface must be studied and additions made to the Recommendation, if necessary.

c) Study is required of the need for a guard delay between the receipt of the proceed-to-select signal and the start of the address signalling. A guard delay longer than the duration of Z polarity for call confirmation plus the duration of the character interval of the call confirmation character may assist in the design of the switching exchange. On the other hand it will tend to increase the call set-up time.

d) When manual call establishment and release is used what procedures should be defined and what changes are required to the interface? Consideration is also required of the use of manual and automatic operation during the same call.

Question 1/VII - point Q* — The interface between DTE and DCE for synchronous services

1) *General purpose interface*

The completion of Recommendation X.21, which provides the basis of and defines the important parameters for a general purpose interface between DTE and DCE for synchronous services. Consideration is required of the following points, bearing in mind that control signalling will be in full International Alphabet No. 5 at the DTE-DCE interface.

a) What additions are needed to Recommendation X.21 for a general purpose synchronous interface such as:

Timing between protocol events;

Time out safeguards;

Definition of characters used for network signalling and addressing;

Provisions for manual calling and answering;

Busy conditions or call not accepted by DTE;

Failure of DTE or DCE to observe interface operations;

Fail-safe operation;

The use of burst or continuous isochronous data transfer across the DTE-DCE interface?

b) The completion of the interface protocol (the events and their relationship that occur at the interface) for:

Direct call;

Multiple address;

Network recall;

Control signalling between the DTEs.

2) *Basic interface*

It is recognized that while a general purpose interface will find widespread use there is in addition a need for a basic interface using fewer interchange circuits than is the case for the general purpose interface bearing in mind that signal element timing shall be provided by the network independent from the user's data signal. Consideration is required of the following points bearing in mind that control signalling will be in full International Alphabet No. 5 at the DTE-DCE interface.

a) What degree of co-operation in network control, e.g. idle characters during clear-line period is necessary from the DTE to achieve a basic interface?

b) Will the DTE be required to add or delete bits for network control purposes such as are required for envelope construction or complete non-data envelopes for speed-matching purposes?

In considering these points, the following should be borne in mind:

i) need for bit sequence independent data transmission;

ii) unambiguous means of call establishment and call clearing taking into account i);

iii) the additional features as outlined in 1.b);

iv) is an envelope needed as the most efficient way of achieving the above features? If not, what are the other alternatives to be recommended?

v) is an envelope needed at the interface for use by the customer for transmitting data over the network?

vi) is an envelope needed for call establishment and clearing?

vii) is an envelope needed for the additional facilities listed in point 1.b)?

If an envelope is recommended:

viii) what are the envelope characteristics?

The implications to network operation, such as transmission, switching and signalling, must be considered. Should the needs of network operation affect the users' interface?

ix) should envelope alignment be maintained at all times (locked to the network) or should it be re-established at the beginning of each call? Should it be maintained only during the call set-up period, during the call, or for some period after the call is terminated?

x) should there be a fixed phase relationship between the envelopes on the go and return transmission paths? If so, should this relationship be maintained during the call set-up period, during the call, or for some period after the call is terminated?

xi) what means should be employed to achieve envelope alignment and what will be done if synchronization is lost?

ANNEX 1

(to Question 1/VII - point Q)

The following points were agreed during the 1968-1972 study period:

1. Bit timing shall be provided by the network. To achieve bit sequence independence, bit timing must not be derived from transitions of the binary data signals.

2. The connect-through signal is to be generated by the network and when received by the DTEs data transmission and reception can commence. This signal will indicate that all bits sent by either terminal after the connect-through indication is received shall be delivered to the corresponding terminal after the receipt of the connect-through signal at that corresponding terminal.

Note. — At the local station, the connect-through indication may be followed by either bits originated in the distant DTE or in the network. If generated in the network, the maximum duration and pattern of these bits shall be specified after further study.

3. Data bits delivered to the network before the clearing signal is applied from the same DTE must be delivered to the distant DTE before the clear signal arrives at that DTE. This may require safeguards in the signalling system, e.g. centralized system.

Note. — During the clear-down process, bits generated by the network may be received by the DTEs. The maximum duration and pattern of such bits shall be specified after further study.

4. The " proceed to select ", " incoming call " and " call confirmation " indications will be signalled at the interface by unique signals (operation of interchange circuits, exchange of coded characters, or both) to provide positive operation at the interface and to avoid collision.

ANNEX 2

(to Question 1/VII - point Q)

Definitions for interchange circuits

(proposed by Mr. F. W. Warden, *Chairman of NRD2, on interfaces between DCE and DTE)*

The following definitions are proposed for the interchange circuits used in the interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for synchronous working over public data networks.

1. *Protective ground*

This will be the same circuit as in Recommendation V.24.

2. *Signal ground or common return*

This will be the same circuit as in Recommendation V.24.

3. *Transmitted data*

Direction: To DCE.

The data signals originated by the DTE to be transmitted via the data circuit to one or more remote data stations are passed over this circuit to the DCE.

This circuit is also used to transfer network control signals from the DTE to the DCE according to the interface signalling scheme used in the appropriate Recommendation.

4. *Received data*

Direction: From DCE

The data signals generated by a remote data station and transmitted via the data network are passed over this circuit to the DTE.

The circuit is also used to transfer network control signals from the DCE to the DTE according to the interface signalling scheme used in the appropriate Recommendation.

5. *Control DTE source*

Direction: To DCE

A transition from an OFF condition to an ON condition on this circuit occurs when the DTE wishes to:

a) initiate a call;

b) answer a call.

A transition from an ON condition to an OFF condition on this circuit occurs when the DTE:

a) requests that the connection be cleared down;

b) is a confirmation response to a clear request from the DCE.

A momentary OFF condition on this circuit is used to indicate to the DCE and the network that the DTE is sending a network control signal on the associated transmitted data circuit. The OFF duration is equal to the duration of the network control signal.

A steady OFF condition indicates that the DTE is in a free line or rest condition.

During all other times a steady ON condition is maintained on this circuit to maintain the connection.

6. *Control DCE source*

Direction: From DCE

A steady ON condition on this lead indicates to the DTE that data transfer can take place.

A transition from an ON condition to an OFF condition on this circuit occurs:

a) in response to the clearing signal previously given by the DTE over the control DTE source interchange circuit and indicates that clear-down of the call is in progress;

b) when the connection has been cleared by the other DTE or by the network and data transfer can no longer take place from this station.

After a suitable guard delay (to be defined) the DTE can originate a new call or may be in a condition to receive a new call.

A steady OFF condition indicates that the network is in a free line or rest condition.

7. *Signal element timing*

Direction: From DCE

The definition of circuit in Recommendation V.24 applies.

8. *Byte timing*

Direction: From DCE

An OFF to ON transition on this lead is used to align network control signals between the DTE and the DCE. An ON to OFF transition has no significance.

The following definitions are necessary to understand the above:

a) *Network control signals:* these are the signals or characters which are used in the interface signalling scheme and are transferred between the DTE and the DCE for the purpose of call establishment, call disconnection or for control signalling during the data phase.

b) *Data phase:* during the data phase, data signals are transferred between DTE which are connected via the network.

Question 1/VII - point R — Definition of terms arising during the study of public data networks

Continue the preparation of definitions which arise during the study of all the points of Question 1/VII.

ANNEX

(to Question 1/VII - point R)

The following list of definitions was still under study during the 1968-1972 period.

1. *Information (inquiry) facility*

A facility whereby a user, by sending a predetermined address from the terminal installation, may gain access to general information regarding data communication services.

Note. — Access may be provided, for example, for directory inquiry, charging inquiry, fault reporting.

2. *Polling*

A definition for this term has been drawn up by I.S.O. (Index number 13.13.2). Further clarification of the facility " polling " is required—it will also be necessary to define " master (control) station " and " slave (subsidiary) station ".

3. *Remote terminal identification*

A facility provided by the network for automatically transmitting to a user's terminal installation an agreed identification code relating to the remote user's terminal installation (or installations) to which a connection has been established.

Note. — The identification may be of the called terminal installation to the caller or of the calling terminal installation to the called terminal installation or identification of each terminal installation to the other and normally occurs only before the users may transmit data.

4. *High-speed multiplex link*

A means of enabling a DTE to have several access channels to the data network over a single circuit.

Note. — Three likely methods have been identified:

a) Packet interleaving
b) Byte interleaving
c) Bit interleaving.

5. *Call-back when busy terminal installation becomes free (automatic recall)*

A facility which enables the originator of a call attempt to a busy terminal installation to request the network to establish the call when the busy terminal installation becomes free.

6. *Timing supplied by network*

Timing signals transferred from the data circuit-terminating equipment on a separate interchange circuit which control the transfer of digits across the transmitted data and received data circuits.

7. *Manual calling*

This facility permits the entry of selection signals from a calling terminal installation at an undefined character rate. The characters may be generated at the DTE or the DCE.

8. *Manual answering*

With this facility a call is established only if the called user signals his readiness to receive it.

9. *Automatic calling*

With this facility selection signals must be entered contiguously at the full character rate.

The address characters will be generated in the DTE.

Note. — A limit may be imposed by the Administration to prevent more than a permitted number of ineffective call attempts to the same address within a specified period.

10. *Automatic answering*

With this facility the called data terminal equipment automatically responds to the " calling " signal and the call may be established whether or not the called terminal is attended.

11. *Data collection*

A facility for gathering small quantities of data from a nominated group of users, assembling them within the network into a single message for delivery to another nominated user.

12. *Multiple lines at the same address*

The facility of permitting a user to receive calls to a single address on more than one access circuit.

13. *Incoming calls barred*

A facility which permits a terminal installation to make outgoing calls only.

14. *Redirection of calls*

A facility which permits a called user to request the network to transfer a call to another nominated address. This may be for:

i) all calls following the request;

ii) individual calls.

15. *Priority facility*

A facility which gives a user preference over the other users.

Priority may be given for instance to handling of the call, packet transfers, and other services provided by the network.

16. *Synchronous data networks*

A data network which uses a method of synchronization between data circuit-terminating equipment (DCE) and the data switching exchange (DSE) and between DSEs, the data signalling rates being controlled by timing equipment within the network.

TERMS FOR INTERWORKING BETWEEN SYNCHRONOUS DATA NETWORKS

17. *Signal unit*

The smallest defined group of bits on the line used for the transfer of signal information.

18. *(Signal) message*

Signal information pertaining to one call or management action sent at one time on the line. A message may consist of one or more signals transmitted as one or more signal units.

19. *Associated signalling*

A mode of common channel control signalling in which the signalling path(s) terminate(s) on the same exchanges as the information bearer circuits that it (they) control(s):

quasi-associated signalling
non-associated signalling
fully-dissociated signalling

as Glossary of terms specific to signalling system No. 6 (see the *Green Book*, Vol. VI)

20. *Stuffing character*

A character used on isochronous transmission links to take account of differences in clock frequencies.

21. *Self-protected signalling system*

A signalling system with inherent guards against failures or errors in either the signalling terminals or the signalling link.

22. *Continuity check (path check, circuit check)*

A check made of the information bearer channel or channels in a connection to verify that an information path exists.

23. *Idle signal unit*

A signal unit containing no information but serving only to maintain unit synchronization.

24. *Filler character*

A defined number of bits added to control signals to make the total number of bits equal to the number of bits defined for the signal unit.

25. *Idle character*

A control character that is sent when there is no information to be sent.

26. *Inactive character*

A character that is sent in data mode as part of the customer's data when no active data is to be sent.

27. *Aligner*

A device used to align the elements of one data structure to particular elements of another structure and, in some cases, also to change between the two structures.

28. *Frame*

A frame is a structure which allows a receiver to uniquely identify an information bearer channel. A frame is necessary in a multiplexed data stream.

29. *Forward set-up*

Seizure of information bearer channels sequentially in the direction of calling to called terminal.

30. *Backward set-up*

Seizure of information bearer channels sequentially in the direction of called to calling terminal. Backward set-up is only feasible with common channel signalling systems.

31. *En bloc signalling*

A method of signalling where all the necessary signals pertaining to one call are sent as an entity.

32. *Overlap signalling*

A method of signalling where all the necessary signals pertaining to one call are sent discontinuously with some signals being sent forward before other necessary signals are received.

33. *Diversity of common signalling channels*

Methods of providing common signalling channels whereby more than one channel is available on a route, either normally or abnormally, for example under failure conditions.

34. *Synchronous signalling system*

A common channel signalling system where the signals are organized into isochronous signal units. Idle signal units are used to maintain unit synchronization.

35. *Asynchronous signalling system*

A common channel signalling system where signal messages are separated by indeterminate intervals.

36. *Adaptive channel allocation*

A method of multiplexing where the information capacities of channels are not predetermined but are assigned on demand.

37. *Status channel*

A channel indicating whether a group of bits is for data or control use.

38. *Status bit*

A binary digit, belonging to an envelope, which gives the indication that all the information bits of this envelope (i.e. all the bits which are not required for the operation of the data transmission channel) are either data bits or control bits.

39. *Indicator bit*

A binary digit, belonging to an envelope, which gives the indication that *some* of the information bits of this envelope are not of the same mode as those of the previous envelope.

40. *Framing bit*

A binary digit which is used for frame synchronization.

41. *Synchronization bit*

A binary digit which is used for character synchronization.

42. *Framing pattern*

A unique pattern of framing bits.

43. *Distributed framing pattern*

The word " distributed " is used when the bits of the framing pattern are not altogether, but are distributed in regular places in the frame.

44. *Permanently locked envelope*

It is used when envelopes are always separated by a number of bits corresponding to an integer number of envelopes.

45. *Homogeneous multiplex*

Multiplex in which all the channels are at the same rate.

46. *Transmission code violation*

Digits which are not in the transmission code and which, when used in small quantities, can give some more information without significantly affecting the spectrum of signal.

47. *Intervention signal*

It is a control signal which is not used by the network, but is transmitted end-to-end for customer purposes.

48. *Bipolar violation*

A " one " digit which is not in accordance with the rule of the bipolar code.

49. *Recall signal*

A signal originated by the user, after the call set-up has been completed, used to control the network in some way other than disconnect.

Question 1/VII - point S* — Multiplex structure for international links between synchronous data networks

Considering

the principles of the multiplex structure that have been defined in Recommendation X.50,

that additional user data signalling rates may be recommended in the future,

that the international multiplex structure may have an effect on the interface between the DCE and the DTE,

that decentralized inter-exchange signalling may be required on links between synchronous data networks, that end-to-end signalling may be required,

that transit switching will be required,

that multiplex structures more suitable for interworking between certain networks may be required,

it is necessary to study:

1) what constraints, if any, need to be placed on the mix of different channel bearer rates in a heterogeneous multiplex;

2) what framing performance is required with respect to:

a) the detection of loss of frame alignment, and

b) the recovery of frame alignment;

3) what detailed framing structure should be adopted;

4) what methods should be used to provide the 4-octet multiframe on individual channels;

5) in the 4-octet multiframe, how should the framing and status bits be specified and what should be their relationship to control and data bytes;

6) what provision should be made in the multiplex structure to accommodate different bearer rate/user rate ratios that may be defined in the future;

7) what additional multiplex structures, if any, should be provided for interconnexion of certain networks.

Question 1/VII - point T — Timing and synchronization

Considering

that terminals on one synchronous data network will have to interwork with terminals on other synchronous data networks,

that terminals on synchronous data networks will have to interwork with terminals on anisochronous data networks,

that terminals on synchronous data networks may have to interwork with analogue modems on telephone networks,

and the agreed basis for study annexed to this point,

it is necessary to study:

1. what timing and synchronization procedures should be recommended for interworking between synchronous data networks:

a) are synchronized clocks to be preferred? If so, how are they to be synchronized? For example, what would be the parameters of the synchronization channel and what procedures would need to be standardized for establishing and recovering synchronization? It should be noted that Special Study Group D is also considering this problem;

b) if the toleration of a degree of slip is to be preferred, how is the slip to be controlled? For example, what clock accuracy would have to be established and how much storage would have to be provided?

2. how are looped-backed clocks to be implemented in anisochronous data networks and what effect will this have on the DTE-DCE interface:

3. what timing and synchronization provisions must be made for interworking between terminals on a synchronous data network and low-speed start-stop terminals on anisochronous data (and possibly Telex) networks;

4. what timing and synchronization provisions must be made for interworking between terminals on a synchronous data network and analogue modems on a telephone network;

5. what are the required relationships between timing and synchronization in new data networks and voice PCM networks.

ANNEX

(to Question 1/VII - point T)

During the 1968-1972 period, the following points were agreed as a basis for further study:

1. *Timing and synchronization for synchronous or plesiochronous working*

Although in some cases the provision of an overspeed facility might have some advantages, the overhead involved did not justify its general use. The general preference is for synchronized clocks or the tolerance of a limited amount of slip with appropriate safeguards such as high stability clocks and the provision of storage.

It is known that within national networks full synchronization can be provided. Such national networks can be mutually synchronized with gateway clocks having an effective stability of one part in 10^{11} by the use of a synchronization control channel with a capacity of 100 to 1000 bit/s. This can be provided either by a special channel or by part of a common signalling channel.

2. *Timing and synchronization for interworking between synchronous and anisochronous networks*

There would appear to be little difficulty for lower speed start-stop connections, e.g. up to 200 bit/s as the bearer rates of the synchronous network would be considerably higher.

At higher rates all connections should be set up in a full duplex mode. It can be assumed that the anisochronous network will be clock-transparent and that therefore looped-back clocks at the anisochronous terminal can be employed.

3. *Timing and synchronization for interworking between synchronous networks and modems on the telephone network*

There are a number of alternatives which might be ranked in the following order:

a) The use of full duplex working and the provision of a new modem with the facility for a looped-back clock;

b) the use of buffering at the boundary of the synchronous network. Though these buffers might be rather expensive they would be located at high traffic points;

c) the use of transition encoding, although this method would use bandwidth in the synchronous network in a highly inefficient manner;

d) no interworking.

Question 1/VII - point U* — Centralized control signalling for international connections between synchronous data networks

Considering

that Recommendation X.70 has defined a system for decentralized signalling between anisochronous data networks,

that it has been agreed to produce Recommendations for both centralized and decentralized signalling systems for synchronous data networks, that compatibility may have to be achieved between

a) local, i.e. user, and international signalling;

b) centralized and decentralized inter-exchange signalling;

c) inter-exchange signalling on anisochronous data networks and inter-exchange signalling on synchronous data networks;

d) different user classes of service on the same network;

that the facilities to be provided by the network are defined in Recommendations X.1 and X.2 and are being further considered under Question 1/VII - points A and B,

that it has been recognized that there would be technical advantages in the adoption of an " error detection only " procedure in which corrupted signal units would be discarded at the receiving terminal, the design of the signalling procedures being organized so that " hang-ups " did not occur,

that many telecommunication services may have to be accommodated in the one joint user network,

that some points of agreement are listed in the Annex to this Question,

what detailed centralized signalling system is to be recommended?

Important points are:

1) What signal unit size should be adopted and how will these signal units be formed into messages?

2) How will its idle condition be recognized?

3) What form of error control should be used?

4) What form of signalling procedures should be adopted?

5) How should the available codes be assigned?

ANNEX

(to Question 1/VII - point U)

During the 1968-1972 period the following points were agreed as a basis for further study:

1. Recommendation X.70;

2. The principles concerning signalling between synchronous networks which are set out below.

a) *Inter-exchange signalling*

Taking into account the present uncertainty over the traffic patterns on international links, the study of both centralized and decentralized signalling systems is recommended with a view to the production of Recommendations for both types of system.

It is proposed that the procedure for handling head-on collisions with two-way working and the inverse order testing of circuits should be as defined in Recommendation X.70 (paragraphs 1.6 and 2.3).

The signalling system should provide for transit working. Where both-way circuits are employed on a given international link, a single coherent method of transmission and signalling should be employed.

b) *Centralized signalling system*

C.C.I.T.T. Signalling System No. 6 is unsuitable in its present form for data networks, nevertheless its desirable features should be used as a basis for the development of a suitable system and the possibility of a common system for both digital telephony and data should not be discarded at this stage.

Some major changes are necessary to the C.C.I.T.T. Signalling System No. 6 because the present error control procedures and, in particular, the block structure of the system limit the speed of the link carrying the common channel to approximately 2.4 kbit/s for satellite circuits and to approximately 4.8 kbit/s for cable circuits.

It is recommended that any centralized signalling system be capable of:

— operating at speeds up to about 50 kbit/s and

— handling a mixed group of traffic containing all recommended user classes of service.

It is considered that where the centralized signalling system controls bearer channels limited to the lower speed user classes of service, the speed of the common channel link could, with advantage, be lower than 50 kbit/s. For example, where routes are limited to bearer channels belonging to classes 3 and 4 (600 bit/s and 2.4 kbit/s), the centralized signalling system could be carried by a link operating at about 9.6 kbit/s.

The question of diversity was considered and it was recommended that the centralized signalling system should be capable of providing facilities for changeover to standby channels and also providing quasi-associated operation as provided for in C.C.I.T.T. Signalling System No. 6.

It is considered reasonable to adopt a message structure where the smallest amount of control signalling information sent as an entity, called a signal unit, contains a fixed number of binary digits and where the message length can vary from one to a predetermined maximum number of units.

It is recommended that signalling information should be protected by the use of a cyclic code.

It is recommended that forward set-up be adopted initially but that the signalling system should contain sufficient spare capacity so that backward set-up could be adopted later if this was required.

The following points relating to the question of path check, that is the proving of the circuit to be provided for the subscriber before it is handed over, have been agreed:

— path check facilities should be provided on a link-by-link basis;

— the precise form of the path check would depend on the envelope structure to be adopted;

— the centralized signalling system should provide sufficient capacity to accommodate the control signals necessary for path check. Examples of such signals are the " check O.K. ", " check not O.K. " and " continuity " signals provided by the C.C.I.T.T. Signalling System No. 6.

It has been further agreed that user identification characters should be sent over the bearer channel as this facility is optional and the characters would otherwise cause unnecessary loading of the common channel signalling system.

Question 1/VII - point V* — Decentralized control signalling for international connections between synchronous data networks

Considering

that Recommendation X.70 has defined a system for decentralized signalling between anisochronous data networks,

that it has been agreed to produce Recommendations for both centralized and decentralized signalling systems for synchronous data networks,

that compatibility may have to be achieved between:

a) local, i.e., user, and international signalling,

b) centralized and decentralized inter-exchange signalling,

c) inter-exchange signalling on anisochronous data networks and inter-exchange signalling on synchronous data networks,

d) different user classes of service on the same network, that the facilities to be provided by the network are defined in Recommendations X.1 and X.2 and are being further considered under Question 1/VII – points A and B,

that some networks have constraints on the permitted density of " ONES ",

that many telecommunication services may have to be accommodated in the one joint user network,

what detailed decentralized signalling system is to be recommended?

Points for consideration are:

1) Can the signalling system defined in Recommendation X.70 be adopted for synchronous data networks? If so,

2) Should the system take advantage of a synchronous envelope structure?

3) What unique signalling characters should be chosen to replace the continuous polarity conditions inherent in the Recommendation X.70 system?

Note. — See paragraph 2a) of the Annex to Question 1/VII - point U.

Question 1/VII - point W — What are the characteristics of and requirements on the bearer channels over which the 64-kbit/s aggregate multiplex bit rate channels are to be carried?

Question 1/VII - point X — Error Control

What should be the essential characteristics of an error control equipment for use with a DTE operating over the public data network? Compatibility with the equipment specified in Recommendation V.41 is a desirable objective. This includes study of the effectiveness of the cyclic check character with the error characteristics of digital circuits, e.g. the effect of " bit slip " as well as other points.

Question 1/VII - point Y — Security in data networks

Considering

1. That there is a trend towards introduction of data processing systems using more and more real time applications via the telecommunications networks;

2. That in the planned new data communication networks which are being studied within C.C.I.T.T., there seem to be possibilities to offer special operational and technical means to ensure security in data communication;

3. That the new data networks will be interconnected internationally in the same way as the telephone and telex networks and that consequently there will be a need for Administrations to agree upon a common policy,

what technical and operational means should be provided in new data networks regarding security of the communication, and how could these means be introduced?

PAGE INTENTIONALLY LEFT BLANK

PAGE LAISSEE EN BLANC INTENTIONNELLEMENT

SUPPLEMENTS TO RECOMMENDATIONS AND QUESTIONS CONCERNING DATA TRANSMISSION

Contributions received during 1968-1972 which are published on account of their special interest

PART I

Data transmission over telephone or telex networks

(Special Study Group A)

Supplement No.	Source	Title	Study point to be concerned with	Page
1	Federal Republic of Germany	Study of the general switched telephone network with a view to its suitability for data transmission	L, O, S + T, V	295
2	U.S.A.	4800 and 9600 bits per second data transmission over international circuits	L	309
3	Spain (C.T.N.E.)	Test of data transmission over a switched network at 600/1200 bit/s	L	319
4	Racal-Milgo Ltd.	2400 bit/s data transmission tests on the United Kingdom public switched network	L, O	328
5	Federal Republic of Germany	Investigations into the suitability of modems in conformity with Recommendation V.26 for 2400 bit/s data transmission on the international switched telephone network	L, O	332
6	United Kingdom Post Office	Field tests of V.26 modem on the general switched telephone network	L, O	339
7	United Kingdom Post Office	Transmission tests of the V.26 modem between the United Kingdom and Australia	L, O	341
8	Racal-Milgo Ltd.	International data transmission tests on the public switched telephone network at 2400 and 1200 bit/s	L, O	343
9	U.S.A.	Data transmission measurements	L, O	348
10	GM/FT 6	Transmission requirements of data channels for signalling system No. 6	L, O, U	354
11	Italy	2400 bit/s data transmission tests on the Italian public switched network	L	354
12	N.T.T.	Study of parallel data transmission systems using the push-button telephone signalling frequencies	Q *bis*	367
13	I.B.M. Europe	Study of parallel data transmission systems using the push-button telephone signalling frequencies	Q *bis*	370

Supplement No.	Source	Title	Study point to be concerned with	Page
14	United Kingdom Post Office	The characteristics of the United Kingdom public switched telephone network	S + T (L)	372
15	N.T.T.	Measurement of phase distortion and transmission loss between subscribers	S + T	385
16	Norway	Statistics of Norwegian switched telephone network	S + T, V (L)	393
17	N.T.T.	Transmission characteristics of the general switched telephone network	S + T, V	404
18	Study Group IV	Limits of impulsive noise for data transmission	U, V	409
19	Italy	Wideband data transmission tests	Z	414
20	U.S.S.R.	Tests of a data transmission system over wideband circuits	Z	426
21	France	Characteristics of group links for wideband signal transmission	Z	428
22	France	Wideband modem tests	Z	434
23	United Kingdom Post Office	48 kilobit/s transmission tests	Z	448
24	Communications Satellite Corporation	Considerations in the transmission of data via satellite-linked connections	AC	451
25	Communications Satellite Corporation	Demand-assigned data transmission using the SPADE system for satellite-linked connection	AC	471
26	Austria	Random noise simulator	AD	474
27	A.T.T.	Medical data sets	AH	476

PART II

Data transmission over public data networks

(Study Group VII)

Supplement No.	Source	Title	Study point to be concerned with	Page
28	Joint Working Party NRD	Data service requirements	1/VII	479
29	Joint Working Party NRD	Customer interface in Recommendation X.21	Q	482

Supplement No. 1

FEDERAL REPUBLIC OF GERMANY. — *(Contribution COM Sp. A—No. 101, November 1970)*

STUDY OF THE GENERAL SWITCHED TELEPHONE NETWORK WITH A VIEW TO ITS SUITABILITY FOR DATA TRANSMISSION

1. *Test programme*

1.1 *Test points*

During the period from January to August 1970 the German Administration made extensive measurements in the general switched telephone network of the Deutsche Bundespost so as to obtain a survey of the characteristics of telephone connections, which are of interest with regard to the present and future data signalling rates. These measurements supplement the tests carried out in 1966, the results of which are published in C.C.I.T.T. Document COM Sp. A—No. 95 (1964/1968) (see Supplement No. 14, *White Book*, Vol. VIII).

The results of the tests performed in 1966 and 1970 are compared to allow a statement to be made about possible changes in the transmission performance.

As in 1966 all measurements were made from subscriber station to subscriber station in order to obtain results corresponding to practice. In 85 places throughout the Federal Republic of Germany a Deutsche Bundespost test van—which was specially equipped for these measurements—was connected with subscriber stations of the general switched telephone network. These tests covered the majority of the tertiary exchanges (Figure 1). The test programme and the limited time available for these measurements allowed only interworking with one central measuring point, i.e. with the data laboratory at the Fernmeldetechnisches Zentralamt. As a rule, four to six switched connections were established between the test van and the central measuring point.

1.2 *Measured characteristics*

The following characteristics of the connections were measured:

a) overall loss;

b) impulsive noise rate at various thresholds;

c) attenuation distortion;

d) group delay distortion;

e) bit and block error rates in the case of data transmission at 200 bit/s (modem V.21, full duplex);

f) peak individual distortion in the case of data transmission at 200 bit/s (modem V.21);

g) bit and block error rates in the case of data transmission at 1200 bit/s (modem V.23);

h) peak individual distortion in the case of data transmission at 1200 bit/s (modem V.23);

i) bit and block error rates in the case of data transmission at 2400 bit/s (modem V.26) for
   1) alternative A and
   2) alternative B;

j) overall character error rate, rate of character errors due to incorrect timing and rate of character errors identified as code errors in the case of parallel data transmission with 20 characters per second without timing (modem V.30) (modulation rate of 40 bauds).

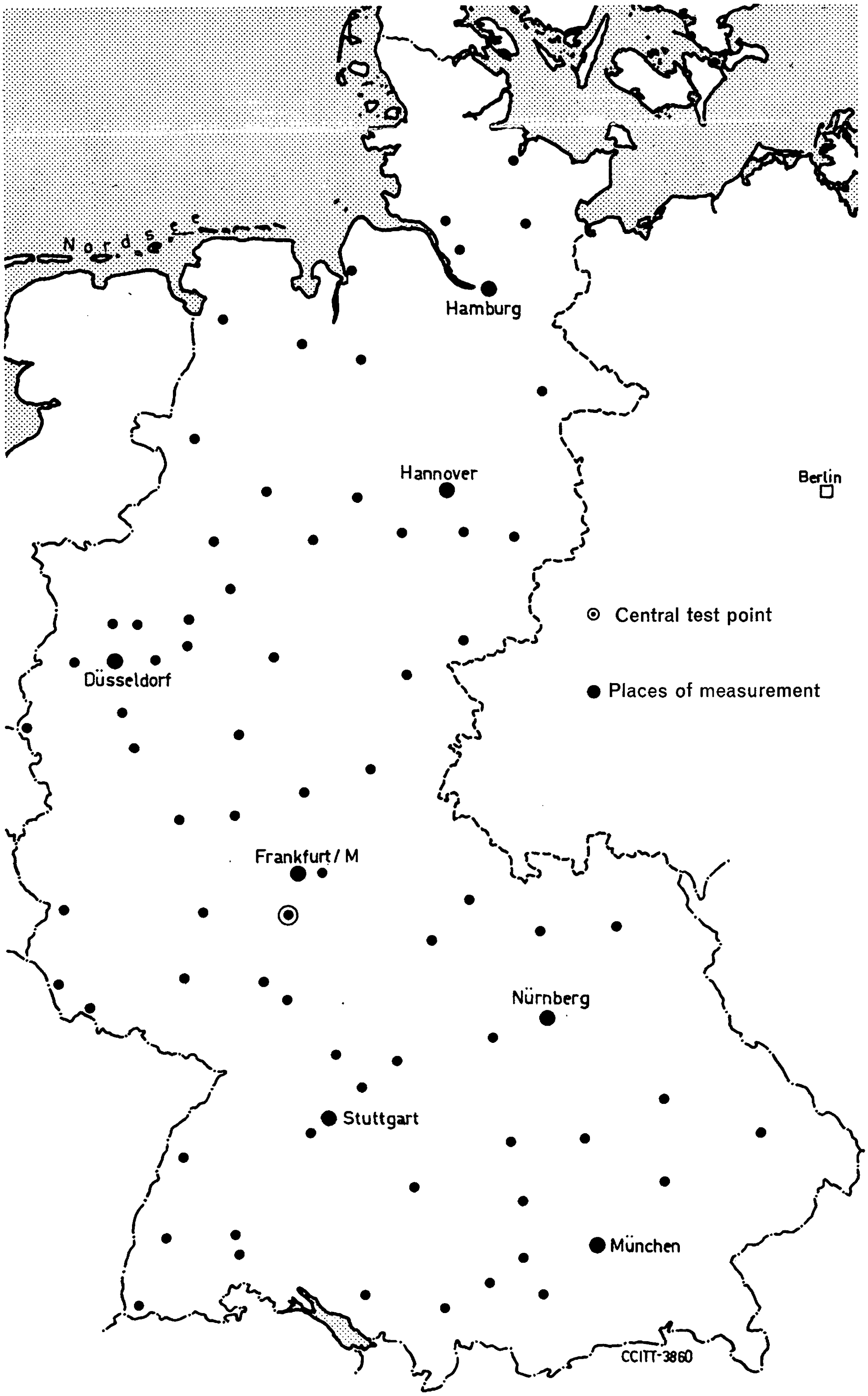


FIGURE 1. — **Survey of the places of measurement**

The places where the test van had been set up were so selected that the majority of tertiary exchanges were covered. More detailed measurements were made in areas with a relatively large number of modems. The location of the telephone stations with respect to their exchanges was selected under the same aspects as in 1966, i.e. that the distribution of the lengths of the subscribers' lines was not more favourable than that encountered in practice.

All data transmission tests were made on workdays between 0800 and 1900 hours.

1.3 *Test equipment and modems*

The impulsive noise rate at different thresholds was measured by means of the impulsive noise counter, type 4H1, of Messrs. Siemens A.G.

Attenuation and group delay distortions were measured by means of the Siemens sweep-frequency delay measuring set (Rel 3K 200) and then photographed.

Bit and block error rates as well as peak individual distortions were measured by means of the data test set 1-3 of Messrs. Trend via an adaptor connected with the error distribution analyser, type 1005, of Standard Radio and Telegraph, Bromma, Sweden.

As far as the measurement of parallel data transmission was concerned parallel signal generators were used at the sending end and Siemens error rate counters for parallel characters were applied at the receiving end.

Modems which comply with C.C.I.T.T. Recommendations V.21, V.23 and V.30 and which the subscriber has to hire from the Deutsche Bundespost for use in the general switched telephone network were employed for serial data transmission at 200 bit/s and 1200 bit/s as well as for parallel data transmission. As far as serial data transmission at 2400 bit/s was concerned, use was made of modems 2002/24 of Racal-Milgo. The latter modems comply with Recommendation V.26.

2. *Test results*

2.1 *Overall loss*

The overall loss of the subscriber-to-subscriber lines terminated with 600 ohms was measured at 1000 Hz. The values for 500 Hz to 3500 Hz were derived from the photographs taken during the attenuation distortion measurements. Figure 2 shows the relative cumulative frequency distribution of the overall loss. The values for the overall loss not exceeded in 50% and 95% of the cases are listed in Table 1. A comparison of the overall loss at 1000 Hz measured in 1970 with that determined in 1966 reveals that the new values are about 2 dB below those measured in 1966.

TABLE 1

a_r in dB cumulative frequency	50%	95%
500 Hz	16.2	21.5
1000 Hz	14.8	20.8
1000 Hz (1966)	16.5	22.4
1500 Hz	17.2	22.8
2000 Hz	18.8	24.5
2500 Hz	20.8	26
3000 Hz	22.6	28.5
3500 Hz	25.2	—

2.2 *Attenuation and group delay distortions*

A large number of attenuation and group delay tests were made in the same manner as in 1966. A comparison with the results of 1966 shows that there is hardly any difference for the collective of the tested connections. Therefore reference is made to the curves of 1966.

2.3 *Impulsive noise rate*

The relative cumulative frequency distribution of noise pulses occurring at 15-minute intervals is plotted in Figure 3.

The impulsive-noise measuring instrument and its application were in conformity with C.C.I.T.T. Recommendation V.55.

2.4 *Distortion measurements*

The distortion of the data signals on a transmission link is of special interest with regard to possible future interconnections of different data transmission networks. Therefore, the peak individual distortions on the entire transmission link—i.e. sending modem → telephone network → receiving modem—were measured for transmissions at 200 bit/s and 1200 bit/s (Figure 4). The results show that for 50% of the tested connections the distortion does not exceed 2% at 200 bit/s and 10% at 1200 bit/s. Ninety-five per cent of the connections operate with distortions of < 5% at 200 bit/s and < 16% at 1200 bit/s.

2.5 *Data transmission tests*

The measurement of the characteristics of each switched connection dealt with in 2.1, 2.2 and 2.3 above were followed by data transmission tests carried out with a view to measuring the block and bit error rates in the case of serial transmissions at signalling rates of 200 bit/s, 1200 bit/s and 2400 bit/s (alternatives A and B) and to measure the character error rate in the case of parallel data transmission at a signalling rate of 20 characters/s (modulation rate of 40 bauds).

At 200 bit/s measurements were made in the full duplex mode of operation. With the other transmission methods the calling station was at first the sending station and then the called station. That means all modes of transmission were used on all switched connections in both directions. Because of the large number of tests the time for one measurement had to be reduced to 5 minutes (C.C.I.T.T. Recommendation V.25 specifies 15 minutes). However, numerous comparative studies revealed that this practice did not cause any falsification of the results.

The tests at 2400 bit/s according to C.C.I.T.T. Recommendation V.26 were made under the same transmission conditions as the tests at 1200 bit/s. At both speeds, the modem at the receiving end was connected in series with a compromise equalizer the characteristic of which is plotted in Figure 17. This equalizer corrected the mean attenuation distortion of telephone connections in the Deutsche Bundespost network and the group delay distortion of two carrier sections and 20 km subscriber line with a 0.9 mm diameter of the wires and g-type loading. Approximately 600 transmission tests were made and there was no case where the compromise equalizer was not sufficient.

In the case of serial transmission, the 511-bit quasi-random test pattern was sent isochronously in conformity with C.C.I.T.T. Recommendation V.52.

In the case of parallel data transmission all combinations possible in the 2×1 out of 4 code were sent without timing according to C.C.I.T.T. Recommendation V.30 in the sequence signal combination → rest combination → signal combination . . .

2.5.1 *Block error rates*

Block error correction methods are generally used in the data terminal equipment for the correction of transmission errors. In practice it is, therefore, of particular importance to know the block error rate. For the data transmission tests the error rates of the following block lengths were measured for all rates:

32, 64, 128, 256, 512, 1024 and 2048 bits.

Figures 5, 6, 7 and 8 show the relative cumulative frequency distributions of the block error rates at different signalling rates.

The relative cumulative frequency distribution for a specific block length and different signalling rates are plotted in Figures 9, 10, 11, 12, 13, 14 and 15.

2.5.2 *Bit error rates*

Although bit error rates alone do not indicate the error distribution in the telephone channel and can therefore not be applied to the establishment of error correction methods, their results are always used to compare different transmission methods and perhaps also different data transmission networks. Figure 16 shows the relative cumulative frequency distributions of the bit errors for the measured signalling rates. For comparison, the 1200 bit/s curve measured in 1966 was also plotted in this figure.

2.5.3 *Error rate in the case of parallel data transmission*

The redundant transmission code 2 × 1 out of 4 allows an evaluation of the transmitted information to be already made in the receiving modem. Thus, we measured not only the tótal number of character errors and the number of character errors due to incorrect timing, which may result therefrom, but also the number of characters the receiving modem identified as being incorrect, the so-called code error. The error rates determined in this manner were so low that they cannot be represented in the form of curves.

2.6 *Discussion of the test results*

The extensive study of the general switched telephone network of the Deutsche Bundespost with a view to its suitability for data transmission revealed that:

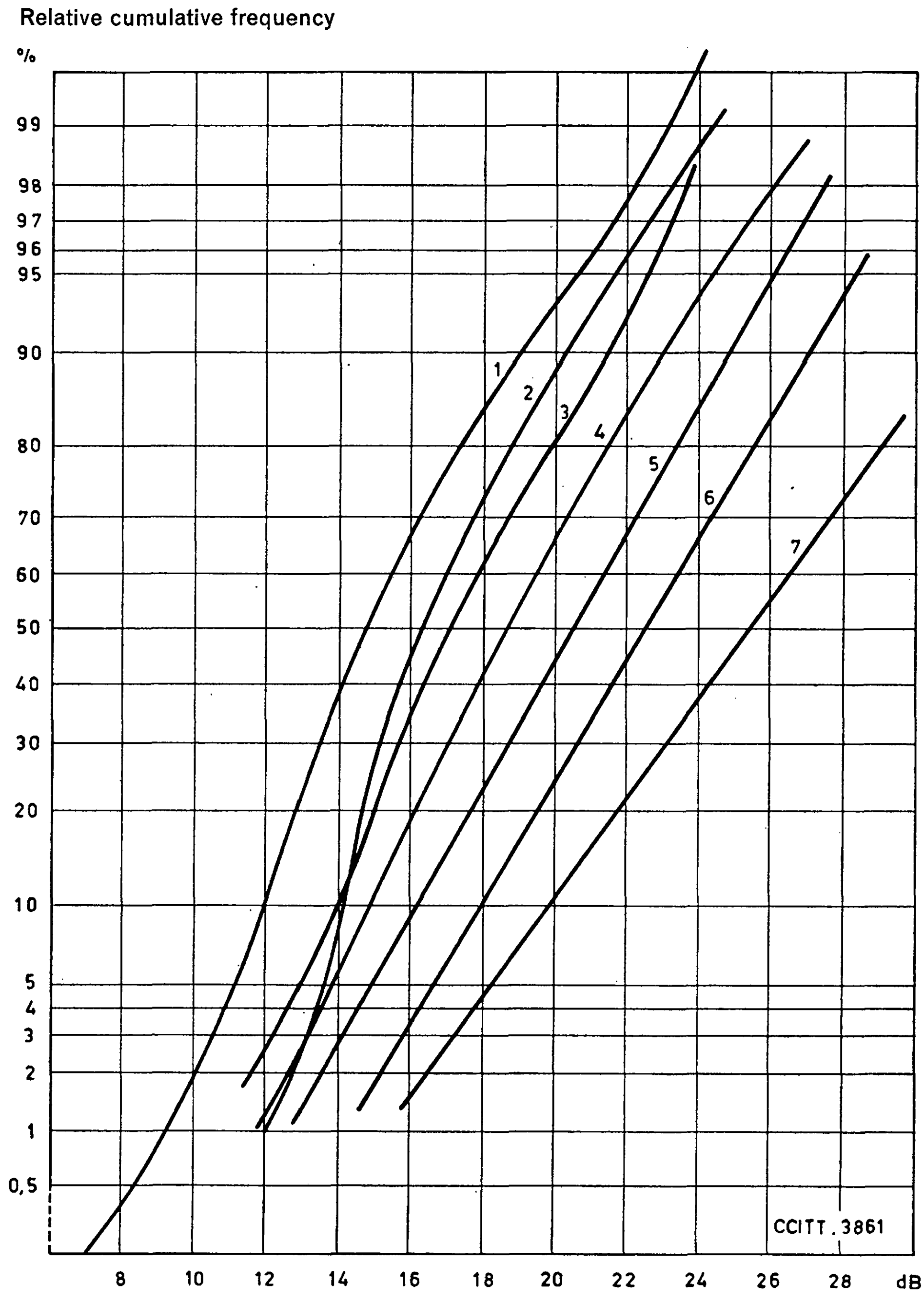
1. the transmission performance of the existing datel service has been clearly improved by continuous modifications in the network and replacement of the exchanges;
2. transmissions at 2400 bit/s in the general switched network can be carried out under the same conditions as at 1200 bit/s without the insertion of additional equalizers other than the compromise equalizer. The block error rates are even still lower than those at 1200 bit/s;
3. parallel data transmission is an extraordinarily reliable method.

The improvement of quality is verified by Figure 16 and Table 1. The decrease of the overall loss by around 2 dB results from the improvements made in the network. A comparison of curves 2 and 4 on Figure 16 shows that in 1966 the bit error rate at 1200 bit/s was five times as high as in 1970. This is due to the fact that in many exchanges the old two-motion selectors were replaced by the new EMD switches.

As to transmissions at 2400 bit/s the measurements indicated that for alternatives A and B the same bit error rates can be expected as at 1200 bit/s (Fig. 16). The slight differences between alternatives A and B account for the finite number of tests. No essential differences were found to exist between alternatives A and B.

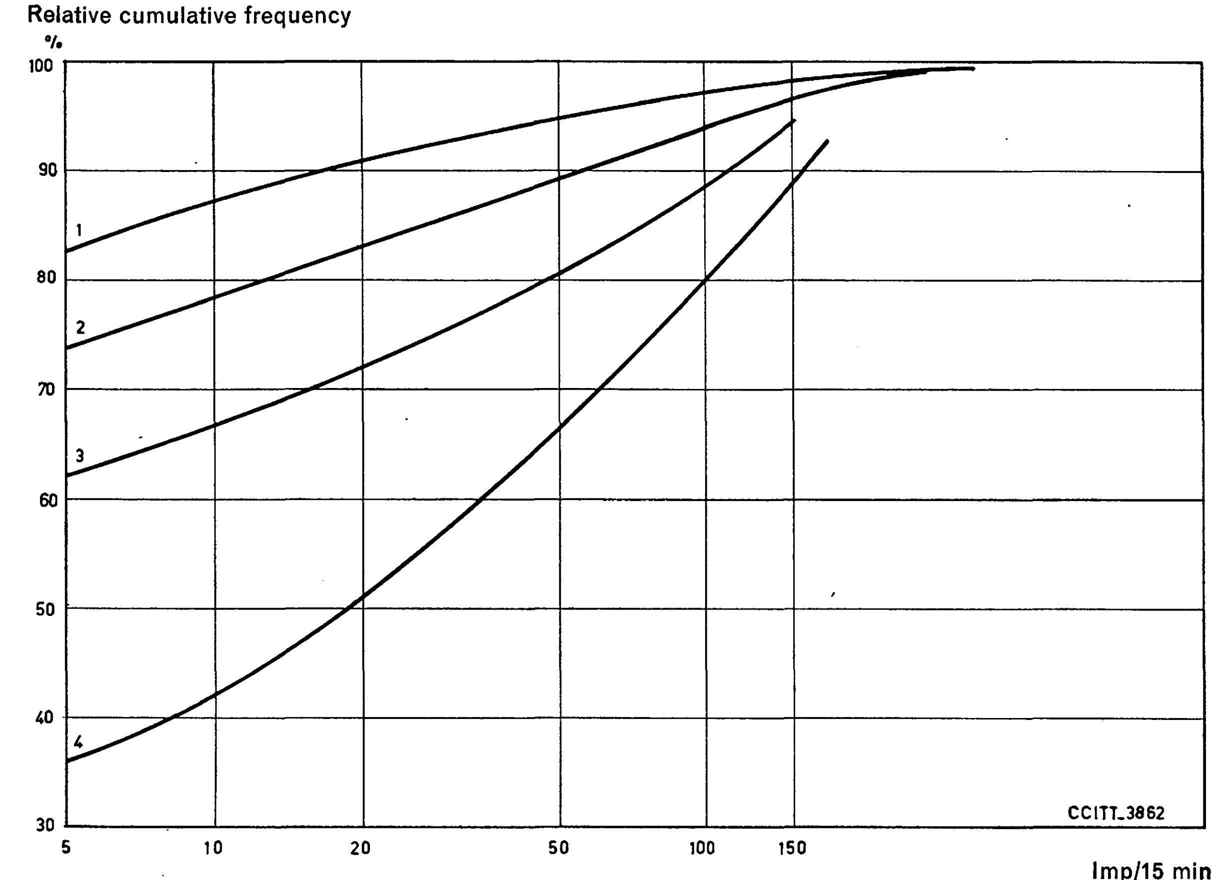
A comparison of the curves for the block error distribution in Figures 9 to 15 shows that due to bursts the block error rates are lower for higher speeds. The tests indicate that the lowest block error rates were always measured for transmissions at 2400 bit/s even for the comparatively short blocks of 32 bits. When comparing the signalling rates of 200 bit/s and 1200 bit/s it becomes obvious that the block error rates at 200 bit/s are lower when the blocks are short, while at 1200 bit/s better results are obtained with longer blocks.

For about 95% of the measured connections no transmission errors were found to occur with parallel data transmission. For the remaining 5% errors were generally indicated by the quality detector in the modem [Recommendation V.30, circuit 110 (Data signal quality detector)] at the in-station. Undetected errors were only found in the case of severe bursts. In practice this should not, however, have any serious consequences because block error correcting methods are also applied in these cases. The high percentage of correct transmissions does not allow more accurate statistical information to be given for the measured number of erroneous transmissions.



1 = 1000 Hz
2 = 500 Hz
3 = 1500 Hz
4 = 2000 Hz
5 = 2500 Hz
6 = 3000 Hz
7 = 3500 Hz

FIGURE 2



Impulsive noise
Threshold
1 = 20 dB
2 = 25 dB
3 = 30 dB
4 = 40 dB

FIGURE 3

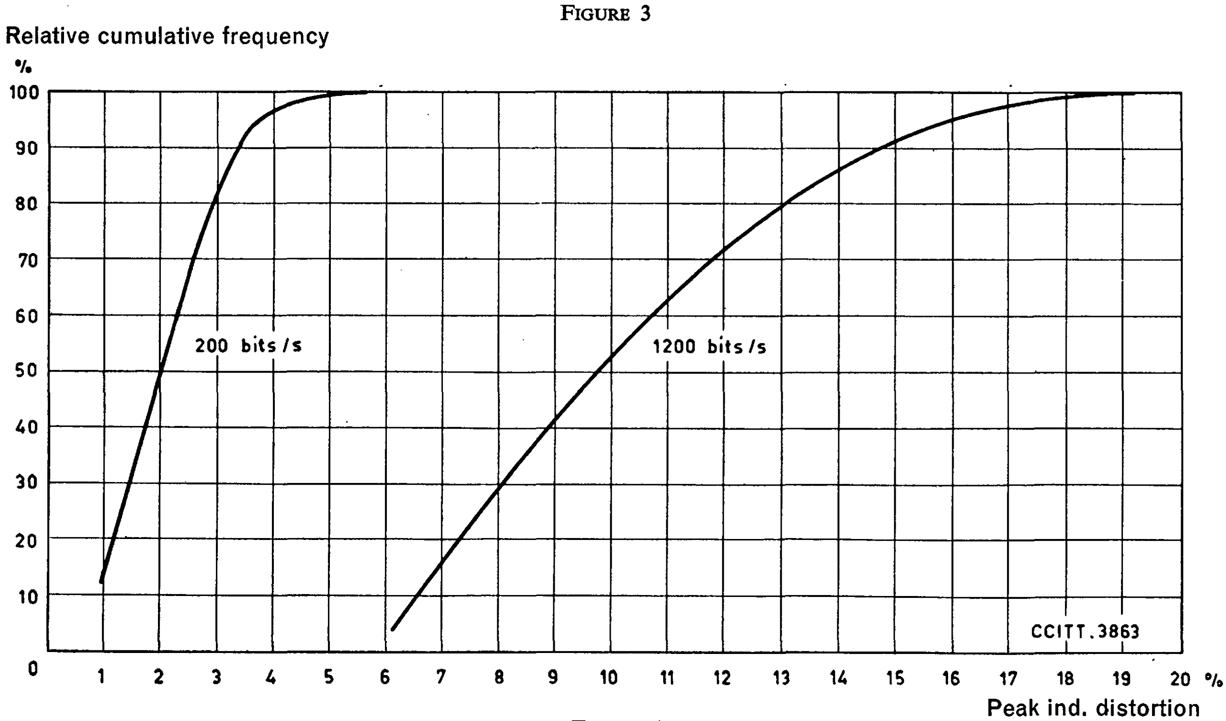
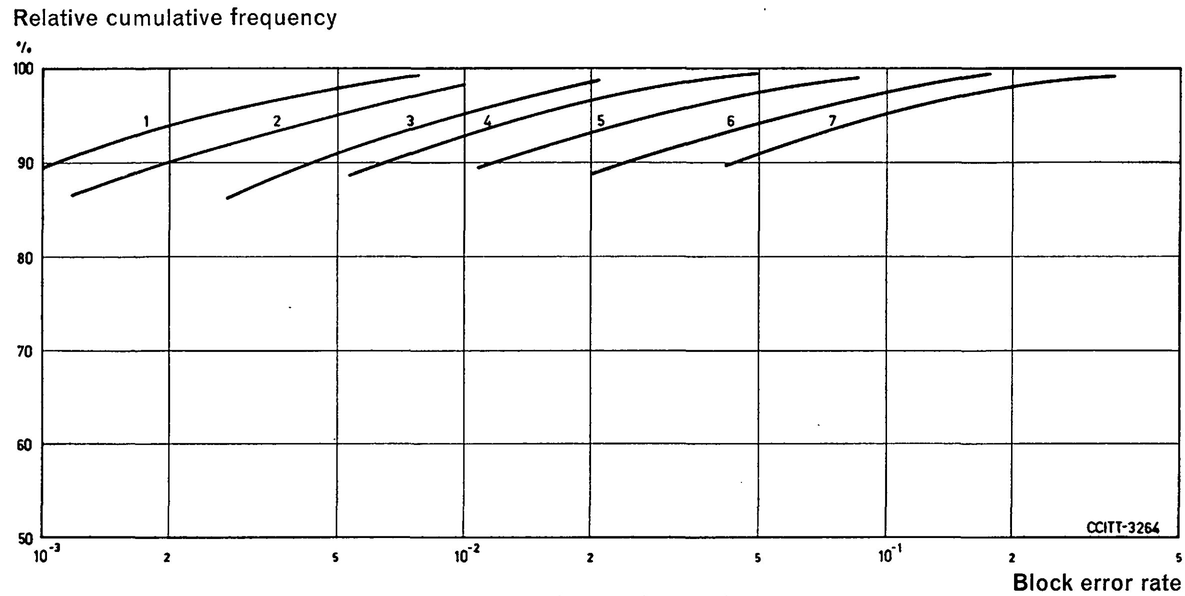


FIGURE 4

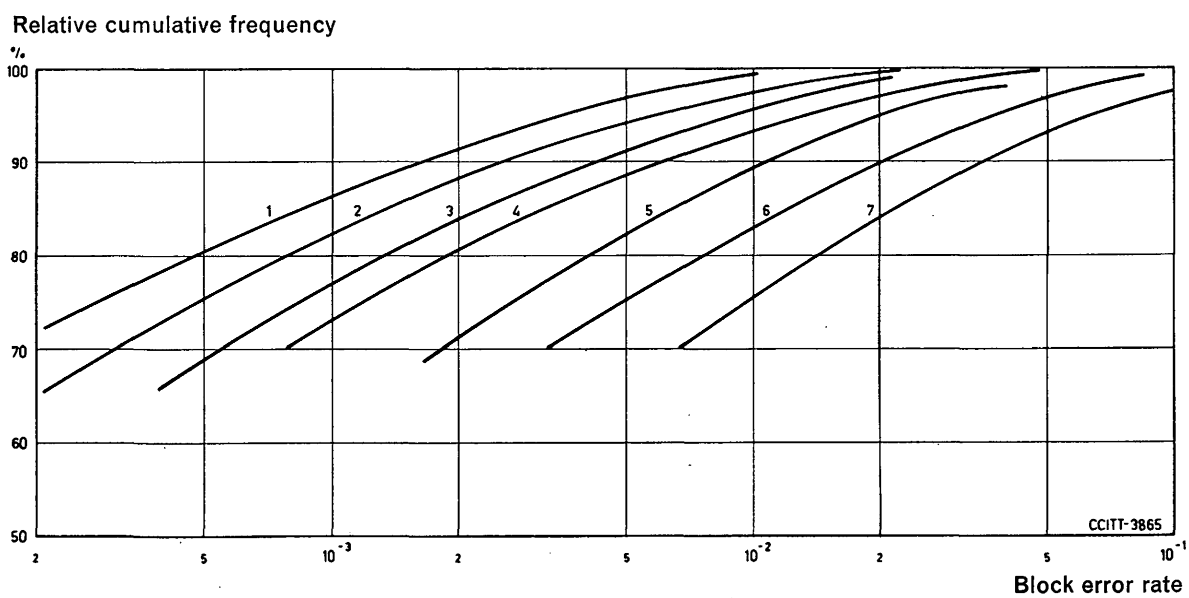


Transmission speed 200 bit/s
Modem V.21

FIGURE 5

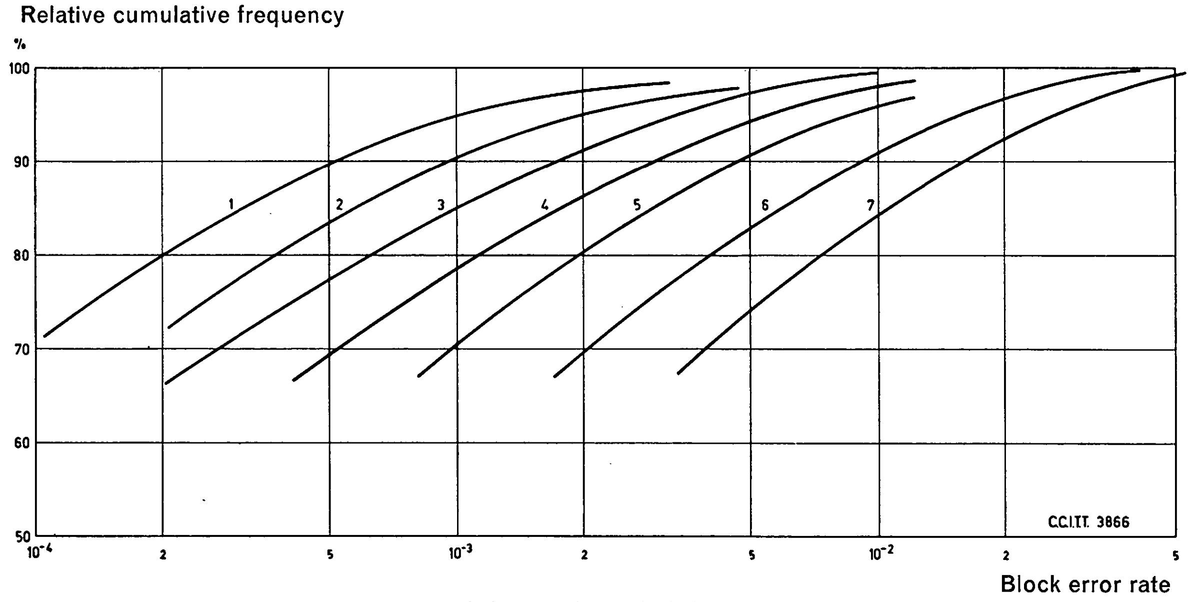
Block length

1 = 32 bits	5 = 512 bits
2 = 64 bits	6 = 1024 bits
3 = 128 bits	7 = 2048 bits
4 = 256 bits	



Transmission speed 1200 bit/s
Modem V.23

FIGURE 6

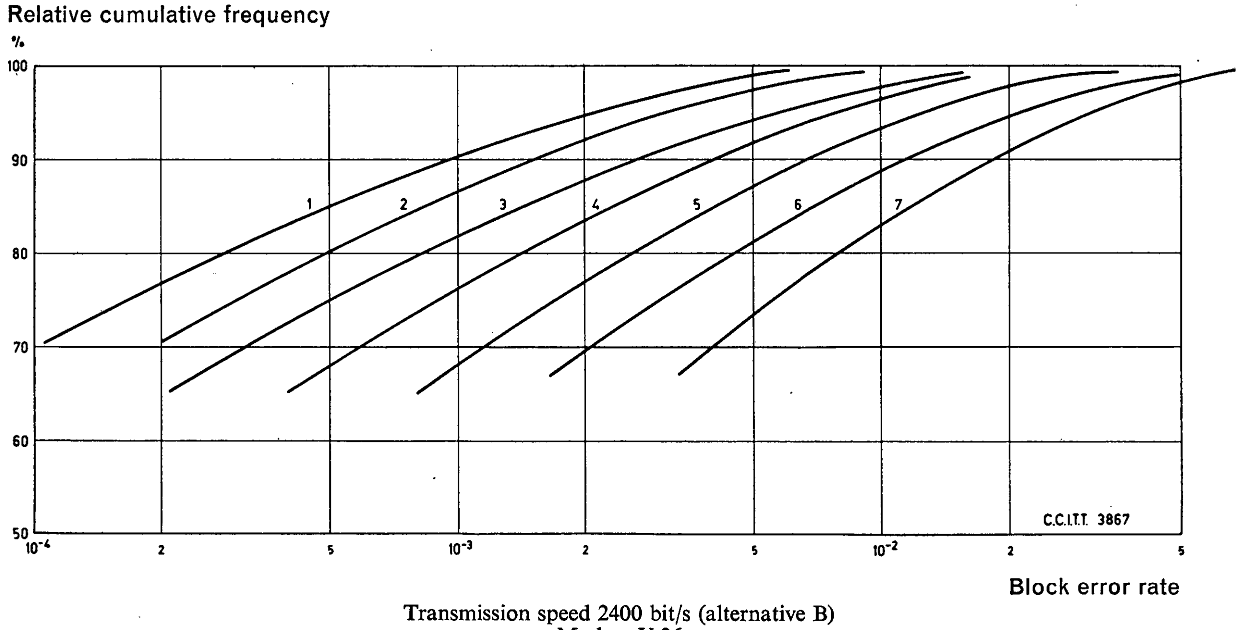


Transmission speed 2400 bit/s (alternative A)
Modem V.26

FIGURE 7

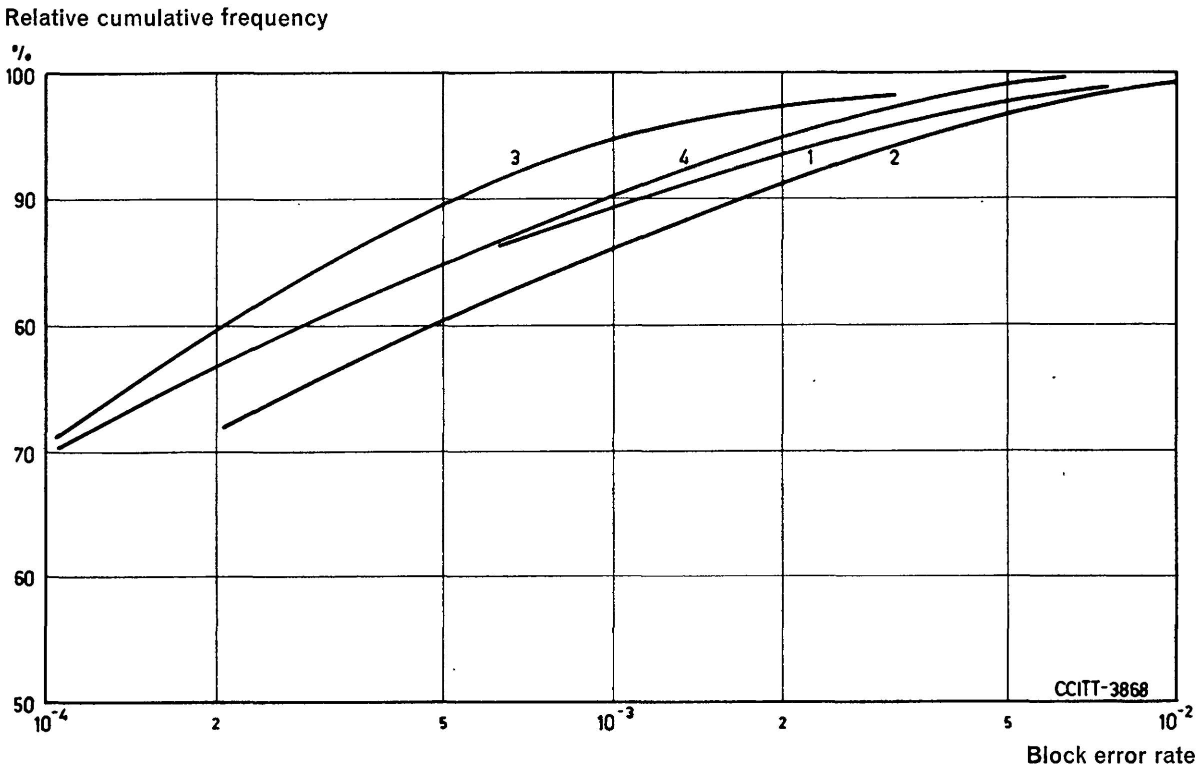
Block length

1 = 32 bits	5 = 512 bits
2 = 64 bits	6 = 1024 bits
3 = 128 bits	7 = 2048 bits
4 = 256 bits	



Transmission speed 2400 bit/s (alternative B)
Modem V.26

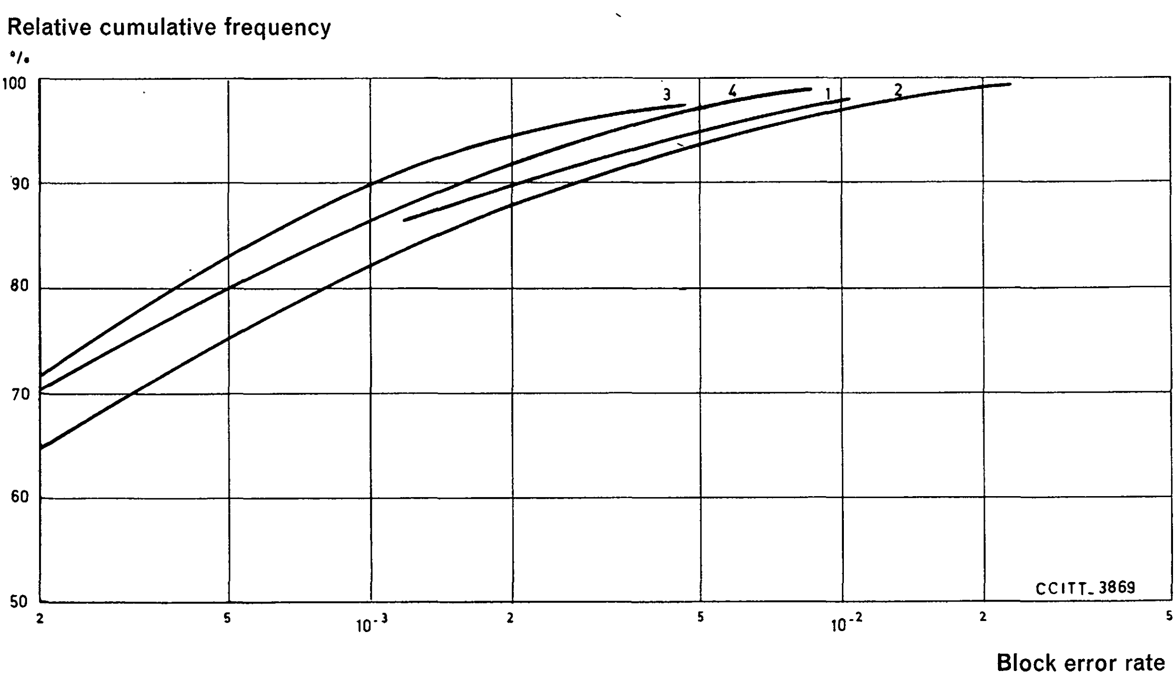
FIGURE 8



Block length 32 bits

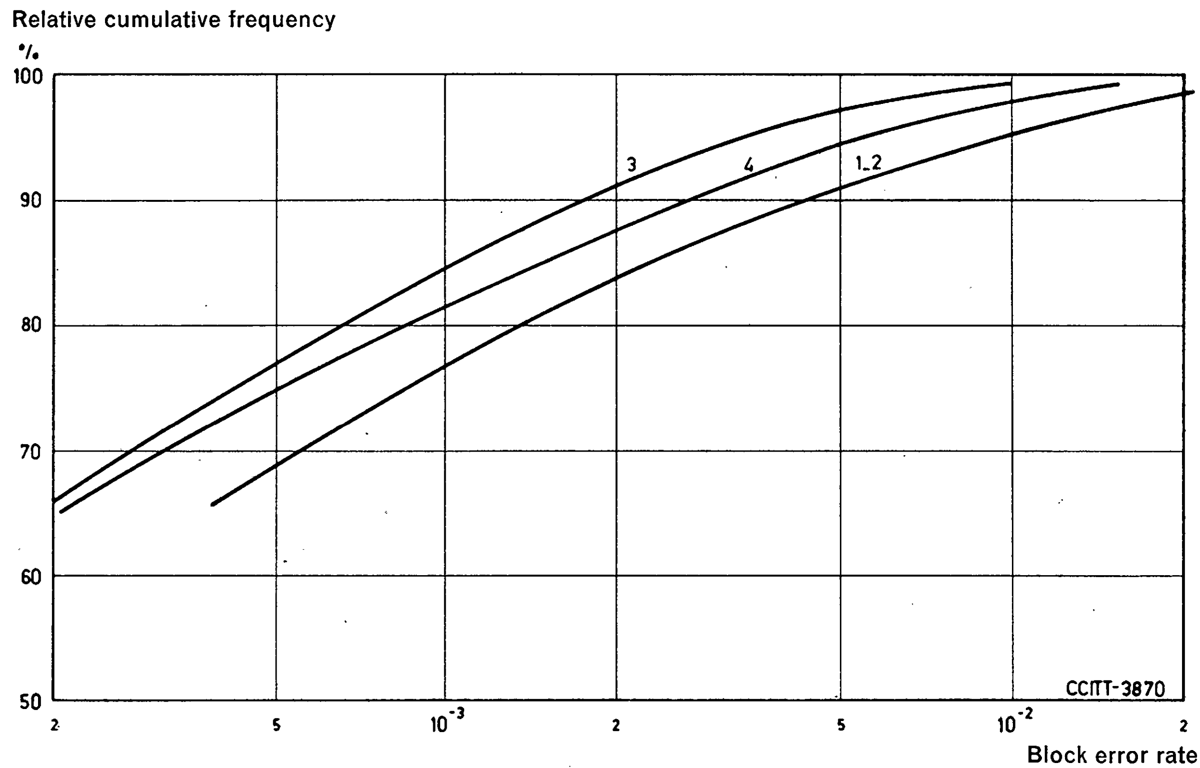
FIGURE 9

1 = 200 bit/s 3 = 2400 bit/s (A)
2 = 1200 bit/s 4 = 2400 bit/s (B)



Block length 64 bits

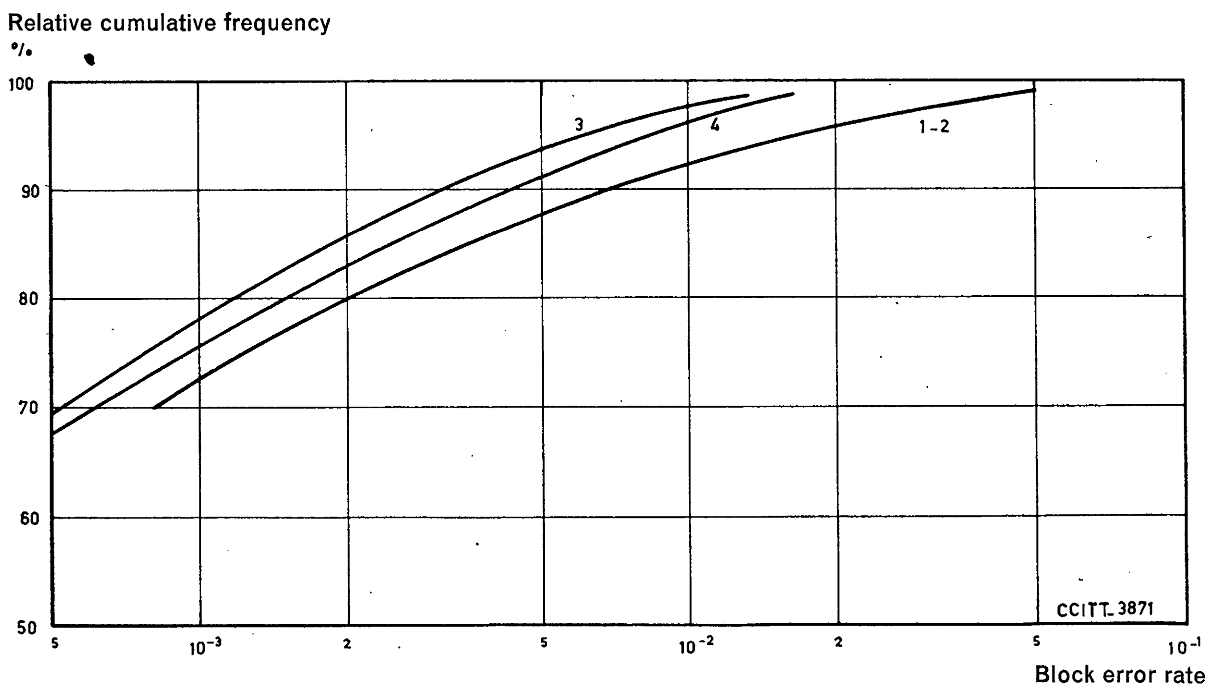
FIGURE 10



Block length 128 bits

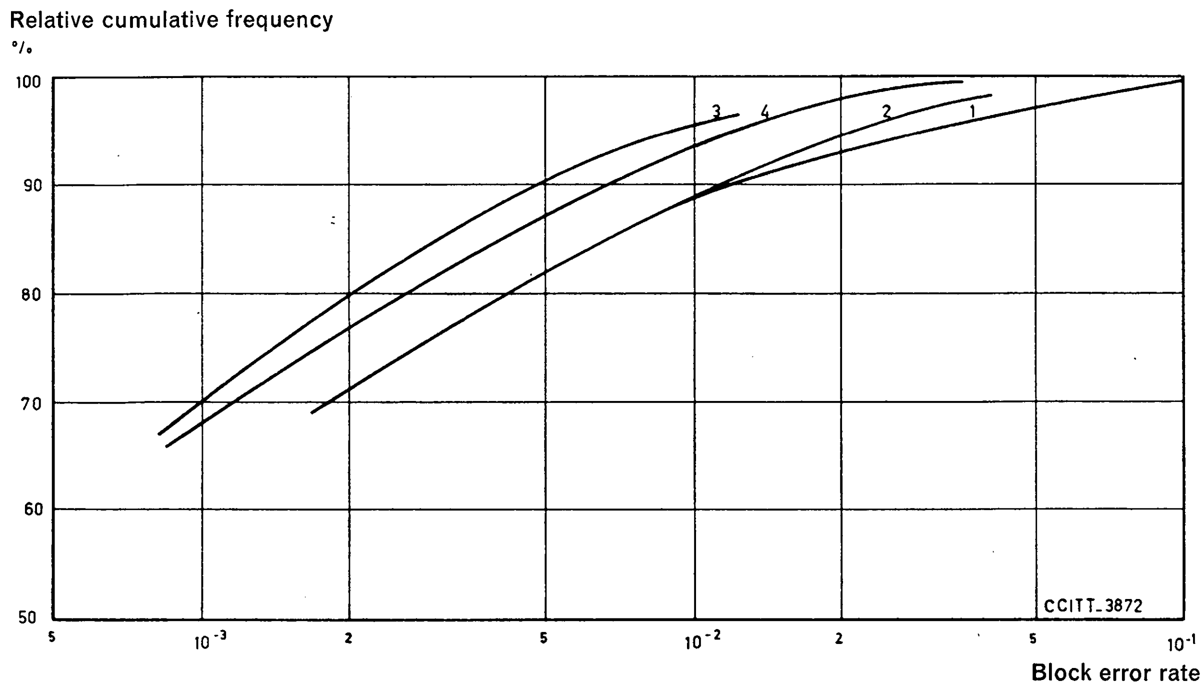
FIGURE 11

1 = 200 bit/s 3 = 2400 bit/s (A)
2 = 1200 bit/s 4 = 2400 bit/s (B)



Block length 256 bits

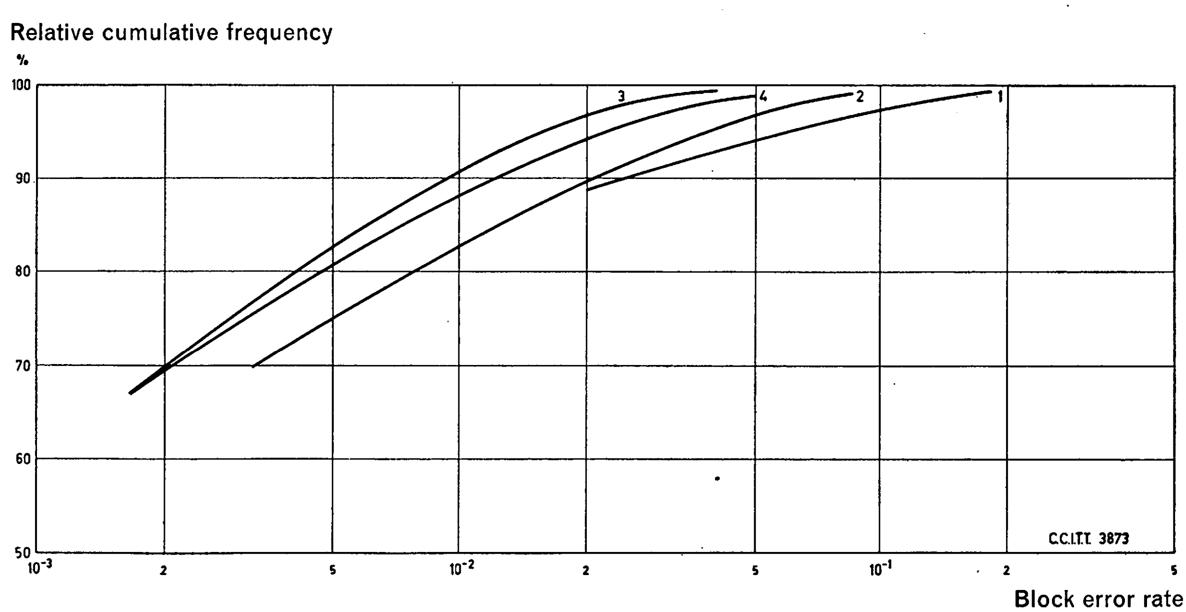
FIGURE 12



Block length 512 bits

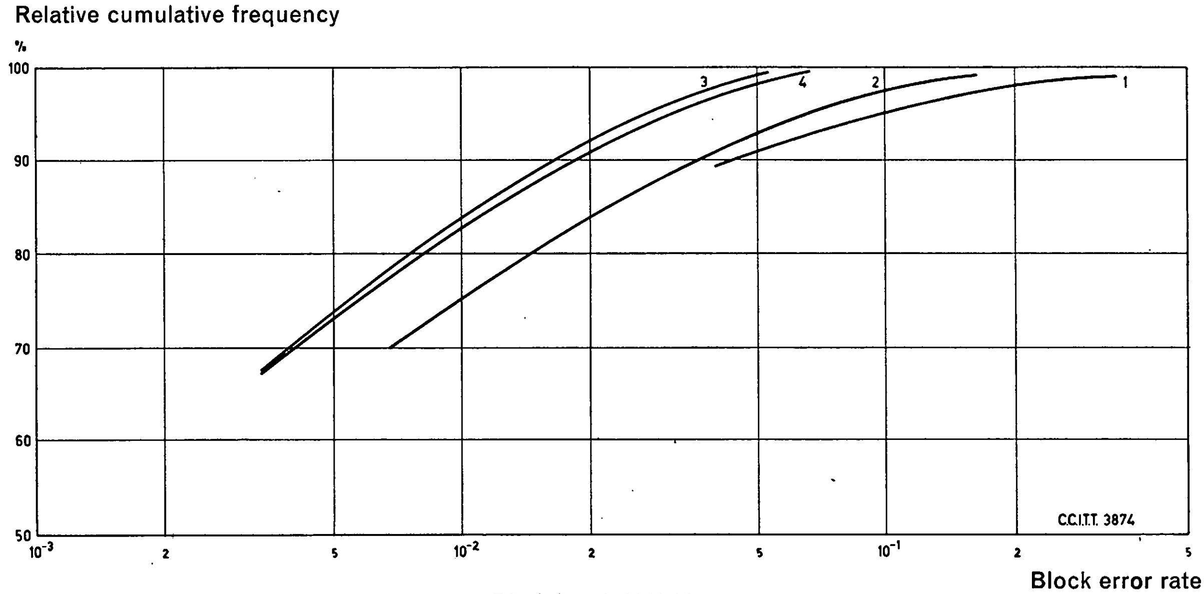
FIGURE 13

1 = 200 bit/s 3 = 2400 bit/s (A)
2 = 1200 bit/s 4 = 2400 bit/s (B)



Block length 1024 bits

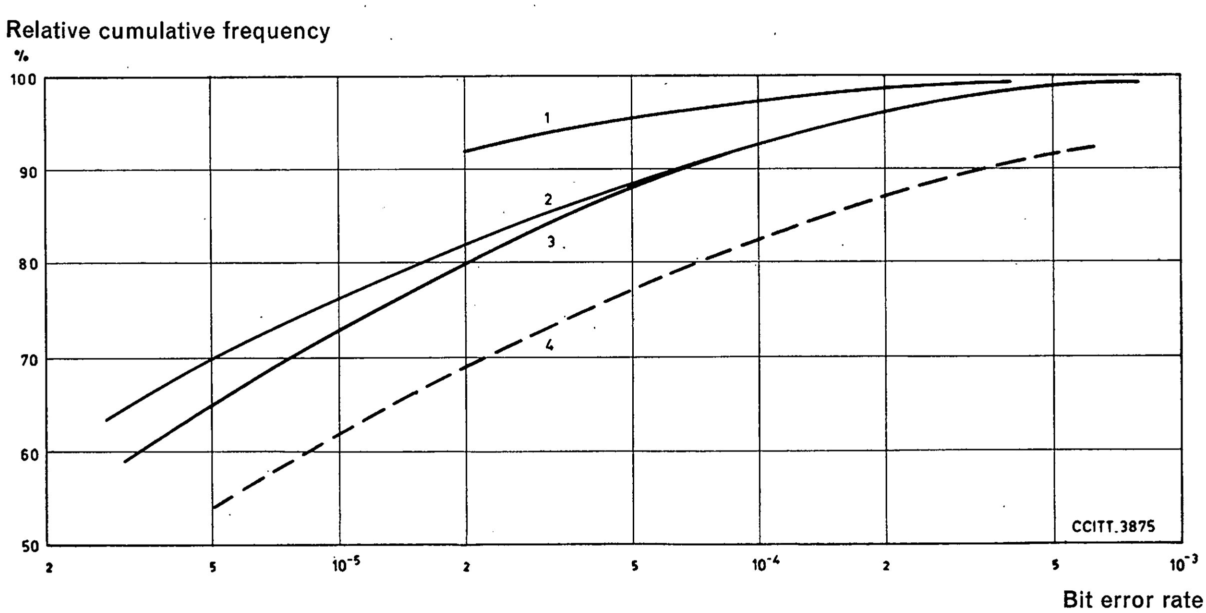
FIGURE 14



Block length 2048 bits

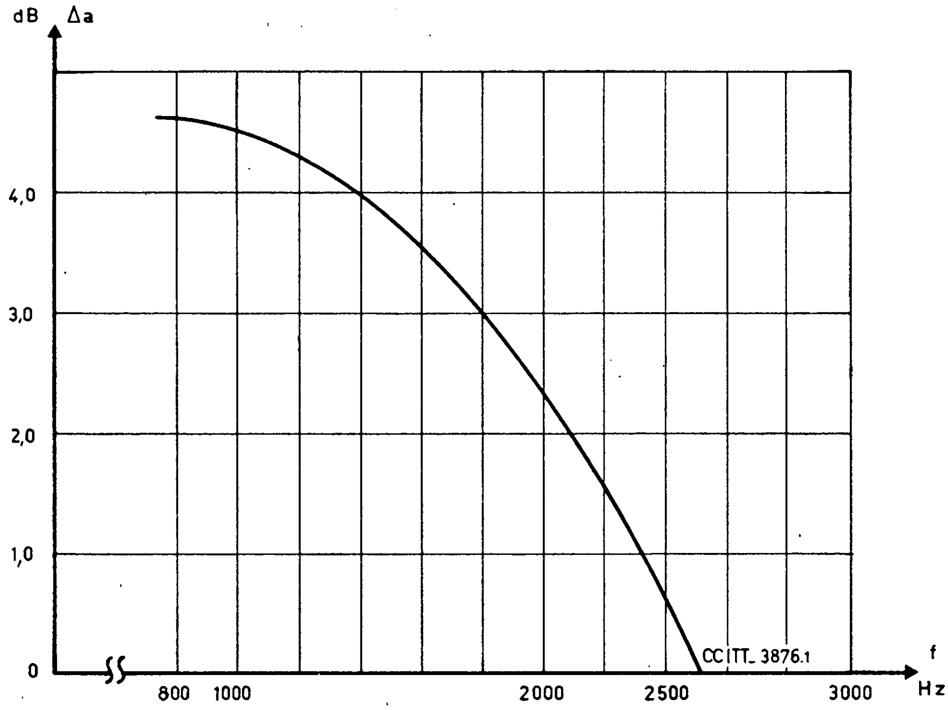
1 = 200 bit/s 3 = 2400 bit/s (A)
2 = 1200 bit/s 4 = 2400 bit/s (B)

FIGURE 15

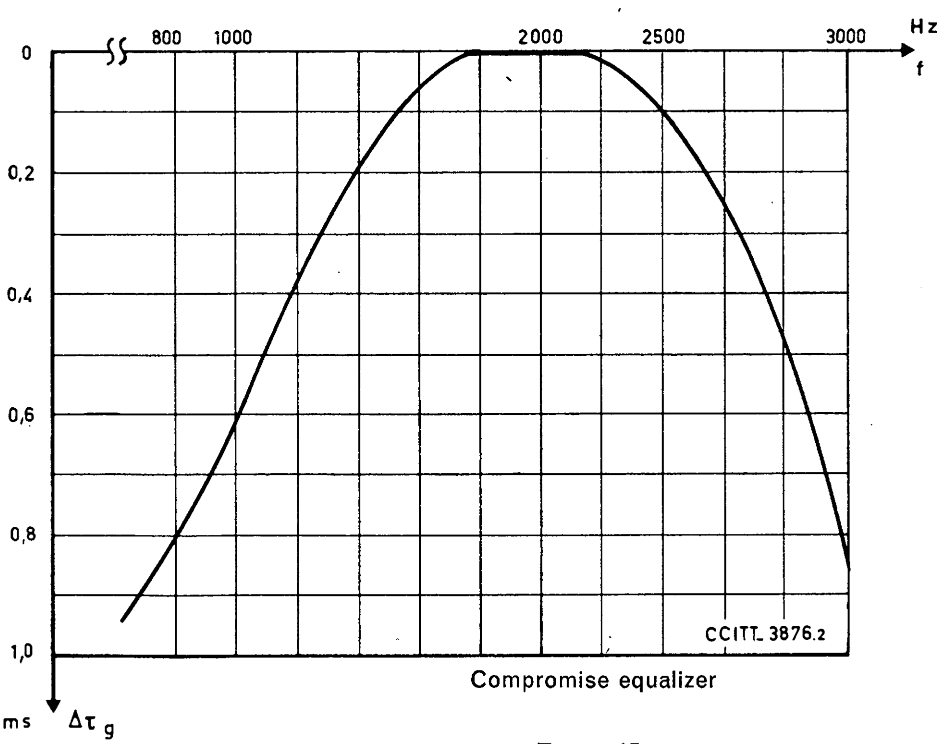


1 = 200 bit/s 3 = 2400 bit/s (A)
2 = 1200 bit/s 4 = 1200 bit/s (1966)
= 2400 bit/s (B)

FIGURE 16



f (Hz)	Δa (dB)
800	4.6
1200	4.4
1800	3
2000	2.4
2500	0



f (Hz)	$\Delta\tau g$ (ms)
800	0.8
1000	0.6
1200	0.35
1500	0.1
2000	0
2400	0.1
3000	0.85

Compromise equalizer

FIGURE 17

Supplement No. 2

UNITED STATES OF AMERICA. — *(Contribution COM Sp. A—No. 104, November 1970)*

4800 AND 9600 BIT PER SECOND DATA TRANSMISSION OVER INTERNATIONAL CIRCUITS

I. *Introduction*

This contribution contains the results of data transmission tests which are thought to be interesting and useful to Special Study Group A. Neither the modems used, nor the test procedures, nor the implied test limits are intended to represent recommendations.

Several data modems are now available which will operate at rates of 4800 and 9600 bits per second over selected voice grade channels. In the spring of 1970, tests were conducted to determine the capability of several long haul circuits to support these data rates at error rates of 1 in 10^5 or better. These tests were implemented to correlate performance against actual circuit characteristics. Two types of data modems were used for these tests, the majority of the tests being accomplished with a modem having switch-selectable transmission rates of 4800 and 9600 bits per second. Tests were conducted at both of these data transmission rates with this modem. Some tests were also accomplished with a different modem having switch-selectable transmission rates of 2400, 4800 and 7200 bits per second. Tests were conducted only at 4800 bits per second with this modem.

The data presented in this report were derived from end-to-end circuit tests of long tandem-connected voice channels leased from various commercial carriers. Although the channel links which make up the end-to-end circuit often provide a superior data transmission capability, the overall circuit characteristics between the end users was of primary concern during these tests.

II. *Tests at 4800 and 9600 bit/s with the SSB modem*

A. *General*

1. The objective of these tests was to achieve 40 hours of test on each circuit; 12 hours of circuit parameter measurements and 28 hours of modem performance measurements. Two circuits were selected for each of six geographical terminal configurations with the exception of Washington to Hawaii where three circuits were tested. This arrangement permitted alternate test of media, enhanced validity of data and provided continuous use of a voice order wire during all tests. During the modem testing, emphasis was placed on the 9600 bit/s data rate. Modem test periods ranged from one to three hours and encompassed all times of the day to include a variety of loading conditions. Ten second performance readouts were recorded. Similarly, circuit tests were run over all representative periods of the day; circuit conditions such as signal-to-noise ratio, impulse noise, phase jitter, and phase hits were measured most frequently due to their known adverse effect on modem performance.

2. The modem used for these tests employs a single sideband AM (SSB) partial response modulation scheme along with an adaptive equalizer. The partial response system used was a class IV (1, 0, −1) technique [1] with a symbol rate of 4800 symbols per second: the equalizer was a digital implementation of a 29-tap transversal filter employing an adaptive tap weight adjustment algorithm.

3. The circuits used for these tests were all long-haul voice grade circuits. The major portion of the circuits consisted of either submarine cable, satellite or tropospheric scatter channels as identified in the

tables, but there were tail circuits at each end provided by the carriers to connect the test sites to the main channels. In the case of the Hawaii-Washington tests, the voice grade facilities of the United States carriers were used between Washington D.C. and California, a distance of approximately 2900 miles. For that particular circuit the total length of 5300 miles was composed of nearly half land line and half submarine cable. A similar situation existed for the satellite channel between these two points.

B. *Discussion of data transmission performance*

1. The data transmission performance on all 25 circuits is summarized in Table 1. The circuits are identified by their transmit to receive terminals. Additional test data presented are the overall average bit error performance at 4800 bit/s and at both data rates, the percentage of ten-second test intervals during which the modem performance was 10^{-5}, 10^{-4}, and 10^{-3}, respectively. It should be noted that, in some cases, a low average bit error rate does not necessarily correspond with a high percentage of 10^{-5} or better performance and conversely, in other cases, a high percentage of transmission of 10^{-5} or better does not always correspond to a low error rate. These apparent disparities are due to the statistical inter-relationship between error distributions and long-term averages. Another observation is that performance in opposite directions on the same circuit did not necessarily correspond even closely in some cases. This indicates that the " opposite direction " circuits are truly different and separate circuits.

2. Referring to Table 1, it can be seen that nine circuits (2, 4, 5, 6, 8, 10, 13, 15, 17) can be considered definite candidates for 9600 bit/s transmission. In all cases for this group, the average bit error rate was between 10^{-4} and 10^{-5}, and on seven of these circuits, a 10^{-5} or better error rate was demonstrated in between 92% and 98% of the 10-second intervals measured.

3. Two of the circuits (11, 12) in Table 1 are considered to be marginal for 9600 bit/s performance. The overall error rate is slightly in excess of 10^{-4} on these circuits, but the percentage of 10^{-5} second intervals with 10^{-5} performance or better exceeds 80%. 4800 bit/s transmission on these two circuits should be entirely feasible based on the acquired 9600 bit/s test data.

4. Three other circuits (3, 14, 19) will support 4800 bit/s based on the data shown in Table 1. However, they did not pass 9600 bit/s with acceptable performance.

5. With the exception of one circuit from Washington to Hawaii, all other circuits passed both 4800 and 9600 bit/s but with an unacceptable error rate (10^{-3} to 10^{-4}). An interesting observation on these circuits, the majority of which are tropo, is that reducing the data rate from 9600 to 4800 bit/s did not, in most cases, appreciably improve the error rate performance.

C. *Channel parameters degrading data transmission performance*

1. *General*

As can be seen in the previous section of this report, no circuit tested was able to support 9600 bit/s with an overall average error rate of 10^{-5} or better. Therefore, certain channel parameters, either alone or in combination, materially affected modem operation. Absolute correlation between channel parameters and modem performance were measured sequentially rather than simultaneously. However, channel parameters known to affect modem operation were measured frequently, and in most cases their relationship to modem operation can be determined with a high degree of confidence.

2. *Probable degrading factors*

The probable degrading factors to modem operation are shown in Tables 2a, b and c. These tables show the significant circuit parameters for twenty-four of the twenty-five circuits tested. Impulsive noise, phase jitter, phase hits and dropouts appear to be major degrading factors to high-speed modem operation. Cases of poor phase delay and frequency response are also shown. In the case of some of the tropo circuits, rapid variations in signal level were noted, and in one case actual dropouts were experienced during modem operation which did not appear during the dropout tests. The following comments are presented on the significant degrading factors:

a) *Impulsive noise counts*

Seven of the twenty-five circuits tested exhibited excessive impulsive noise counts. A level of 68 dBrn0 was used in these tests as the reference maximum for impulse counts and the composite data signal level was −13 dBm0 in all cases. Three hundred counts or more within 15 minutes of impulses greater than 68 dBrn0 were considered excessive.

b) *Phase jitter*

Based on previous test experience with 9600 bit/s modems in the presence of phase jitter, a peak-to-peak jitter of 6° or more was considered excessive for modem operation at 9600 bit/s. Eight of the circuits tested had excessive phase jitter. This degrading factor was present among all of the media tested.

c) *Phase hits*

The presence of phase hits adversely affects modem operation. However, no laboratory or field experimentation had been conducted to determine the precise relationship between phase hits and modem performance. Therefore, the threshold was rather arbitrarily set for 15° over a 15-minute measurement period. Counts greater than 100 during this period were considered excessive. (Three circuits were found with excessive amounts of phase hits.) If 10 hits in 15 minutes were considered excessive, nine circuits would fall into the phase hit category. It should be noted that phase hits were measured on only half the circuits tested due to the fact that only one phase hit test metre was available.

d) *Dropouts*

Significant dropouts were found to be present on six of the circuits tested. A drop in signal-to-noise ratio below 15 dB constituted a dropout for the purposes of this test. The duration of dropouts in the majority of these cases would by itself provide an error rate within an order of magnitude of that actually observed on the circuit. Dropouts were observed on both satellite and tropocircuits.

III. *Tests at 4800 bit/s with the VSB modem*

A. *General*

1. The objective of these tests was to achieve 8 hours of test on each circuit taken during the business day in the eastern United States. Up to 3 hours would be taken for circuit parameter measurements and up to 5 hours would be used for modem performance measurements. Circuits were selected between Washington, D.C. and two overseas terminal locations to which the circuits were specified to meet A.T. & T. C2 or C.C.I.T.T. M.102 transmission requirements. Tests with this modem were conducted only at the 4800 bit/s transmission rate. Bit and block errors were recorded at intervals of 10^6 bits transmitted.

2. The modem used for these tests employs a vestigial sideband AM(VSB) modulation scheme along with an adaptive equalizer. The modulation rate of the fully suppressed 2300 Hz carrier was 2400 symbols per second and four-level modulation was used. The automatic equalizer was an analogue type with 13 taps.

Start-up time to fully train the equalizer was approximately 8 seconds and modem hold-over time for which a restart is not necessary was approximately 1.4 seconds. The data scrambling/descrambling scheme used causes bursts of three-bit errors when channel errors occur.

3. The circuits used for this test were long-haul voice bandwidth circuits ordered against the A.T. & T. or C.C.I.T.T. M.102 requirements. The major portion of the circuits consisted of either submarine cable or satellite channels as identified in the tables, but national tail segments existed on all services to interconnect the terminal locations with the international facilities.

B. *Discussion of data transmission performance*

1. The data transmission performance for these tests is summarized in Tables 3 and 4. The recording intervals of the test equipment was 10^6 bits transmitted instead of the 10-second intervals used for the previous tests. No attempt was made to rank these circuits in order of their performance.

2. The effects of the error bursts caused by the scrambling and by short-term disturbances of the channel can be seen by comparing the average bit error rate with the relatively high percentage of test intervals during which an error rate of 1×10^{-5} or better was achieved. This effect is also demonstrated by the relatively high percentage of error-free 2400-bit blocks transmitted.

C. *Channel parameters degrading data transmission performance*

Although substantially less test data were accumulated during these tests than those previously described herein, it appeared that impulse noise, phase hits and channel dropouts (or gain hits) were the most probable cause of most of the errors.

D. *Conclusions*

The services tested met the 1×10^{-5} bit error rate criterion in a sufficiently high percentage of the test intervals to be considered quite usable for all but the most highly demanding applications. When errors did occur, they were clustered tightly enough to usually cause very few block errors. From a user's point of view, therefore, only infrequent retransmission of data blocks in error would be required. Despite the fact that the bit error rate occasionally exceeded 1 in 10^{-5} for the 10^6 bit test intervals, the throughput of error-free data blocks for the entire duration of each of the tests was better than 99%. It would seem from the results of these tests that the use of a block error rate criterion of performance is a more valid representation of the transmission systems' capability to handle user data. Use of such a criterion also prevents a very short period of a very high bit error density from disqualifying a service for operational use.

BIBLIOGRAPHY

[1] KRETZMER, E. P.: " Generalization of a Technique for Binary Data Communication ", *IEEE Transactions on Communication Technology*, Vol. Comm-14, No. 1, February 1966.

TABLE 1

DATA PERFORMANCE SUMMARY (9600/4800 bit/s SSB modem)

Test route	9600 bit/s test					4800 bit/s test					
	Length of test (h)	Average bit error rate	% of 10-s intervals achieving given BER			Length of test (h)	Average bit error rate	% of 10-s intervals achieving given BER			
			10^{-5}	10^{-4}	10^{-3}			10^{-5}	10^{-4}	10^{-3}	
Philippine Is. to Hawaii	11.5	3.2×10^{-4}	16	65	99	1.8	1.2×10^{-4}	99	99.5	100	1
	9.4	5.8×10^{-5}	93	98	100		—	—	—	—	2
Hawaii to Philippine Is.	12.3	1.6×10^{-4}	24	67	100	2.0	3.9×10^{-6}	98	99.5	100	3
	10.2	3.8×10^{-5}	97	99	100	—	—	—	—	—	4
Hawaii to Washington, D.C.	1.0	7.3×10^{-5}	62	97	100	—	—	—	—	—	5
	2.0	9.0×10^{-5}	97	99	100	—	—	—	—	—	6
Washington, D.C. to Hawaii	2.4	4.8×10^{-4}	11	57	96	—	—	—	—	—	7
	1.2	8.3×10^{-5}	95	98.5	99	—	—	—	—	—	8
	0.7	3.0×10^{-3}	39	85	91	—	—	—	—	—	9
Japan to Hawaii	10.2	1.3×10^{-5}	98	99	100	—	—	—	—	—	10
	14.2	1.2×10^{-4}	81	92	99	—	—	—	—	—	11
Hawaii to Japan	10.5	1.4×10^{-4}	87	93	98	—	—	—	—	—	12
	13.6	3.5×10^{-5}	69	96	100	—	—	—	—	—	13
Japan to Philippine Is.	13.0	2.3×10^{-4}	60	81	94	1.3	4.0×10^{-5}	86	94	99.5	14
	10.3	3.3×10^{-5}	92	97	99	1.3	8.7×10^{-8}	99.8	100	100	15
Philippine Is. to Japan	12.6	4.1×10^{-4}	51	75	93	1.4	3.9×10^{-4}	76	83	98	16
	11.6	2.4×10^{-5}	95	99	100	1.3	1.6×10^{-5}	95.5	98	100	17
Okinawa to Philippine Is.[a]	0.8	1.2×10^{-2}	0	0	0	11.5	1.1×10^{-4}	67	72	83	18
	3.9	6.3×10^{-4}	39	40	91	7.0	2.8×10^{-5}	97	99	100	19
Philippine Is. to Okinawa[a]	0.9	6.6×10^{-3}	0	0	0	11.0	2.3×10^{-4}	79	88	96	20
	4.6	9.4×10^{-4}	0	1	72	6.2	7.6×10^{-4}	83	89	97	21
Okinawa to Japan[a]	8.4	3.9×10^{-4}	45	71	96	6.8	2.4×10^{-4}	91	94	97	22
	8.7	1.1×10^{-3}	23	63	86	4.4	2.7×10^{-4}	71	81	95	23
Japan to Okinawa[a]	8.5	9.9×10^{-4}	41	65	73	6.8	1.7×10^{-4}	92	95	97	24
	7.5	4.0×10^{-4}	43	62	87	3.1	2.2×10^{-4}	96	98	99	25

[a] Indicates dominant tropospheric scatter link.

TABLE 2 a

CHANNEL PERFORMANCE SUMMARY (9600/4800 bit/s SSB modem)

Test route	Peak-peak phase jitter and major freq. comp.	Group-delay variation (μs)			Net loss variation (dB)		Imp. noise count/15 min at level (dBrn0)			Test-tone/noise (dB) [a]	P-P level stab. (dB)	[b]
		0.5-2.8 kHz	0.6-2.6 kHz	1.0-2.6 kHz	0.3-3.0 kHz	0.5-2.8 kHz	60	64	68			
Philippine Is. to Hawaii (5300 miles)	10° 60, 120, 180	255	255	180	+1.8 −0.1	+1.0 −0.1	20	3	2	47.4	0.5	1
	3° 60, 120, 180	270	270	165	+1.2 −0.0	+1.2 −0.0	0	0	0	41.7	0.75	2
Hawaii to Philippine Is.	2.96° 60, 120, 360	285	285	198	+2.4 −1.6	+1.0 −1.6	2202	186	57	46.1	0.30	3
	1.0° 60, 120, 180	315	315	219	+1.0 −2.5	+1.0 −2.5	4398	5	0	44.2	0.30	4
Washington, D.C. to Hawaii (5300 miles)	1.6° 120	450	210	195	+1.8 −1.0	+1.8 −1.0	7825	94	7	36.2	0.45	7
	<1.0° 60, 120, 180, 360	540	150	150	+1.7 −1.7	+1.0 −1.2	132	22	4	43.2	0.30	8
	6.0° 60, 80, 120, 180, 270	370	93	93	+1.5 −1.5	+1.5 −1.0	4197	3047	637	41.5	0.95	9
Hawaii to Washington, D.C.	7.0° 60, 120, 180	1305	255	255	+2.3 −2.2	+2.3 −2.2	3196	7	1	38.7	1.1	5
	2.0° 60, 120, 180	330	180	120	+2.4 −2.4	+1.1 −2.4	66	52	39	41.5	0.5	6

[a] To convert TT/N to S/N subtract 13 dB.

Note. — Impulse noise thresholds for circuits terminating at Washington and Hawaii are 2 dB lower than shown.

[b] Circuit numbers correspond to the circuit numbers of Table 1.

TABLE 2 b

CHANNEL PERFORMANCE SUMMARY (9600/4800 bit/s SSB modem)

Test route	Peak-peak phase jitter and major freq. comp.	Group-delay variation (μs)			Net loss variation (dB)		Imp. noise count/15 min at level (dBrn0)			Test-tone/noise (dB) [a]	P-P level stab. (dB)	
		0.5-2.8 kHz	0.6-2.6 kHz	1.0-2.6 kHz	0.3-3.0 kHz	0.5-2.8 kHz	60	64	68			
Japan to Hawaii (4200 miles)	2.5° 50, 60, 100, 150, 300	1020	195	66	+1.2 −1.0	+0.7 −0.8	816	559	558	41.9	0.60	10
	3.0° 60, 150, 180, 300	621	216	96	+2.5 −0.0	+1.3 −0.0	35	25	16	37.6	0.35	11
Hawaii to Japan	2.2° 50, 60, 100, 150, 180, 300	480	230	150	+3.0 −1.5	+1.5 −1.5	1548	155	79	42.2	1.15	12
	2.1° 50, 60, 100, 120, 150, 180	266	156	104	+4.0 −0.5	+2.3 −0.5	428	250	150	42.4	0.25	13
Japan to Philippine Is. (1875 miles)	7.0° 50, 60, 100, 120, 150, 180	1800	1800	330	+0.8 −4.7	+0.5 −1.7	1179	603	348	40.8	0.58	14
	3.5° 60, 120	450	180	135	+1.7 −0.5	+0.3 −0.5	973	413	143	48.8	0.68	15
Philippine Is. to Japan	8.15° 50, 60, 100, 150, 180	690	690	690	+1.8 −0.6	+1.8 −0.0	2300	1225	611	42.7	0.08	16

[a] To convert TT/N to S/N subtract 13 dB.

Note. — Impulse noise thresholds for circuits terminating at Washington and Hawaii are 2 dB lower than shown.

TABLE 2 c

CHANNEL PERFORMANCE SUMMARY (9600/4800 bit/s SSB modem)

Test route	Peak-peak phase jitter and major freq. comp.	Group-delay variation (μs)			Net loss variation (dB)		Imp. noise count/15 min at level (dBrn0)			Test-tone/noise (dB) [a]	P-P level stab. (dB)	
		0.5-2.8 kHz	0.6-2.6 kHz	1.0-2.6 kHz	0.3-3.0 kHz	0.5-2.8 kHz	60	64	68			
Okinawa to Philippine Is. (1000 mile-tropo)	15.5° 60, 120, 180	1510	750	315	+3.2 −2.0	+0.5 −2.0	9821	2600	137	36.4	2.7	18
	14.5° 60, 120, 180	405	270	125	+5.0 −0.8	+1.5 −0.8	10150	7250	399	41.0	2.8	19
Philippine Is. to Okinawa	14.7° 60, 120, 180	660	390	315	+6.0 −1.5	+2.0 −0.5	5026	1151	496	41.8	1.76	20
	14.9° 60, 120, 180	750	750	330	+1.0 −0.7	+1.0 −0.7	7147	1257	585	42.9	1.75	21
Okinawa to Japan (1000 mile-tropo)	3° 60, 120, 180	285	165	165	+1.4 −0.6	+1.4 −0.6	715	81	22	48.7	1.2	22
	2.5° 60, 120, 180	387	246	120	+1.5 −0.0	+1.5 −0.0	483	153	66	48.3	1.1	23
Japan to Okinawa	4.3° 60, 120, 180	210	120	90	+2.0 −0.2	+2.0 −0.2	974	524	188	47.5	2.61	24
	3.03° 60, 120, 180	225	120	120	+2.5 −0.5	+1.5 −0.5	529	242	99	48.5	2.70	25

[a] To convert TT/N to S/N subtract 13 dB.

TABLE 3

DATA PERFORMANCE SUMMARY (4800 bit/s VSB modem)

Test route	Length of test (min)	Average bit error rate	% of 10^6-bit intervals achieving given bit error rate			Average block error rate (2.4 kb/block)	% of 10^6-bit intervals achieving given block error rate		
			10^{-5}	10^{-4}	10^{-3}		10^{-3}	10^{-2}	10^{-1}
Canberra, Australia, to Washington, D.C.	270	1.1×10^{-4}	92	98	99	1.3×10^{-3}	89	99	100
Washington, D.C., to Canberra, Australia	288	4.1×10^{-5}	88	98	99	3.2×10^{-3}	73	92	100
Madrid, Spain, to Washington, D.C.	62	1.4×10^{-4}	84	84	95	6.7×10^{-3}	82	84	100
Washington, D.C., to Madrid, Spain	270	1.1×10^{-4}	76	92	93	No test data recorded			

TABLE 4

CHANNEL PERFORMANCE SUMMARY (4800 bit/s VSB modem)

Test route	Peak-peak phase jitter and major freq. comp.	Group-delay variation (μs)			Net loss variation (dB)		Imp. noise count/15 min at level (dBrn0)			Test-tone/noise (dB)	S/N (dB) [a]
		0.5-2.8 kHz	0.6-2.6 kHz	1.0-2.6 kHz	0.5-3.0 kHz	0.5-2.8 kHz	60	64	68		
Canberra, Australia, to Washington, D.C.	9.2° 20, 40, 60, 100, 180 Hz	2300	900	450	+3.0 −0.7	+3.0 −0.7	120	7	0	39	22 [b]
Washington, D.C., to Canberra, Australia	No test data	2850	950	450	+3.6 −0.7	+2.8 −0.7	No test data recorded				
Madrid, Spain, to Washington, D.C.	7.0° 50, 60, 80, 120, 150 Hz	1050	500	500	+5.5 −0.5	+1.2 −0.5	>999	15	0	41	29
Washington, D.C., to Madrid, Spain	No test data	3250	1600	475	+6.0 −0.8	+1.9 −0.8	No test data recorded				

[a] Send data level = −12 dBm0. [b] Send data level = −17 dBm0.

Supplement No. 3

SPAIN (C.T.N.E.).—*(Extract from Contribution COM Sp. A—No. 122, December 1970)*

TEST OF DATA TRANSMISSION OVER A SWITCHED NETWORK AT 600/1200 BITS

1. *General considerations*

The following is a summary of tests of data transmission carried out during 1969 on the switched Spanish telephone network.

2. *Equipment used*

2.1 *Transmission equipment*

Two ITT modems, GH-2002, were used with technical characteristics adjusted to conform with C.C.I.T.T. Recommendation V.23. Neither delay nor amplitude equalizers were employed.

2.2 *Measurement equipment*

The equipment used was SRT's error analyser ERA M-1004. This equipment repeatedly transmits a programme or block of 1024 bits which includes all possible combinations of binary 0 and 1 in words of seven bits plus one of redundancy. The total number of erroneous bits received is detected and registered. The number of line outages which interrupt transmission is also registered at the time the outage occurs.

3. *Circuits tested*

The measurements were taken on a looped circuit involving three intra-city circuits and two inter-city circuits. Each of the two parts of a loop (Figure 1) consists of an automatically established telephone circuit between corresponding subscribers' equipments located in the Gran Vía Central, Madrid.

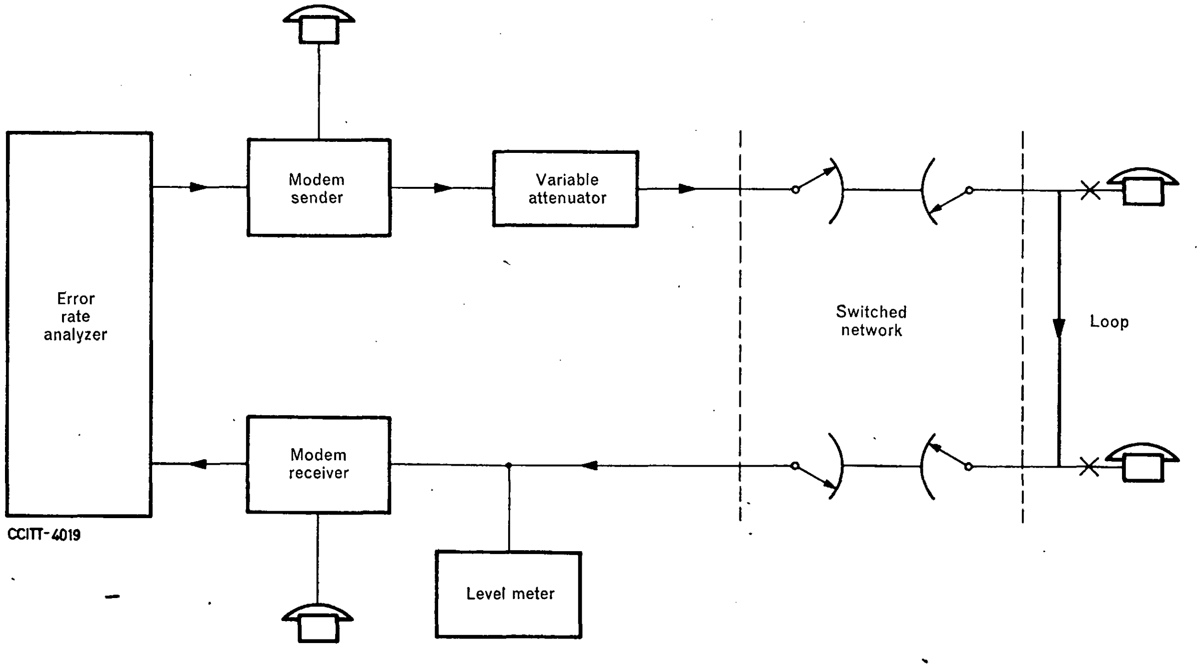


FIGURE 1. — Set-up

3.1 *Intra-city circuits*

The loop is closed by connecting the two pairs of wires of the corresponding telephones (leaving these free) at the distant central. In this manner, a telephone circuit is established formed by four switching centrals and two intra-city cables without loading coils.

The following intra-city Madrid circuits were tested:

A — " rotary " type centrals — cable length of 13 km.

B — " rotary " type centrals — cable length of 8 km.

C — " rotary " type centrals and cross bars — total cable length of 6 km.

3.2 *Inter-city circuits*

The loop is closed by connecting the four wires of the corresponding circuits entering the inter-city automatic central at the distant city leaving the rest of the telephone circuit, towards the subscriber, free. The inter-city telephonic connection achieved in this manner is forced by two sections of a high frequency system.

The described manner of establishing the loop between two inter-city connections results in the corresponding tariff impulse generators having an influence over the number of errors, due to its presence in the line output to each modem.

After confirming that the greatest cause of error (Graph 1) is due to the induction produced by the tariff impulses in the receiving modem (at which they arrived with levels up to -26 dBm), the corresponding tariff generator was disconnected; which is equivalent to an inter-city connection in which the calling subscriber is the data emitter. In order to simulate the reverse connection, the tariff generator was left at the receiver during a part of the tests with Bilbao, and figured as a separate circuit having the designation Madrid-Bilbao-Madrid (reverse direction).

The following inter-city circuits were tested:

D — Madrid-Barcelona-Madrid

E — Madrid-Bilbao-Madrid

F — Madrid-Bilbao-Madrid (reverse direction).

4. *Test characteristics*

Sixty-two distinct connections were effected over the total number of circuits which were investigated. In each connection successful samples of 340 blocks were transmitted. That is to say, approximately 350 000 bits at levels of emission of 0, -6 and -12 dBm while registering the following parameters concerning each sample:

a) Hour and day. The hours of transmission were normally on working days from eight in the morning until eight in the evening.

b) Type of circuit.

c) Speed of transmission.

d) Level of emission.

e) Level of reception of the binary 1.

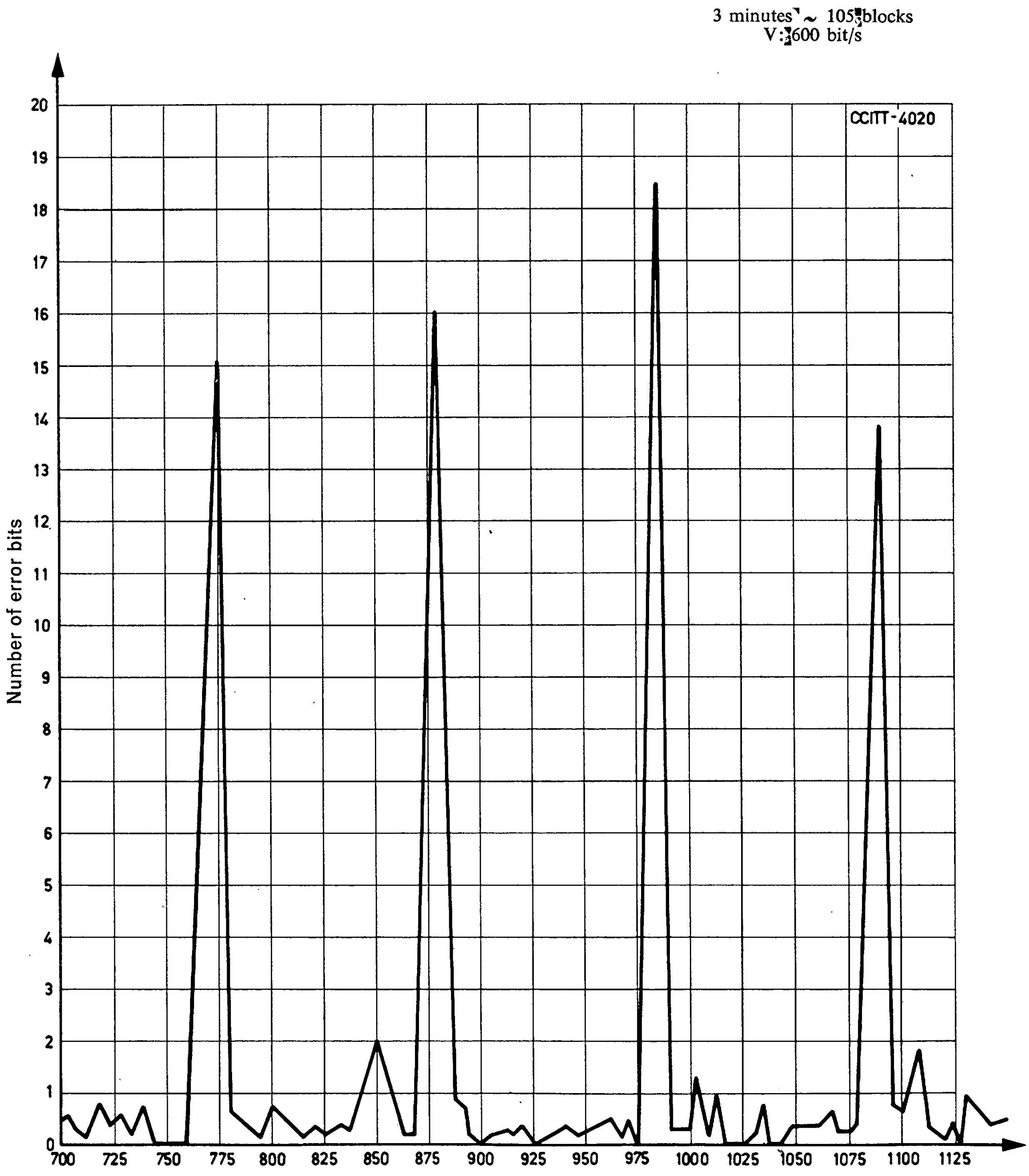
f) Number of 1024-bit blocks transmitted.

g) Total number of error bits received in the sample.

h) Error proportion over the bits in each sample:

$$P_e = \frac{\text{No. of bits received with error}}{\text{No. of blocks transmitted} \times 1024 \text{ bits/block}}$$

The number of self-restoring line outages occurring during the transmission of a sample were also registered although these values were not taken into account for the analysis.


3 minutes ~ 105 blocks
V: 600 bit/s
CCITT-4020
Number of error bits
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
700
725
750
775
800
825
850
875
900
925
950
975
1000
1025
1050
1075
1100
1125
Number of transmission blocks

GRAPH 1

The levels of white noise and impulse noise were measured.

The test was finished at eight in the evening, and amplitude-frequency curves were traced of the last connection. The various graphs are collected in the attached Appendix.

5. *Results*

Table 1 is a summary of the results obtained for each circuit and speed. The proportion of error bits is specified with reference to 10^{-6}.

A comparative study was made of the average and the median P_e obtained for the samples of 340 blocks transmitted during each test. In every case the median was notably inferior to the average, which indicates that P_e's of a low value were much more frequent than those of a high value in all of the tests undertaken.

The average white noise in the 3-kHz band oscillated between —40 and —50 dBm in the various samples.

In samples of impulsive noise, taken for Madrid's switched network during 15-minute periods, 4 impulses having a level superior to −18 dBm were observed and this number increased to 12 during the hour of greatest traffic.

6. *Summary*

In order to study the influence of telephonic traffic and the level of reception with respect to the proportion of errors P_e, the results of the tests have been summarized in Graphs 2, 3 and 4.

6.1 *Variation with the time of day (Graph 2)*

For every half-hour of the same day, the coefficient between the proportion of errors in each sample and its average value obtained for each half-hour of the same day has been calculated. Furthermore, the variation in the average and the median of the coefficients so obtained has been represented graphically over the entire day.

The two anomalous peaks at 08.00 hrs. and at 15.30 hrs., not reflected in the median, are due to manipulations of the circuits and coincide with change of shift of maintenance personnel at the telephone centrals being used.

6.2 *Influence of the level of reception*

The values of the proportion of errors as a function of the emission and reception levels has been represented graphically for every one of the established loops and for each of the two data transfer rates. The following conventions were used:

Sign	*Emission level*
+	0 dBm
++	−6 dBm
+++	−12 dBm

Furthermore, by taking into account the powerful influence which the totally random parameters (impulsive noise, phase jitter), taken together with the received signal level, have over the number of errors obtained in each case, it was possible to approximate the values given using the method of least squares for straight line regression.

From these graphs and by the use of similar methods, Graphs Nos. 3 and 4 have been calculated and drawn as a summary of the measurements taken.

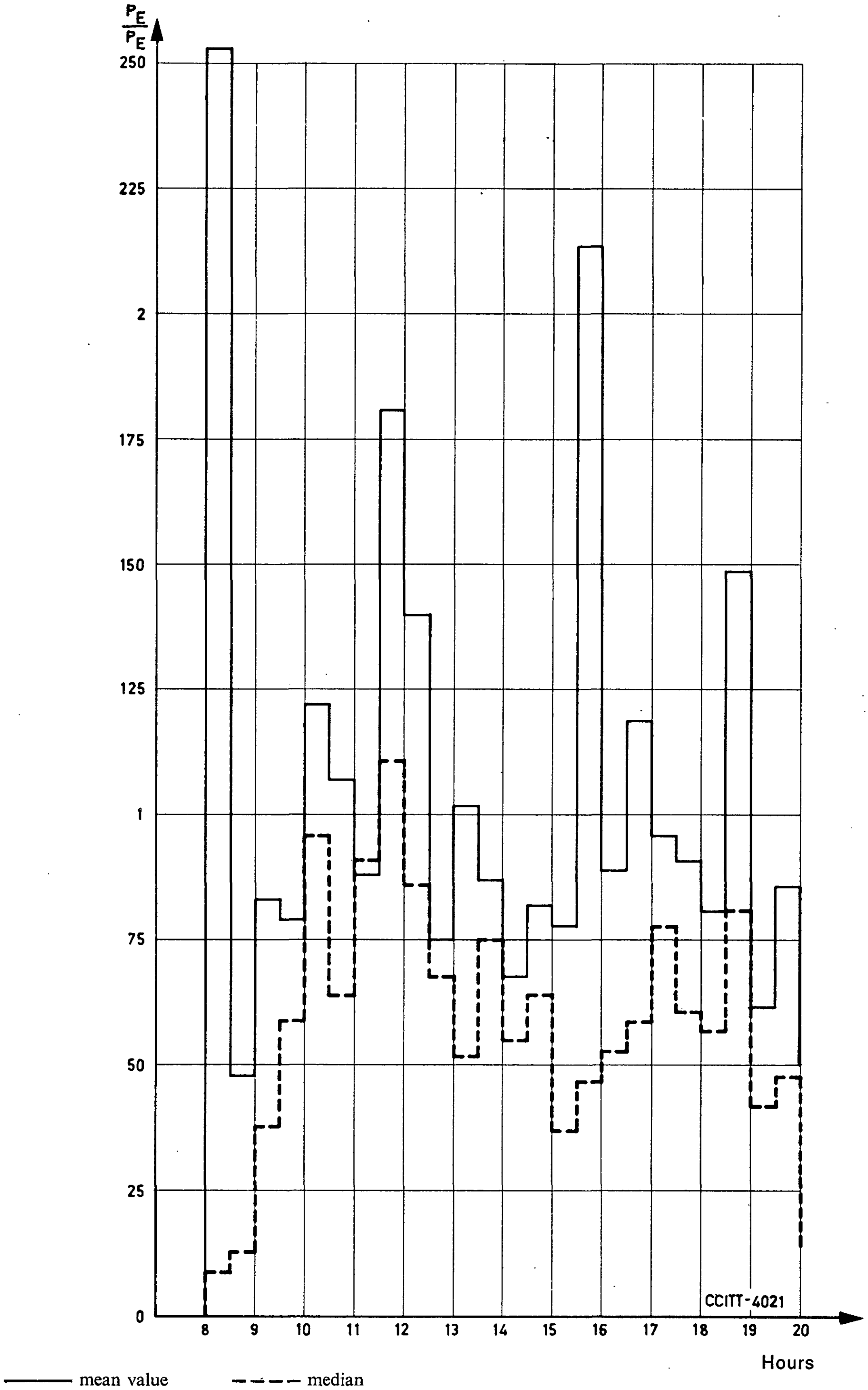
7. *Conclusions*

Once the overloading of the channel modulators has been avoided and correction has been made for the interference introduced by the tariff impulses, the proportion of bit errors conforms to the limits established by Recommendation V.53 of the C.C.I.T.T. White Book.

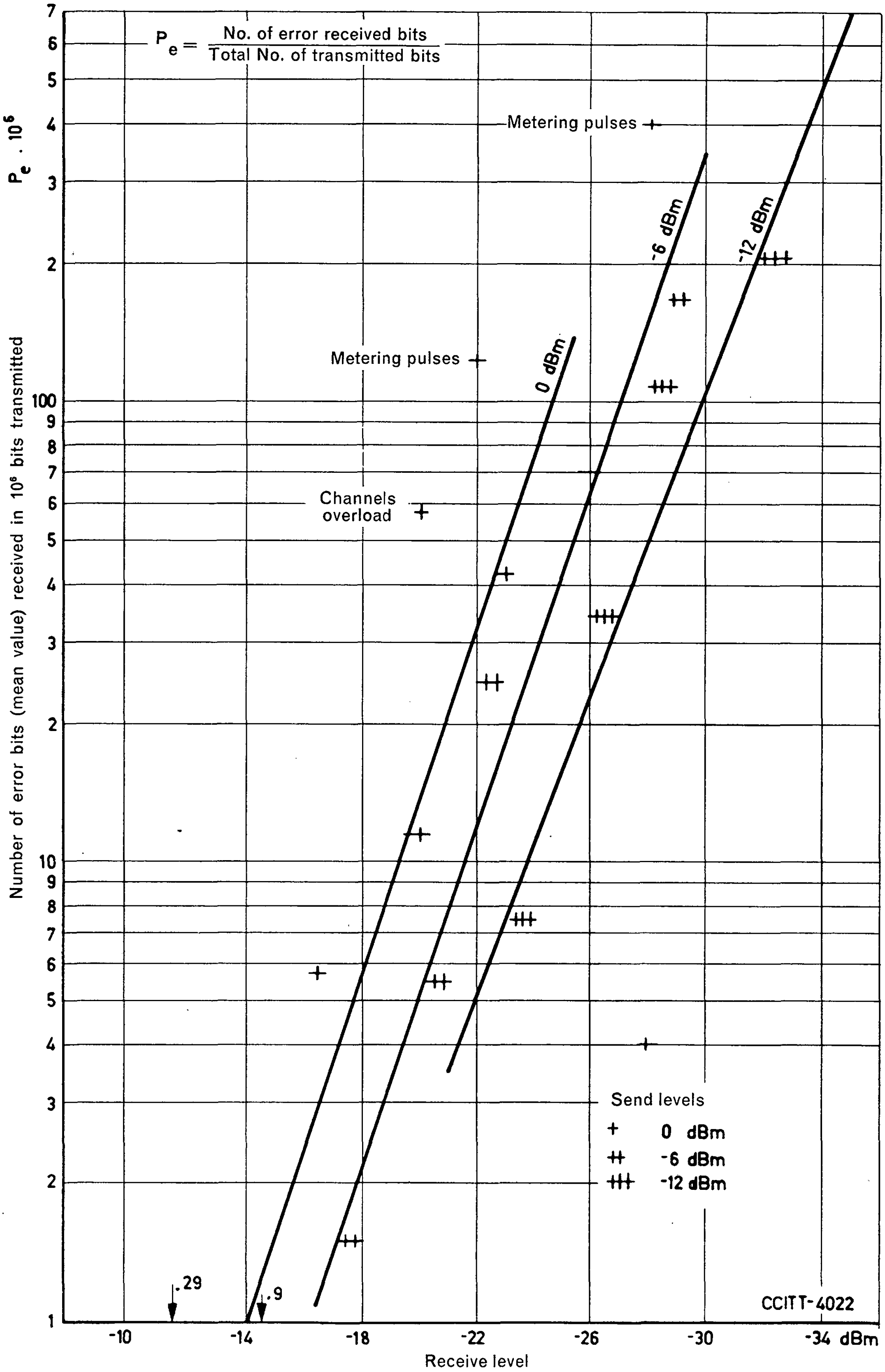
Morèover, with the indicated exceptions, an appreciable betterment of these limits can be observed especially where the data transmission network is restricted to the switching centrals employing cross bars avoiding those of the " rotary " type.

TABLE 1

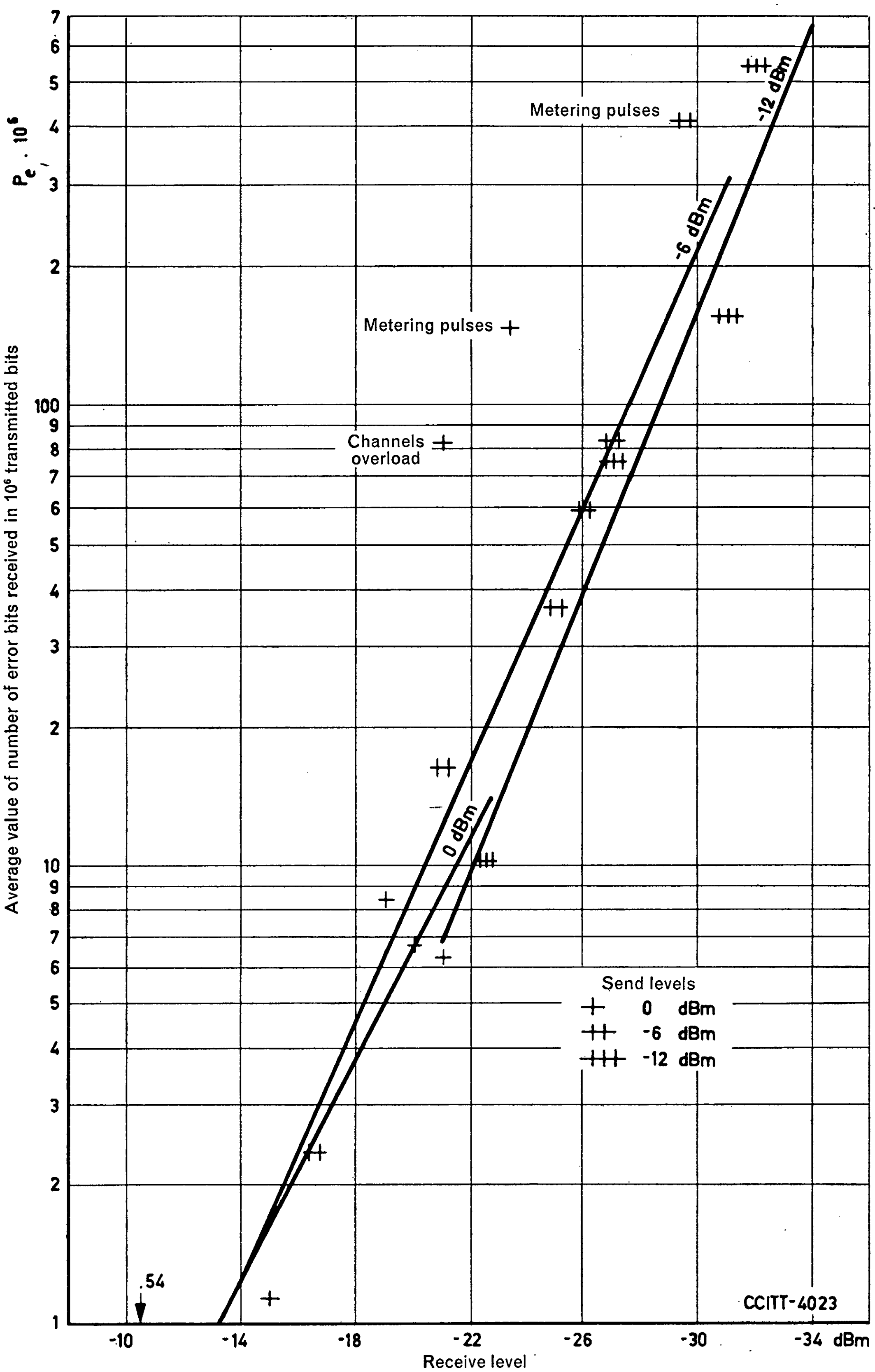
Circuits	Loop and modulation rates (bit/s)	Receive level (dBm)	Send level (dBm)	No. of blocks transmitted 1024 bit/block	Number of erroneous bits	P_e (error rate) 10^6
						Mean value
A	600	−16.5	0	25 864	280	10.57
		−22.5	−6	27 990	1 020	35.59
		−28.5	−12	27 644	5 522	195.07
	1200	−20	0	42 882	229	5.21
		−26	−6	42 612	2 354	53.95
		−32	−12	38 412	9 839	250.14
B	600	−14.5	0	13 523	178	12.85
		−20.5	−6	12 906	335	25.35
		−26.5	−12	13 235	612	45.16
	1200	−15	0	40 686	50	1.20
		−21	−6	38 426	916	23.28
		−27	−12	37 130	8 441	222.01
C	600	−11.5	0	29 241	6	0.20
		−17.5	−6	27 383	33	1.18
		−23.5	−12	25 920	146	5.50
	1200	−10.5	0	43 719	22	0.49
		−16.5	−6	48 736	139	2.78
		−22.5	−12	42 454	411	9.45
D	600	−20	0	24 082	1 066	43.23
		−26	−6	22 572	1 224	52.95
		−32	−12	21 416	4 006	182.67
	1200	−20	0	34 685	1 847	52.00
		−26	−6	33 169	2 656	78.20
		−32	−12	32 100	10 504	319.56
E	600	−23	0	10 983	759	67.76
		−29	−6	11 015	2 624	232.64
		−35	−12	10 231	6 956	663.96
	1200	−19	0	18 894	152	7.86
		−25	−6	17 822	845	46.30
		−31	−12	21 041	4 018	186.48
F	600	−22	0	14 199	2 584	177.72
		−28	−6	13 066	5 833	435.96
		−34	−12	12 878	19 261	1460.60
	1200	−23.5	0	16 895	2 254	130.28
		−29.5	−6	16 774	8 224	478.79
		−35.5	−12	14 913	20 023	1311.18


$\frac{P_E}{P_E}$
250
225
2
175
150
125
1
75
50
25
0
8
9
10
11
12
13
14
15
16
17
18
19
20
Hours
CCITT-4021
mean value
median

GRAPH 2



GRAPH 3 — **Error rate in switched network of CTNE at 600 bit/s**



GRAPH 4 — **Error rate in switched network of CTNE at 1200 bit/s**

PHASE HITS TESTS MADE AT THE DATA SWITCHING CENTRE IN ALCÁNTARA (MADRID) ON TELEPHONIC CIRCUITS WITHOUT EQUALIZATION, ON 5 SEPTEMBER 1970, WITH THE PHASE JITTER METER, HLI, MODEL 44 EQUIPMENT

1. *Circuit :* Alcántara-Hermosilla-Alcántara (Rotary)
(Madrid intra-city switching network)

Characteristics:		
	Sending level (dBm)	+1.5
	Receiving level (dBm)	−15
	Average jitter (°)	10
	Minimum p-p jitter (°)	2.5

Threshold	No. of impulses phase hit	Time (min)	Observations
5°	189	5	The time for the first test was 9 h 30 min and for the last 10 h 30 min
10°	41	5	
15°	3	15	
20°	11	15	
25°	0	15	

---

2. *Circuit :* Alcántara-Valencia-Alcántara-Santo Domingo-Alcántara (point to point)

Characteristics:		
	Sending level (dBm)	−4
	Receiving level (dBm)	−7
	Average jitter (°)	10
	Minimum p-p jitter (°)	4.0

Threshold	No. of impulses phase hit	Time (min)	Observations
5°	1	5	From 10 h 30 min until 11 h 45 min
10°	15	5	
15°	11	15	
20°	0	15	

---

3. *Circuit :* Madrid-Guadalajara-Madrid (point to point)

Characteristics:		
	Sending level (dBm)	−1
	Receiving level (dBm)	−7
	Average jitter (°)	1.0
	Minimum p-p jitter (°)	2.5

Threshold	No. of impulses phase hit	Time (min)	Observations
5°	28	5	The time was around 12 h
10°	0	15	

---

4. *Circuit :* Málaga-Madrid (inter-city switching network)

Characteristics:		
	Sending level (dBm)	0
	Receiving level (dBm)	−9
	Average jitter (°)	1.0
	Minimum p-p jitter (°)	2.0

Threshold	No. of impulses phase hit	Time (min)	Observations
5°	49	5	Time started at 12 h 45 min until 13 h 30 min
10°	18	5	
15°	9	5	
20°	8	5	
25°	1	5	
30°	0	5	

RACAL-MILGO LTD.—*(Contribution COM Sp. A—No. 170, December 1971)*

2400 BIT/S DATA TRANSMISSION TESTS ON THE UNITED KINGDOM PUBLIC SWITCHED NETWORK

1. *Introduction*

During April and May 1971, tests were carried out on the United Kingdom public switched telephone network to compare data transmission error rates at 1200 and 2400 bit/s. The units used were a Post Office Datel ID modem complying with C.C.I.T.T. Recommendation V.23 and a Racal-Milgo modem 2200/24 complying with V.26. Special approval was given by the Post Office for the test series.

2. *Acceptable limits*

Because of the limited experience of using 2400 bit/s on the public switched network, the V.23 modem was used as a comparison reference. This is particularly useful in the United Kingdom where there are circuits on which it is necessary to reduce the operating speed, and where error rates can be encountered which would be unacceptable for commercial data transmission. In many of these cases, by terminating the call and dialling a second time, acceptable results are obtained. In consequence, a simple presentation of overall results is misleading. The following types of information are therefore provided:

a) an overall analysis of the percentage of calls falling into various categories (Table 1);

b) cumulative probability of block error rates using various acceptability limits (Figures 1, 2 and 3);

c) cumulative probability of bit error rates (Figure 4).

TABLE 1

OVERALL ANALYSIS

There were 79 tests in which a direct comparison between the V.23 and V.26 modems could be made, i.e. 79 pairs of tests on 79 different circuits.

79 tests involved the two modems	100%
In 65 cases both modems could operate at their maximum speeds	82%
In 7 cases the V.23 had to be dropped to 600 bit/s while the V.26 ran at 2400 bit/s	9%
In 4 cases the V.23 had to be dropped to 600 bit/s and the V.26 to 1200 bit/s	5%
In 2 cases the V.23 had to be dropped to 600 bit/s and the V.26 would not synchronize at all	2.5%
In 1 case the V.23 would run at 1200 bit/s and the V.26 had to be dropped to 1200 bit/s	1.5%

Notes:

1. The V.26 four-phase modem used is also capable of operation at 1200 bit/s using two-phase modulation. The baud rate is unchanged.

2. In addition to the 79 tests analysed above, there were a small number of cases where a test had to be abandoned owing to operator intervention or disconnection.

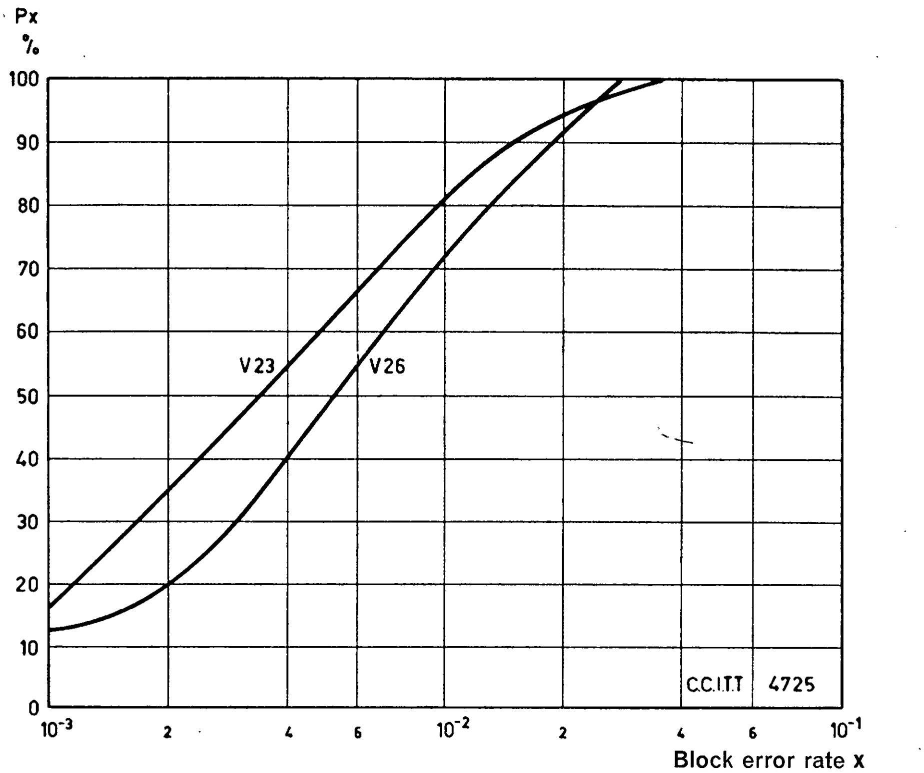


FIGURE 1. — **Cumulative block error rate (511 bits) all locations excluding results worse than 3×10^{-2}**

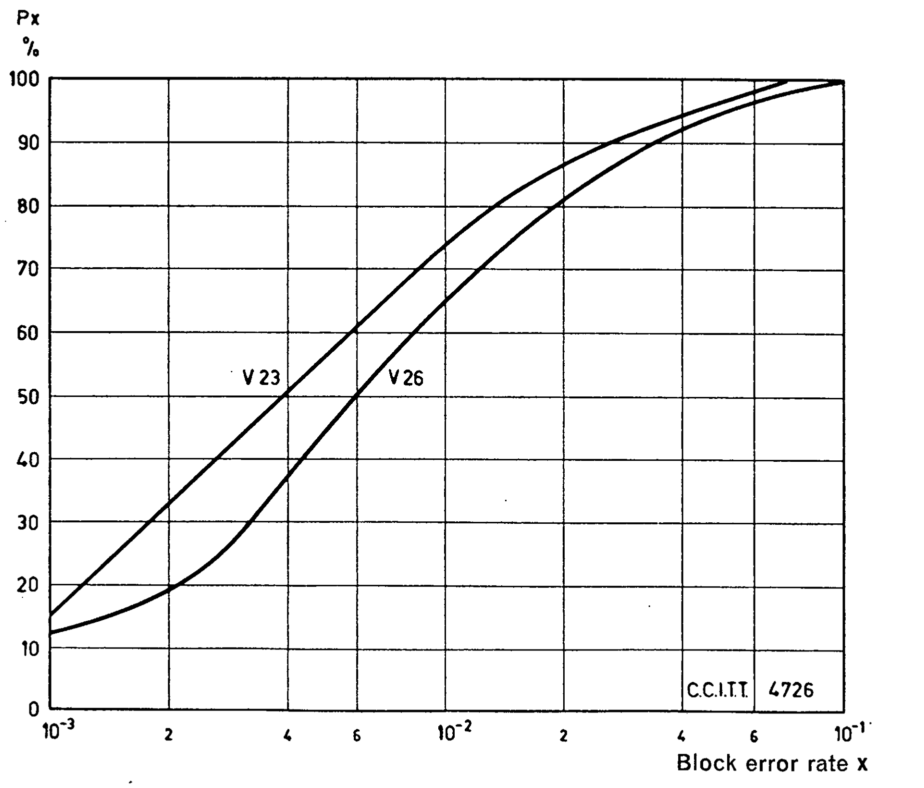


FIGURE 2. — **Cumulative block error rate (511 bit) all locations excluding results worse than 10^{-1}**

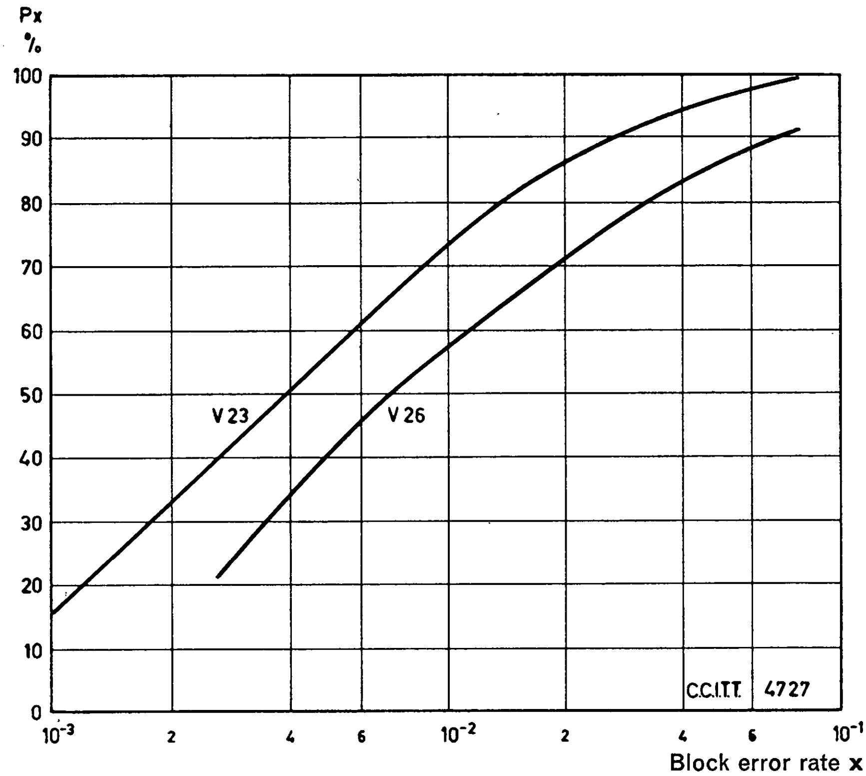


FIGURE 3. — **Block error rate (511 bit) all results**

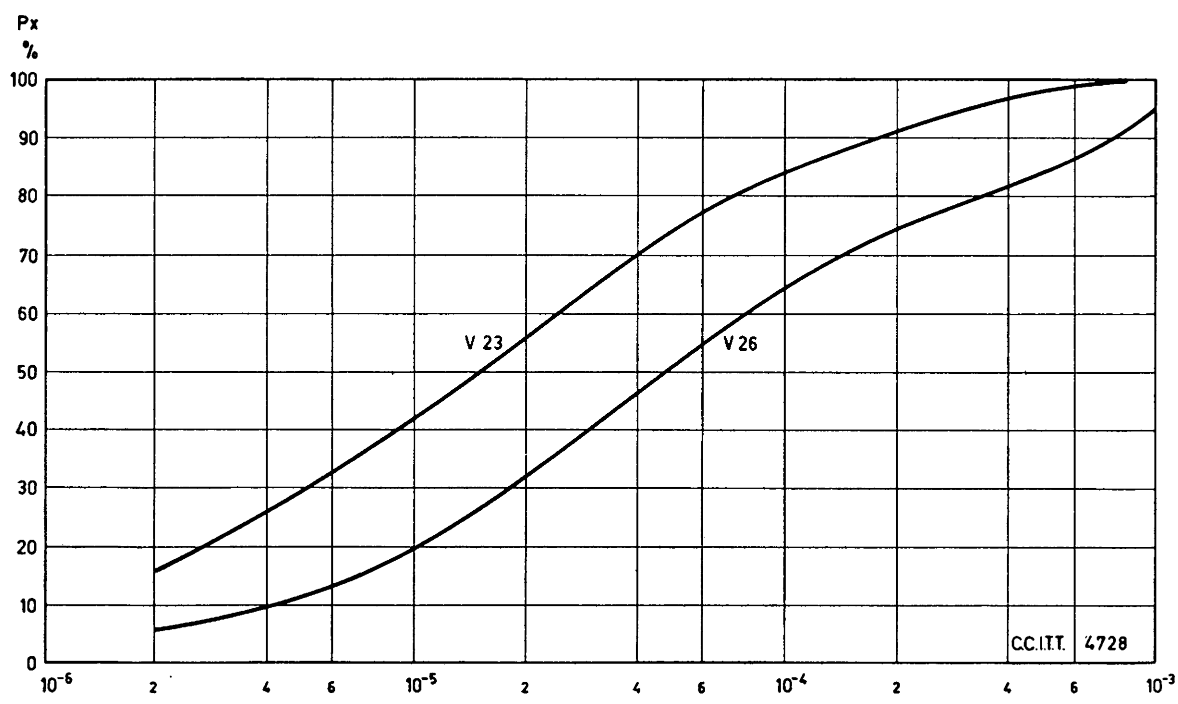


FIGURE 4. — **Cumulative bit error rate all results**

3. *Test locations*

The locations used fall into the following groups:

a) the laboratory in Reading to various London sites;

b) between various London sites;

c) from sites in the middle and North of England to London and the Reading laboratory.

In all cases the tests were from private subscriber premises including the local ends.

4. *Test procedure*

The graphical results are based on tests where it was possible to operate both modems at their maximum speed on the same circuit for at least 3½ minutes each (5×10^5 bits at 2400 bit/s) although in most cases much longer tests were run. Table 1 analyses those tests where it was not possible to operate at maximum speed.

The only block error rate measured was for a block length of 511 bits. Tests were monitored aurally and, where there was a temporary disruption due to time signals, this was allowed for in the result in order to assess the performance of the line itself. The audible monitoring also assisted attempts to determine the source of errors.

Transmit levels of −13 dBm were used throughout on both modem types and the receivers were set to a fixed sensitivity.

5. *Comments on results*

Figures 1 and 2 provide information on the probability of block error rates no worse than the value shown on the abscissa ignoring source data worse than 3×10^{-2} and 10^{-1} respectively. Figure 1 is typical of the result obtained by the user who re-dials when the retransmission rate of his block error protected equipment is too high, or when initial voice contact is bad.

The most significant factor for the user at these speeds is normally the number of useful bits per second available at the receiving end after error correction. The relationship between this figure and block error rate depends on the overall system. A simple comparison can be made by assuming that each block error " loses " 511 bits of contribution to the average throughput. On this basis the V.26 modem provides approximately double the throughput of the V.23 unit in all cases.

6. *Source of errors*

Three major sources of errors have been considered:

a) amplitude and delay distortion;

b) impulse noise;

c) listener echo.

a) The standard fixed compromise equalizer of modem 2200/24 was used. No attempt was made to optimize it to the line statistics of COM Sp. A—No. 54 (see Supplement No. 14). The Bundespost tests reported in COM Sp. A—No. 101 (see Supplement No. 1) used the same modem but with a different fixed equalizer. The V.23 modem is the standard unit supplied by the Post Office for public switched network use in the United Kingdom. It does not contain a line equalizer.

As part of the tests, the effect of varying the equalizer characteristic was tried. When the error rate was already low, some small improvement was obtained. When the error rate was high, little or no improvement resulted. It is concluded therefore that line distortion is not the primary source of errors at 2400 bit/s on the circuits tested. The addition of a frequency shift secondary channel at 420 ± 30 Hz also had no degrading effect. No significant difference was found between modulation alternatives A and B.

b) Impulse noise was a primary source of errors. Audible monitoring showed that error bursts seen on the error rate test set coincided with impulses heard on the line.

c) The effect of listener echo is difficult to assess during line trials of this kind. At least some of the problems at certain bad sites are probably associated with this phenomenon.

Supplement No. 5

FEDERAL REPUBLIC OF GERMANY.—*(Contribution COM Sp. A—No. 178, December 1971)*

INVESTIGATIONS INTO THE SUITABILITY OF MODEMS IN CONFORMITY WITH RECOMMENDATION V.26 FOR 2400 BIT/S DATA TRANSMISSION ON THE INTERNATIONAL SWITCHED TELEPHONE NETWORK

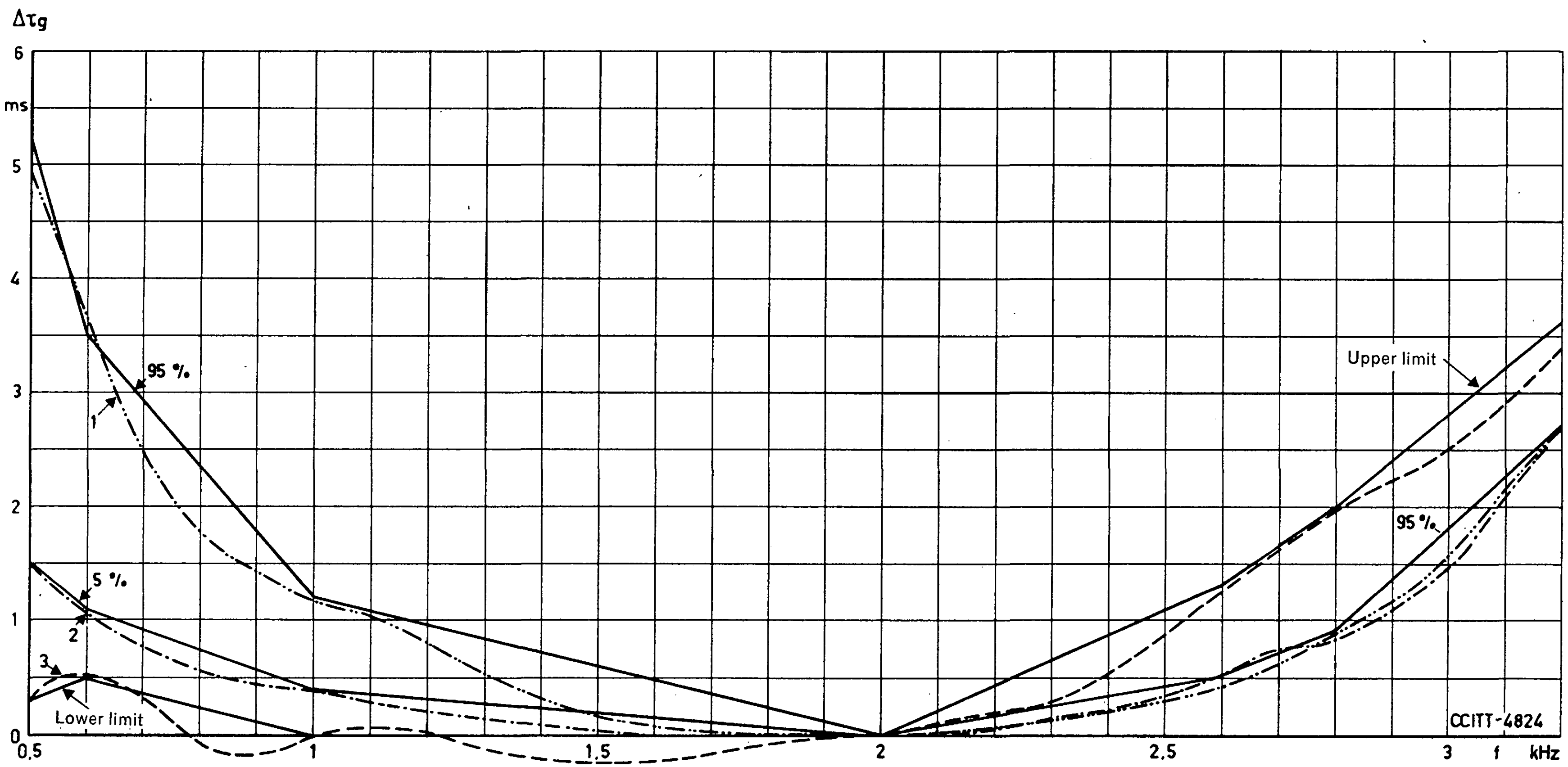
Further to the German Contribution COM Sp. A—No. 101 (see Supplement No. 1) which includes, among other things, the results of the tests concerning the use of the modem specified in Recommendation V.26 on the switched telephone network of the Federal Republic of Germany, this contribution investigates the use of this modem on international switched telephone connections.

Since the drawing of conclusions from the result of the data transmission on some international connections on its general applicability is not considered to be representative enough, the transmission quality was tested in the laboratory under the worst conditions. The tests were made on the basis of Document COM Sp. A—No. 150[1] which furnishes information about the characteristics of international switched telephone connections.

A line simulator was used to simulate the worst attenuation and group delay distortions listed in Document COM Sp. A—No. 150, Tables 6 and 22 (cf. Figures 1 and 2). Before the line simulator white noise was applied together with the signal. The signal-to-noise ratio was measured behind the line simulator. In those cases where no line simulator was inserted the interfering noise was limited by filters. A compromise equalizer was added as a separate unit before the receiver. This compromise equalizer is identical with that used in the V.23 modems of the German Administration and also with that employed for the study of the V.26 modem in the German national telephone network (see Supplement No. 1).

---

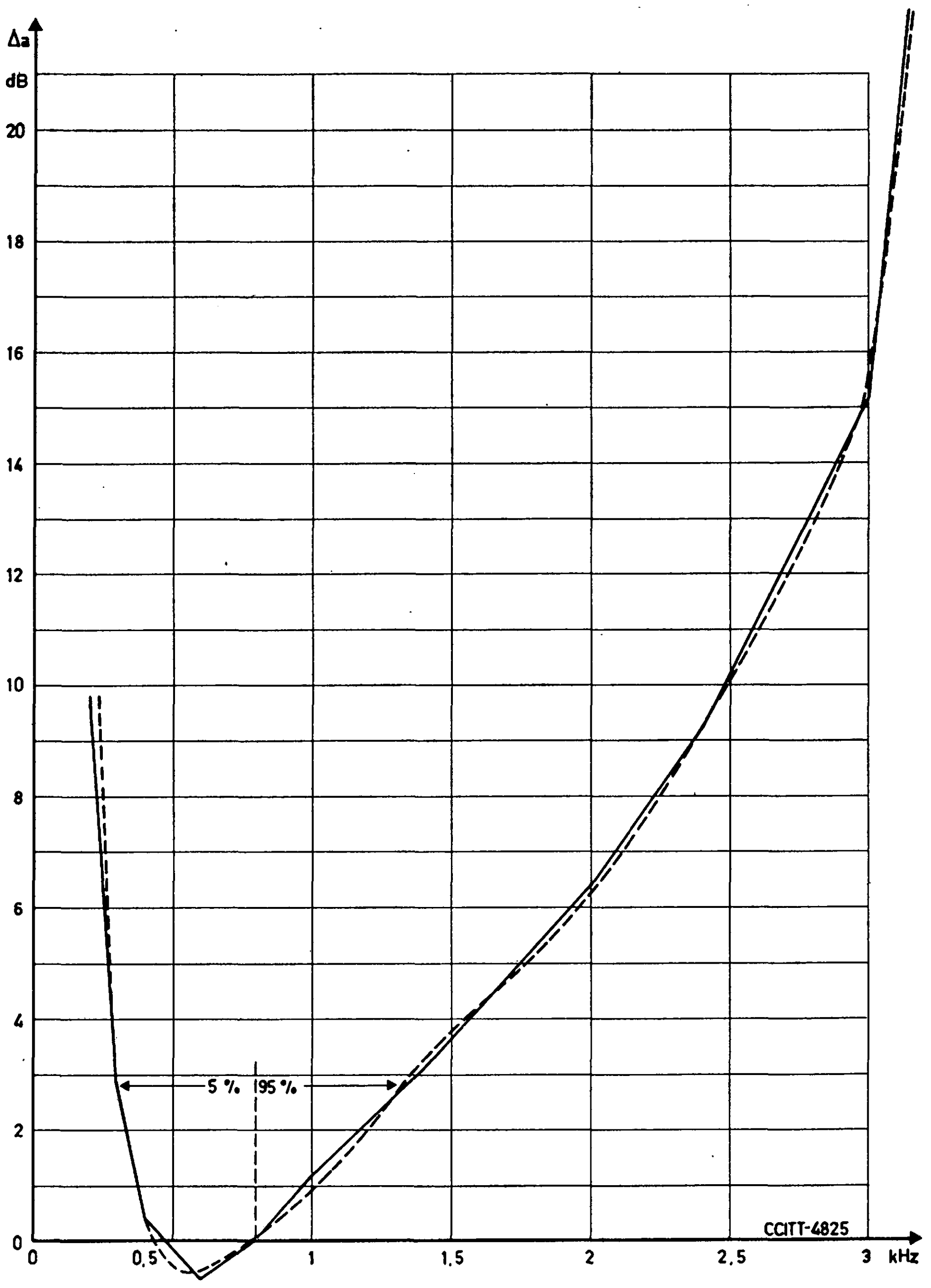
[1] See Annex 1 to Question 3/XVI of the *Green Book*, Vol. III.



——— delay distortions as shown in Table 22 of Contribution COM Sp.A — No. 150

—··—··— , —·—·— , — — — } delay distortions of the line simulator

FIGURE 1



——————— attenuation distortion as shown in Document COM Sp.A — No. 150, Table 6

– – – – – – – attenuation distortion of the line simulator

FIGURE 2

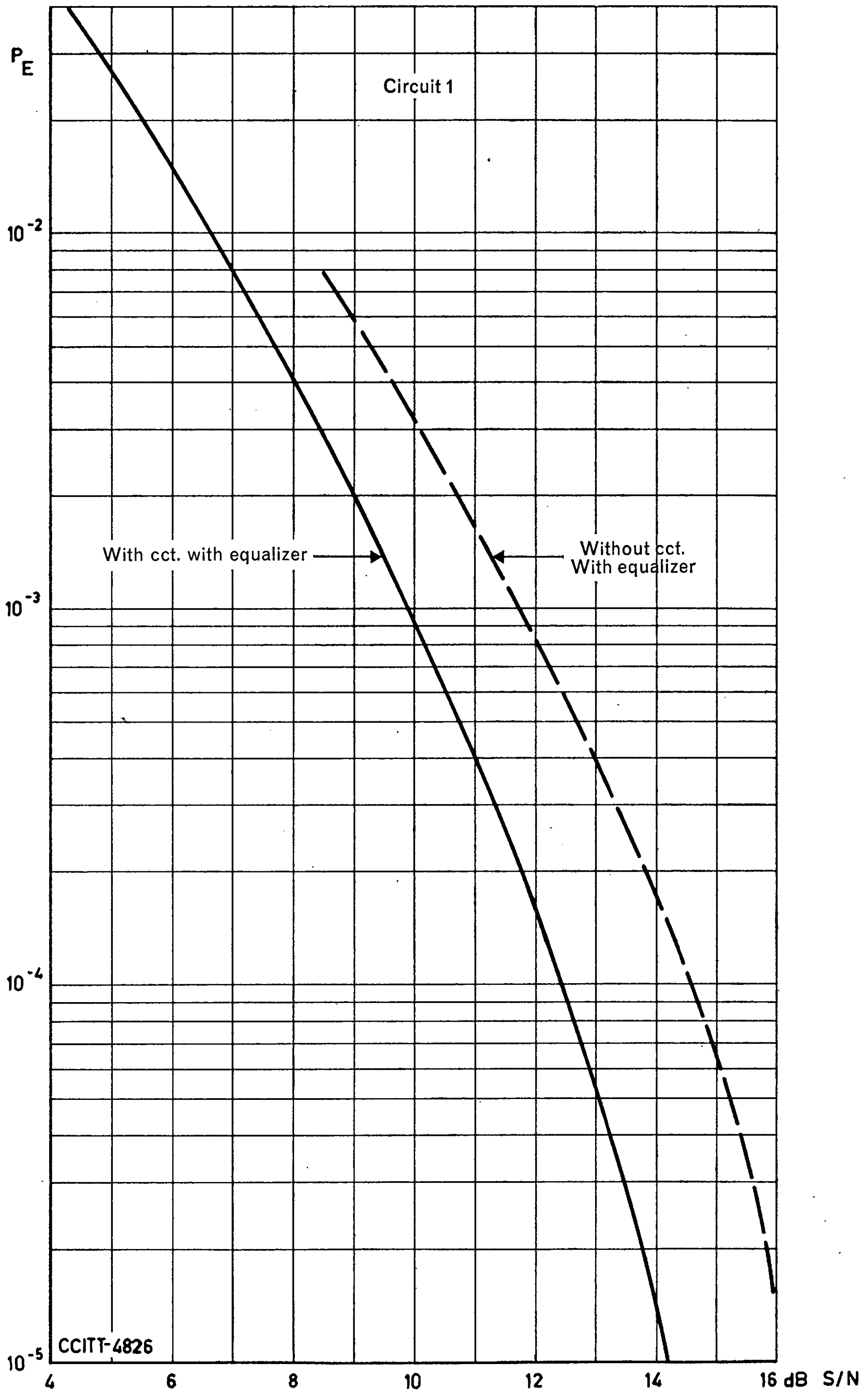


FIGURE 3. — **Circuit 1**

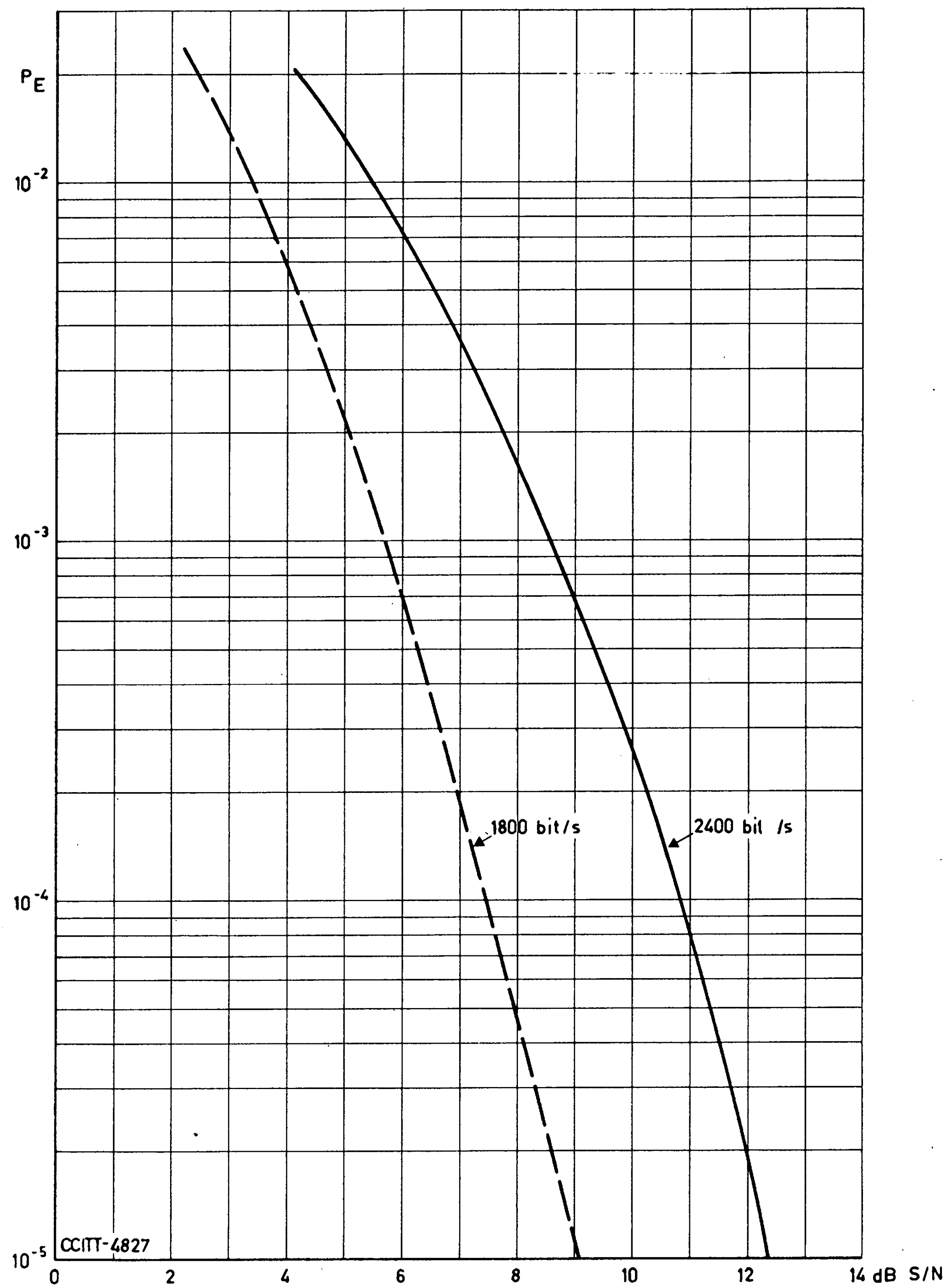


FIGURE 4. — **Circuit 2**

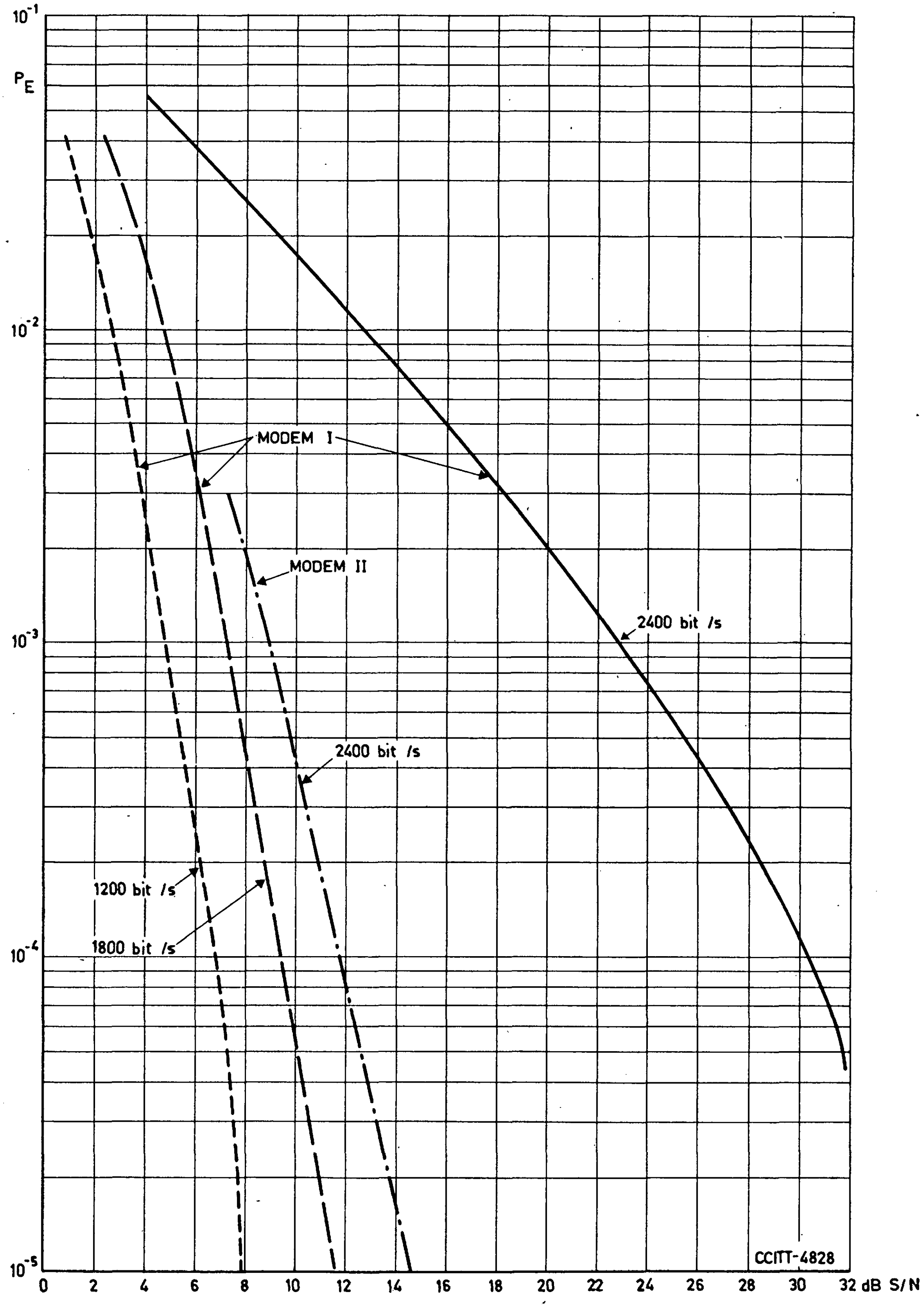


FIGURE 5. — Circuit 3

Equipments supplied by two manufacturers were available for the measurements. These measurements were not only carried out between equipments from the same manufacturer but also between equipments of different manufacturers. The internal equalizers were switched off. The results of the measurements, carried out on circuits 1 and 2 (Figures 3 and 4) with the two different modems, differ but slightly so that they were not shown separately.

In Figure 5, which shows the transmission characteristics under extreme conditions on the circuit (circuit 3), there is a wide difference between the test results obtained for the two modems. This difference is probably to be attributed to the group delay differences between the sending and receiving filters in the modems which together with the characteristic of the connected compromise equalizer yielded an insufficient compensation. In the case of a corresponding optimization of the overall equalization, where allowance had to be made for the distortion inherent in non-equalized filters, even better results could probably be obtained with both modems.

The pronounced deviation of the signal-to-noise characteristic of one of the modems (cf. Figure 5) shows that the transmitting capacity is limited by the high dissymmetry of the group delay distortion. Reduction of the signalling rate to 1800 bit/s allowed the signal-to-noise ratio to be improved by more than 10 dB, while a further decrease of the rate to 1200 bit/s resulted in only a 3-dB gain.

In the light of the findings of the German Administration a decrease of the signalling rate from 2400 bit/s to 1800 bit/s seems also to be sufficient for the operation on international connections with extremely dissymmetric distortion.

A result that has to be specially mentioned is the fact that a compromise equalizer suffices to equalize the line characteristics of an international connection. If this equalizer is designed so that it can be switched on and off, the signal-to-noise ratio can be improved by 4 dB in the case of back-to-back operation.

It seems to be worth while to continue the study of the question of compromise equalizers. Splitting up of the equalizer between transmitter and receiver would allow a better adaptation of the international connections to the relevant national networks.

Supplement No. 6

UNITED KINGDOM POST OFFICE.—*(Contribution COM Sp. A—No. 181, December 1971)*

FIELD TESTS OF V.26 MODEM ON THE GENERAL SWITCHED TELEPHONE NETWORK

1. *Introduction*

In support of Document COM Sp. A—No. 153, the United Kingdom Post Office is now in a position to report upon an extensive series of tests conducted to establish the degree of success that can be achieved in the transmission of data at 2400 bit/s using V.26 modems on the general switched telephone network. Previous work had established that the performance would be unsatisfactory on trunk connections unless equalizers were used. For these tests therefore the modems were fitted with two types of fixed compromise equalizers. Equalizer 1 was designed to give a group delay of −0.5 ms at 700 and 2900 Hz relative to 1800 Hz and about 7 dB linear decrease of insertion loss across this band. Equalizer 2 was designed to give a group delay of −1.2 ms at 700 and 2900 Hz relative to 1800 Hz. The insertion loss was a maximum at 1000 Hz and was 1 dB and 9 dB less at 700 and 2900 Hz respectively.

Equalizer 1 was used on all connections. Tests were also done with Equalizer 2 on a representative selection of connections to enable a comparison to be made.

2. *Scope of tests*

The tests were carried out in two stages: firstly on trunk connections and subsequently on calls confined to the London area primarily in order to confirm that the use of the equalizer did not impair short-distance performance excessively. No tests have been carried out on international connections. Four stations were used for the trunk tests, one being permanently sited in Central London, and the remaining three being moved about to selected locations throughout the United Kingdom. Tests were carried out between all the provincial locations and London and also between each set of three provincial locations. Both directions of call establishment and both directions of transmission were tested. All four stations were equipped with Equalizer 1. Only one station (provincial) was also equipped with Equalizer 2.

The London area tests were conducted in a similar manner to the trunk tests but the locations were confined to within about 30 km of Central London.

3. *Results*

Each data test was of 3 minutes 28 seconds duration, corresponding to 500 000 bits transmitted. If the number of bit errors received in 3 minutes 28 seconds exceeded 500 (1 in 10^3) the connection was classified as unsatisfactory.

Table 1 summarizes the number of tests made, percentage of satisfactory connections and average error rates of only the satisfactory connections.

Table 2 shows the number of routes having given connection success rates. Of the 31 trunk connections which were unsatisfactory at 2400 bit/s 21 were retested at 1200 bit/s and if necessary 600 bit/s using V.23 modems with equalizer type 1. Of those retested six failed at 1200 bit/s and one also failed at 600 bit/s.

TABLE 1

SUMMARY OF TESTS RESULTS

	Equalizer No. 1		Equalizer No. 2	
	Trunk tests	London tests	Trunk tests	London tests
a) Number of test locations	16	10	5	3
b) Number of routes tested	30	18	15	9
c) Number of tests included [a] in data results	515	354	121	87
d) % of tests c) with error rate better than 1 in 10^3	94%	99%	94%	100%
e) Average bit error probability for satisfactory tests	4.2×10^{-5}	2.2×10^{-5}	2.0×10^{-5}	2.35×10^{-5}
f) Average 511 bit block error probability for satisfactory tests	6.8×10^{-3}	3.7×10^{-3}	3.0×10^{-3}	2.9×10^{-3}

[a] Each connection generally permitted two tests, one in each direction of transmission. However, the number of tests excludes attempts which failed to produce a speech connection due to network congestion, etc., and those calls which were disconnected before completion of tests due to operator intervention etc., but includes operator-interrupted calls when disconnection was not produced.

TABLE 2

PERCENTAGES OF SATISFACTORY CONNECTIONS
FOR TRUNK ROUTES AT 2400 BIT/S

Number of routes [a]	Cumulative percentage of routes	Percentage of connections with error probability better than 10^{-3}
½	100.0	50
½	98.3	67
½	96.7	70
½	95.0	73
½	93.3	75
1½	91.7	80
1½	86.7	83
½	81.7	86
2	80	87
1	73	89
1	70	90
½	67	91
19½	65	100

[a] The presence of halves arises because some connections were satisfactory in one direction of transmission only.

4. *Conclusions*

The tests have shown that provided an equalizer is incorporated, a fairly high percentage of connections on the United Kingdom general telephone network will enable 2400 bit/s data to be transmitted using V.26 modems at an error rate of 1 in 10^3, or better. Some routes were found on which the percentage of connections giving a satisfactory performance was below 80%. No route was found on which it was impossible to obtain a satisfactory connection if repeated attempts were made.

Comparison of the results obtained at the station with two equalizers indicates that the number of satisfactory connections is not significantly affected by the different equalizer characteristics but that the more severe equalizer gave about half the error rate of the other on trunk connections. On London connections there was little difference between the error rates. Before optimum equalizer characteristics can be specified, further study will be necessary.

Supplement No. 7

UNITED KINGDOM POST OFFICE.—*(Contribution COM Sp. A—No. 215, March 1972)*

TRANSMISSION TESTS OF THE V.26 MODEM BETWEEN THE UNITED KINGDOM AND AUSTRALIA

1. *Introduction*

The Australian Post Office and the United Kingdom Post Office have carried out a short series of data transmission tests at 2400 bit/s and 1200 bit/s using V.26 modems via connections established on the Public Switched Telephone Network (PSTN). Some tests at 1200 bit/s using V.23 modems were also included for comparison. Fixed compromise equalizers were used at each end of the circuit connected to the receive side of the modem. The equalizers had a group delay of −1.2 ms at 700 Hz and 2900 Hz relative to 1800 Hz. The insertion loss of the equalizer used in London was a maximum at 1000 Hz and 1 dB and 9 dB less at 700 Hz and 2900 Hz respectively; the equalizers used in Australia had a slope of −8 dB between 700 Hz and 2900 Hz.

2. *Scope of tests*

The tests were carried out via the international circuit between London and Sydney allocated for data transmission. The composition of this circuit is given in the Appendix. Initially test connections were established between London and Melbourne but when transmission was found to be unsatisfactory at 2400 bit/s further testing was carried out between London and Sydney. Calls were originated from both testing stations via a manually operated switchboard in the originating country. Each connection was switched 4-wire throughout. Echo suppressors are included in this Datel circuit but were not disabled in these tests.

3. *Results*

The results of the tests are summarized in Table 1.

4. *Conclusions*

The tests have shown that using a compromise equalizer of the type being introduced for use on the U.K. national network it is possible to transmit data at 2400 bit/s between London and Sydney via the circuit at present allocated for public switched network data transmission at lower rates. Transmission from Sydney to London was not possible nor was satisfactory transmission in either direction when the international circuit was extended to Melbourne.

Satisfactory data transmission was achieved in both directions between London and Sydney and between London and Melbourne at 1200 bit/s using V.26 modems in the four-phase mode at a modulation rate of 600 bauds. Satisfactory performance was also achieved using V.23 modems at 1200 bit/s. The same compromise equalizers were used at 1200 bit/s (PM and FM) as at 2400 bit/s.

TABLE 1

Call No. and calling station	Transmission direction	Rate (bit/s)	Modu-lation	Errors in test of 5 × 10^5 bits (980 blocks)		Remarks
				bit	block	
1	Melbourne-London	2400	PM	—	—	Unable to phase
	”	1200	”	0	0	
London	London-Melbourne	2400	”	5835	525	
	”	”	”	—	—	Unable to phase
	”	1200	”	2	1	
	”	”	”	0	0	
2 Melbourne	Melbourne-London	2400	PM	—	—	Unable to phase
	”	1200	”	0	0	
	”	”	FM	0	0	
	London-Melbourne	2400	PM	395	257	
	”	”	”	258	227	
	”	1200	”	0	0	
	”	”	FM	0	0	
	”	”	”	5	2	No equalizer used
3 London	Sydney-London	2400	PM	—	—	Unable to phase
	London-Sydney	”	”	6	4	
4 Sydney	Sydney-London	2400	PM	—	—	Unable to phase
	”	”	”	1472	679	Equalizer at Sydney only
	”	”	”	592	267	Equalizers at both Sydney and London
	London-Sydney	”	”	4	1	

APPENDIX

Composition of data circuit between London and Sydney

London IME/A—Widemouth B	907/C10 cable	4 kHz	Bandwidth
Widemouth B—Tuckerton	1609/C7 TAT 3 cable	3 kHz	
Tuckerton—White Plains	3/C10 cable	4 kHz	
White Plains—Montreal	not known at present	4 kHz	
Montreal—Vancouver	1201/C4 microwave	4 kHz	
Vancouver—Sydney	TASI via cable	3 kHz	

The circuit comes down to audio at all the above stations.

Supplement No. 8

RACAL-MILGO LTD.—*(Contribution COM Sp. A—No. 244, August 1972)*

INTERNATIONAL DATA TRANSMISSION TESTS ON THE PUBLIC SWITCHED TELEPHONE NETWORK AT 2400 AND 1200 BIT/S

1. *Introduction*

A series of international data transmission tests has been carried out on the public switched telephone network with two main objectives:

a) to assess the probability of satisfactory operation at 2400 bit/s using V.26 techniques;

b) to compare alternative modulation methods for reduced speed operation at 1200 bit/s.

The equipment used was Racal-Milgo Modem 2200/24 modified so that it could be switched between speeds and modulation methods. It includes a fixed compromise equalizer normally used on leased circuits. No attempt was made to optimize this for international switched network use. The reduced speed methods compared were:

a) 1200 bit/s, 1200 bauds, two-phase, modulation angles 90° and 270°;

b) 1200 bit/s, 600 bauds, four-phase, modulation V.26 B (the filters were not changed for 600-baud operation).

2. *Test procedure*

Tests were made between Reading, England, and the following locations; the figures showing the number of incoming and outgoing connections.

Belgium (Brussels)	7 + 7
Denmark (Copenhagen)	6 + 6
Federal Republic of Germany (Darmstadt)	9 + 8
Norway (Oslo)	7 + 8
South Africa (Pretoria)	8 + 6
Sweden (Stockholm)	6 + 6
Switzerland (Berne)	7 + 7

Each connection was tested in both directions using 2400 bit/s and the two alternative 1200 bit/s methods. Measurements were made of both bit and block error rate (511-bit block) and the duration of each measurement was at least 3½ minutes.

The transmit power was −10 dBm and the received power level was measured for each connection in both directions.

Where possible, calls were established by dialling and they were all subscriber-to-subscriber with no attempt to establish special routing. The effect of interference by timing signals was eliminated.

3. *Overall results*

Table 1 shows a summary of the overall results. The first line of the table shows the percentage of calls where data transmission was not possible at all due to inability to synchronize the modem and/or the error rate test set. The figure of 31 % at 2400 bit/s emphasizes the need for a reduced speed capability. Figures are then provided for calls where synchronization was possible but criteria of 10^{-3} for bit error rate and 10^{-1} for block error rate was not achieved.

TABLE 1

OVERALL ANALYSIS OF RESULTS

	2400/4 ø		1200/4 ø		1200/2 ø	
	Bit	Block	Bit	Block	Bit	Block
Synchronization not possible	31%	31%	4%	4%	4%	4%
Synchronized but error rate not acceptable	11%	13%	16%	14%	6%	6.5%
Error rate acceptable	58%	56%	80%	82%	90%	89.5%
Mean error rate of " acceptable " results	5.8×10^{-4}	2.8×10^{-2}	2.2×10^{-4}	2.1×10^{-4}	1.4×10^{-4}	1.7×10^{-2}

Note. — " Acceptable " defined as bit error rate less than 10^{-3}: block error rate less than 10^{-1}.

Table 1 also shows the average bit and block error rates for each of the three modulation techniques used, when the rates were better than the acceptability criteria.

4. *Distribution of errors*

Figures 1, 2, 3 and 4 show the cumulative error probability, both bit and block, for each of the three modulation techniques, and both for all test results and for those better than the acceptability criteria. It will be seen that when the failures have been excluded, there is only a small difference between 2400 bit/s and the two alternative 1200-bit/s methods; particularly for block error rate.

5. *Received signal level*

The received signal level varied between —26 dBm and —48 dBm when using a transmit power of —10 dBm. The arithmetic mean of the dBm values of the received signal levels is —33.7 dBm. There was some correlation between high error rate and low received signal level but many exceptions were observed. For example a number of acceptable error rates were measured at received signal levels in the range —40 dBm to —44 dBm.

6. *Relationship between bit and block error rates*

When using the modulation technique of Recommendation V.26 errors are most likely to occur in pairs or multiples of pairs. With a random error source the ratio of block error rate to bit error rate will approximate to 256 : 1 for the block length used. If the errors occur in bursts then this ratio can be expected to fall. The ratio is therefore a crude indication of error distribution.

The mean values of this ratio are:

2400 bit/s, four-phase, alternative B	165
1200 bit/s, four-phase, 600 bauds	164
1200 bit/s, two-phase, 1200 bauds	195

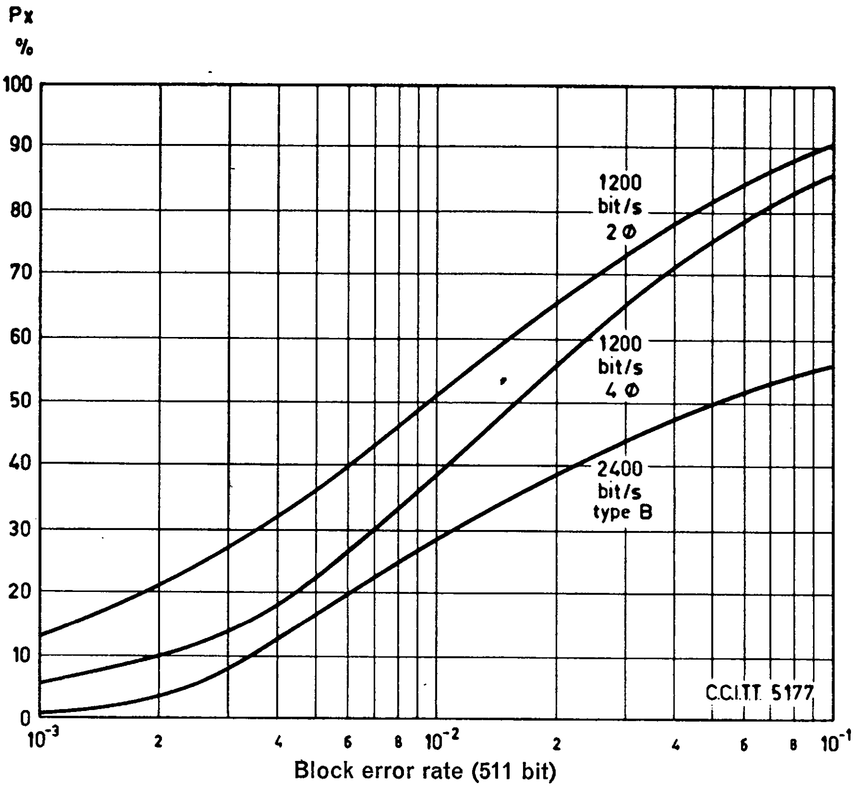


FIGURE 1. — Cumulative block error rate, all results

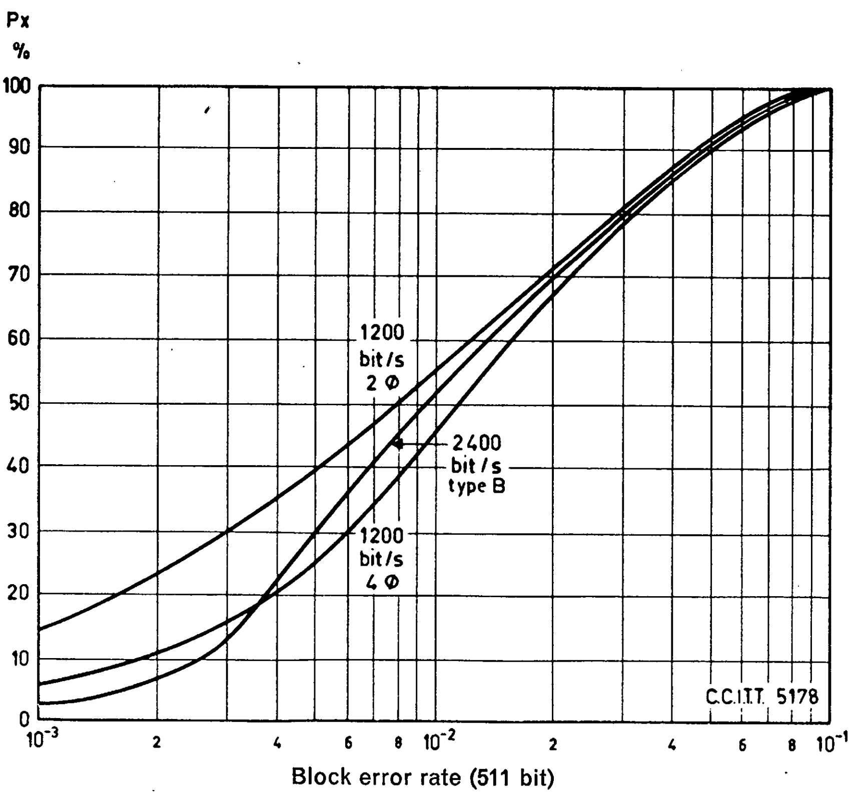


FIGURE 2. — Cumulative block error rate excluding results worse than 10^{-1}

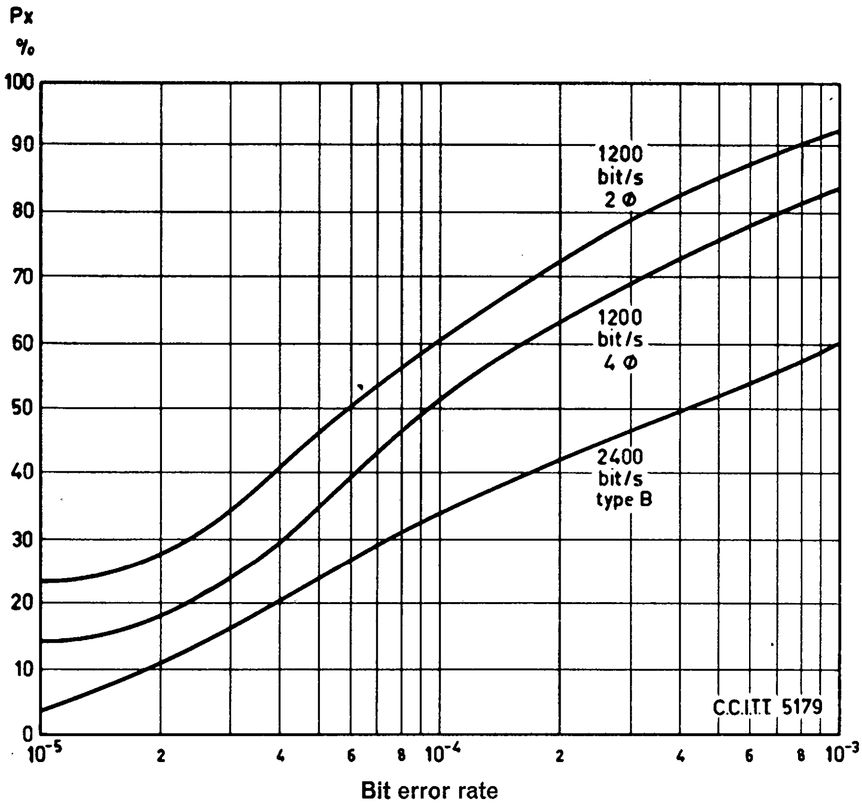


FIGURE 3. — **Cumulative bit error rate all results**

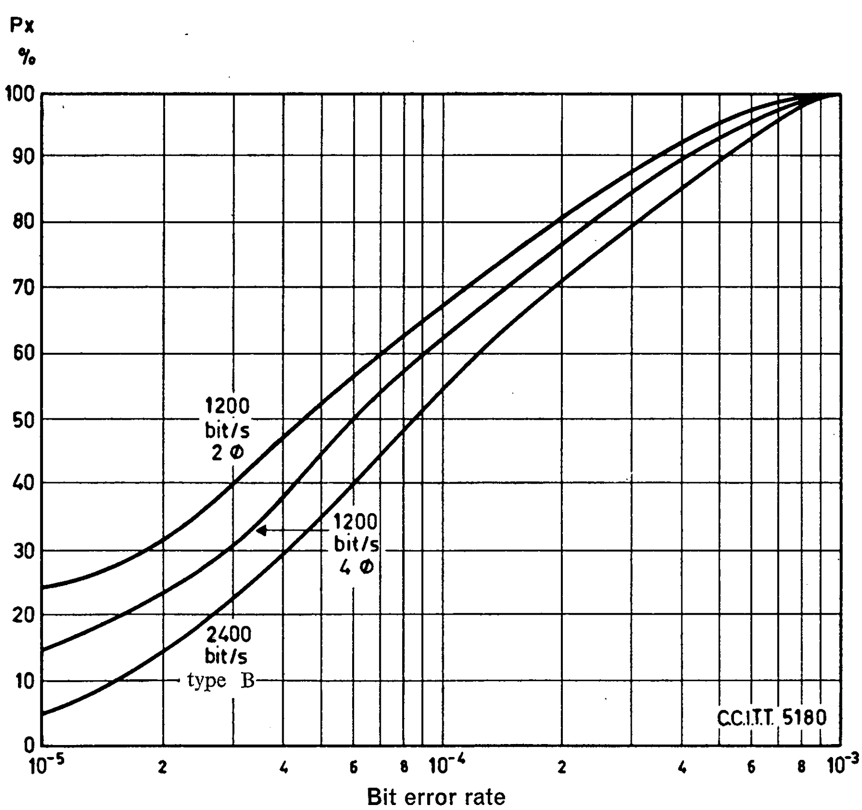


FIGURE 4. — **Cumulative bit error rate excluding results worse than 10^{-3}**

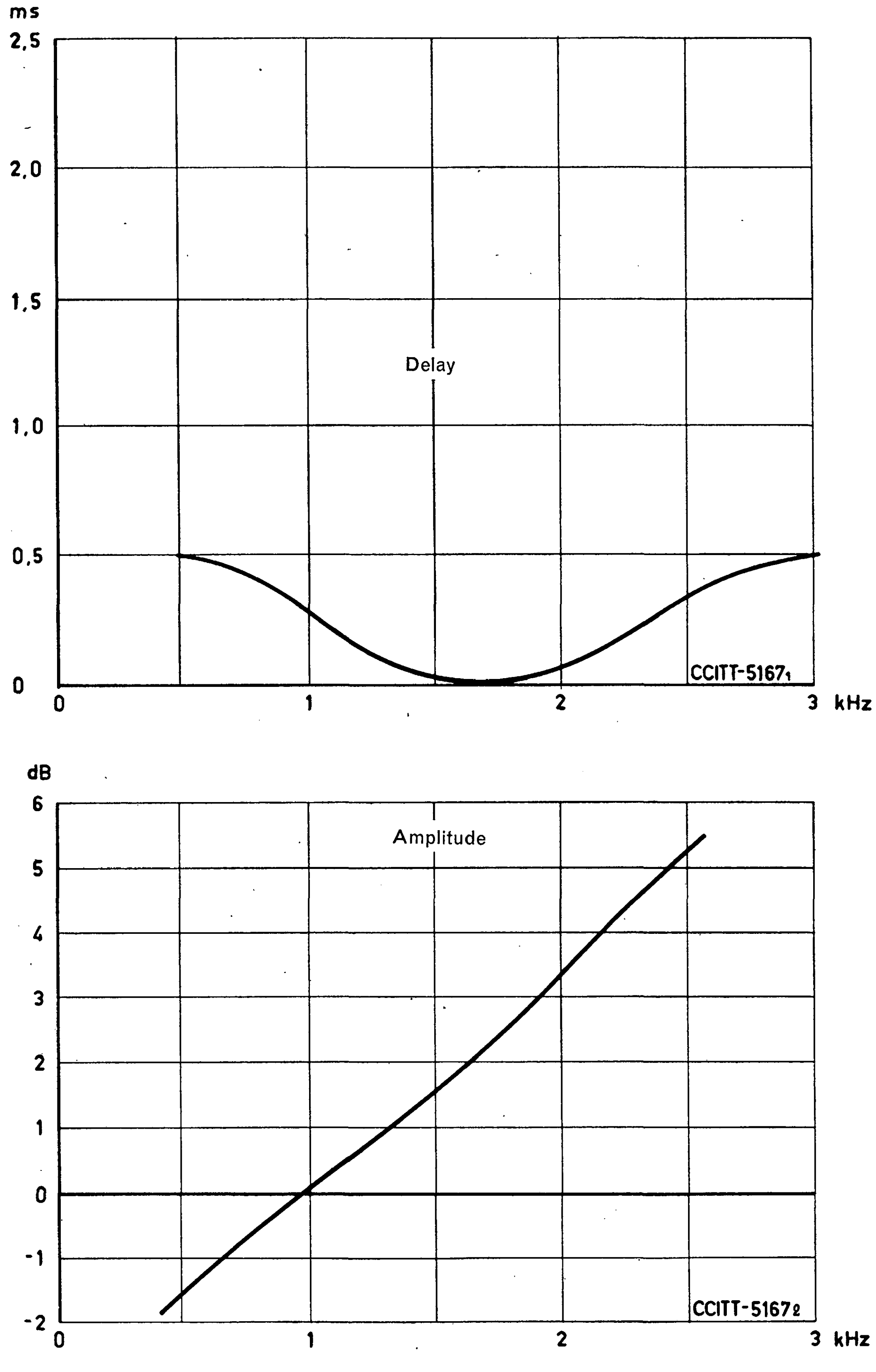


FIGURE 5. — Characteristics of fixed equalizer

7. *Conclusions*

International data transmission at 2400 bit/s on the public switched telephone network appears practical but it may be necessary to establish a call more than once to obtain an acceptable error rate. When an acceptable line is used the difference in error rate, particularly block error rate, between 2400 bit/s and 1200 bit/s (phase modulation) is very small.

Reduced rate operation at 1200 bit/s provides a reliable fall-back facility. Overall, the two-phase technique resulted in a lower mean error rate than four-phase modulation and, perhaps more important, had a higher probability of reaching a minimum acceptable error rate. The only international route tested over which 1200 bit/s four-phase resulted in lower error rate than 1200 bit/s two-phase was between England and South Africa using the submarine cable circuit via Ascension Island. In this case, presumably due to bandwidth restriction, the mean bit error rates were identical while block error rate favoured the four-phase modulation with mean results of 1.5×10^{-2} and 2.5×10^{-2}.

Throughout the tests a fixed, rather weak, compromise equalizer was used. Some of the results would probably have been improved by the use of a more optimal characteristic.

Supplement No. 9

UNITED STATES OF AMERICA.—*(Contribution COM Sp. A—No. 249, September 1972)*

DATA TRANSMISSION MEASUREMENTS

1. *Introduction*

The test programmes being carried out by the communication carriers, manufacturers and government agencies on data transmission parameters continue to produce valuable data on the factors which significantly affect data communication capabilities. One of the tests carried out in 1971 used a switched network to determine its ability to support data transmission at 2400 bit/s. The transmission media consisted primarily of privately-owned microwave and troposcatter links and one leased submarine cable link, all interconnected through electronically controlled reed relay type switches. These brief test results are presented as one example of the type of data service which can be obtained over a non-public switched network and may be helpful to others concerned with the engineering of data communication systems.

1.1 This test was undertaken to establish the data-handling capability of a switched network consisting of both data grade trunks and voice grade trunks. The test programme was conducted between one fixed point and three different remote points. Between these points it was possible to select seven different circuit routings which included one, two or three trunks in tandem with overall lengths between 700 and 4000 kilometres. Data were gathered on more than 180 circuits established on a dial-up first call basis. The tests were run on a 24-hour basis to ensure that different traffic loading conditions would be included. The first hour of each test period was devoted to measuring channel parameters followed by four 30-minute tests of error rate performance measurement on different types of modems.

1.2 Each test was performed over either a Data Grade Channel (A) or a Voice Grade Channel (B). The specified channel parameters for the A channels (Data Grade) were as follows:

Frequency response (Hz)	One trunk	Two tandem trunks	Three tandem trunks
300-3000 500-2800	−1.0 to +3.0 dB −0.5 to +1.5 dB	−1.5 to +4.0 dB −0.5 to +2.0 dB	−1.5 to +5.0 dB −1.0 to +2.5 dB
Envelope delay (Hz)			
500-2800 600-2600 1000-2600	600 microseconds 300 microseconds 100 microseconds	1200 microseconds 600 microseconds 200 microseconds	1800 microseconds 900 microseconds 300 microseconds

Max net loss variation:	± 2 dB
Max change in audio freq.:	± 5 Hz
Phase jitter (pk to pk):	15°
Impulse noise:	15 counts in 15 minutes above 72 dBrn0
Phase hits:	100 hits in 15 minutes above 15°
Dropouts:	Not more than 9 milliseconds cumulative in a 15-minute test period where the S/N drops below 10 dB
S/N ratio:	26 dB

1.3 The channel parameters specified for the Voice Grade (B) channels were as follows:

Frequency response (Hz)	One trunk	Two tandem trunks	Three tandem trunks
300-3000 700-2300	−3.0 to +8.0 dB −1.0 to +3.0 dB	−4.0 to +11.0 dB −1.5 to +4.0 dB	−5.5 to +14.0 dB −2.0 to +5.5 dB

Envelope delay (Hz):	Not specified
Phase jitter:	Not specified
Impulse noise:	Not specified
All other parameters:	Same as for A channels

2. *Modem performance measurements*

2.1 The various modems were evaluated by measuring the bit error rate (BER) and block throughput (BTP) of each modem using a pseudo random sequence of 2047 bits and a block size of 672 bits. A ten-second interval was used for measuring and recording data. Particular attention was paid during this test to categorizing the modem performance data in terms of random or burst phenomenon. In order to do this the measured BER and BTP relationship was investigated. If all the bit errors occurred randomly, it can be shown [1] that:

$$\text{BTP} = (1 - \text{BER})^N \text{ or BER} = 1 - \text{BTP}^{\frac{1}{N}} \tag{1}$$

where N is the number of bits in the block. The block throughput vs bit error rate was plotted for the 672-bit block size and used to compute the various hypothetical values of BER and BTP. Modem performance was considered acceptable if the measured BTP was equal to or greater than 95 per cent which corresponds to a BER of 7.5×10^{-5} in accordance with equation (1) above. A modem was considered to be significantly affected by burst error mechanisms if the measured BER was at least a magnitude greater than the hypothetical BER calculated from equation (1) when using the measured BTP. Cumulative distribution plots were prepared from the measured and calculated data and the probabilities of acceptable modem performance were obtained.

2.2 The four modems used in this test were of the following types:

Type 1 was a 2400-bit/s modem using modulation characteristics equivalent to C.C.I.T.T. Recommendation V.26, Alternate B, without an external equalizer and without the backward channel.

Type 2 was a type 1 modem with a fixed compromise equalizer added in tandem.

Type 3 was a quadrature sideband AM modem using a " tail cancelling " automatic equalizer. This modem was capable of either 2400 bit/s or 4800 bit/s operation bit was primarily used for 2400 bit/s operation.

Type 4 was a 4800-bit/s quadrature sideband AM modem with a transversal automatic equalizer.

3. *Test results*

3.1 This test programme has yielded a vast amount of data on the performance of data modems on various types of channels. These data are being examined and correlated in various ways to examine the effects of various combinations of channels such as the number of trunks in tandem, types of channel, channel mileage, etc. For the purposes of this brief paper, we have assembled some of the test results in terms of three groups:

Group 1 data were taken over channels approximately 800 kilometres long consisting of two tandem trunks.

Group 2 data were taken over channels which were primarily 2400 or 3200 kilometres long consisting of two tandem trunks.

Group 3 data were taken over channels which were predominantly 3200 or 4000 kilometres in length consisting of three tandem trunks.

3.2 The average channel characteristics for each of the groups are summarized below for the main error-causing characteristics. Since virtually all the channels met the noise, level stability, frequency

[1] Kuhn, T. G., Retransmission Error Control, *IEEE Transactions on Communications Systems*, Vol. CS-11, No. 2, June 1963.

translation and harmonic distortion specifications, we have not included these measurements in the table.

ENVELOPE DELAY

Freq. (kHz)	A channels (microseconds)			B channels (microseconds)		
	1	2	3	1	2	3
0.5-2.8	1218	1610	1208	3786	3770	4515
0.6-2.6	225	383	355	2282	1864	2796
1.0-2.6	130	69	91	397	323	264

AMPLITUDE RESPONSE

Freq. (kHz)	A channels (dB)			B channels (dB)		
	1	2	3	1	2	3
0.3-3.0	−0.7 +6.8	−0.9 +5.7	−1.0 +7.6	−1.4 +6.6	−1.4 +6.7	−0.5 +7.6
0.5-2.8	−0.7 +3.5	−0.9 +2.9	−1.0 +3.9			
0.7-2.3				−1.4 +0.9	−1.4 +1.4	−0.5 +0.7

	A channels			B channels		
	1	2	3	1	2	3
Phase jitter (degrees—pk to pk)	24.1	18.5	16	28.2	24.5	26.9
Impulse counts—No. of counts that exceeded 72 dBrn0	50	97	41	56	123	55
Dropouts—percentage of circuits which exceeded minimum threshold	41.2	30.8	36.7	35.7	36.7	53.7
Phase hits—percentage of circuits which exceeded minimum threshold	67	53	53	80	96.3	100

Note. — Minimum thresholds: Dropouts—Not more than 0.001% of any given test period where the *S/N* ratio was less than 10 dB.

Phase hits—100 or less hits per 15 minutes at 15° or less.

3.3 The modem Bit Error Rate (BER) and Block Throughput (BTP) performance data for each group of tests are summarized below for the A and B channels and for each type of modem.

$$\text{BER} = \frac{\text{Number of bits in error}}{\text{Total bits transmitted}} \qquad \text{BTP} = \frac{\text{Number of good blocks}}{\text{Total blocks transmitted}}$$

GROUP 1

Modem	A channels		B channels	
	BER	BTP	BER	BTP
Type 1	1.4×10^{-4}	0.9845	1.8×10^{-4}	0.9865
2	2.3×10^{-4}	0.9835	7.1×10^{-5}	0.9908
3	1.0×10^{-3}	0.9805	1.1×10^{-3}	0.9675
4	1.5×10^{-2}	0.90	3.3×10^{-2}	<0.90

GROUP 2

Modem	A channels		B channels	
	BER	BTP	BER	BTP
Type 1	2.5×10^{-5}	0.9921	3.6×10^{-4}	0.9865
2	4.0×10^{-5}	0.9913	1.5×10^{-4}	0.9885
3	5.0×10^{-5}	0.9915	9.0×10^{-4}	0.9815
4	1.0×10^{-3}	0.9815	2.2×10^{-3}	0.9620

GROUP 3

Modem	A channels		B channels	
	BER	BTP	BER	BTP
Type 1	2.7×10^{-5}	0.9925	1.6×10^{-4}	0.9865
2	5.0×10^{-5}	0.9915	4.0×10^{-4}	0.9840
3	1.3×10^{-4}	0.9905	5.0×10^{-4}	0.9590
4	1.3×10^{-3}	0.9750	1.8×10^{-3}	0.9690

3.4 *Summary*

3.4.1 *Channel characteristics.* In comparing the performance of the various types of data modems with the channel parameters, several significant factors become apparent:

a) Phase jitter is a random error-causing mechanism and severely limits modem performance when peak-to-peak values in excess of 15 degrees are found on a channel. The average phase jitter was always in excess of 15 degrees. The spectral content was usually found to be harmonics of the power supply frequency and on a large number of circuits a 250-Hz component was found which severely degraded modem performance.

b) Impulse noise is a burst error-causing mechanism which causes a high bit error rate. Both the A channels, which averaged 63 counts, and the B channels, which averaged 76 counts, were significantly worse than the specified 15 counts.

c) Dropouts, also a burst error-causing mechanism, were excessive for 33 per cent of the A channels and 43 per cent of the B channels.

d) Phase hits were excessive on 61 per cent of the A channels and 91 per cent of the B channels and were a major cause of burst errors.

e) Envelope delay is a random error-causing mechanism. Very few of the A channels met the specification for this parameter; however, modem performance was acceptable (BTP ≥ 0.95) over most of these circuits. Although there is no delay specification for B channels, acceptable modem performance was obtained on more than 60 per cent of these channels. This indicates that delay was not in itself a major degrading factor to modem performance. However, with an envelope delay substantially out of specification, a modem's tolerance to some of the other parameters present on these circuits may have been reduced.

f) Frequency response is also a random error-causing mechanism, and, as with envelope delay, was not considered to be a primary degrading factor. Acceptable performance was achieved over many circuits that exhibited a frequency response that was substantially out of specification. However, with a frequency response far out of specification, the modem's tolerance to other degrading factors may also be reduced.

g) The signal-to-noise ratio, level stability, frequency translation and harmonic distortion values for virtually all tested channels were within specifications and these parameters were not considered to be major degrading factors.

3.4.2 *Modem performance*. The modem performance for all channels is summarized in the following Table. In each category the following code is used to identify the results:

A is the median Bit Error Rate (BER) defined as

$$\frac{\text{The number of bits in error}}{\text{Total number of bits transmitted}}$$

B is the median Block Throughput (BTP) defined as

$$\frac{\text{The number of error-free 672-bit blocks}}{\text{Total number of blocks transmitted}}$$

C is the probability of obtaining a BER of 1×10^{-4} or less on a first try dial-up basis.

D is the probability of obtaining a BTP of 0.95 or better on a first try dial-up basis.

TABLE

Modem type	Data grade channel (A)				Voice grade channel (B)			
	1	2	3	4	1	2	3	4
A	4.8×10^{-5}	6.1×10^{-5}	1.4×10^{-4}	2.1×10^{-3}	2.4×10^{-4}	1.28×10^{-4}	9.8×10^{-4}	2.7×10^{-3}
B	0.9908	0.9904	0.9893	0.9735	0.9863	0.9875	0.9730	0.9586
C	0.590	0.600	0.465	0.160	0.415	0.470	0.230	0.050
D	0.890	0.875	0.920	0.595	0.725	0.730	0.605	0.570

A = BER B = BTP C = Prob. of BER $\leq 1 \times 10^{-4}$ D = Prob. of BTP ≥ 0.95

Supplement No. 10

JOINT WORKING PARTY ON FIELD TRIALS OF SYSTEM No. 6.—*(Extract from Contribution COM Sp. A—No. 250, September 1972)*

TRANSMISSION REQUIREMENTS OF DATA CHANNELS FOR SIGNALLING SYSTEM No. 6

The basic conclusions of the GM/FT 6 are summarized as follows:

1) The fulfilment of Recommendation M.102 concerning the permissible attenuation distortion and delay distortion with frequency has not been found as an absolute requirement for system No. 6 data links.

2) Instead of this the procedure with the 511-bit test pattern according to Recommendation Q.295, sections 9.2.5 and 9.2.6, is directly related to the operational performance of the common signalling links used in system No. 6. According to Recommendation Q.276, section 6.6.1, a bit error rate of less than 1 in 10^5 is to be obtained.

3) Therefore, it is proposed to specify this test procedure only, whereas the more stringent requirements on attenuation distortion and delay distortion according to Recommendation M.102 shall be left in the system No. 6 specification merely as a guideline for the choice of the channels used as a data link.

4) For purposes of the system No. 6 data links, it seems to be sufficient to meet the requirements for both the attenuation and the delay distortion of this Recommendation M.102 within the frequency band between 1000 and 2600 Hz. Outside of this band no special transmission characteristics need be specified.

Supplement No. 11

ITALIAN ADMINISTRATION.—*(Contribution COM Sp. A—No. 253, August 1972)*

2400 BIT/S DATA TRANSMISSION TESTS ON THE ITALIAN PUBLIC SWITCHED NETWORK

1. *Introduction*

The results of 2400 bit/s data transmission tests are given in this contribution as well as the measures carried out on the circuits of the Italian public telephone switched network, during 1971, by the Italian Public Administration in co-operation with the following companies: SIP (Società Italiana per l'Esercizio Telefonico), Sit-Siemens and ARE.

The above-mentioned tests endeavoured:

a) to evaluate the quality of 2400 bit/s speed data transmission on the telephone switched network;

b) to collect statistics about the transmission characteristics of the connections;

c) to evaluate the performances obtained by the use of different techniques of modulation and equalization.

2. *Test programme*

Tests have been sorted in three groups:

1) local area telephone network tests;
2) telephone short-haul trunk (local and interlocal) network tests;
3) interregional trunk (long-haul) telephone network tests.

A test connection terminal has been placed, during all testing periods, at the Istituto Superiore P.T.T. in Rome. Subsequently, every time some more test stations have been implemented in the local areas involved, as shown in Tables 1 to 3.

The transmission directions and the test areas have been chosen so that the more significant typical connections, as regards the geographical lay-out of potential users, could be examined. Particular attention was given to the third test group.

3. *Characteristics measured*

The following measures have been carried out:

a) loss;
b) group delay-frequency response;
c) amplitude-frequency response;
d) bit error rate;
e) block error rate (511 bits).

4. *Test procedure*

Several connections have been established on each link by calls made from each one of the two ends.

For any connection the characteristics of paragraph 3 have been noticed.

In particular, the data transmission tests have been carried out in both ways of transmission and each test has lasted thirty minutes.

In any case the circuits have been used in normal operational mode, i.e. no special or preventive maintenance work has been done.

5. *Test equipments and modems*

As test terminal equipment the Sit-Siemens Data Tester has been used in order to measure bit and block error rate.

The normal telephone instrumentation has been used for the measuring of amplitude-frequency response, while group delay-frequency response has been measured by the group delay Wandel und Goltermann measuring set.

During the testing, two types of modem have been used, the first one a V.S.B. amplitude modulation modem, with a five-tap automatic equalizer, and the second one a phase modulation modem, conforming to the C.C.I.T.T. Recommendation V.26, equipped with a fixed amplitude and group delay equalizer.

6. *Test results*

6.1 *Loss*

The circuits loss has been measured at 800 Hz, 600-ohm terminating impedance.

The characteristic curves for the three examined connection groups are shown in Figure 1.

TABLE 1

CUMULATIVE RESULTS OF 2400 BIT/S DATA TRANSMISSION TESTS ON THE LOCAL AREA (ROME) SWITCHED NETWORK

Link	Blocks received	Blocks received with error	Block error rate	Bits received	Bits error	Bit error rate	Test duration
1°	38 434	115	$3 \cdot 10^{-3}$	19 640 000	1 362	$6.9 \cdot 10^{-5}$	2 h 15 min
2°	101 448	48	$4.7 \cdot 10^{-4}$	51 840 000	570	$1.1 \cdot 10^{-5}$	6 h
3°	139 491	2050	$1.47 \cdot 10^{-2}$	71 280 000	25 820	$3.6 \cdot 10^{-4}$	8 h 15 min
4°	126 810	596	$4.7 \cdot 10^{-3}$	64 800 000	8 939	$1.4 \cdot 10^{-4}$	7 h 30 min
Total	406 183	2809	$6.37 \cdot 10^{-3}$	207 560 000	36691	$1.16 \cdot 10^{-4}$	24 h

TABLE 2

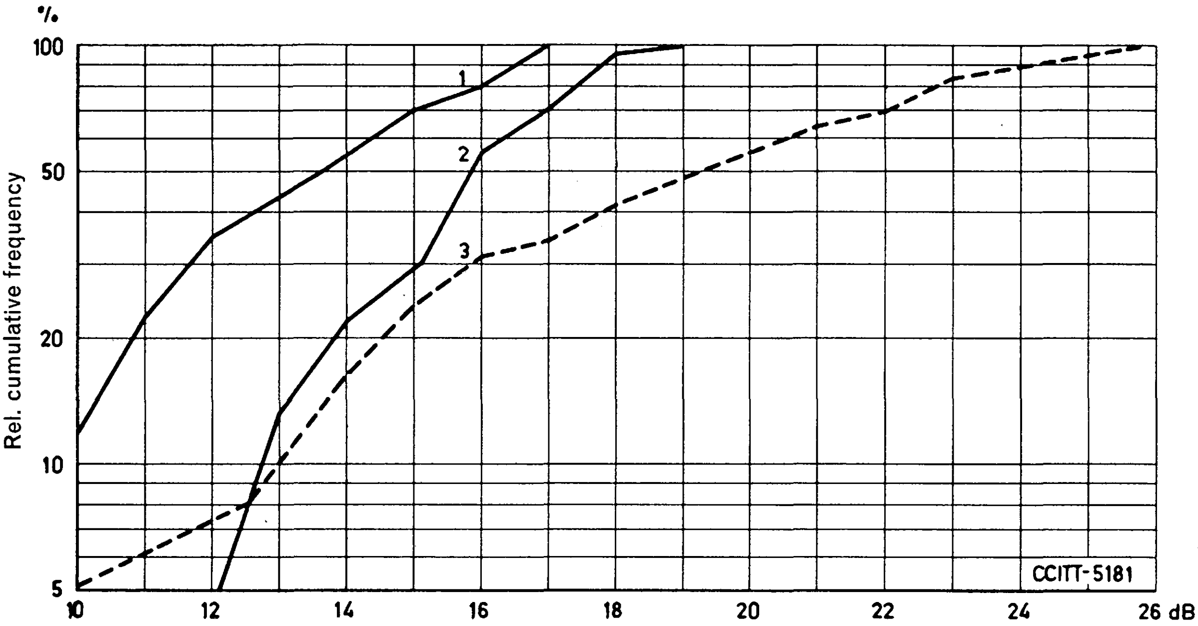
CUMULATIVE RESULTS OF 2400 BIT/S DATA TRANSMISSION TESTS ON SHORT-HAUL TRUNKS OF THE ITALIAN SWITCHED NETWORK

Link	Blocks received	Blocks received with error	Block error rate	Bits received	Bits error	Bit error rate	Test duration
Regional	260 000	366	$1.4 \cdot 10^{-3}$	133 056 000	2 188	$1.6 \cdot 10^{-5}$	15 h 24 min
Interregional	152 172	1 902	$12.6 \cdot 10^{-3}$	77 760 000	19 854	$25.6 \cdot 10^{-5}$	9 h
Total	412 172	2 268	$5.5 \cdot 10^{-3}$	210 816 000	22 042	$1.04 \cdot 10^{-4}$	24 h 24 min

TABLE 3

CUMULATIVE RESULTS OF 2400 BIT/S DATA TRANSMISSION TESTS ON LONG-HAUL TRUNKS OF THE ITALIAN SWITCHED NETWORK

Link	Blocks received	Blocks received with error	Block error rate	Bits received	Bits error	Bit error rate	Test duration
Roma-Milano	173 589	4 584	$26.4 \cdot 10^{-3}$	88 704 000	22 172	$2.5 \cdot 10^{-4}$	10 h 16 min
Roma-Venezia	122 301	2 055	$16.8 \cdot 10^{-3}$	62 496 000	18 162	$2.95 \cdot 10^{-4}$	7 h 14 min
Roma-Bologna	167 389	876	$5.2 \cdot 10^{-3}$	85 536 000	4 828	$0.56 \cdot 10^{-4}$	9 h 54 min
Roma-Padova	185 425	3 002	$16.3 \cdot 10^{-3}$	94 752 000	22 009	$2.3 \cdot 10^{-4}$	10 h 58 min
Roma-Napoli	123 428	1 017	$8.2 \cdot 10^{-3}$	63 072 000	12 052	$1.9 \cdot 10^{-4}$	7 h 18 min
Total	772 132	11 534	$13.8 \cdot 10^{-3}$	394 560 000	79 223	$2.3 \cdot 10^{-4}$	45 h 40 min



1 = local links 2 = short-haul trunks 3 = long-haul trunks

FIGURE 1. — **Relative cumulative frequency distribution of overall loss at 800 Hz**

6.2 *Amplitude-frequency response*

The circuit loss has been measured on 300-3400 Hz frequency band.

The envelope curves of the amplitude-frequency response characteristics, which have been found in the above three types of link, are given in Figures 2, 3 and 4.

Figure 5 shows the different distribution curves between 600 and 3000 Hz losses for the three connection groups examined, while Figure 6 shows the distribution curve for the 3000 Hz loss.

6.3 *Group delay-frequency response*

Figures 7 and 8 give the envelope curves of the group delay-frequency response characteristics which have been found on trunk connections, short and long haul respectively. All the characteristics measured in the delay-frequency response have the minimum point on the abscissa axis.

6.4 *Bit and block error rate*

Figures 9 to 14 give the time distribution of bit and block error rate measured in the three connection groups.

The overall time distribution is shown in Figures 15 and 16.

Figures 17 and 18 show the cumulative distribution of bit error rate and block error rate respectively, referring either individually or totally to the three types of circuit.

No significant difference was found among the results which have been obtained, during the testing, by the use of two different types of modem, nominally as regards a bit and block error rate.

However, it has been noticed that the four-phase modem can resist more to synchronism losses which are caused essentially by impulsive noise.

Comments

The tests which have been carried out have indicated that 2400 bit/s data transmission on switched network can be carried out with no particular device and has a good probability ($\geq$95 %) to obtain no error rate higher than the bound recommended for a 1200-bit/s modem, conforming to the V.23 C.C.I.T.T. Recommendation, operating on the switched network.

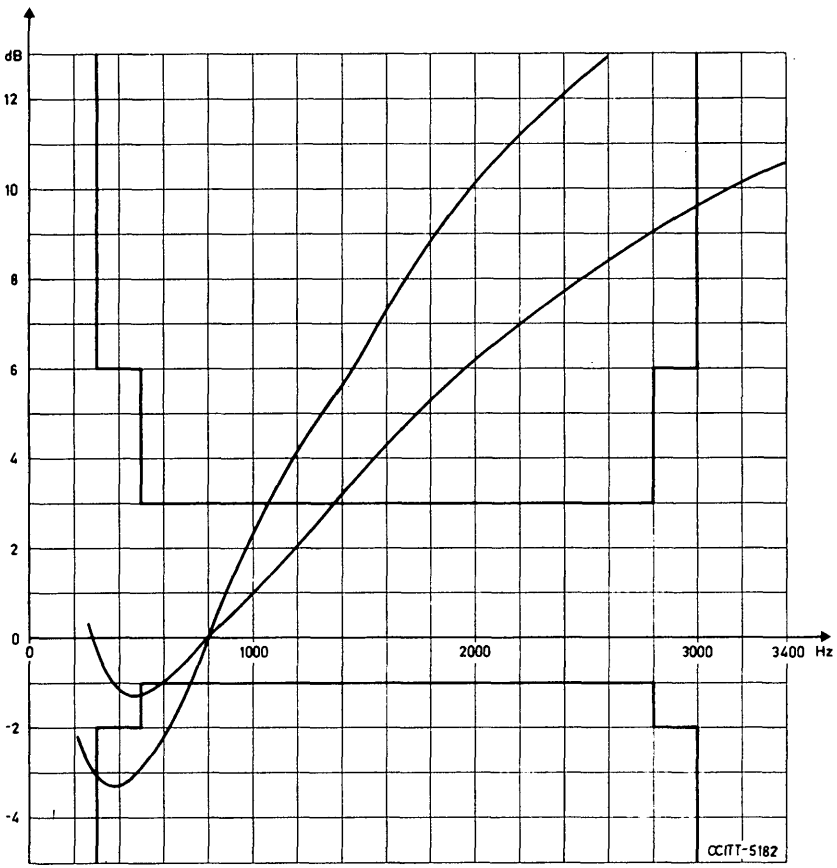


FIGURE 2. — **Local tests—Amplitude distortion**

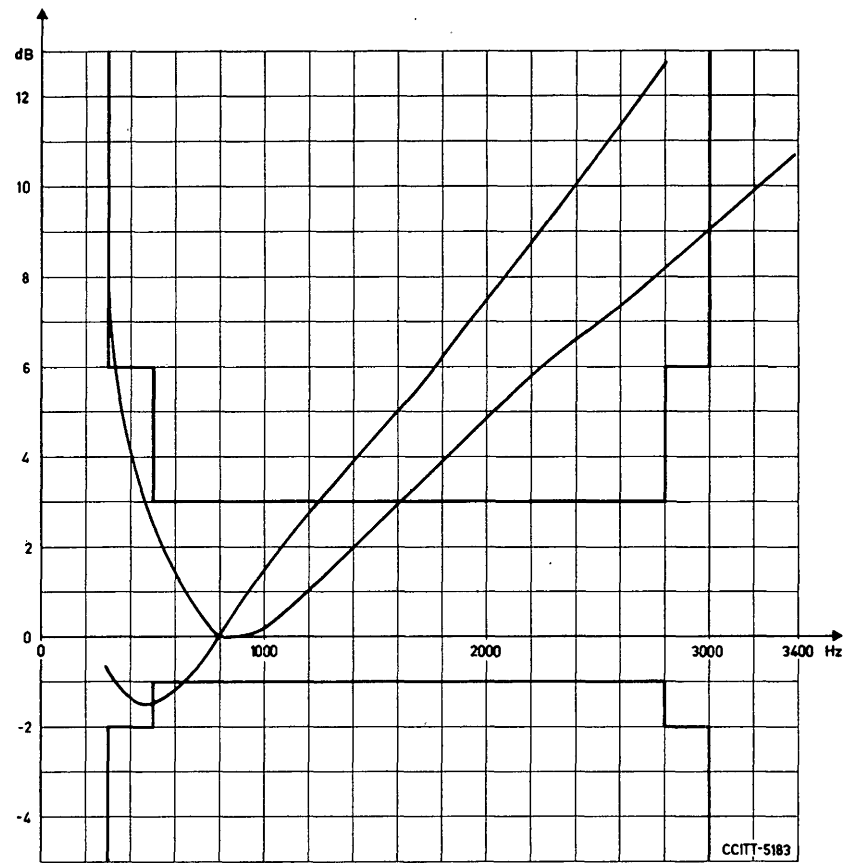


FIGURE 3. — **Short-haul trunks—Amplitude distortion**

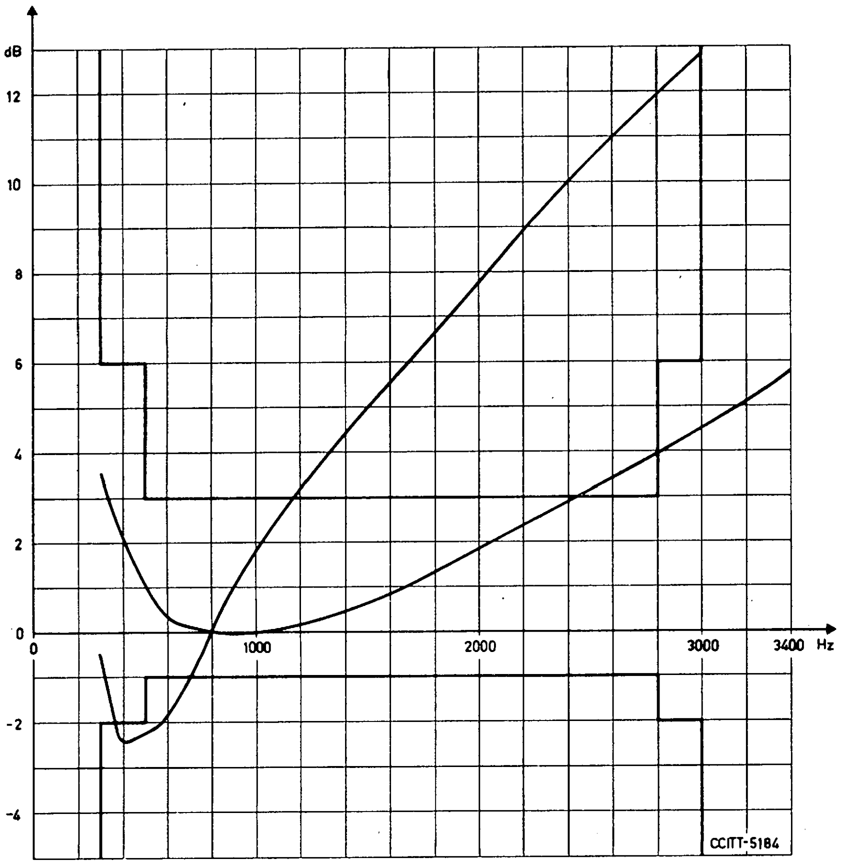
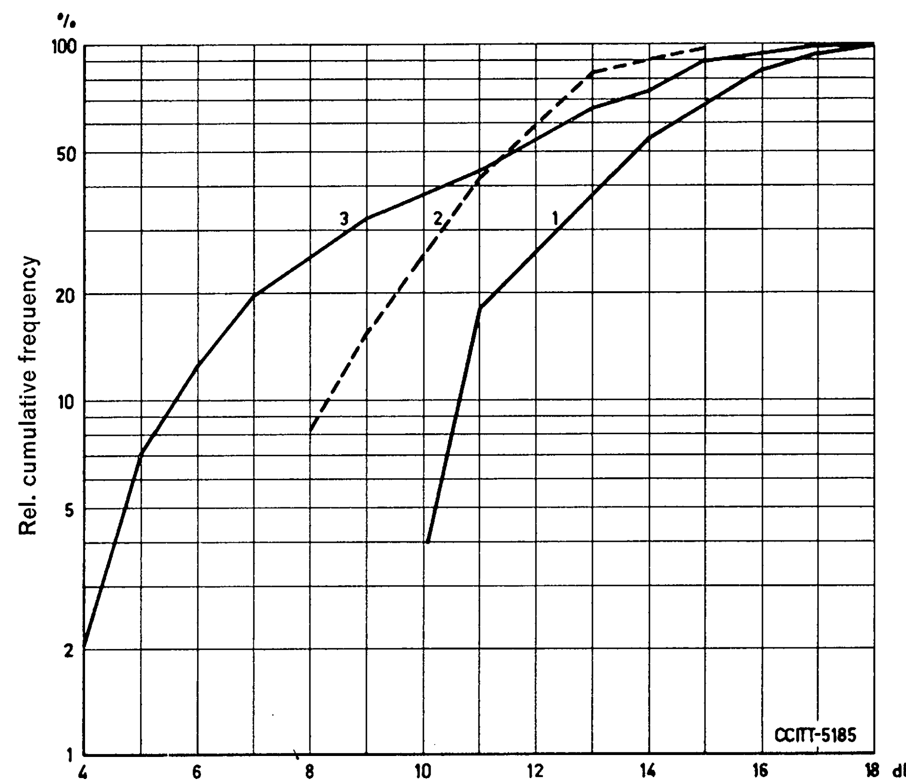
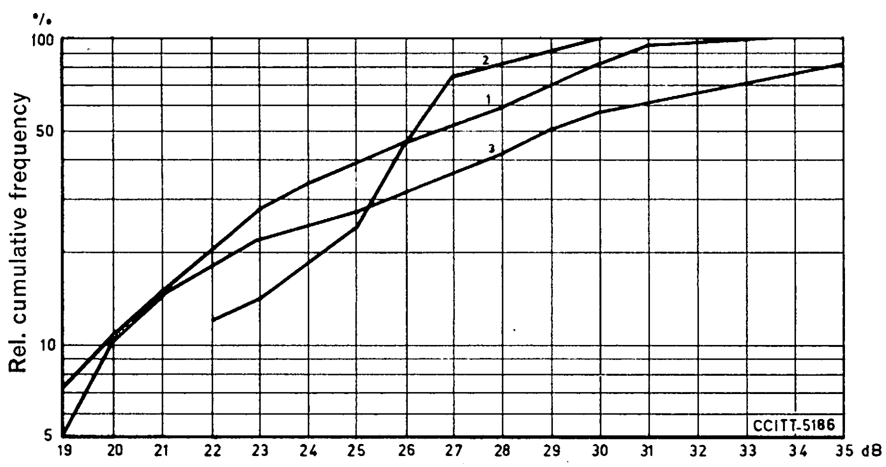


FIGURE 4. — **Long-haul trunks—Amplitude distortion**



1 = local links
2 = short-haul trunks
3 = long-haul trunks

FIGURE 5. — **Relative cumulative frequency distribution of loss difference between 600 and 3000 Hz**



1 = local links
2 = short-haul trunks
3 = long-haul trunks

FIGURE 6. — **Relative cumulative frequency distribution of loss at 3000 Hz**

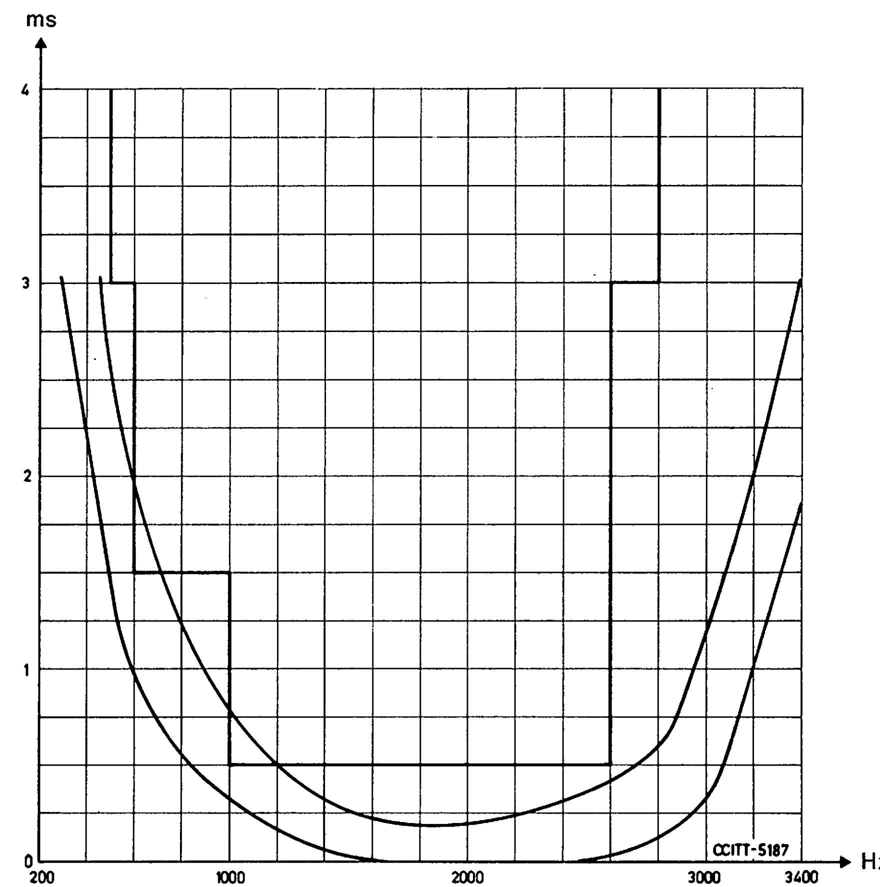


FIGURE 7. — **Group delay distortion (short-haul trunks)**

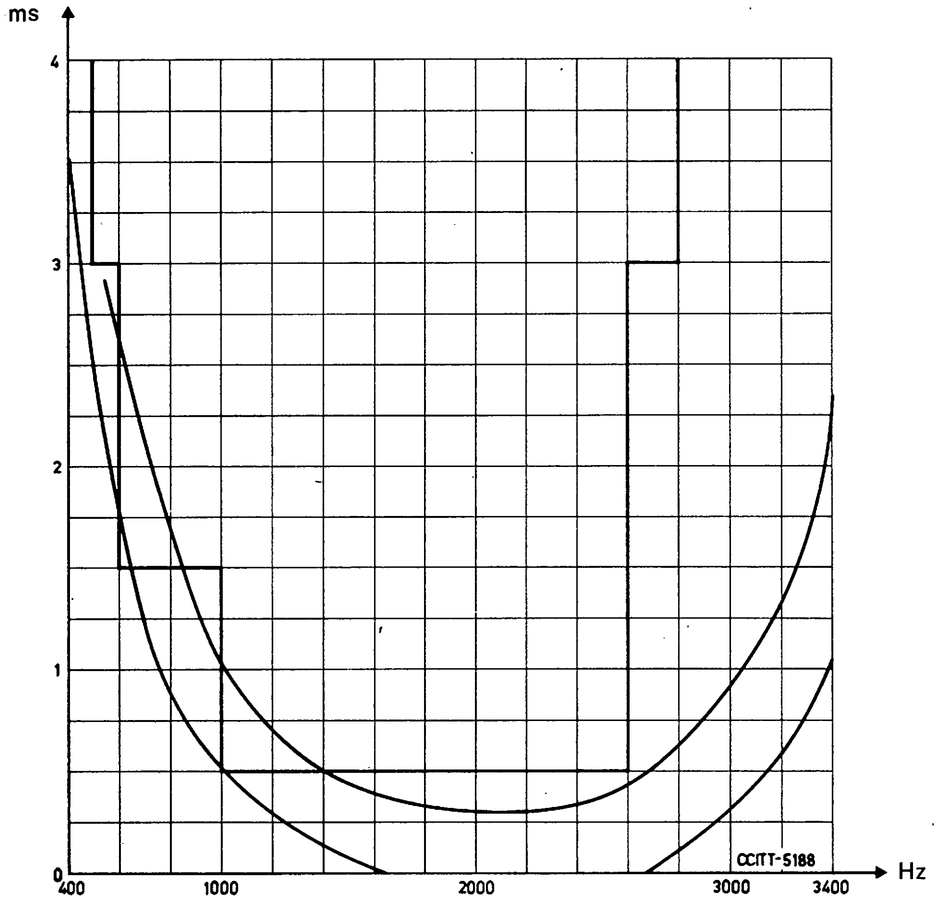


FIGURE 8. — Group delay distortion (long-haul trunks)

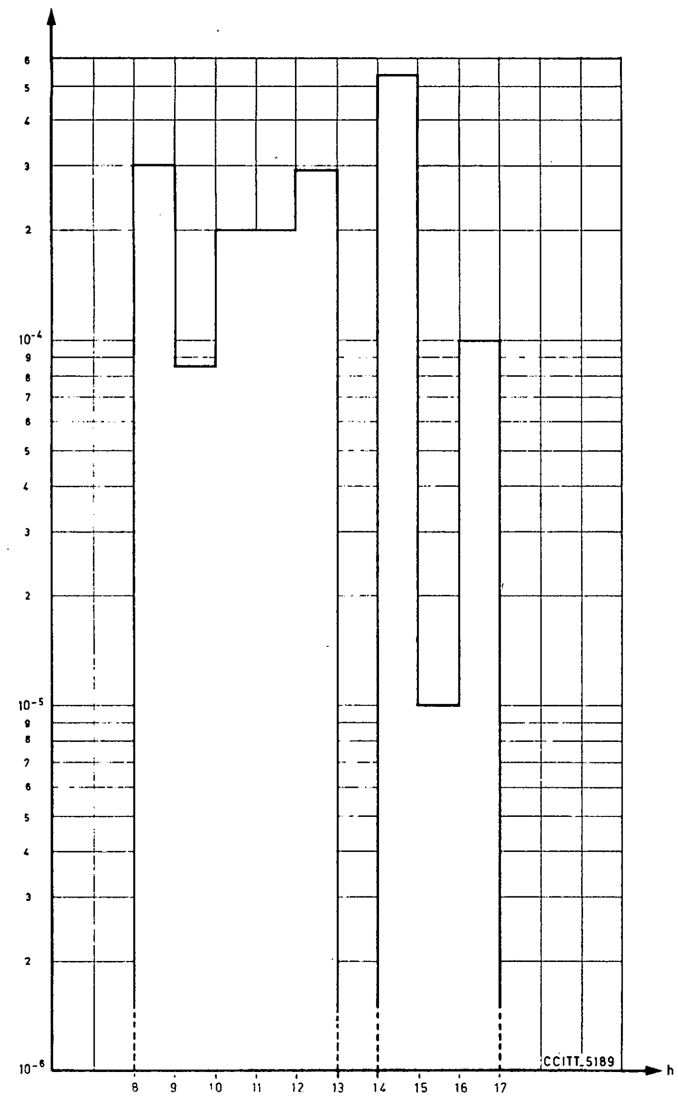


FIGURE 9. — **Distribution of bit error rate versus hour of day (local links)**

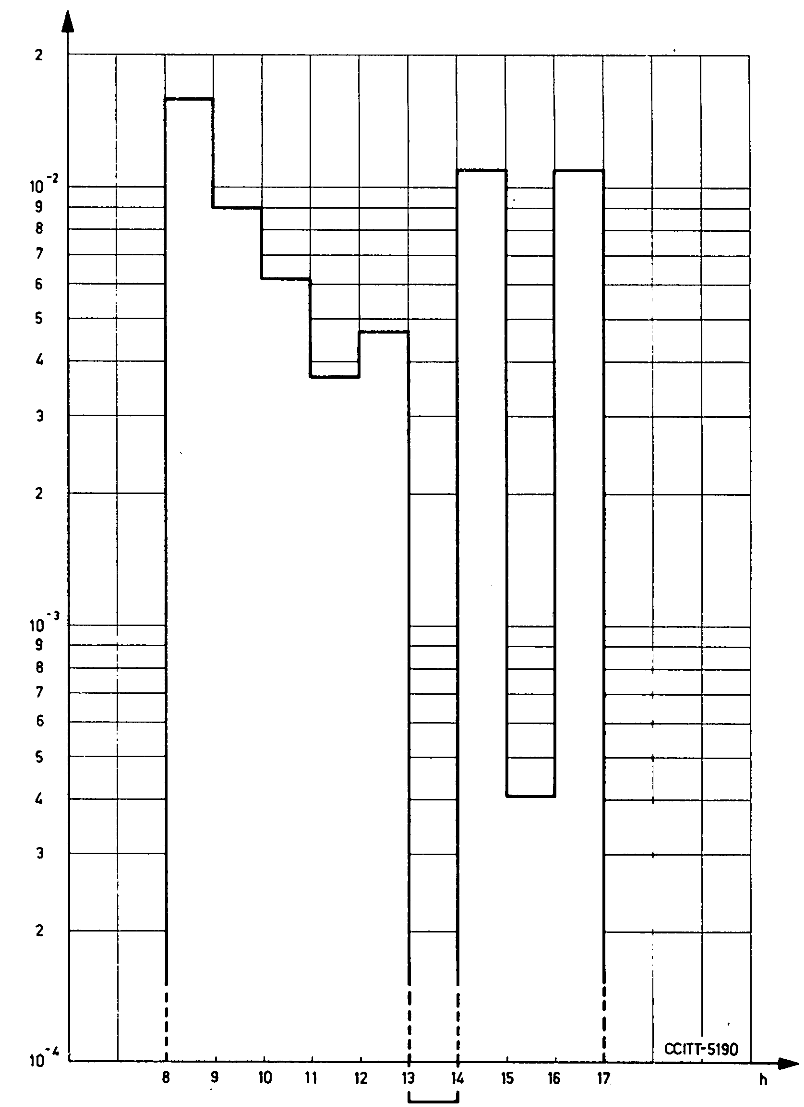


FIGURE 10. — **Distribution of block error rate versus hour of day (local links)**

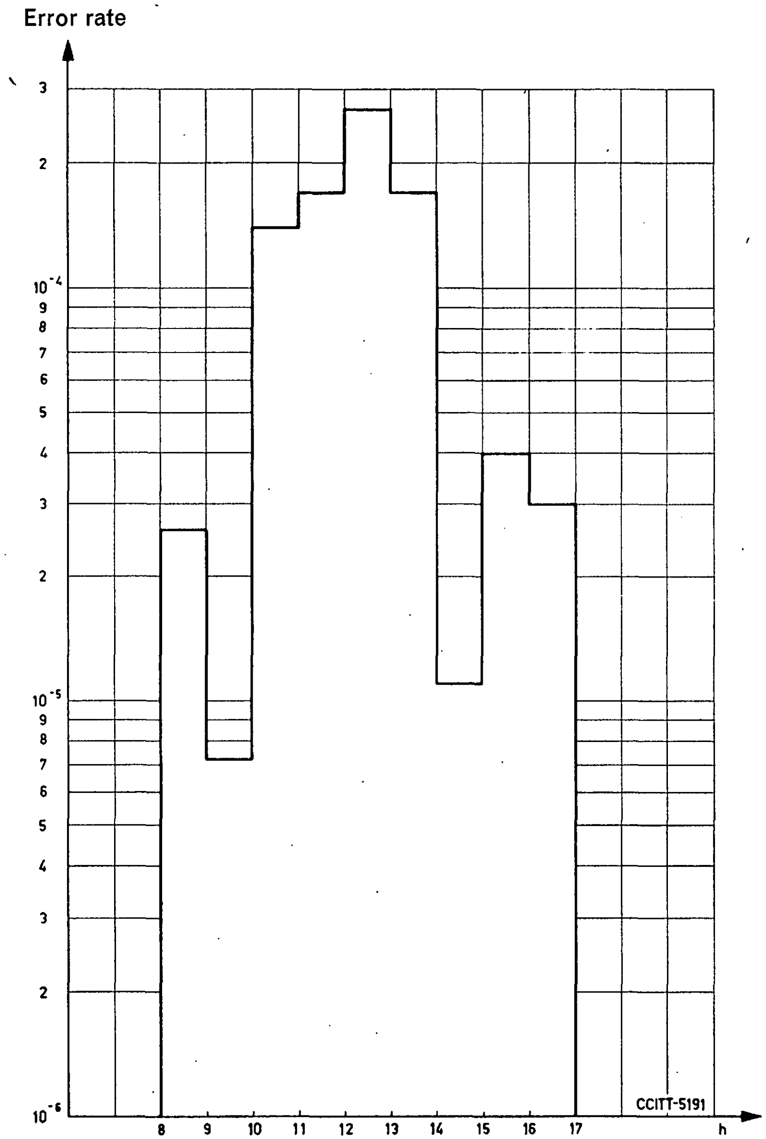


FIGURE 11. — **Distribution of bit error rate versus hour of day (short-haul trunks)**

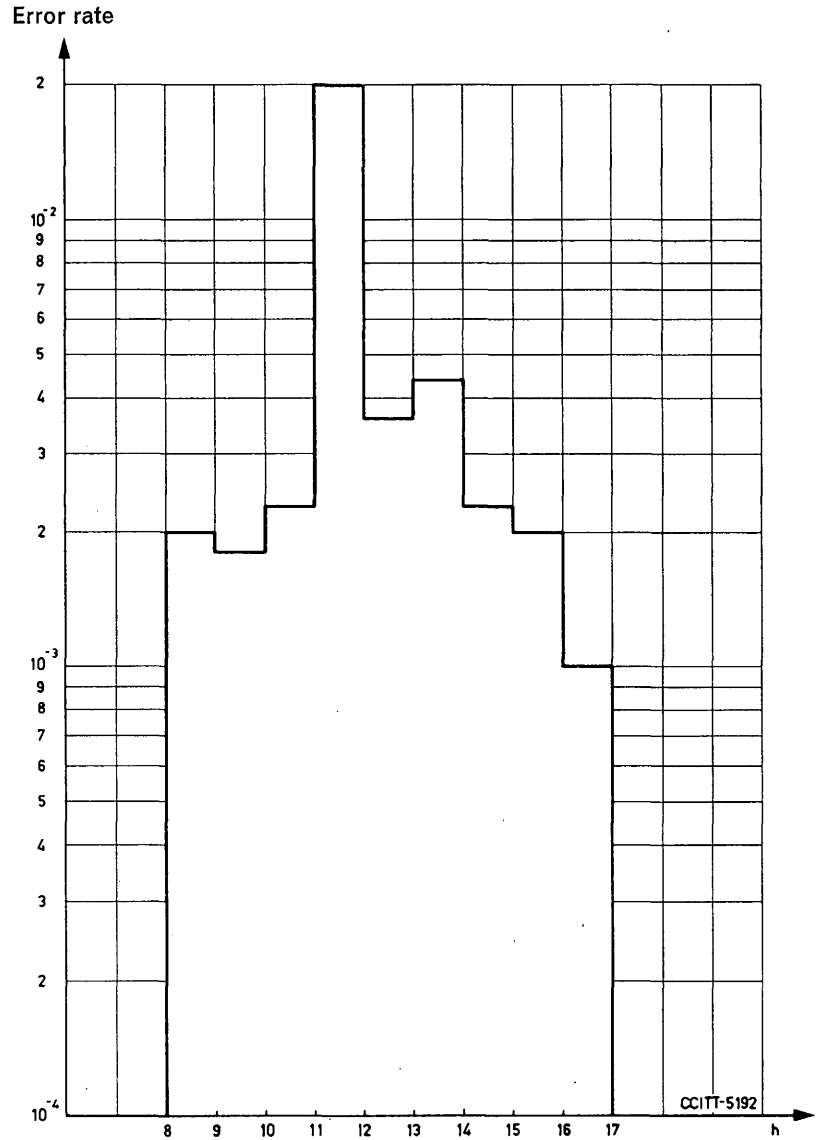


FIGURE 12. — **Distribution of block error rate versus hour of day (short-haul trunks)**

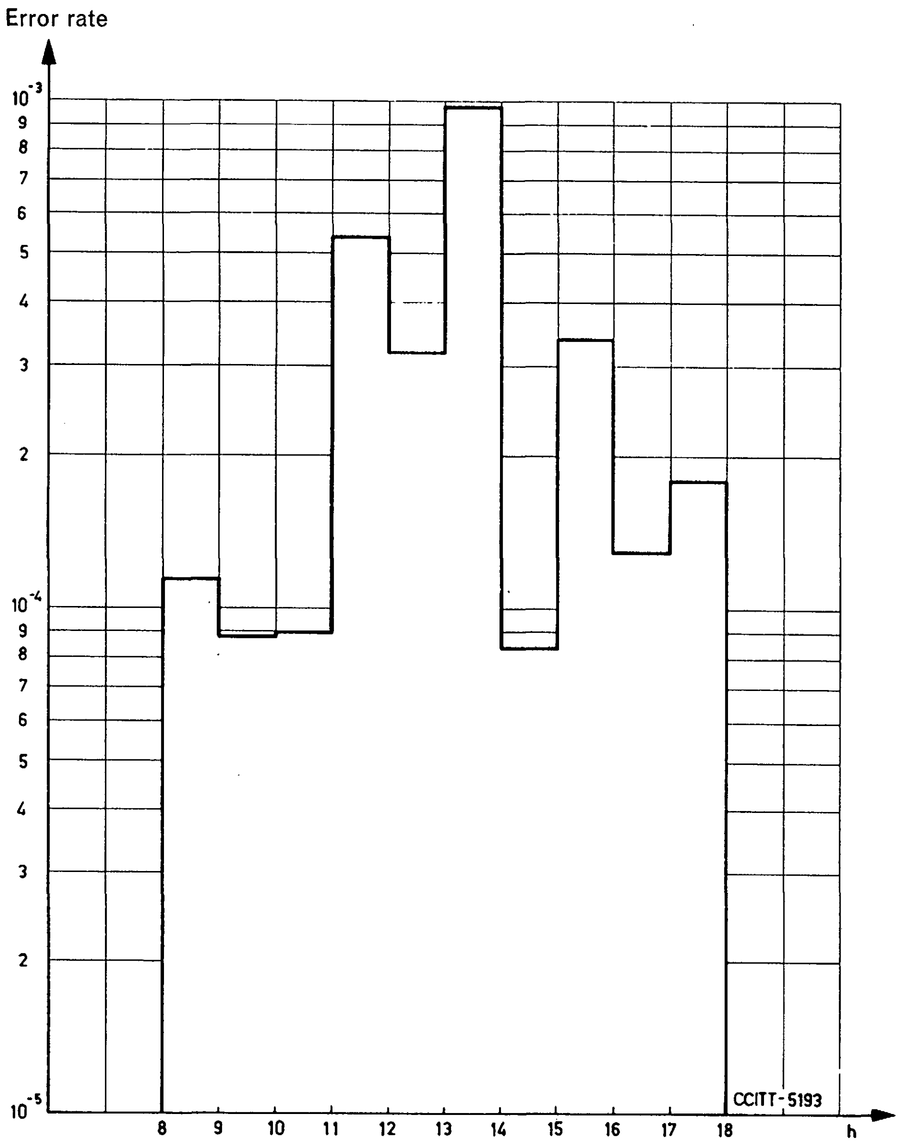


FIGURE 13. — Distribution of bit error rate versus hour of day (long-haul trunks)

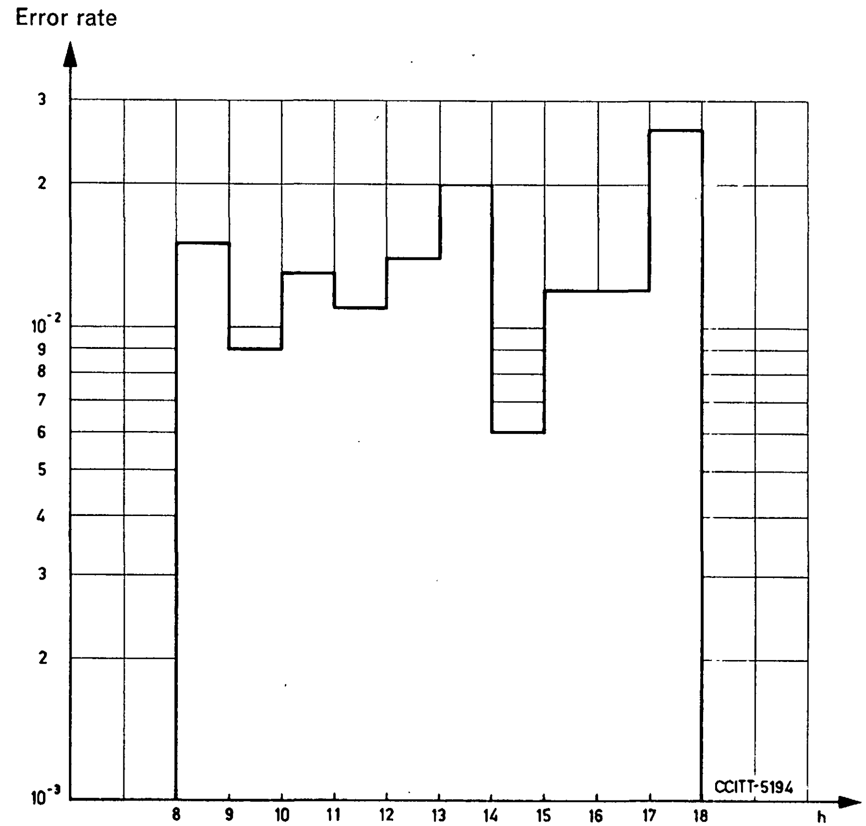


FIGURE 14. — Distribution of block error rate versus hour of day (long-haul trunks)

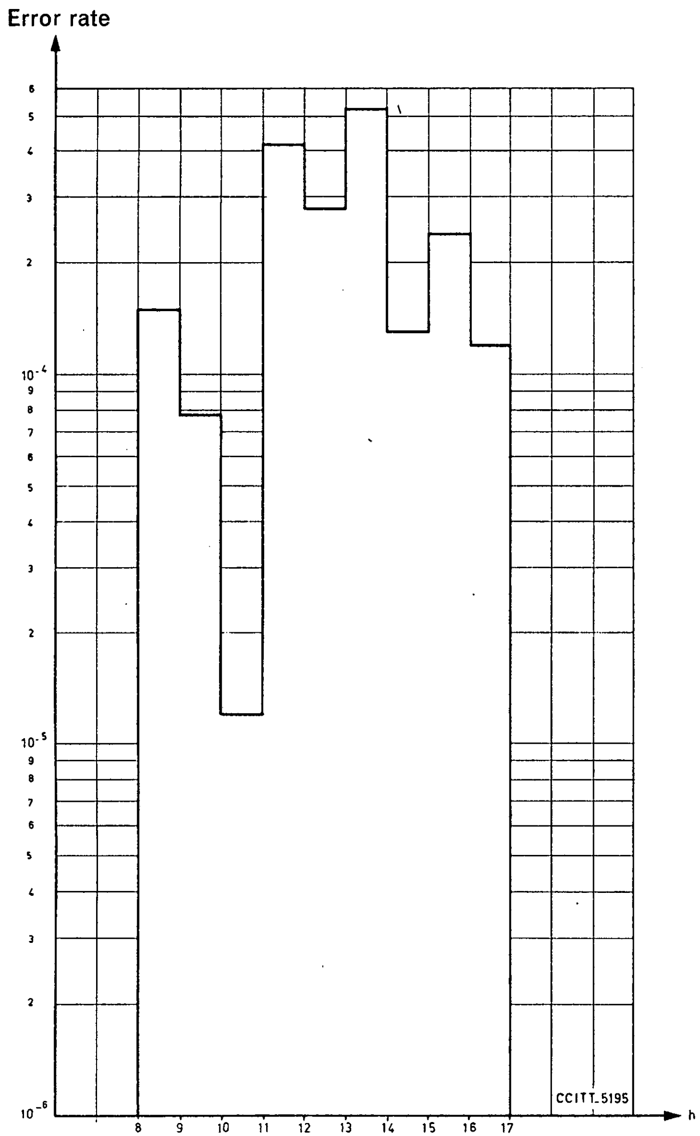


FIGURE 15. — **Distribution of cumulative bit error rate versus hour of day**

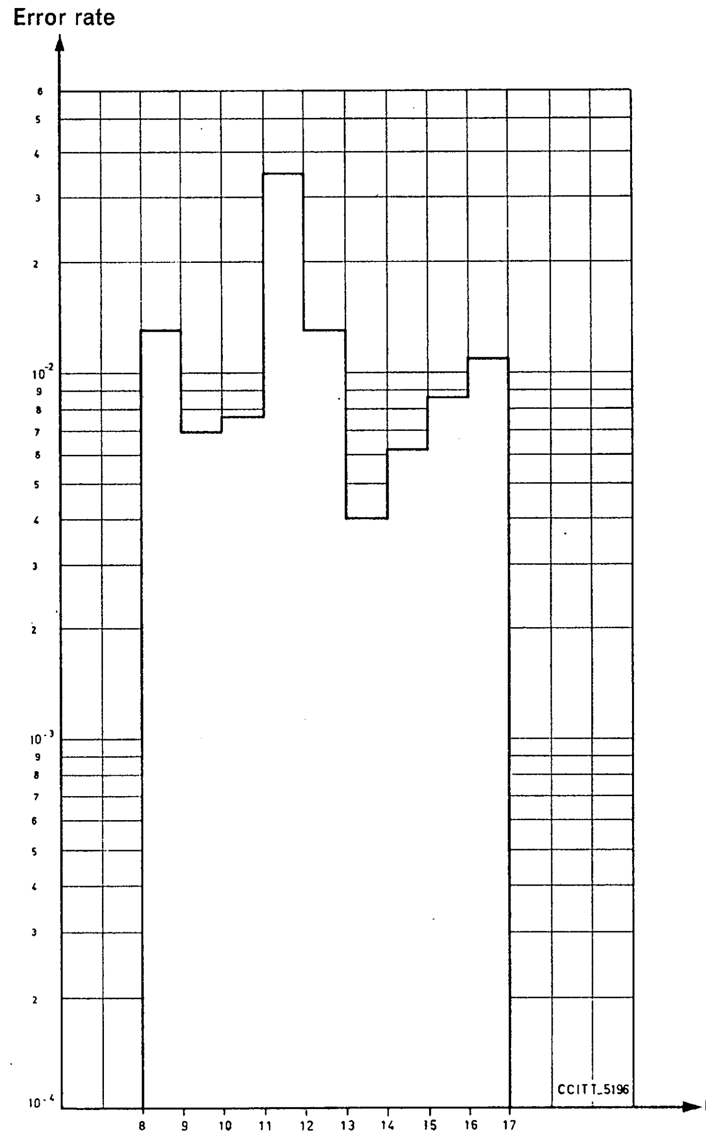
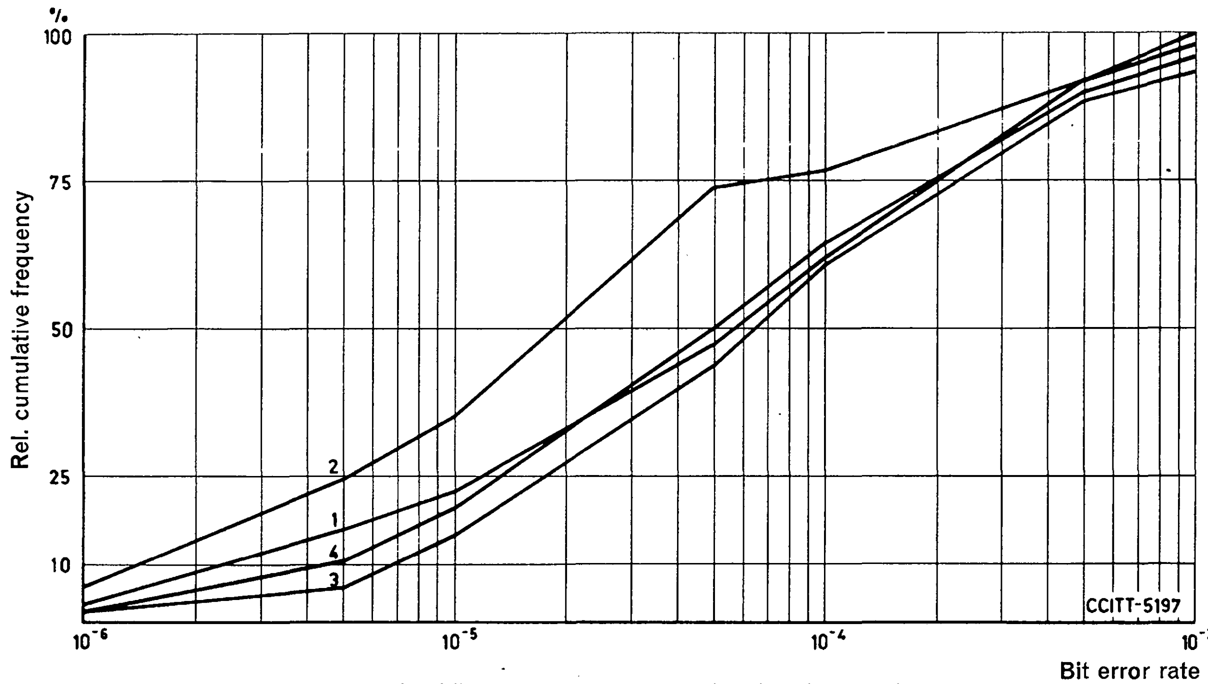
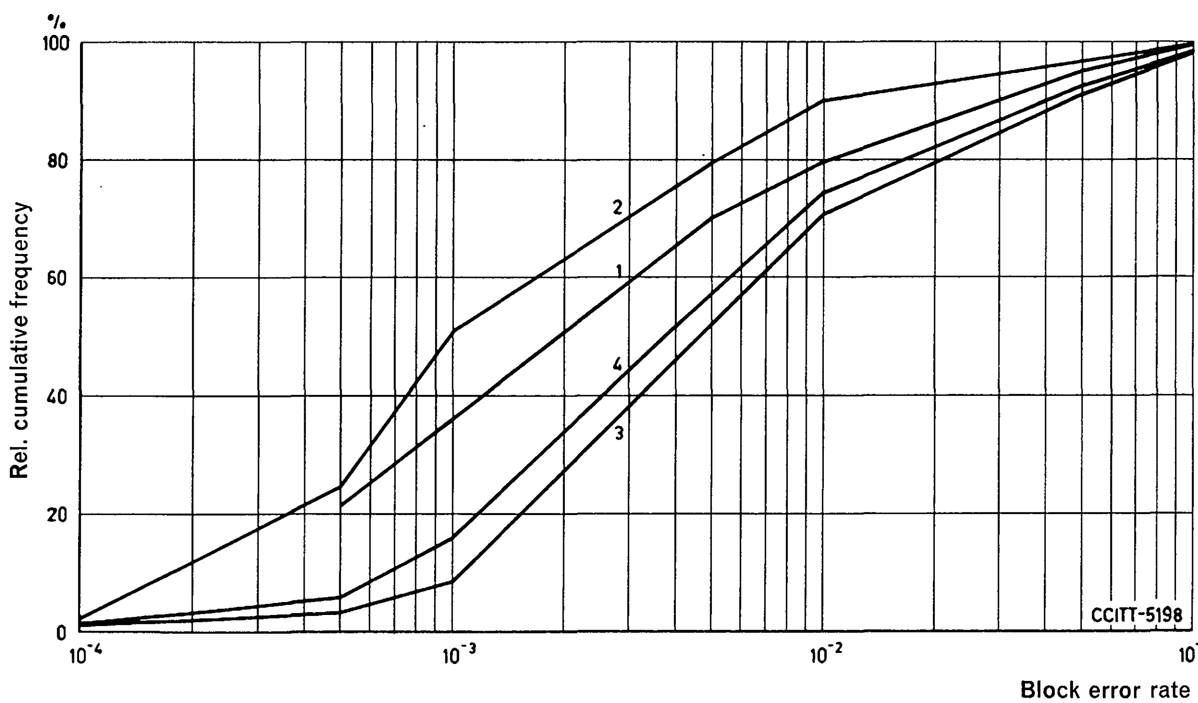


FIGURE 16. — **Distribution of cumulative block error rate versus hour of day**



1 = local links
2 = short-haul trunks
3 = long-haul trunks
4 = cumulative

FIGURE 17. — **Relative cumulative frequency distribution of bit error rate**



1 = local links
2 = short-haul trunks
3 = long-haul trunks
4 = cumulative

FIGURE 18. — **Relative cumulative frequency distribution of block (511 bits) error rate**

Supplement No. 12

NIPPON TELEGRAPH AND TELEPHONE PUBLIC CORPORATION.—*(Contribution COM Sp. A—No. 67, September 1970)*

STUDY OF PARALLEL DATA TRANSMISSION SYSTEMS USING THE PUSH-BUTTON TELEPHONE SIGNALLING FREQUENCIES

Introduction

The push-button telephone set at present has a 4 × 3 push-button arrangement for call connecting, but the number of buttons is too small to transmit characters and signs other than 10 decimal digits. Therefore, N.T.T. has investigated the three-frequency group data transmission system, which is an extended type push-button system.

In this new transmission system, input data can be transmitted from subscribers to the computer through the telephone network on multifrequency signals. Then the computer sends the responses back in a mechanically compiled series of audible word groupings or in FM signals resulting in a hard copy answer (printing on to paper tape).

From our experiments, we suggest the following proposals:

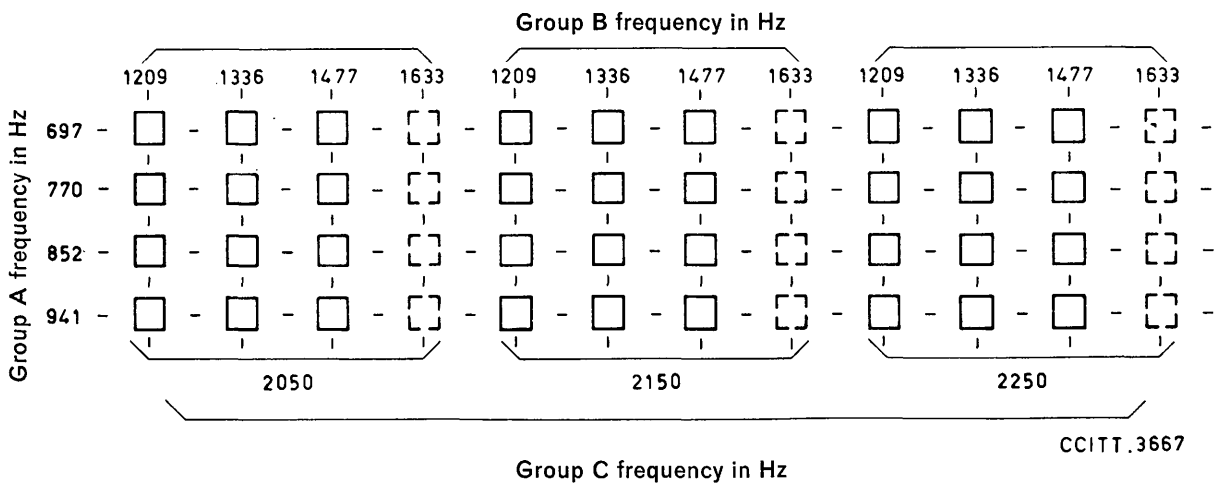
1. *Definition of the nature of the data transmission signals—characteristics of the generated signals*

1) *Frequency allocation*

We propose the frequency allocation of the audio-frequency tones as shown in Figure 1.

Fundamentally, the eleven frequencies are arranged in three groups (A, B and C) of four or three frequencies. Each character, sign and digit is represented by three frequencies, one from each group, and forty-eight codes can be assigned. Figure 1 shows three key groups, each of which is composed of a 4 × 4 key arrangement.

This system is compatible with the push-button telephone signalling system when the group C frequencies are stopped, if necessary.



Note. — The blocks which are represented by this sign are not used in the 4 × 3 × 3 frequency allocation system.

FIGURE 1. — **Frequency allocations**

TABLE 1

FREQUENCY VARIATION TOLERANCE

Group	Percentage of nominal frequency
A	±1.8
B	±1.8
C	±0.9

2) *Frequency variation tolerance*

We propose the limit of frequency variation tolerance shown in Table 1. The limit of Groups A and B is equal to that in Recommendation Q.25.

The transmitted frequency in Group C should be within ±0.9% of the nominal frequency as shown in Table 1. This figure is determined so that the ratio of the allowable frequency range to the frequency difference between adjacent frequencies in Group C will be almost equal to the ratio in Groups A and B.

3) *Level*

Recommendation Q.23 specifies levels for the frequencies of the push-button telephone set as follows:

" The sending level conditions must be such that, on an international connection, they do not exceed the values specified in Recommendation Q.16."

N.T.T. has used the values shown in Table 2 considering Recommendation Q.23.

TABLE 2

LEVEL OF SENDING SIGNALS

Group	Maximum level (dBm)	Minimum level (dBm)
A	−7.5	−12.0
B	−6.0	−11.5
C	−4.0	−11.0

Note. — The level of sending signals is variable with pads.

4) *Timing*

If three frequency-tones are utilized in the keyboard transmission, three tones should be kept sending while a key is pressed, like the push-button telephone set.

2. *Instation terminals*

a) *Signal demodulation*

1) *Sensitivity*

The receiver sensitivity—the minimum receivable level—must meet the following relation:

$$S - L \geq R$$

where S = sending level of the transmitter;
L = maximum overall transmission loss between subscribers;
R = sensitivity of the receiver.

In Japan, the maximum overall transmission loss between subscribers is 32 dB and the maximum subscriber's line loss is 7 dB at 1 500 Hz.

The sending level of the transmitter is adjusted to the subscriber's line loss. When the subscriber's line loss is 0 dB, the sending level is arranged in the minimum level of Table 2. Therefore, the receiving level becomes -36.5 dBm $(-11.5\ -25)$ at 1 500 Hz in the worst case. When the subscriber's line loss is 7 dB, the minimum receiving level becomes -38 dBm $(-6\ -32)$ in the same way.

The overall transmission losses at the Group C frequencies are greater than that at 1 500 Hz. Then, considering this condition and margin, we use -40 dBm as the sensitivity of the receiver.

2) *Response time for signal detection circuits*

According to an investigation into subscriber behaviour, 0.1 % of the sending signals had a duration of less than 39 ms.

We define the response time of signal detection circuits as the duration of three frequency signals in which the receiver should begin to send the corresponding direct current signals.

We propose 30 ± 10 ms for the response time.

b) *Specification of interchange circuits*

1) *Definition of forward channel data interchange circuits*

We adopted the six-lead parallel binary system. Table 3 shows the conversion rule from the multi-frequency signals to the direct current signals. Each frequency group has two receive data leads, because this assignment makes code conversion easier.

2) *Electrical characteristics of interchange circuits*

We propose that the electrical characteristics of interchange circuits should be based on Recommendation V.28.

TABLE 3

RELATION OF EACH FREQUENCY AND RECEIVE DATA LEADS

Frequency (Hz)	Receive data leads		Frequency (Hz)	Receive data leads		Frequency (Hz)	Receive data leads	
	RD1	RD2		RD3	RD4		RD5	RD6
697	0	0	1209	0	0	2050	0	0
770	0	1	1336	0	1	2150	0	1
852	1	0	1477	1	0	2250	1	0
941	1	1	1633	1	1			

Note. — The RD numerical suffix indicates the n·imber of receive data leads.

Supplement No. 13

IBM EUROPE.—*(Contribution COM Sp. A—No. 248, September 1972)*

STUDY OF PARALLEL DATA TRANSMISSION SYSTEMS USING THE PUSH-BUTTON TELEPHONE SIGNALLING FREQUENCIES

Abstract

The user's need of low-cost/low-speed terminals using parallel data transmission in full compatibility with the push-button telephone signalling frequencies is universally recognized. A reply to question 1/A-Point Q*bis* is therefore urgently required.

This contribution proposes the main elements for this reply and complements the previous IBM Europe Contribution COM Sp. A, No. 82 submitted in October 1970.

Parallel data transmission systems can be used economically when a large number of low-cost sending stations (outstations) wish to transmit to a central receiving station (instation) over the switched telephone network (or on leased telephone circuits). In addition to Recommendation V.30, the following system is proposed for parallel data transmission fully compatible with multifrequency push-button telephone signalling devices.

1. *General scheme*

- — Transmitting 16-character combinations (basic system);
- — Transmitting 64-character combinations (extended system);
- — It should be understood that either all 16 combinations or all 64 combinations are made available to the data user without any restriction;
- — The transmission from the instation to the outstation is limited either to simple acknowledgement signals (data collection systems) or to analogue signals (voice answering systems);
- — The system will be asynchronous;
- — A character signalling rate in the range of 10 characters per second will be sufficient.

2. *Frequency allocations*

2.1 The system will be based on two groups of four frequencies, as specified in Recommendation Q.23 as follows:

- — the low group frequencies are:
  697, 770, 852, 941 Hz;
- — the high group frequencies are:
  1209, 1336, 1477 and 1633 Hz.

2.2 The following frequency arrangements are recommended:

2.2.1 *Basic system (16-character combinations)*

Ai (i = 1, 2, 3, 4) and Bj (j = 1, 2, 3, 4) being respectively the frequencies of the low and the high frequency groups, the allocation of combination of frequencies (Hz) for the basic 16-character set will be as specified in Recommendation Q.23 (Point 6).

	B1 = 1209	B2 = 1336	B3 = 1477	B4 = 1633
A1 = 697	1	2	3	Spare
A2 = 770	4	5	6	Spare
A3 = 852	7	8	9	Spare
A4 = 941	Spare	0	Spare	Spare

2.2.2 *Extended system (64-character combinations)*

The extended system of 64 combinations includes:

— the basic system;

— the 26 (or more) alphabetical characters;

— symbols, functional/control characters.

The expansion from the basic set to the extended set is obtained in the following way:

— each character will be identified by the transmission of a combination AiBj immediately followed by a combination AiBj′;

— if $j = j'$ the character belongs to the basic set;

— if $j \neq j'$ the character belongs to the 48 additional characters of the extended set.

3. *Timing*

The system being asynchronous, no timing is needed. Each character is followed by a silent period which is dependent upon the listener echo duration.

The maximum character signalling rate is calculated from the sum of the following:

Basic system (16-character set)

AiBj	minimum duration
+ Silent period	minimum duration

Extended system (64-character set)

AiBj	minimum duration
+ AiBj′	minimum duration
+ Silent period	minimum duration

4. *Backward channel*

(Same wording as paragraph 2.2 of Recommendation V.30.)

5. *Tolerances*

The tolerances on forward transmitted frequencies should be as specified in Recommendation Q.23, i.e., each transmitted frequency must be within 1.8% of the nominal frequency. The instation receiver should cater for ±6 Hz difference due to carrier systems in addition to the transmitted tolerance of ±1.8%.

6. *Power levels*

6.1 *Sending level*

The sending level conditions must comply with Recommendation V.2.

6.2 *Receiving level*

Considering Recommendation V.2 and various statistical values of maximum overall transmission loss between subscribers, it is recommended that the sensitivity of the instation receiver should be −40 dBm.

7. *Interface*

The list of the Data and Control interface interchange circuits at both the instation and the outstation, as well as their electrical characteristics, will be subject for further study.

8. *Character sets*

The character allocation and the definition of the character combinations—other than the 10 decimal digits—for the basic and extended character sets are subject for further study.

Supplement No. 14

UNITED KINGDOM POST OFFICE.—*(Extract from Contribution COM Sp. A—No. 54, September 1970)*

THE CHARACTERISTICS OF THE UNITED KINGDOM PUBLIC SWITCHED TELEPHONE NETWORK

Introduction

The United Kingdom Post Office has carried out a test programme to investigate some of the characteristics of the inland public switched telephone network which are of interest to data transmission. Information relevant to questions posed in Document COM Sp. A—No. 28[1] is given in this contribution and follows the same numbering scheme. Information is also given on frequency offset and an effect of PCM transmission systems. Reference is made to adaptive echo cancellers.

A description of the test programme, and some of the test methods, together with some preliminary results for attenuation/frequency and echo characteristics are reported in the *White Book*, Volume III, Supplement No. 32.

A more comprehensive set of results is now available and forms the major part of this document. The results not only cover a larger number of parameters but also show the effect of weighting the results according to the telephone traffic. It is important to note that this weighting is not ideal for the various classes of data traffic.

[1] See Question 1/A — point L, paragraph 9.

In all diagrams referring to regions the key is as follows:

LTR = London Telecommunications Region;

NWR = North West Region;

SWR = South West Region.

POINT 1.—*In-band signalling systems*

Figure 1 shows the necessary spectral limitations which must be placed upon the line signals of data transmission equipment in order to prevent interference with trunk telephone network VF signalling receivers and other users.

Note 3 of Figure 1 refers to the signalling system AC1. These systems are widely distributed and used in about 10% of the national network. There are no immediate plans for the removal of these signalling systems.

Note 4 of the same figure refers to a few signalling equipments only. It is felt that these need not influence the studies of the question.

POINT 2.—*Presence of echo suppressors*

Except for a very few long routes provided by old carrier systems on lightly loaded cables, there are no echo suppressors in the Post Office trunk network. These few echo suppressor routes are scheduled to be re-routed on modern HF systems and therefore can be disregarded in the study of the question.

The majority of intercontinental circuits used in the general switched network are fitted with echo suppressors having the disabling facility. The remaining suppressors not having the disabling facility are scheduled for early replacement.

POINT 3.—*Subscriber-to-subscriber loss*

Samples of attenuation/frequency characteristics, as measured between regions in the United Kingdom switched telephone network, are shown in Figure 2. These characteristics are plotted relative to the estimated attenuation at 1700 Hz in the absence of echo at this frequency.

The ripples in the characteristics, due to listener echo, correspond to echo delay times of approximately 5 ms. The ripples in the characteristics for within-region links are more widely spaced and correspond to echo delay times of about 2 ms.

Cumulative distributions of attenuation at different frequencies for the different regions are shown in Figures 3 to 8.

For information regarding subscriber-to-subscriber attenuation characteristics over international switched connections, reference should be made to the *White Book*, Volume III, Annex to Question 4 of Study Group XVI. A new investigation is currently in progress but the processed results are unlikely to be available much before the end of the year.

POINT 4.—*Phase distortion between subscribers*

Samples of group delay/frequency characteristics centred on 1.7 kHz, measured between regions, are shown in Figure 9. Unlike the case of insertion loss characteristics no additional information with respect to the ripples due to echo was available and hence the group delay characteristics could not be plotted in full detail. The measurements have been plotted as the mean of the measured points and show no echo component. The characteristics measured on within-region connections are less severe due to the absence of carrier-channel filters in those circuits.

Figures 10 to 16 show traffic weighted cumulative distributions of group delay at various frequencies for the different regions.

POINTS 5, 6 AND 7.—*Phase jitter, sudden signal changes and impulsive noise*

Measurements on these items were not included in the test programme.

POINT 8.—*Signal/listener echo*

Measurements were made of signal to listener echo power ratio and echo delay time in and between the various regions. From these measurements the value of the worst signal/echo ratio observed on each connection in the band 900-2400 Hz was derived.

Regional and National telephone traffic weighted cumulative distributions of these worst values are shown in Figure 17. So far as V.23-type modems are concerned it is known the traffic pattern is such that a higher proportion of data calls encounter lower signal/echo ratios than this figure would imply. Similarly weighted cumulative distributions of echo delay time are given in Figure 18. Additional information relating to the worst signal/echo ratio and echo delay time is given by the scatter diagram of Figure 19.

Considering that the values of signal/echo ratio represent the sum of two transmission losses and two return losses, the very low values observed in some cases seem at first sight to be very difficult to explain. It is generally accepted that balance return losses at 2-wire switching points on the general switched telephone network should rarely fall below 5 dB and therefore, with circuits adjusted to 3 dB transmission loss, signal/echo ratios less than 16 dB should seldom occur. However, there are two factors which may have given rise to the lower values observed.

Firstly, circuits of this type are lined up to " best possible " loss and, if it is assumed that this could lead to zero transmission loss at some frequencies, then signal/echo ratios down to 10 dB may be expected. Secondly, in a proportion of the connections measured, multiple echoes were observed, i.e. more than one echo path was present. The method of echo measurement used in the tests established the aggregate value of the echo components in the frequency band of interest to data transmission. Thus two simultaneously present echoes, each with signal/echo ratios of 14 dB, could have given rise to an entry in the results of 8 dB. Detailed examination of the results has shown that this has occurred in a number of cases. Such figures are nevertheless valid in the context of the work, since, to a great extent, it is the aggregate echo component which is important with respect to the impairment of data signals.

Following on from the analysis of these measurements a study of the question of the method of alignment of amplified circuits has been started. Initial tests on the same trunk route confirm that the majority of circuits had 2-wire to 2-wire losses of less than 3 dB. It is estimated that if all circuits were aligned to 3 dB loss instead of " best possible ", improvements in signal/echo ratio of at least 3 dB at the median value and about 6 dB at the 5% point would be obtained.

POINT 9.—*Noise*

Figure 20 shows the traffic weighted cumulative distributions of line noise. The noise was measured via a filter having 3 dB points at approximately 1100 and 2300 Hz and equivalent noise bandwidth of 1142 Hz. These measurements include only the continuous background noise and specifically exclude impulsive noise.

Similar distributions of signal-to-noise ratio are shown in Figure 21. The received signal-to-noise ratio was measured in the same band as the line noise. The transmitted signal was a tone of 1700 Hz at a level of −6 dBm (into 600 ohms).

For information regarding noise measuremeuts on international connections reference should again be made to the *White Book*, Volume III, Annex to Question 4 of Study Group XVI.

POINT 10.—*Amplitude/amplitude distortion*

Measurements on this item were not included in the test programme.

11. *Frequency offset*

Measurements of the frequency offset showed that it is confined to low values, i.e. less than 0.4 Hz for at least 99% of calls.

12. *Effect of PCM circuit sections*

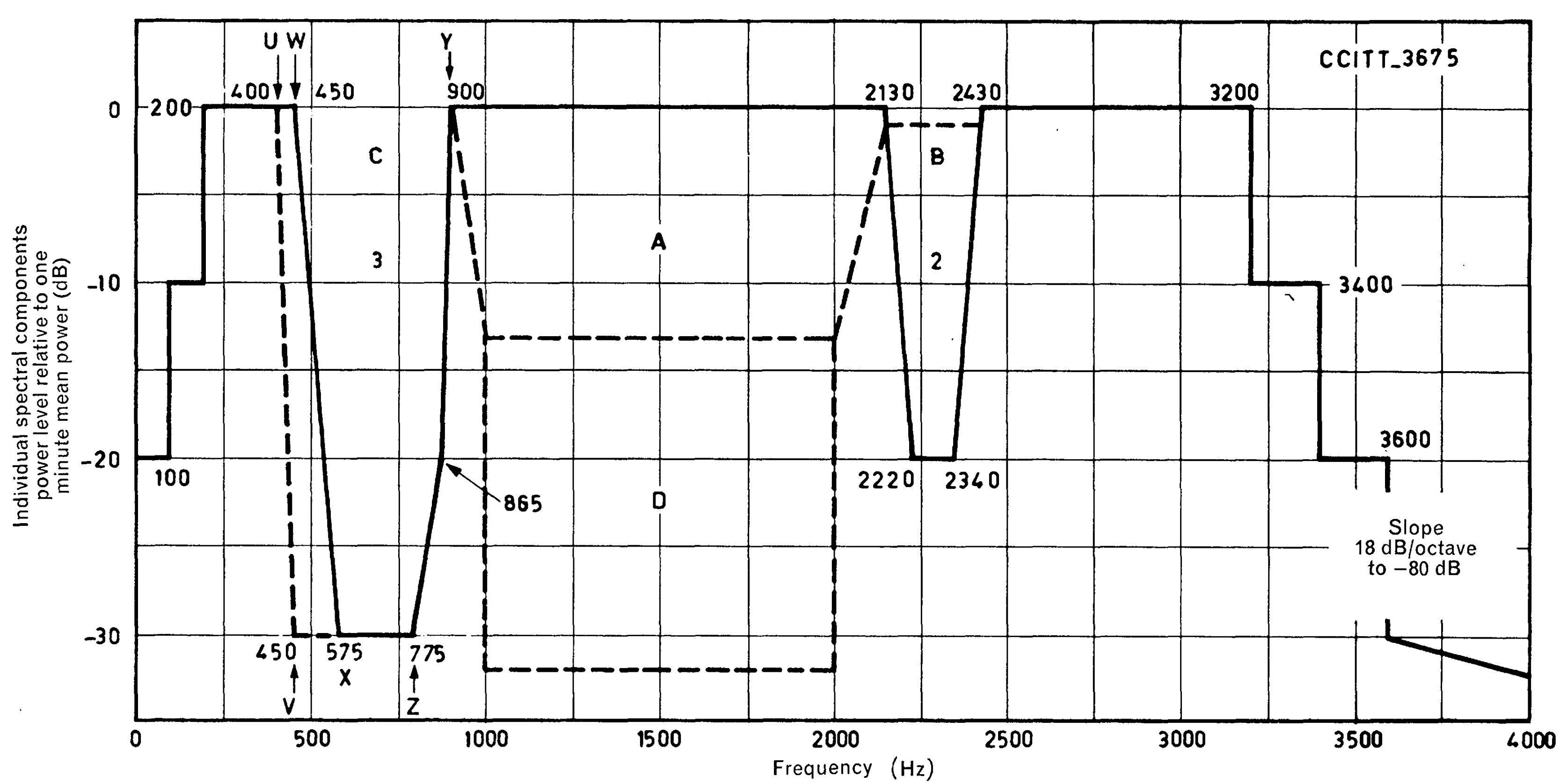
No extensive tests of switched network connections specifically including PCM systems have yet been performed. However, it has become apparent from laboratory and special field tests of low-speed data transmission equipment over 7-unit coded PCM systems that when a simultaneous backward channel is used under certain adverse conditions the data can be impaired. Figure 22 illustrates the circuit configuration which could lead to this situation.

If the balance return loss of the hybrid transformer shown at X is poor within the backward channel band, due to mismatch on the 2-wire side, the input signal to the PCM compandor at Y may consist of a low level forward channel signal together with a high level backward channel signal which has traversed the hybrid transformer. The result of this is shown in Figure 23. The peaks of the interfering signal carry the wanted signal on to a part of the PCM companding law having comparatively large quantizing steps, thereby giving rise to peaks of high quantizing distortion.

So far as the United Kingdom inland network is concerned, experience with the use of modems conforming to Recommendation V.23 has not revealed any case of difficulty due to this effect and the telephone network plans are such that the probability on any call of meeting such difficulty will decrease with time. Thus the effect has been regarded as having little practical importance. However, the effect might assume a greater importance on international calls using, say, a multilevel modem.

13. *Adaptive echo cancellers within the general switched network*

Question 10/XV is concerned with new methods of controlling echo. The use of adaptive echo cancellers has been suggested as one solution. No statistics are available to show the effect of these devices on data transmission but it is thought that the requirements for data transmission might be taken into account at this early stage if Study Group XV can be suitably informed. Conversely, it is suggested that Study Group XV be requested to keep Sp. A fully informed of all developments of this nature.



[1] The " one minute mean power level " shall be calculated by determining the average signal power level in any one minute period with any permitted data input.

[2] Spectral components (up to − 1 dB) are only permitted in area B if accompanied by coincident spectral components in area A or if accompanied by coincident spectral components in area D at a power level not lower than 12 dB below the power level of spectral components in area B. The total power level of all combined spectral components must not exceed 0 dB.

[3] Spectral components are not permitted in area WXZY (450-900 Hz) because false operation of VF signalling receivers (SSAC1) may occur.

[4] Spectral components should not occur in area UVXW (400-575 Hz) because a small proportion of public switched telephone network connections have VF signalling receivers (500/20 ringers) that may be falsely operated. However, where data equipments are subject to C.C.I.T.T. recommendations that require spectral components in that region the requirements will be relaxed.

FIGURE 1. — **Maximum permitted power level of individual spectral components relative to the one minute mean power level[1] of the composite signal to be transmitted to line by data equipment connected to the public switched network**

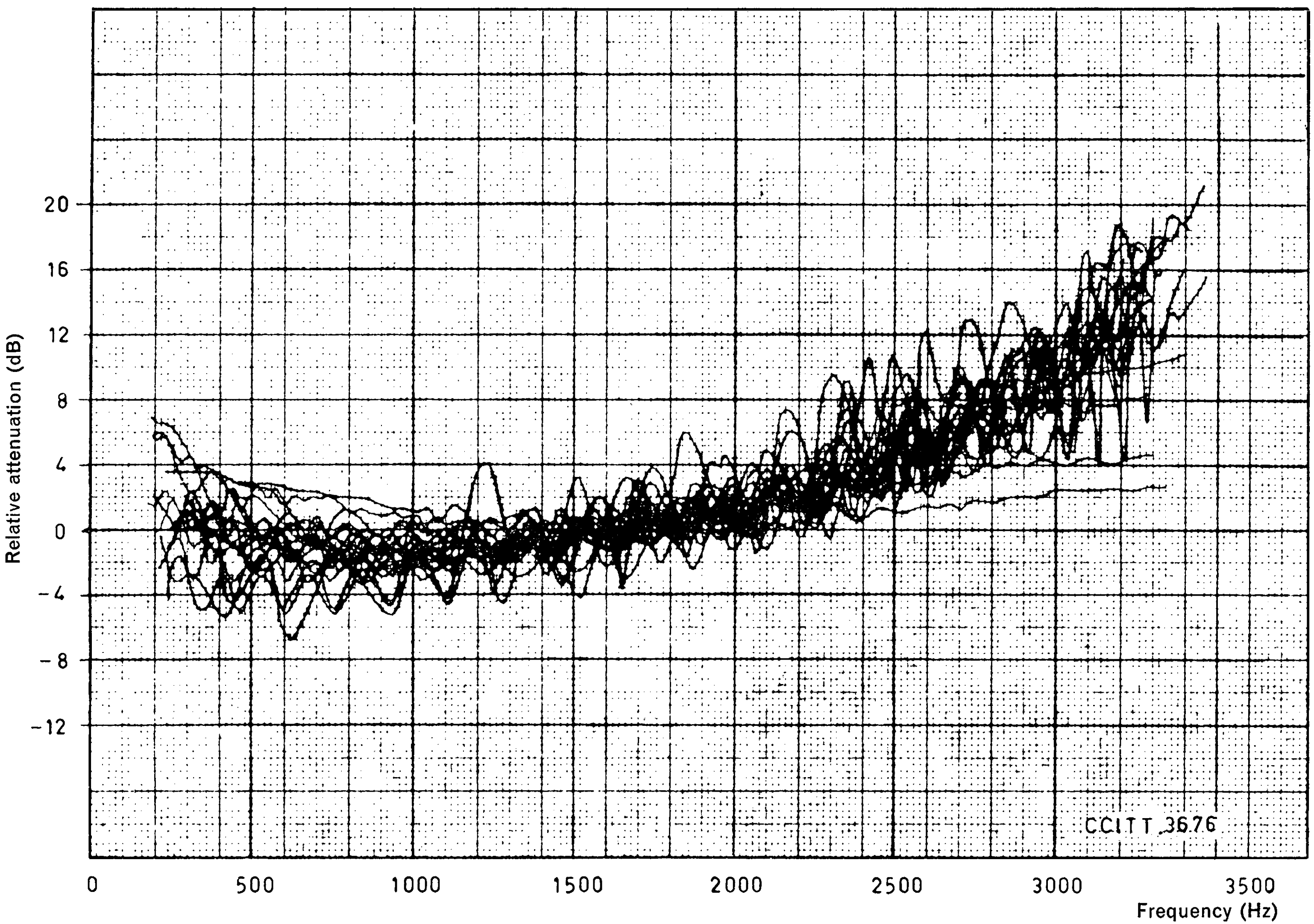
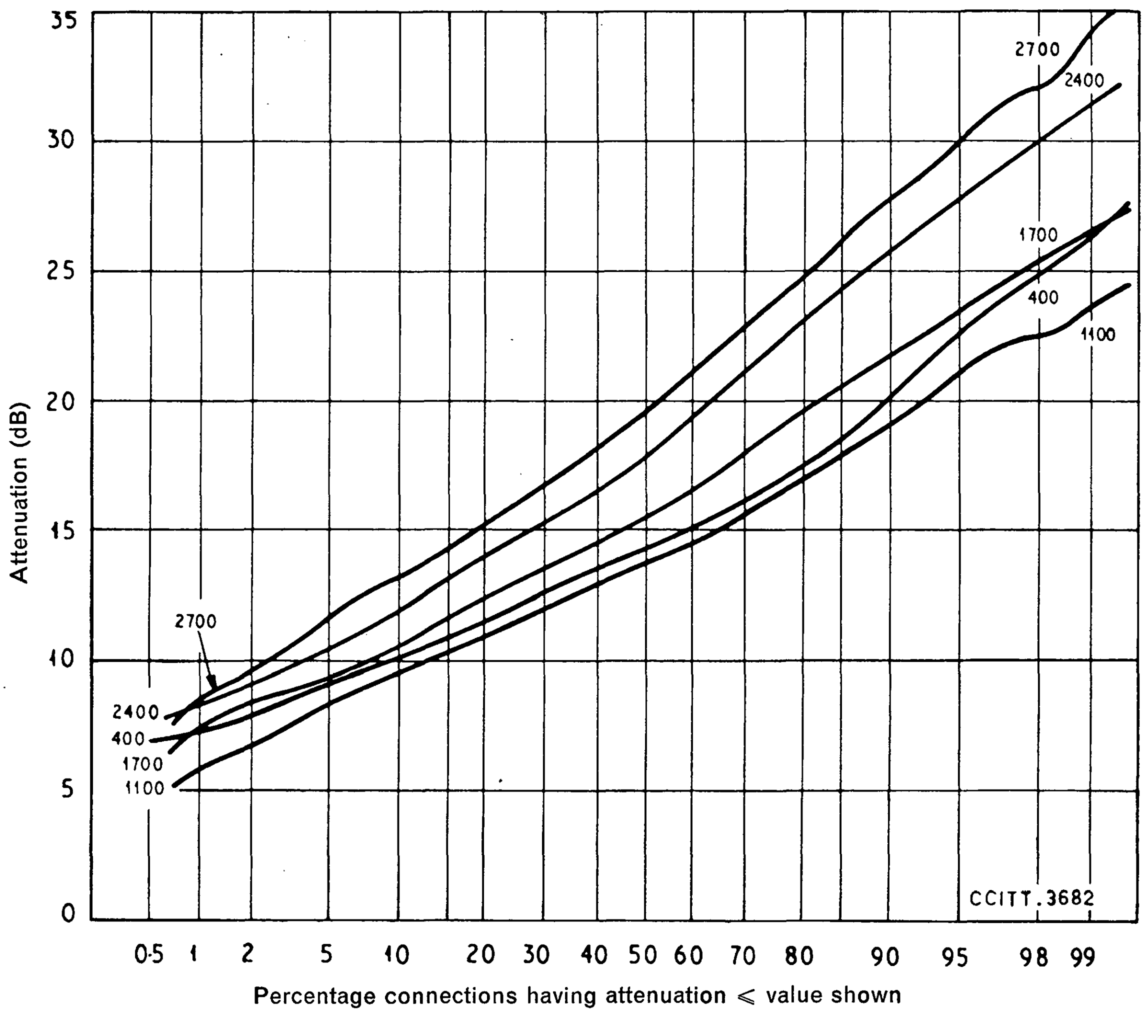


FIGURE 2. — **Samples of attenuation characteristics standardized about 1.7 kHz (SWR and NWR)**



National distribution (from ① ② ③ and ④)

FIGURE 8. — **Traffic weighted cumulative distributions of attenuation**

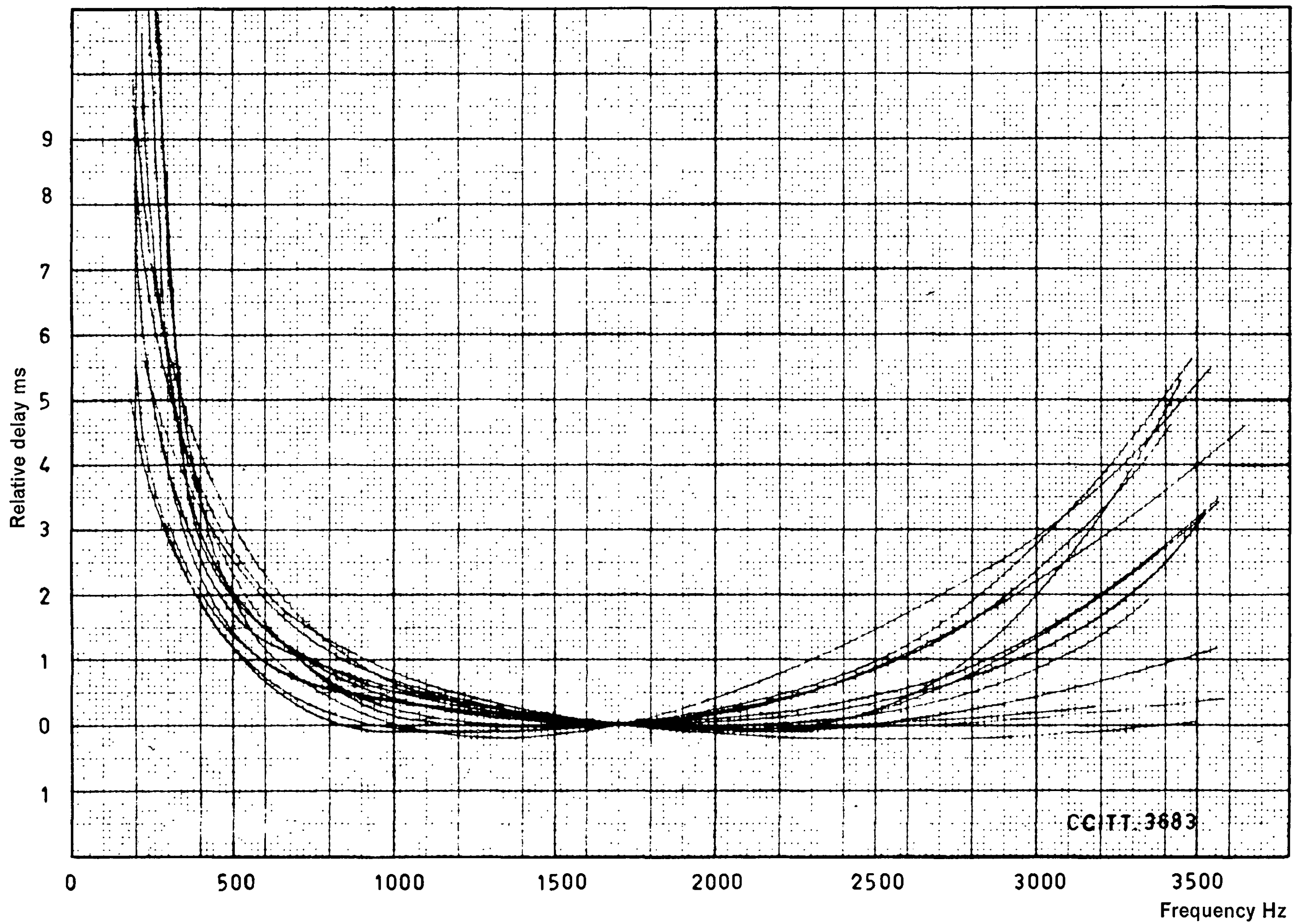


FIGURE 9. — Samples of group delay characteristics (echoes removed) standardized about 1.7 kHz (SWR and NWR)

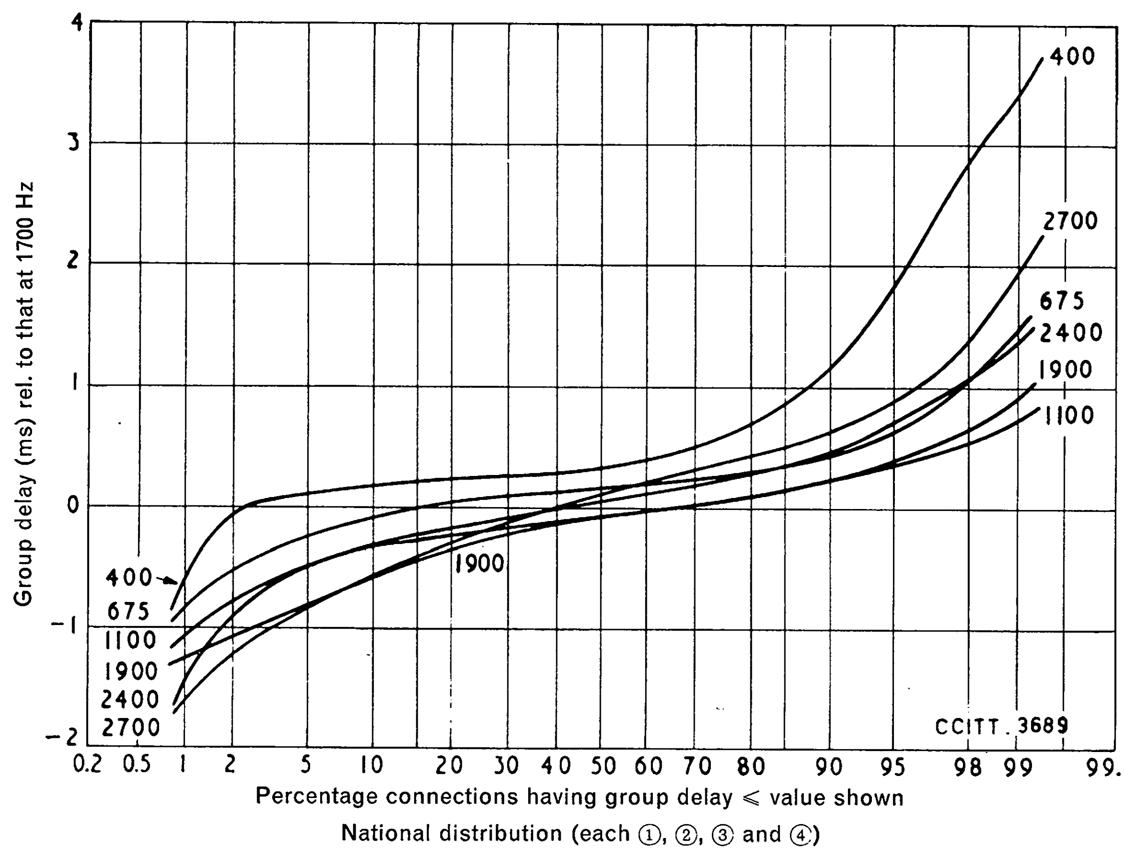
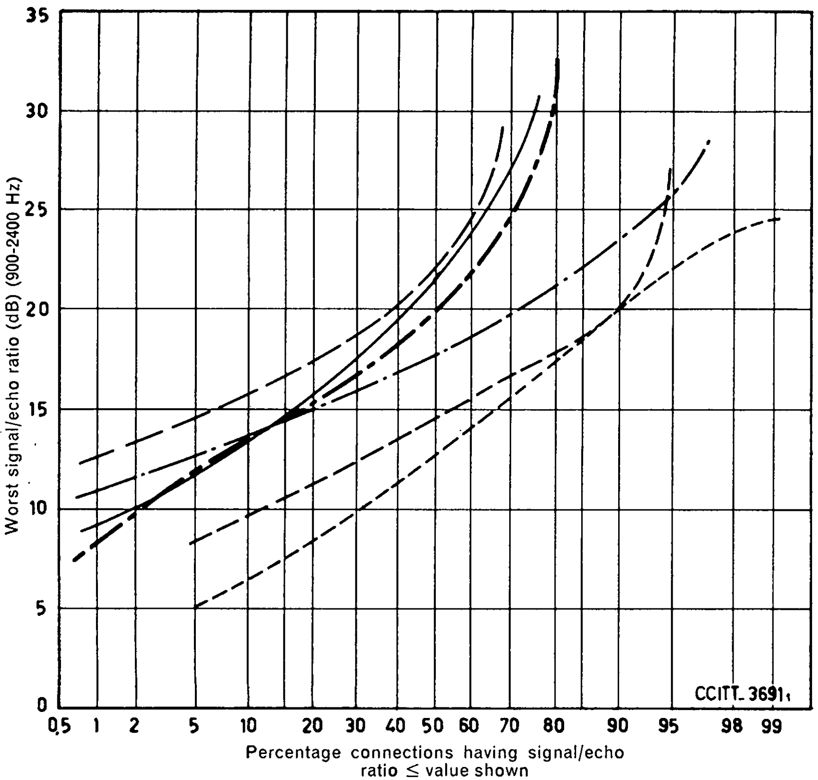
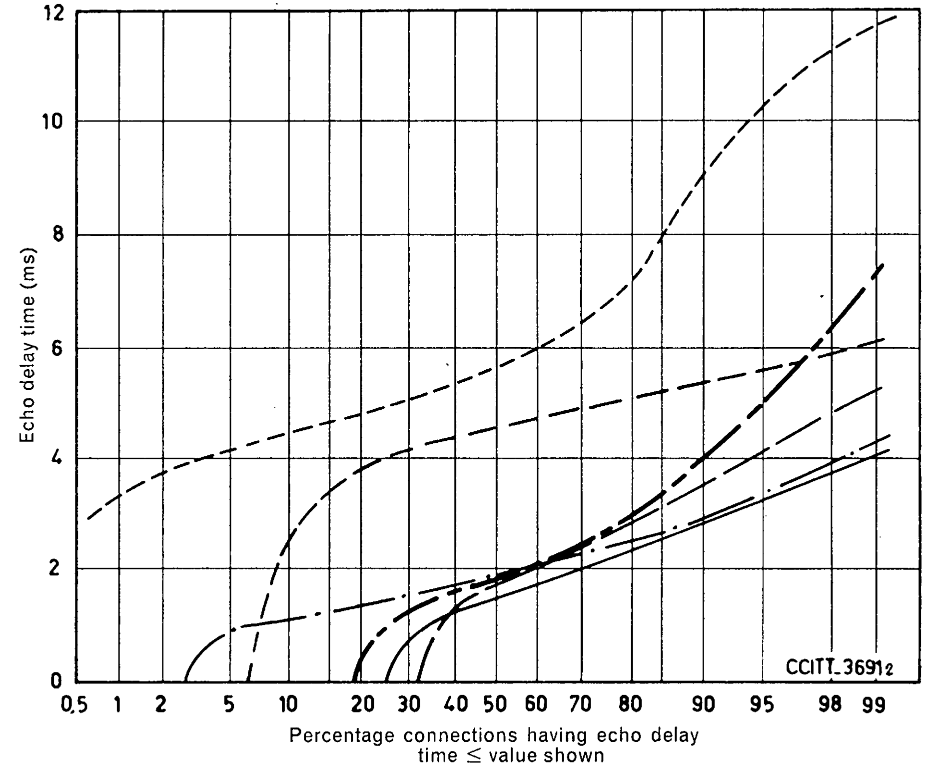


FIGURE 15. — **Traffic weighted cumulative distributions of group delay (relative to that at 1700 Hz)**



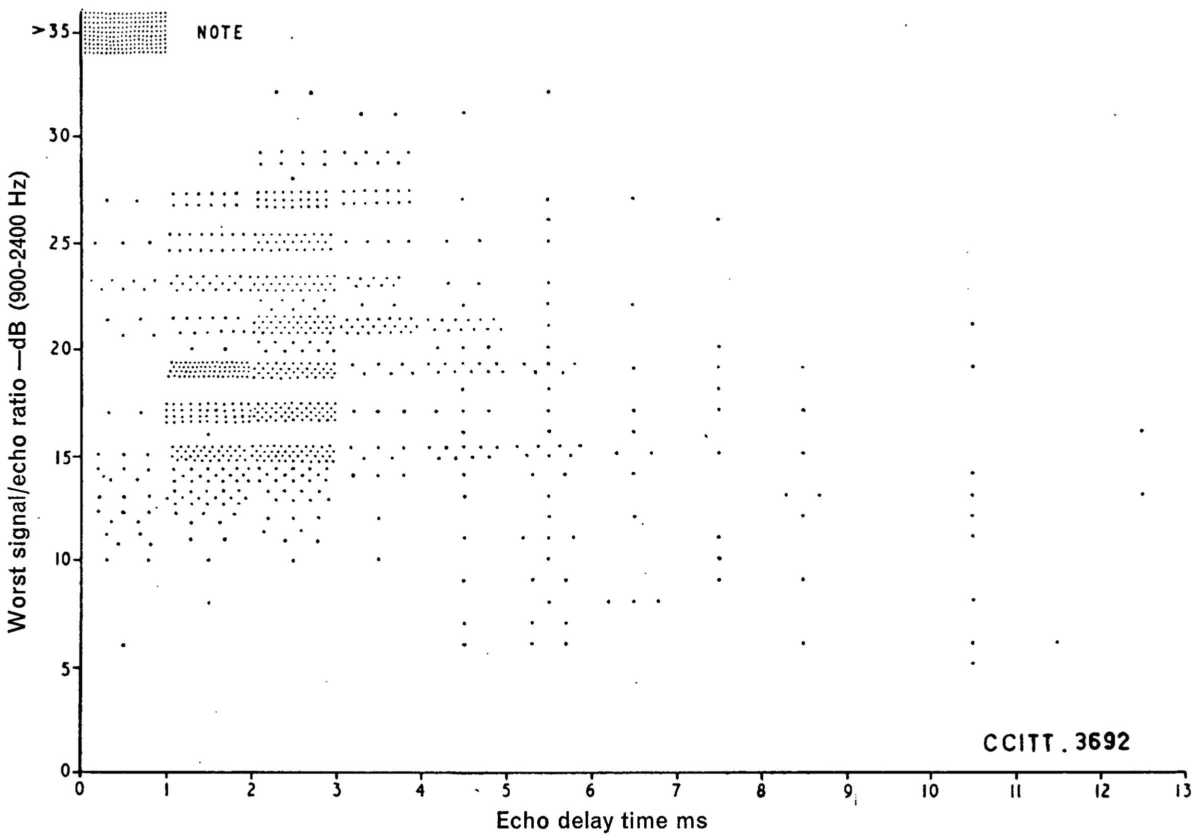
① ———— LTR ② —·—·—·— SWR
③ — — — — NWR ④ - - - - - - SWR-NWR
Traffic weighted

FIGURE 17. — **Traffic weighted cumulative distributions of signal/echo ratio**



⑤ - - - - - - - - Longer trunk circuits as measured
⑥ —·—·—·— National weighted using ① ② ③ and ⑤

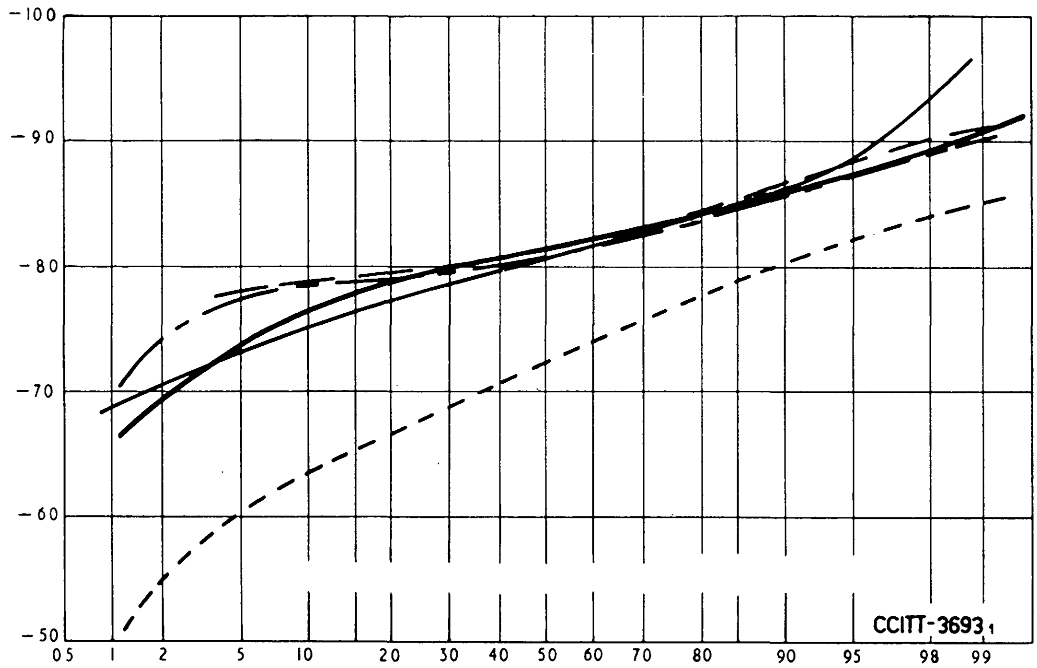
FIGURE 18. — **Traffic weighted cumulative distributions of echo delay time**



Key. — Each dot represents approximately 0.1 % of total connections quantized into 1 dB and 1 ms pockets.

Note. — The delay times of echoes with signal/echo ratios of >35 dB are difficult to determine accurately. For convenience they are all quantized into the pocket shown.

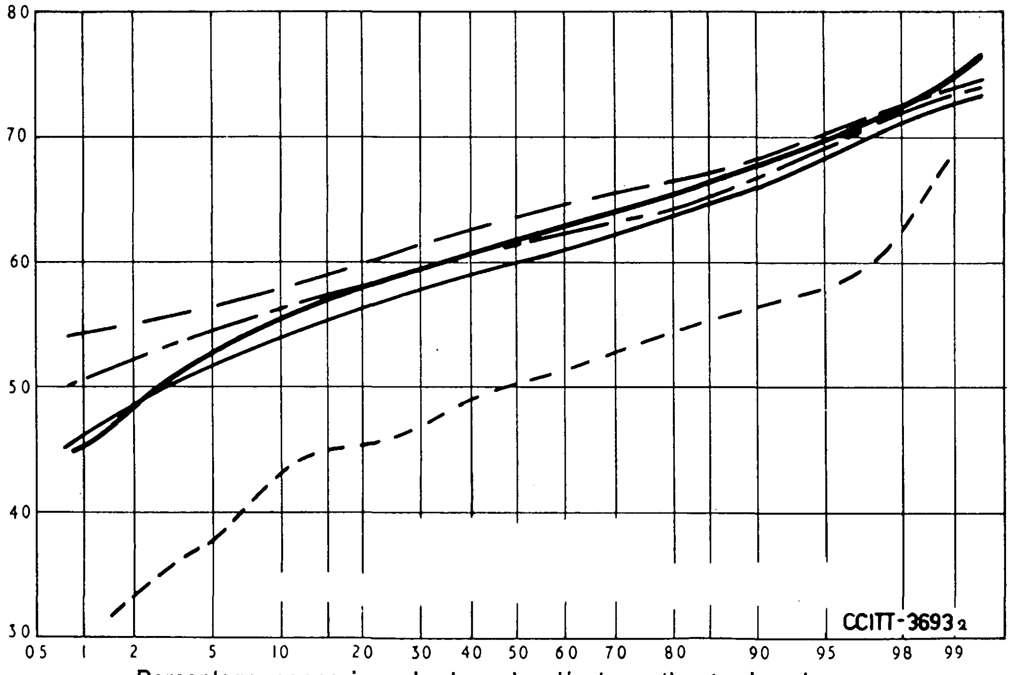
FIGURE 19. — **Scatter diagram of signal/echo ratio versus echo delay time extrapolated for the United Kingdom**



Percentage connexions having line noise ⩾ value shown

Equivalent noise bandwidth 1142 Hz (centre 1700 Hz)

FIGURE 20. — **Traffic weighted cumulative distributions of line noise**



Percentage connexions having signal/noise ratio ⩽ value shown

Transmit level, −6 dBm — Frequency 1700 Hz

Equivalent noise bandwidth 1142 Hz (centre 1700 Hz)

① ———— LTR ② —·—·— SWR ⑤ ━━━━ National

③ — — — NWR ④ - - - - SWR and NWR from ① ② ③ and ④

FIGURE 21. — **Traffic weighted cumulative distributions of signal/noise ratio**

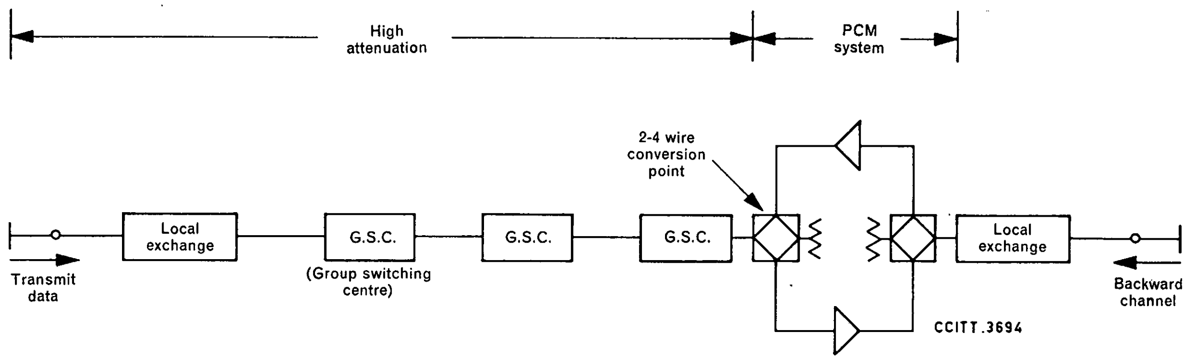


FIGURE 22. — Example of a switched connection involving a PCM system

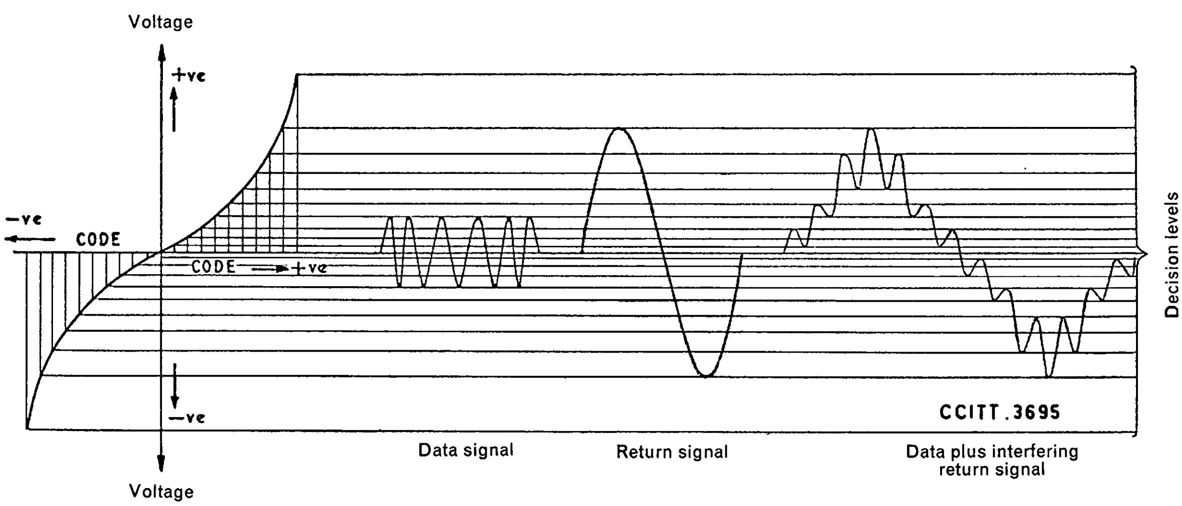


FIGURE 23. — Coding characteristic of PCM showing effect of interfering return signals on data signals

Supplement No. 15

NIPPON TELEGRAPH AND TELEPHONE PUBLIC CORPORATION.—*(Contribution COM Sp. A—No. 68, September 1970)*

MEASUREMENT OF PHASE DISTORTION AND TRANSMISSION LOSS BETWEEN SUBSCRIBERS

Measurements have been carried out over switched telephone network during the period of the field test of facsimile service in 1969. Since the measurements were made over established connections, details of line combinations were not identified except for the subscriber lines. However, the characteristics of many lines involved were included in the measurement results. Therefore, general characteristics of usual connections may roughly be estimated.

1. *Measured lines*

The subscribers under test were chosen in such a way as to include various kinds of actual connections.

Figure 1 shows the locations of subscribers, combination of lines and distances. Long-distance trunks are made up of coaxial or non-loaded cable or microwave carrier facilities, and short-distance trunks are composed of PCM or coaxial carrier facilities or non-loaded cable with or without two-way repeaters.

In all connections, subscriber's line loss is about 5 dB at 1500 Hz.

2. *Measuring method*

Attenuation characteristics were measured with 600-ohm termination. The phase distortion measuring equipment based on Nyquist's principle was used for straightforward measurement of relative group delay time with another auxiliary connection.

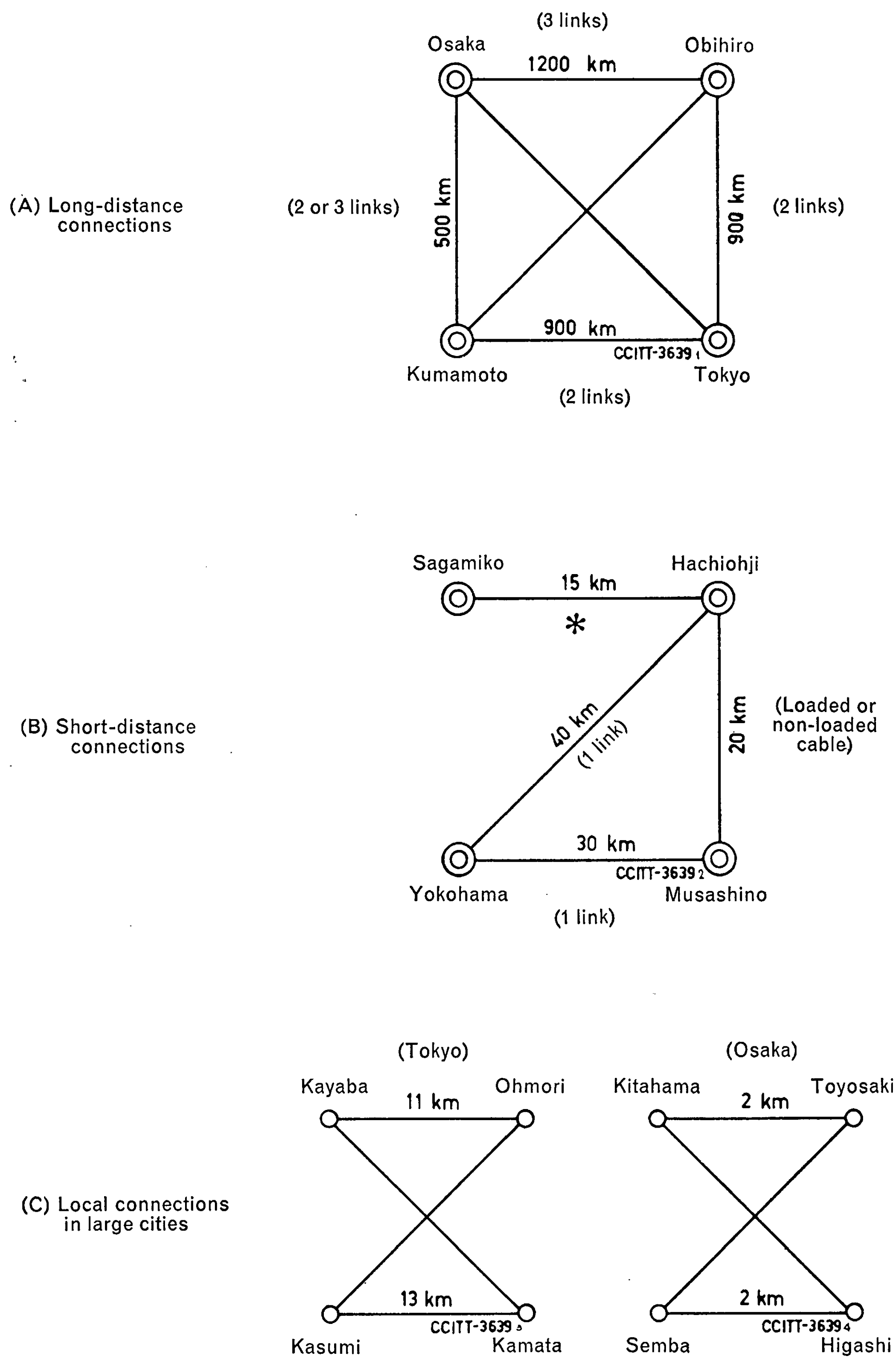
3. *Measurement results*

Typical attenuation and group delay characteristic curves are shown in Figures 2, 3 and 4. Attenuation measurements were made on 201 different connections. Accumulated curve of transmission losses at 1650 Hz (carrier frequency of the facsimile signal) is shown in Figure 5, in which loss for 90% of the connections is less than 25 dB.

Accumulated curve of attenuation distortions in the frequency band between 650 and 2650 Hz (the frequency band of amplitude-modulated facsimile signal) is shown in Figure 6. On 28 connections, measurements were made to obtain their group delay characteristics.

Accumulated distribution of phase distortions in the frequency band between 650 Hz and 2650 Hz is shown in Figure 7.

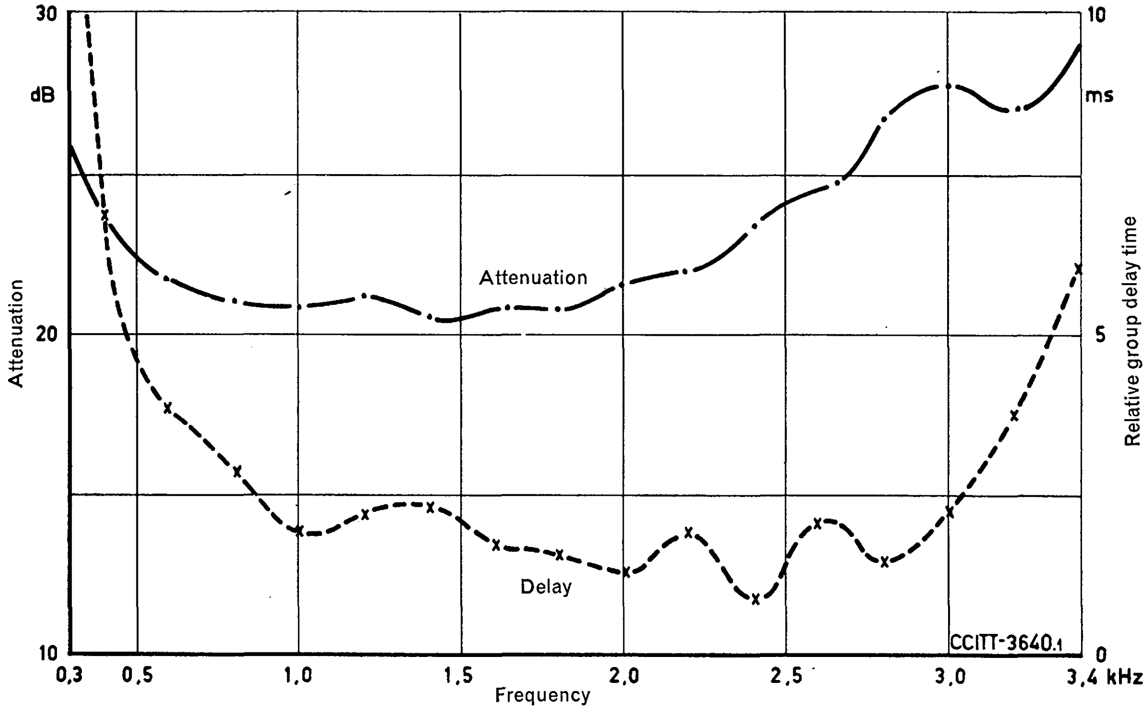
Phase distortion occurs mostly at channel filters in the carrier facility and loaded cable used. Therefore, the group delay characteristics measured is nearly equal to the sum of the group delay characteristics of the above-mentioned parts, except that the hump characteristics may be caused by impedance mismatching.



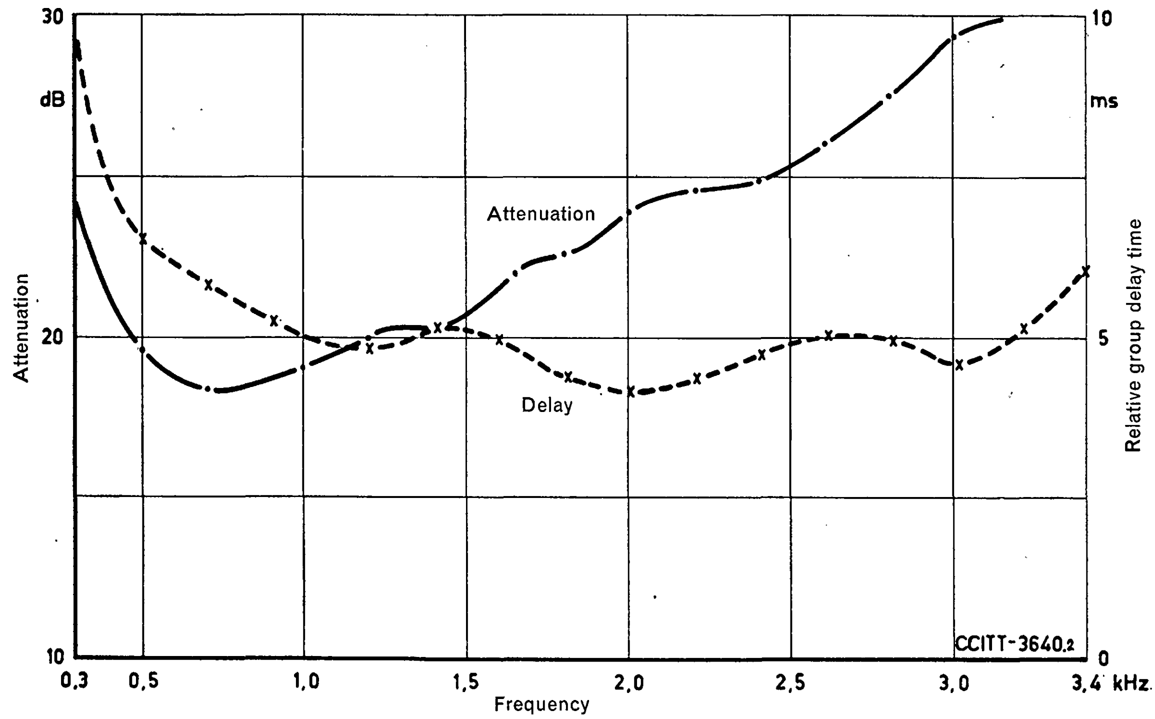
* PCM or loaded cable with two-way repeaters

Note. — A number of carrier links are estimated and distances are approximated from geometrical straight paths.

FIGURE 1. — **Subscribers' locations and measured connections**

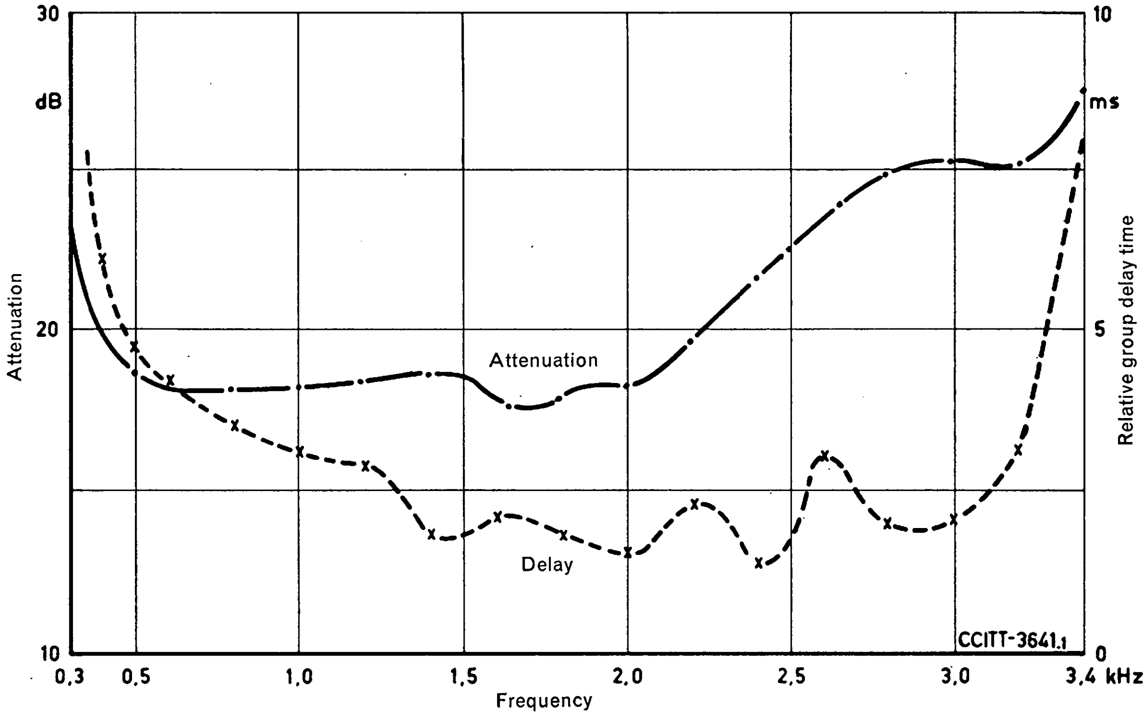


(A) Obihiro—Kumamoto (1600 km)

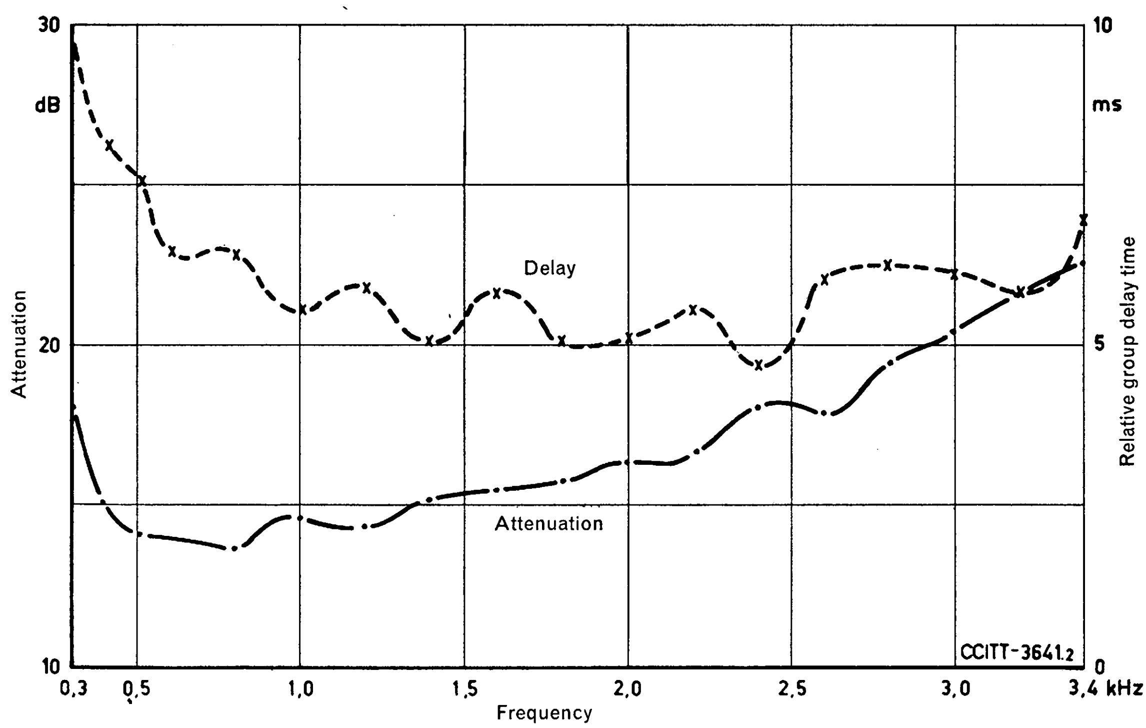


(B) Osaka—Tokyo (400 km)

FIGURE 2 a. — **Attenuation and delay characteristics for long-distance connections**

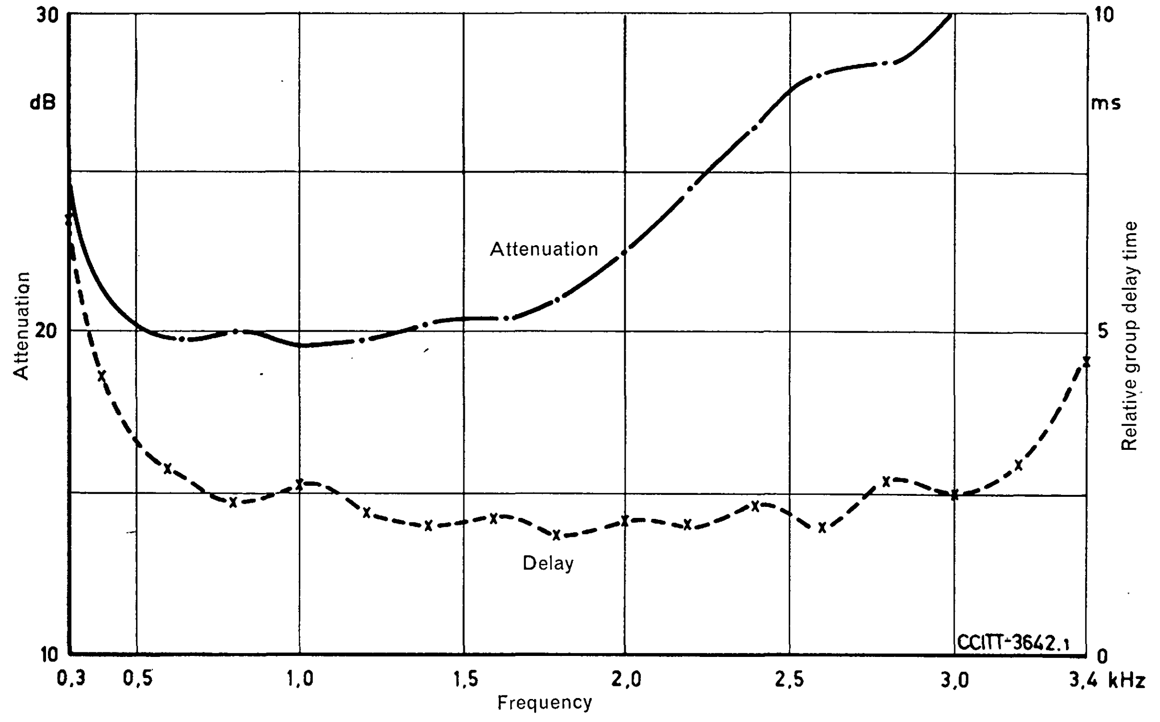


(C) Tokyo—Kumamoto (900 km)

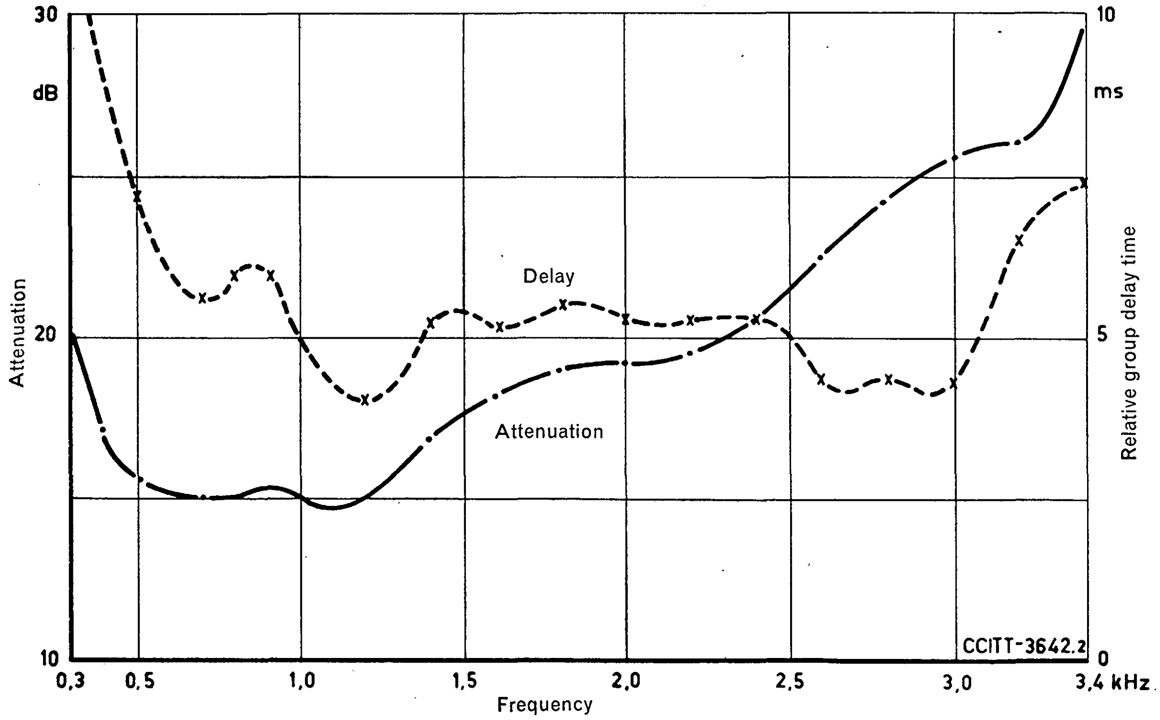


(D) Obihiro—Tokyo (900 km)

FIGURE 2 b. — **Attenuation and delay characteristics for long-distance connections**

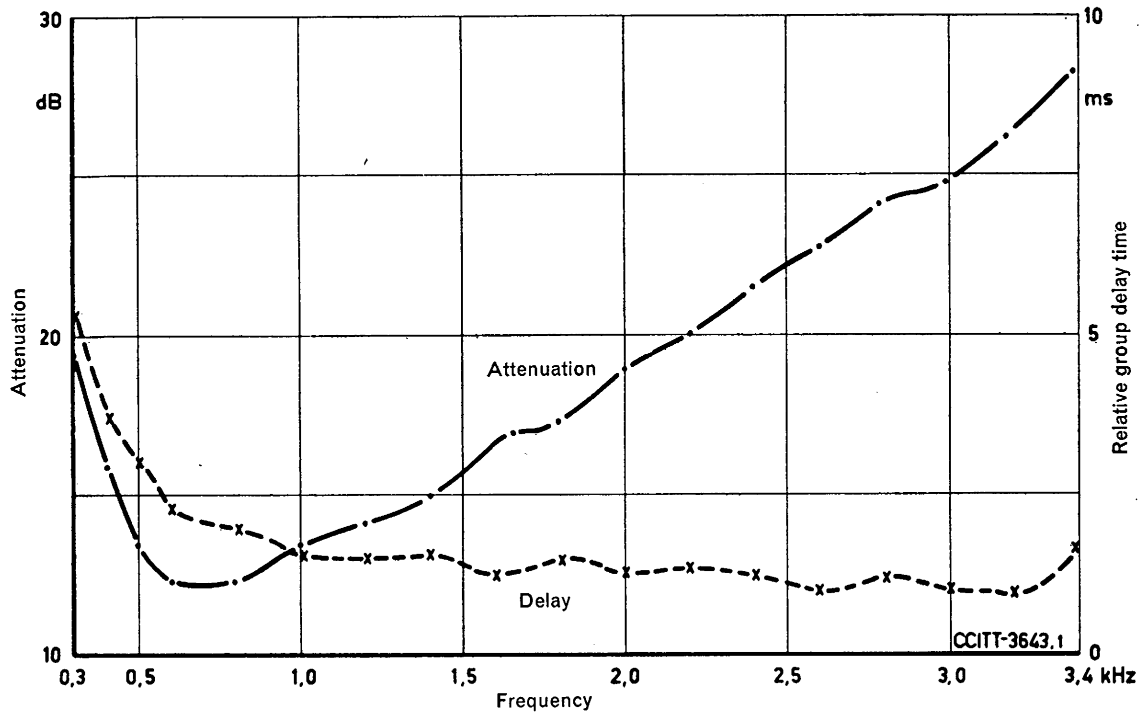


(E) Osaka—Kumamoto (500 km)

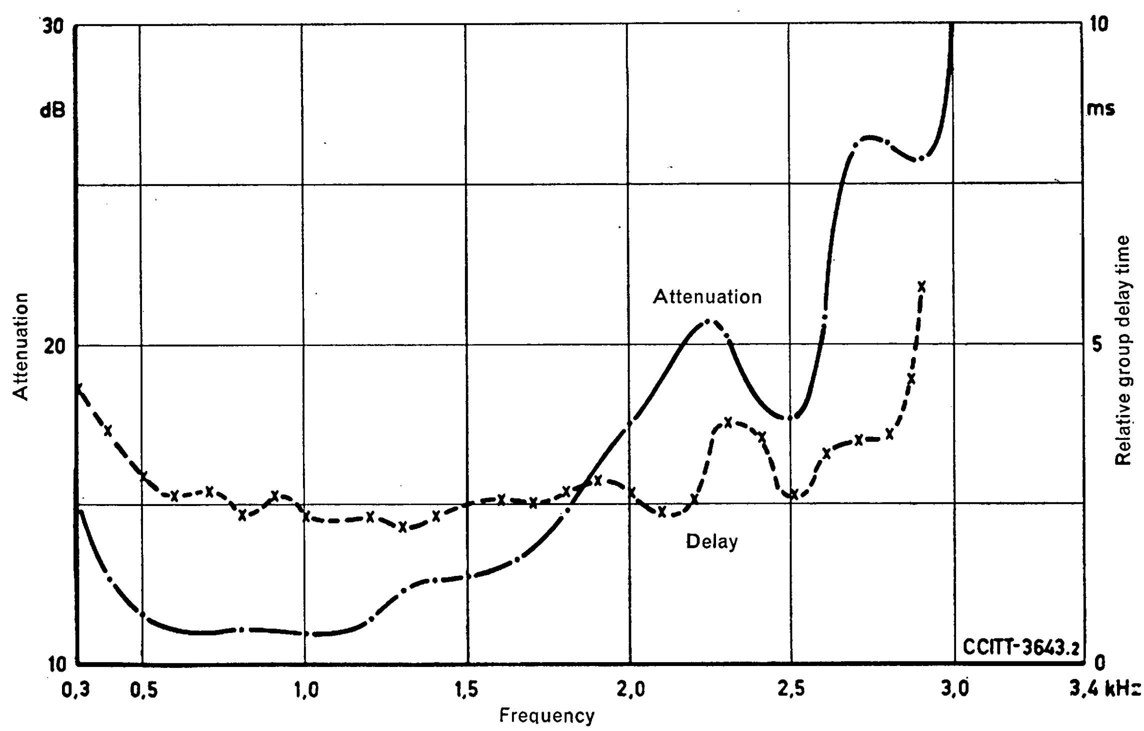


(F) Osaka—Obihiro (1200 km)

FIGURE 2 c. — **Attenuation and delay characteristics for long-distance connections**

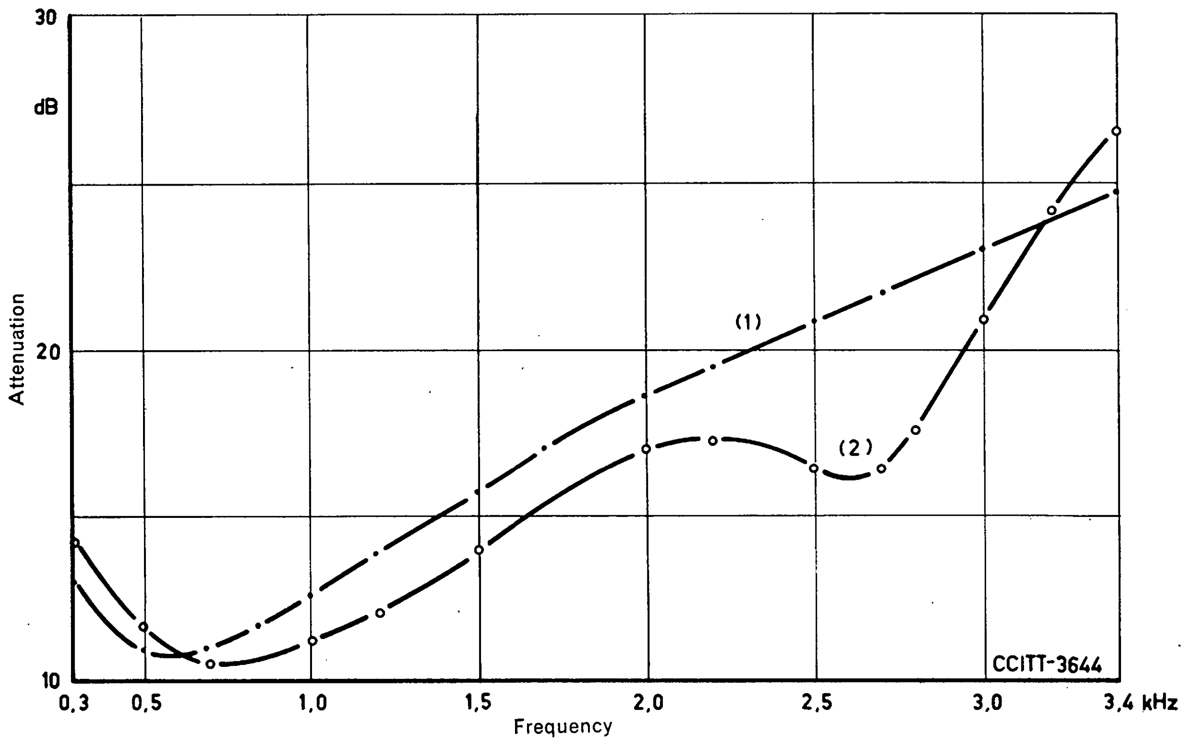


(A) Yokohama—Hachiohji (40 km)



(B) Sagamiko—Musashino (40 km)

FIGURE 3. — **Attenuation and delay characteristics for short-distance connections**



Kitahama—Higashi (Osaka)

Note. — Difference between curves (1) and (2) is due to two different switching routes when the same number is dialled.

FIGURE 4. — **Attenuation characteristics for local connections in a large city**

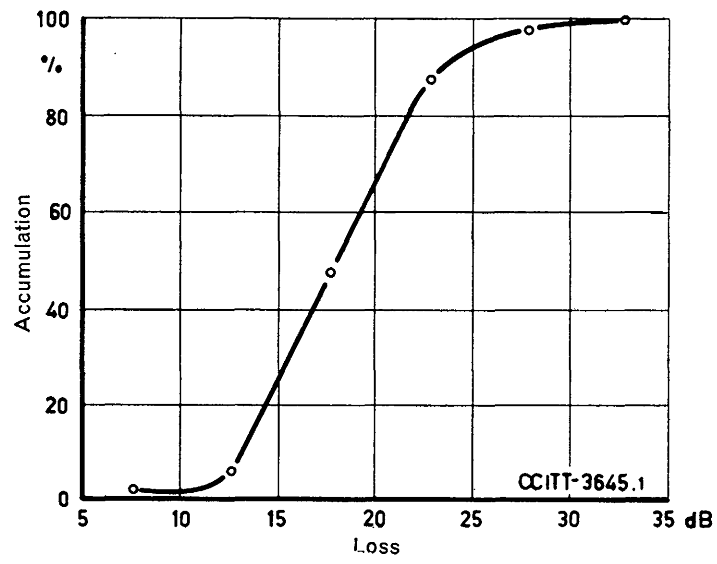


FIGURE 5. — Accumulated distribution of losses at 1650 Hz (201 connections)

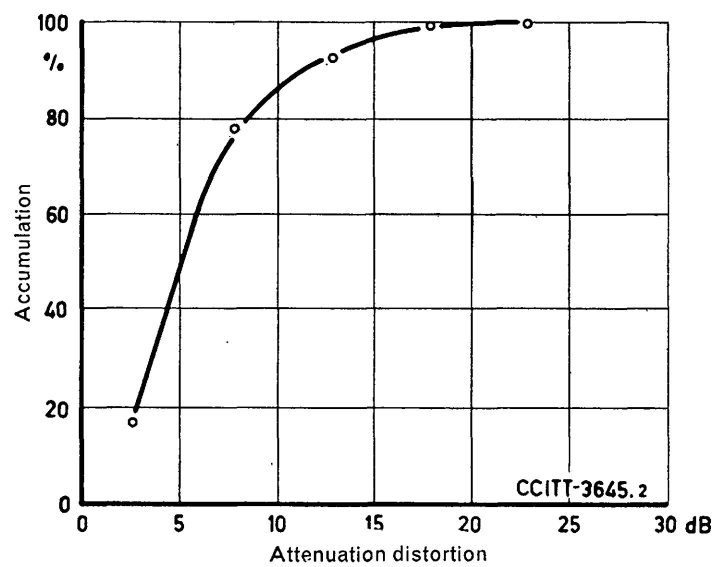


FIGURE 6. — Accumulated distribution of attenuation distortions between 650 and 2650 Hz (201 connections)

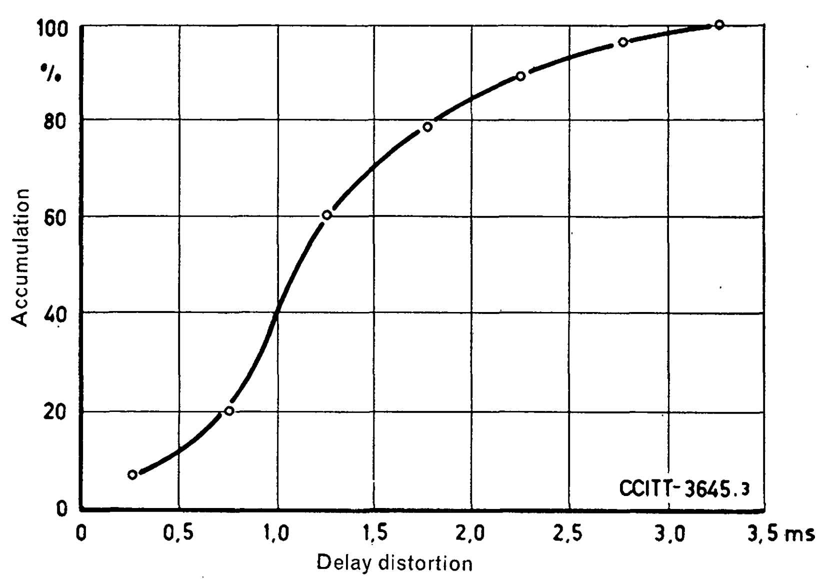


FIGURE 7. — Accumulated distribution of delay distortions between 650 and 2650 Hz (28 connections)

Supplement No. 16

NORWEGIAN ADMINISTRATION.—*(Contribution COM Sp. A—No. 111, December 1970)*

STATISTICS OF NORWEGIAN SWITCHED TELEPHONE NETWORK

Introduction

Referring to Document COM Sp. A—No. 28 [1] (inquiry from the Chairman of Special Study Group A about statistics of public switched telephone networks) the following information is given for the Norwegian telephone network.

1. *Inband signalling systems*

13.2% (2220 circuits) of the total number of national and international trunk circuits use inband line signalling. Of these, C.C.I.T.T. Signalling System No. 4 is used on 750 international circuits and Signalling System No. 5 is used on 10 international circuits. Otherwise 2400 Hz, 500 Hz or 500/20 Hz line signalling is used. Before 1975 it is expected that the line signalling on all circuits using 500 Hz or 500/20 Hz (220 circuits) and also 560 of those using 2400 Hz will be changed to outband signalling.

2. *Presence of echo suppressors*

Echo suppressors are used on 14 international circuits only. These suppressors have a disabling frequency of 2125 Hz. Speech compressors are used for " double talking " under simultaneous backward channel operation.

3. *Subscriber-to-subscriber loss*

The subscriber-to-subscriber losses in the switched Norwegian telephone network is shown in Figure 1.

Curves A and C represent the average and maximum values of these losses. In 80% of the switched connections the losses will be less than shown on curve B.

Subscriber-to-subscriber losses on international circuits have been measured in 1970 under a programme organized by Study Group IV.

4. *Phase distortion between subscribers*

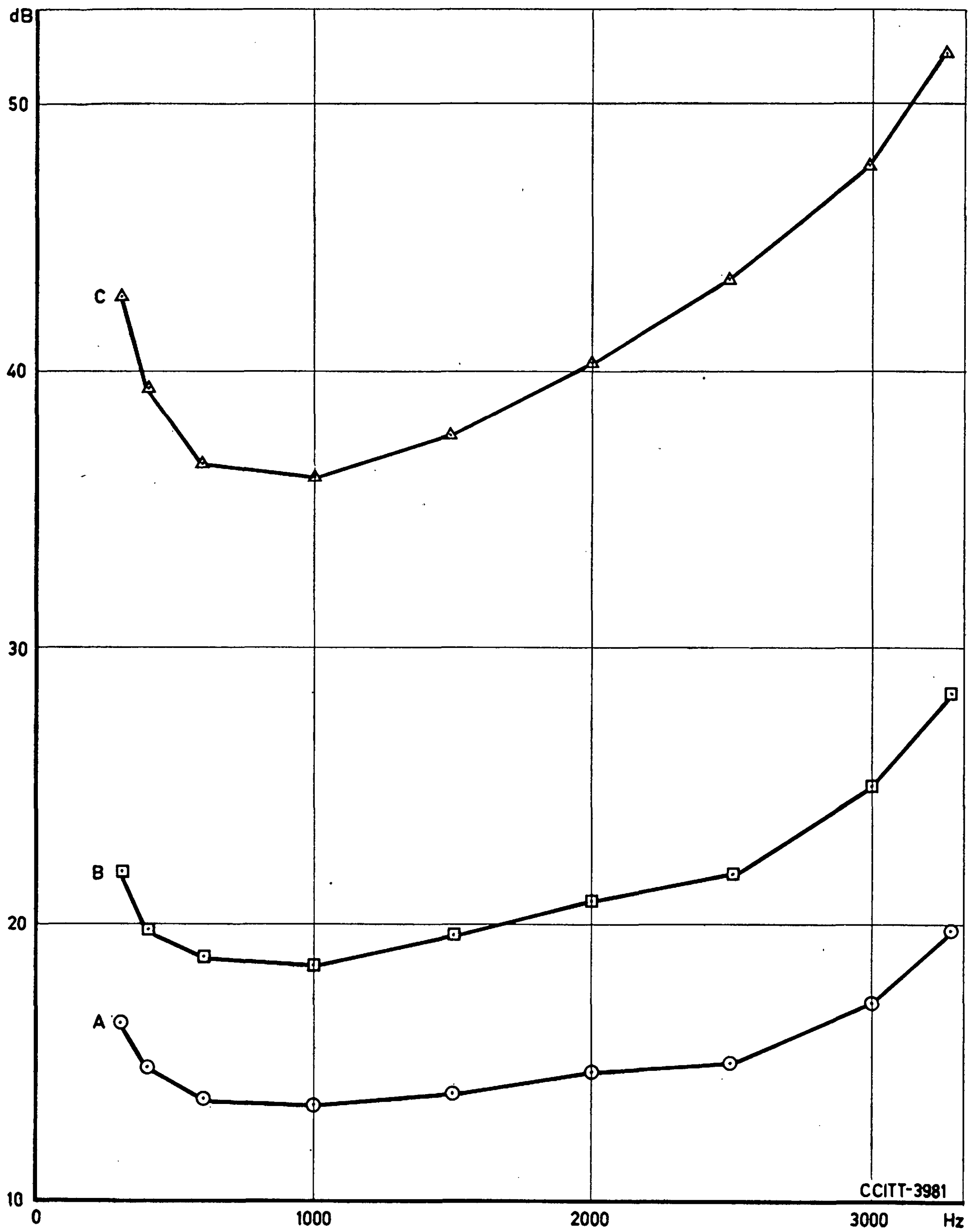
Figure 2 shows the maximum group delay (smoothed curve) expected between two subscribers in the Norwegian switched telephone network. This curve represents the delay of a circuit consisting of 8 sections of carrier frequency systems. (About 60% of the trunk circuits in Norway are carrier systems, representing approximately 91% of total trunk circuit length.)

Group delays on international circuits have been measured in the above-mentioned programme of Study Group IV.

5. *Sudden changes of phase or amplitude or short line breaks*

During March-June 1970 long-term measurements of signal level, phase changes and short breaks were made on three different looped carrier frequency telephone circuits. Total measurement duration was 2500 hours. A 2000-Hz tone, transmitted over the channels, was monitored by a specially designed device. This device fed a time chart recorder with information of transmission loss, phase difference between the transmitted and received tone and occurrence of any line breaks.

[1] See Question 1/A—point L, paragraph 9.



Curve A — average values
Curve B — 80% limit values
Curve C — maximum values

FIGURE 1. — **Subscriber-to-subscriber losses in the Norwegian switched telephone network**

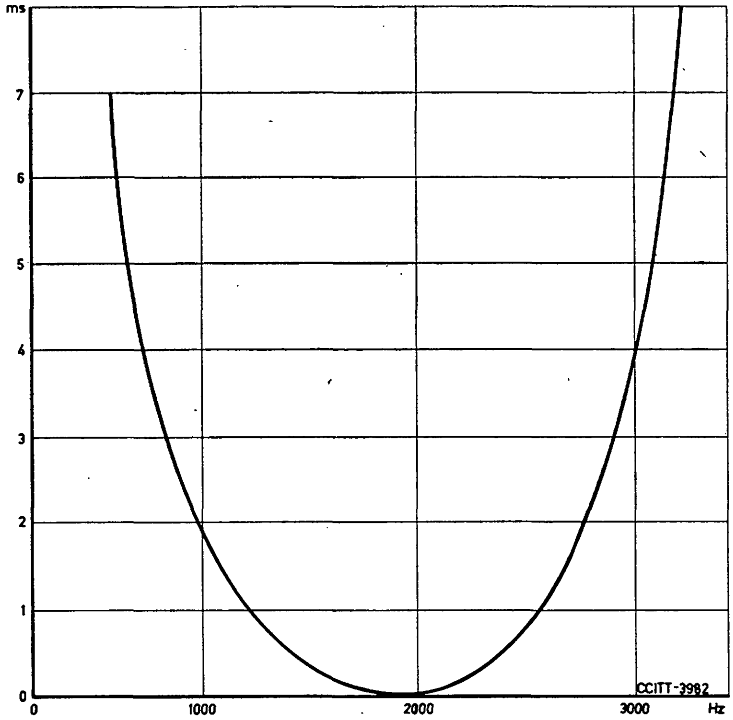


FIGURE 2. — **Maximum group delay distortion between two subscribers in the Norwegian switched telephone network**
(8 carrier sections in tandem)

Table 1 gives the overall results of these measurements.

TABLE 1

	Circuit 1 Oslo Gjøvik Oslo	Circuit 2 Oslo Trondheim Oslo	Circuit 3 Oslo Stavanger Oslo
Transmission Circuit length Measurement duration	Cable (2 carrier sections, symmetrical pair) 2 × 150 km 300 hours	Radio-relay system (2 carrier sections) 2 × 425 km 1200 hours	Radio-relay system (4 carrier sections) 2 × 500 km 1000 hours
Sudden changes in amplitude Short breaks (less than 300 ms) Long breaks Interruptions (total)	30 13 37 1 hour	124 326 72 8 hours	104 244 101 1 hour
Transmission loss exceeding ± 2 dB of nominal value	1.5 hours	10.7 hours	7.5 hours
Phase changes: — less than 10° — more than 10°	 1 0	 16 2	 6 24

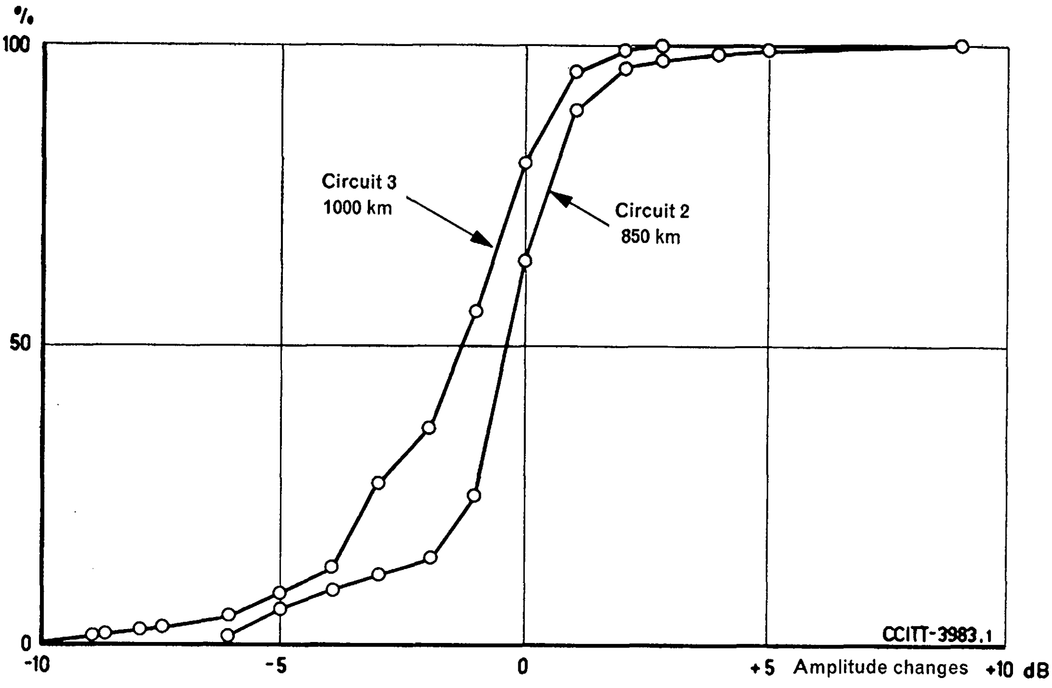


FIGURE 3. — **Cumulative distributions of sudden changes of amplitude for point-to-point circuits on radio-relay systems in the Norwegian telephone network**

(Circuit numbers refer to Table 1)

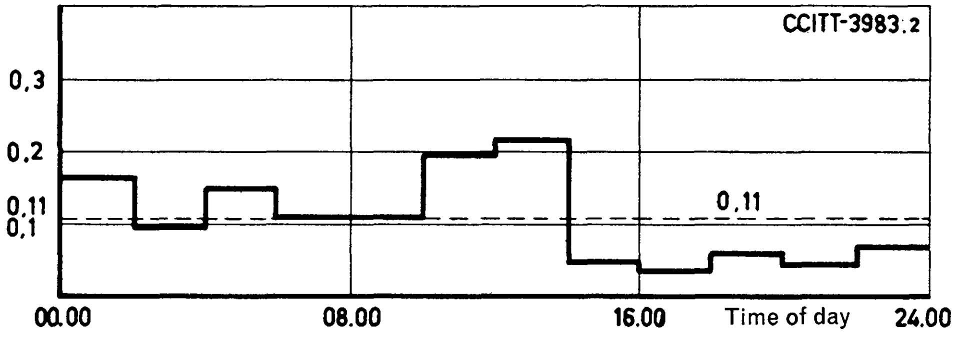


FIGURE 4. — **Average counts of sudden changes of amplitude per hour vs time of day. Circuit 2, two carrier sections on radio-relay systems, 850 km**

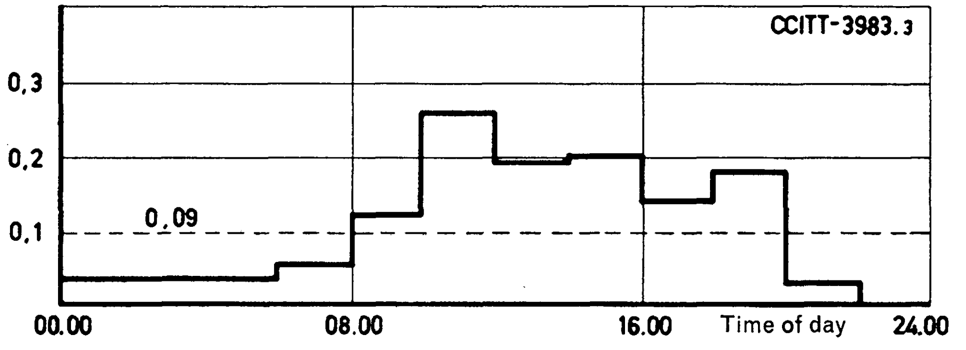


FIGURE 5. — **Average counts of sudden changes of amplitude per hour vs time of day. Circuit 3, four carrier sections on radio-relay systems, 1000 km**

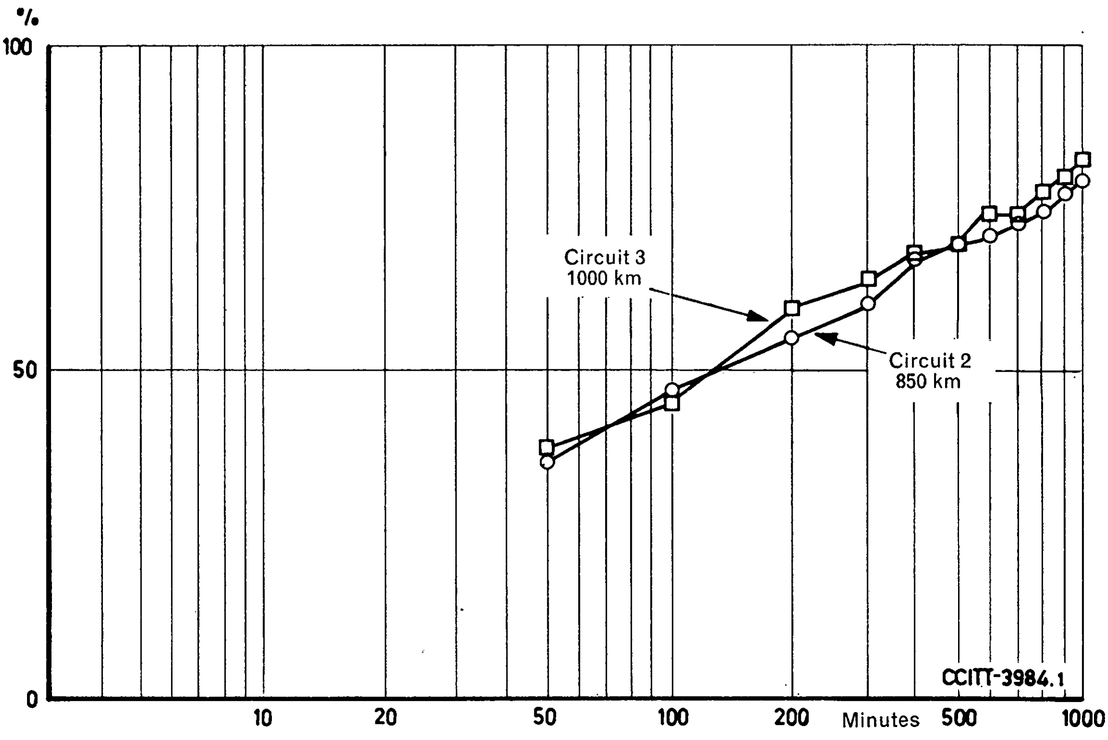


FIGURE 6. — **Cumulative distribution of intervals between sudden changes of amplitude for two point-to-point circuits on radio-relay systems in the Norwegian telephone network**
(Circuit numbers refer to Table 1)

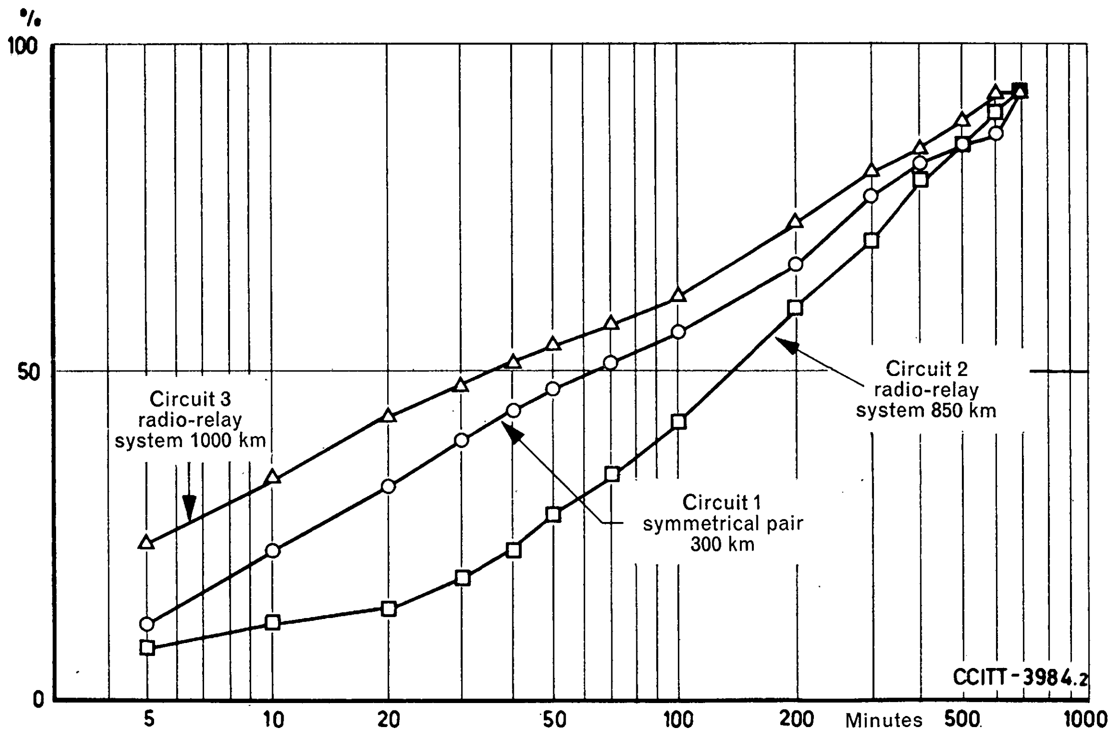


FIGURE 7. — **Cumulative distribution of intervals between short breaks on three different point-to-point circuits in the Norwegian telephone network**
(Circuit numbers refer to Table 1)

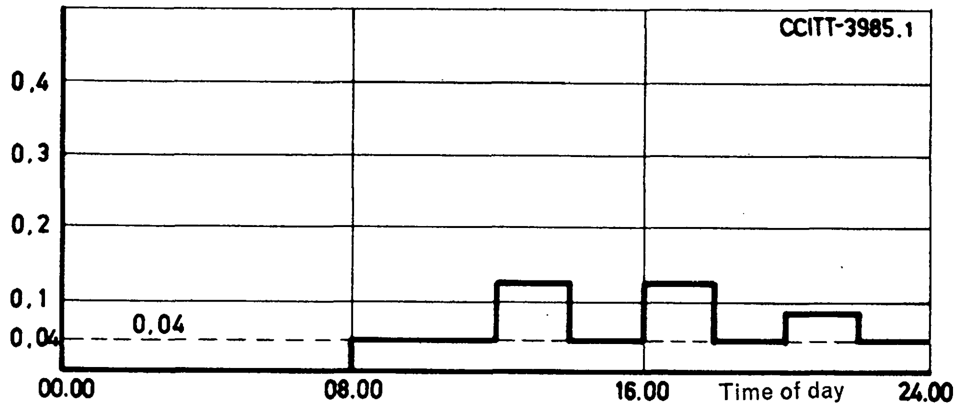


FIGURE 8. — **Average counts of short breaks per hour vs time of day. Circuit 1, two carrier sections on symmetrical pair, 300 km**

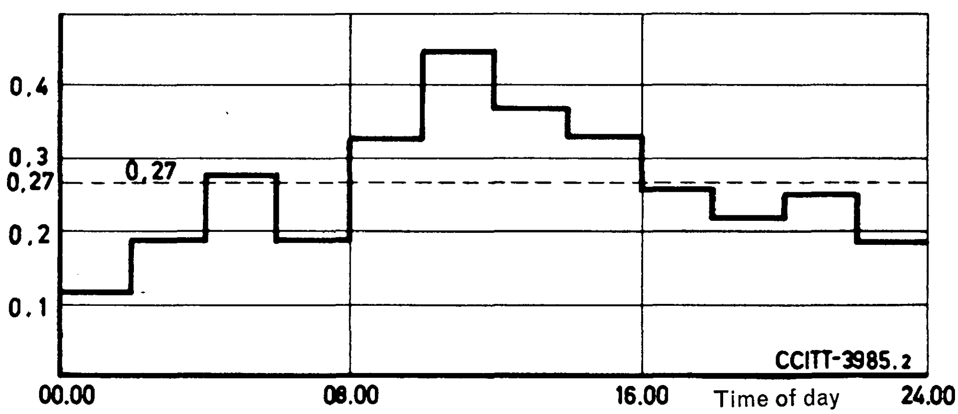


FIGURE 9. — **Average counts of short breaks per hour vs time of day. Circuit 2, two carrier sections on radio-relay system, 850 km**

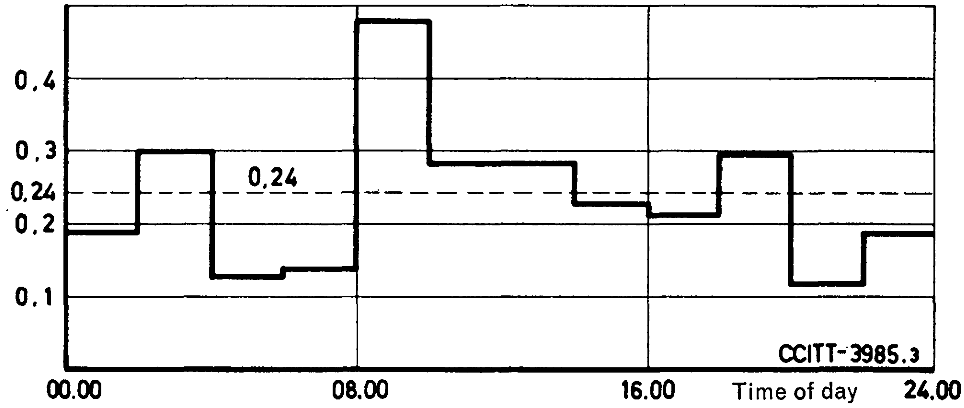


FIGURE 10. — **Average counts of short breaks per hour vs time of day. Circuit 3, four carrier sections on radio-relay system**

Figure 3 shows cumulative distributions of sudden amplitude changes for circuit 2 or 3. On circuit 1 there were insufficient observations to give a representative picture.

Figures 4 and 5 show average counts of the amplitude changes vs time of day for circuit 2 or 3.

Figure 6 shows cumulative distributions of intervals between amplitude changes.

Figures 7 to 10 show the results from the measurements of short breaks. Here Figure 7 represents the cumulative distributions of intervals between breaks, and Figures 8 to 10 the average counts vs time of day.

Breaks in international connections have been measured during October/November 1970 under a programme organized by Study Group IV.

6. *Impulsive noise*

Impulsive noise has been measured:

— through local telephone exchanges

— on short-haul switched circuits

— on switched long-distance circuits.

The counter used was designed according to Recommendation V.55 and is capable of simultaneous, counting on 5 different threshold levels using 5 separate registers. Deadtime can be continuously adjusted from 5 μs to 1 sec.

Impulse counts were taken in 5-minute periods, changing connection every hour.

All impulse noise measurements were made during periods with normal day traffic (0800-1600).

a) *Local telephone exchanges*

The exchanges are in the Oslo area. Information on these is given in Table 2.

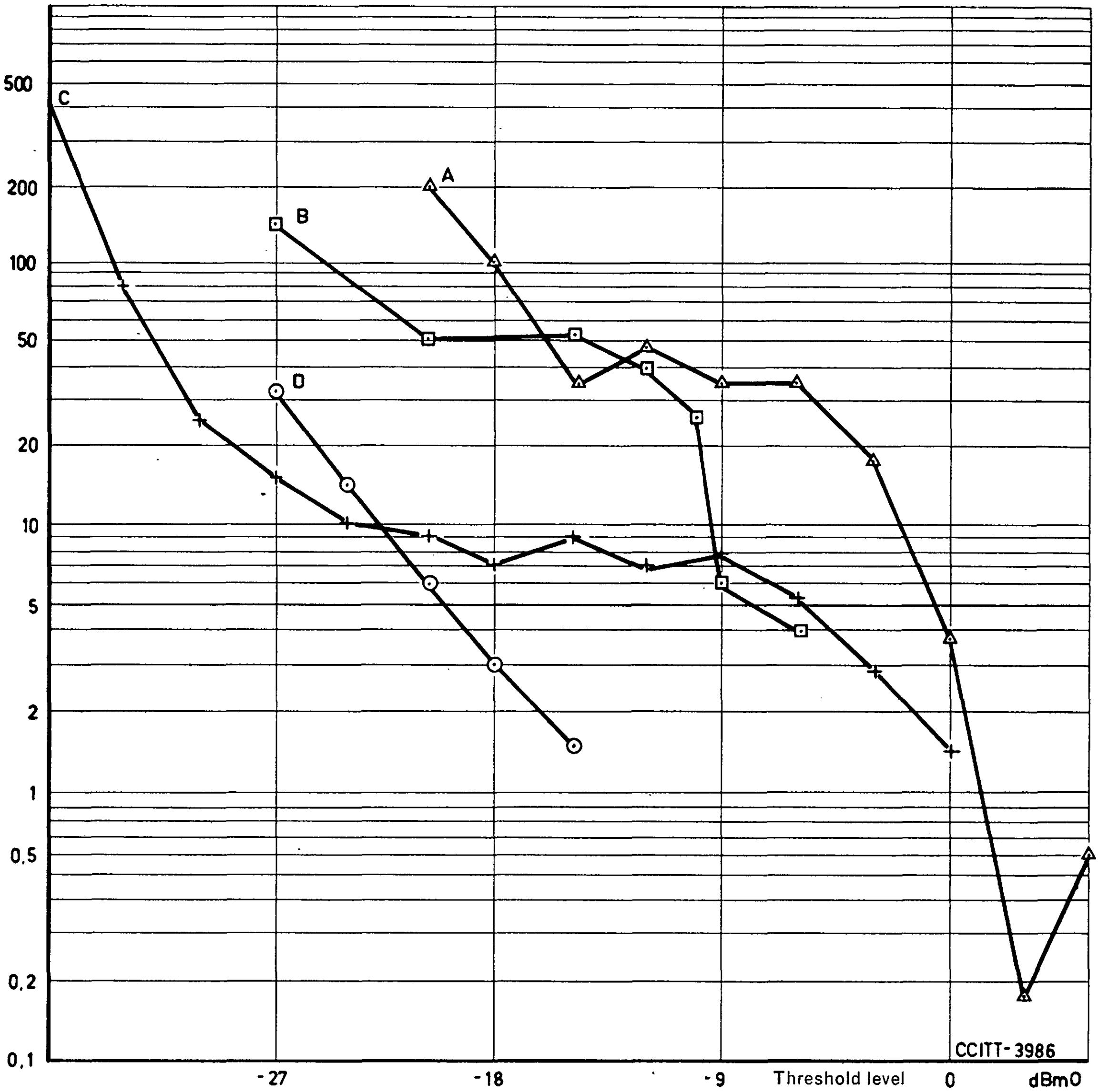
TABLE 2

Exchanges	Type	Installed	Capacity (numbers)	Periods measured	Mean background noise level	Mean impulse count per 5 min at −18 dBm0
A	[a]	1924	16 200	120	−51 dBm0p −23 dBm0 [c]	100
B	[a]	1936	8 000	156	−57 dBm0p −42 dBm0 [c]	50
C	[b]	1963	10 000	192	−61 dBm0p −42 dBm0 [c]	7
D	[a]	1953	6 000	432	−68 dBm0p −28 dBm0 [c]	3

[a] Rotating electromechanical selector.

[b] Co-ordinate selector.

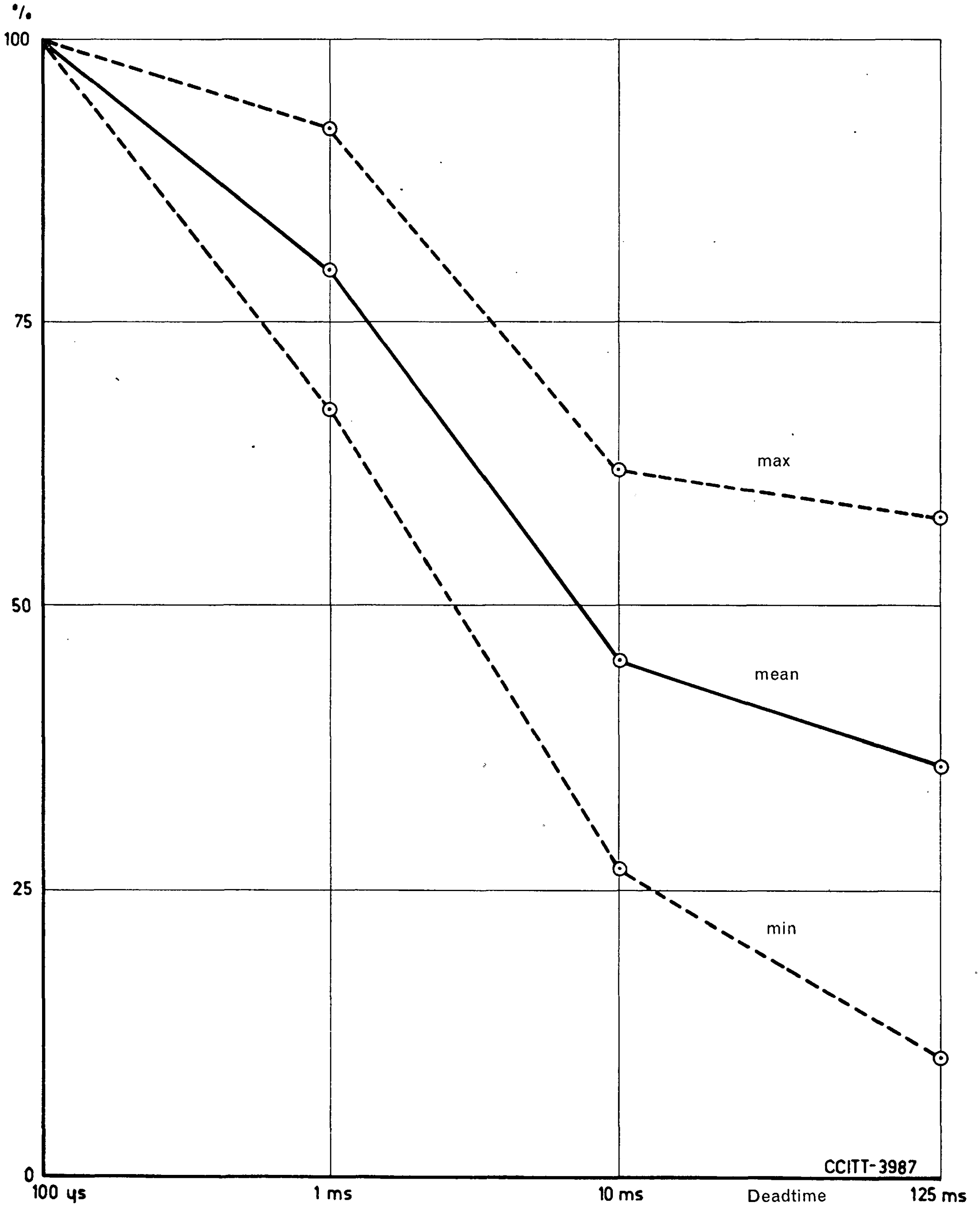
[c] Noise measurement bandwidth 15 Hz-20 kHz.
Nominal level = 0 dBm at the exchanges.



Deadtime 125 ms. No filter used.
Exchange numbers refer to Table 2.

Note.— In exchanges A and C the impulse noise count occasionally increases with the threshold level. This was caused by the fact that all measurements were not made simultaneously.

FIGURE 11. — **Average impulse noise counts per 5 minutes in local exchanges**



Nine tests each of one hour's duration were made. The number of counts are in per cent of maximum counts in each test. Threshold level − 27 dBm0. No filter used.

FIGURE 12. — **Impulse noise counts vs deadtime in local exchange D** (see Table 2)

Figure 11 shows the mean impulse noise counts in relation to threshold levels for these four exchanges. No filter was used, and the counter deadtime set to 125 ms.

In exchange D, a one-hour magnetic tape recording was taken from each of 9 different connections. These recordings were afterwards repeatedly played back into the impulse counter, the deadtime set to different values each time. Figure 12 shows the mean, maximum and minimum impulse noise counts obtained for various deadtimes as percentages of the counts registered with a deadtime of 100 μs. From the figure it was concluded that the impulses appeared in bursts, with a mean distance of 1-10 ms between impulses within each burst.

b) *Short-haul circuits*

Connections were dialled via local exchange D above to exchanges B and C, as shown on the schematic below.

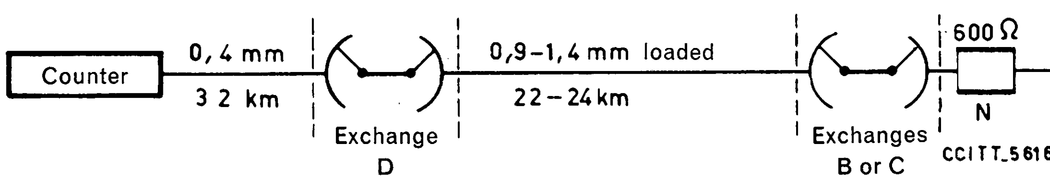


FIGURE I

Subscriber-to-subscriber losses were 12-17 dB at 800 Hz.
Nominal level = 0 dBm at point N.

The mean impulse noise counts per 5-minute periods are shown in Figure 13. The impulse counter was used with the 600-3000-Hz filter given in Recommendation V.55 and the deadtime set to 125 ms. A total of 312 periods were measured.

c) *Long-distance circuits*

Connections were dialled in three different directions: Oslo-Trondheim, Oslo-Bergen and Oslo-Stavanger via the local exchange D above, as shown on the schematic below.

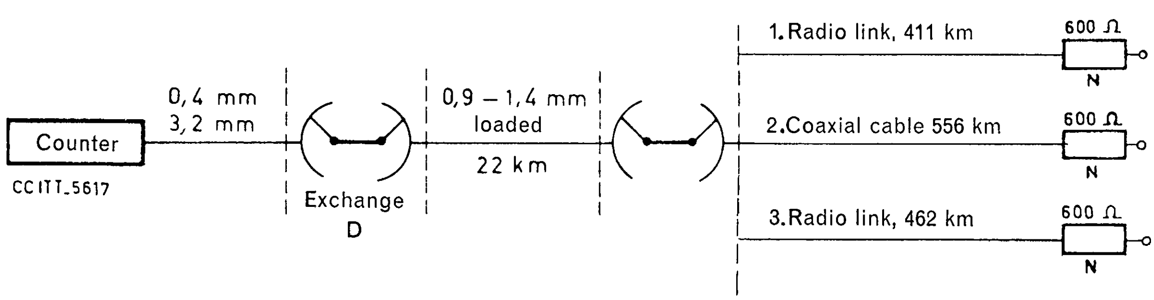


FIGURE II

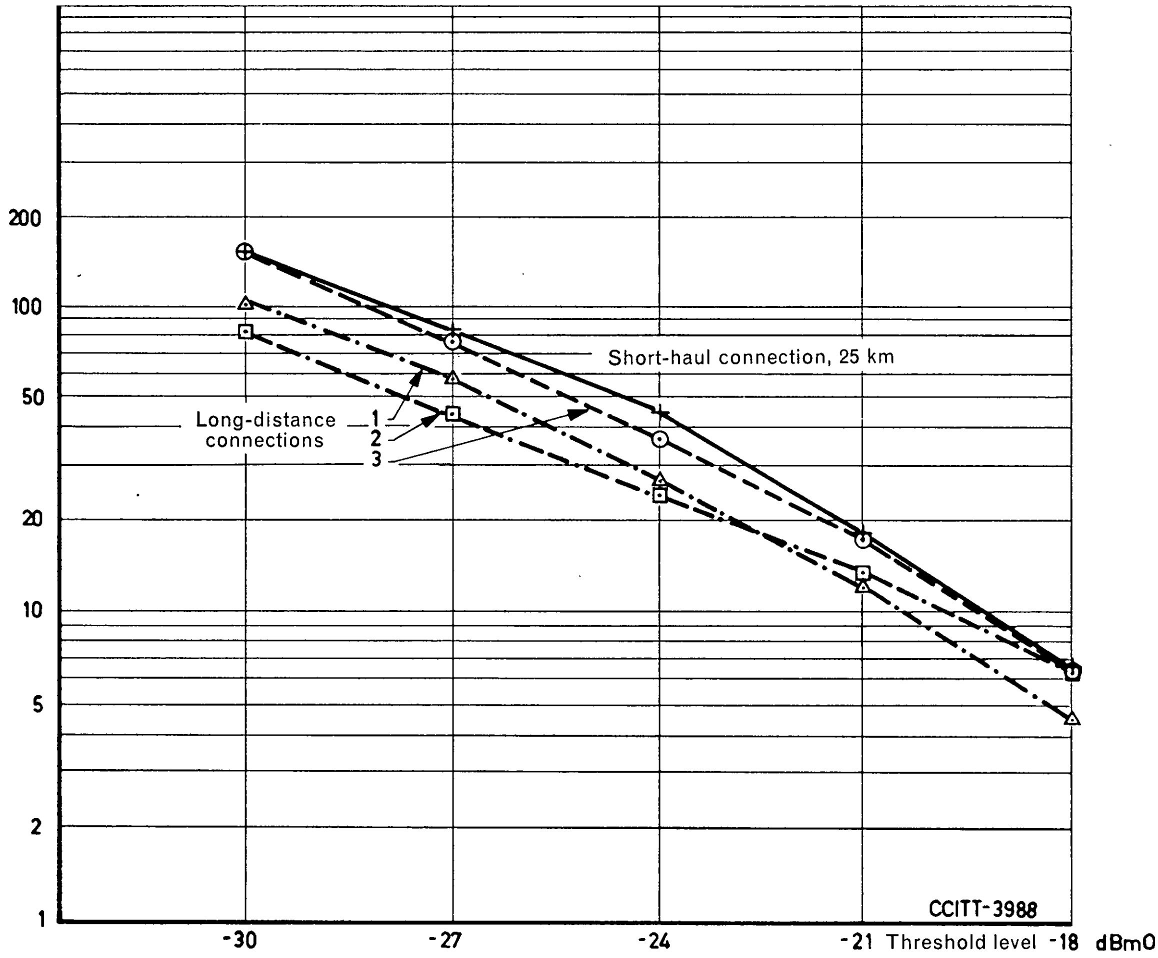
Subscriber-to-subscriber losses were 8-12 dB at 800 Hz.
Nominal level = 0 dBm at point N.

The mean impulse noise counts per 5-minute periods are shown in Figure 13. The impulse counter was used with the 600-3000-Hz filter given in Recommendation V.55 and deadtime set to 125 ms.

200 periods was measured for each connection.

Statistical analysis of the impulse noise counts indicated that the impulse activity within a 5-minute period was approximately log-normally distributed. The results show that for a given circuit there was a probability of about 85% that the impulse noise count in a random 5-minute period was less than 1.5 times the average value.

Impulse noise on international connections has been measured in 1970 under a programme organized by Study Group IV.



The 600-3000-Hz filter recommended in C.C.I.T.T. V.55 was used. Deadtime 125 ms.
Long-distance connection numbers refer to Figure II.

FIGURE 13. — **Average impulse noise counts per 5 minutes on switched connections between subscribers in the Norwegian telephone network**

Supplement No. 17

NIPPON TELEGRAPH AND TELEPHONE PUBLIC CORPORATION.—*(Contribution COM Sp. A—No. 238, August 1972)*

TRANSMISSION CHARACTERISTICS OF THE GENERAL SWITCHED TELEPHONE NETWORK

Introduction

Although some transmission characteristics of the general switched telephone network in Japan were shown in Contribution COM Sp. A—No. 68 (see Supplement No. 15), the data are insufficient to present the overall connection characteristics and the measurement was especially made for facsimile transmission.

Further comprehensive measurement has been continued for data transmission to determine attenuation distortion, group delay distortion, impulsive noise and listener echo. The results are submitted in this contribution.

1. *Attenuation distortion*

Figure 1 shows the average value of attenuation distortions over seven circuit connections between extreme local exchanges. In the national network of Japan, the maximum number of circuits in established connections is seven (i.e. eight switching points).

The overall attenuation distortion between subscribers may be obtained by adding twice the average attenuation distortion of subscribers' lines to the data shown in Figure 1. The average attenuation distortion of subscribers' lines is obtainable, assuming that the attenuation distortion of non-loaded cable has a $\sqrt{f}$ curve and the average transmission loss of subscribers' lines at 1.5 kHz is 3.67 dB in Japan.

2. *Group delay distortion*

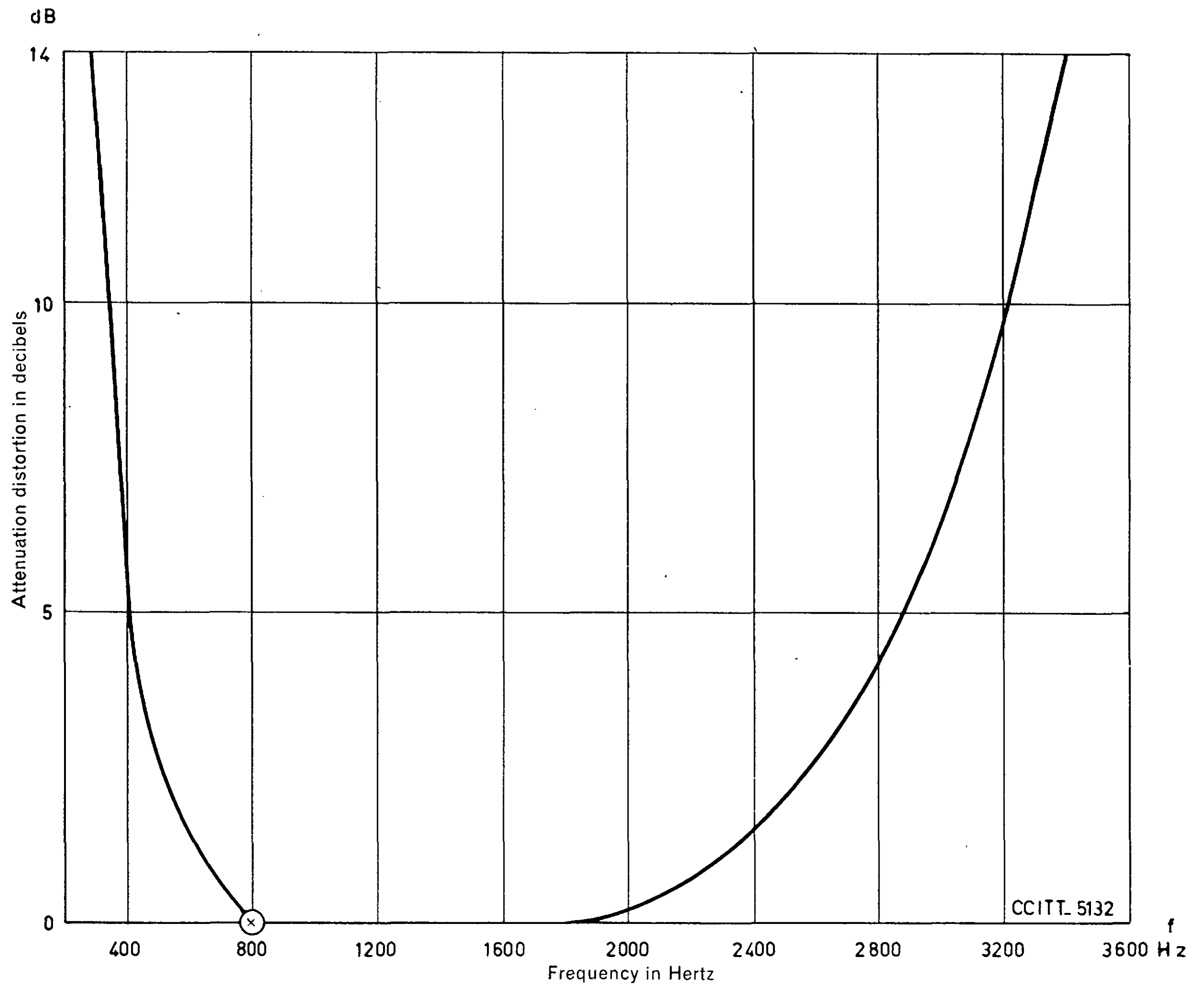
Figure 2 shows the average value of group delay distortions of connections between extreme local exchanges incorporating two loaded cable circuits, five carrier circuits and eight switching points shown in Figure 2. As group delay distortion of subscribers' lines is insignificantly small compared with those of connections between local exchanges, Figure 2 shows approximately the overall group delay distortion between subscribers.

3. *Impulsive noise*

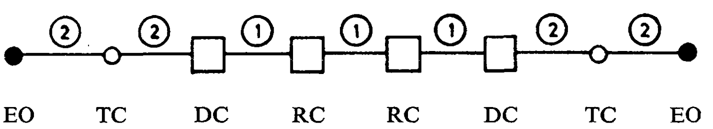
Figure 3 shows the average value of impulsive noise counts at the receiving end of connections between extreme local exchanges under the same conditions as for the group delay distortions.

4. *Listener echo*

Figure 4 shows the cumulative distribution of listener echoes (minimum signal-to-listener echo ratio) for trunk connections between subscribers which incorporate two loaded cable circuits, one carrier circuit and four switching points. This distribution may be regarded as representative of listener echo for the trunk calls in Japan, because most calls are carried by such a connection.



Note 1. — Assumed connection is as follows:

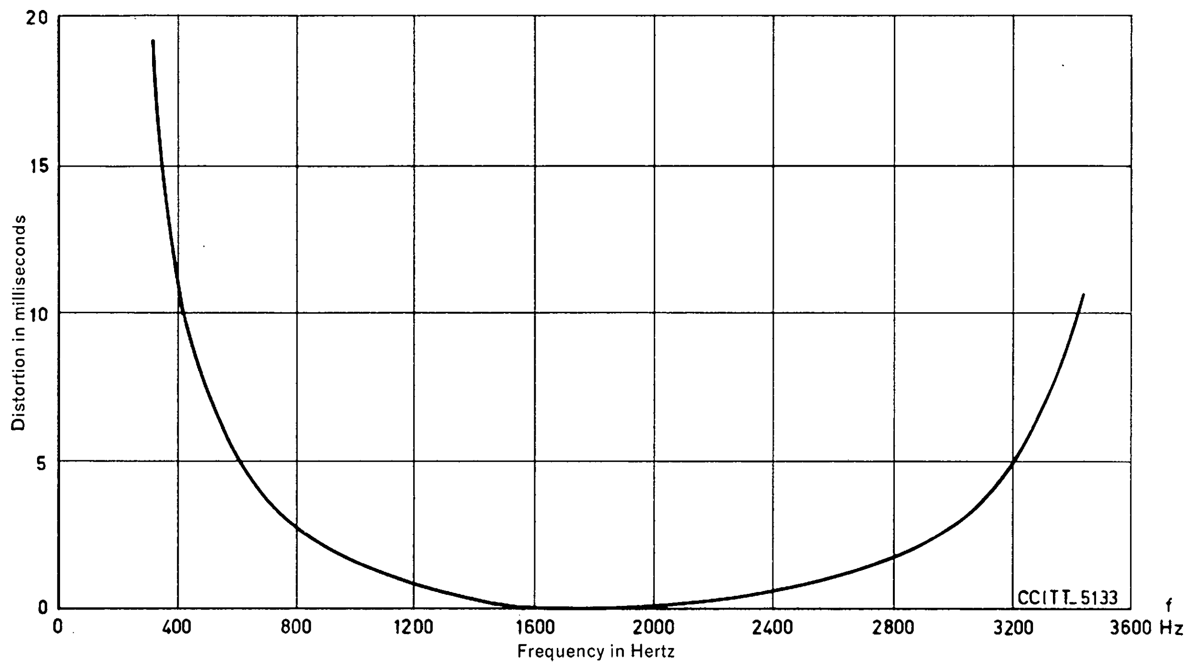


RC and DC = Four-wire switching facilities
TC and EO = Two-wire switching facilities

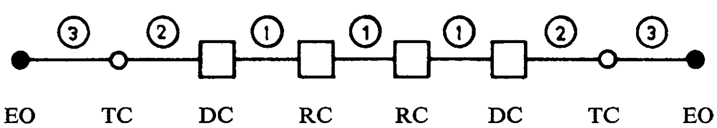
(1) long-distance circuit
(2) short-distance circuit

Note 2. — The curve is obtained by adding measured values of each circuit and switching point.

FIGURE 1. — **Average attenuation distortion between local exchanges**



Note 1. — Assumed connection is as follows:



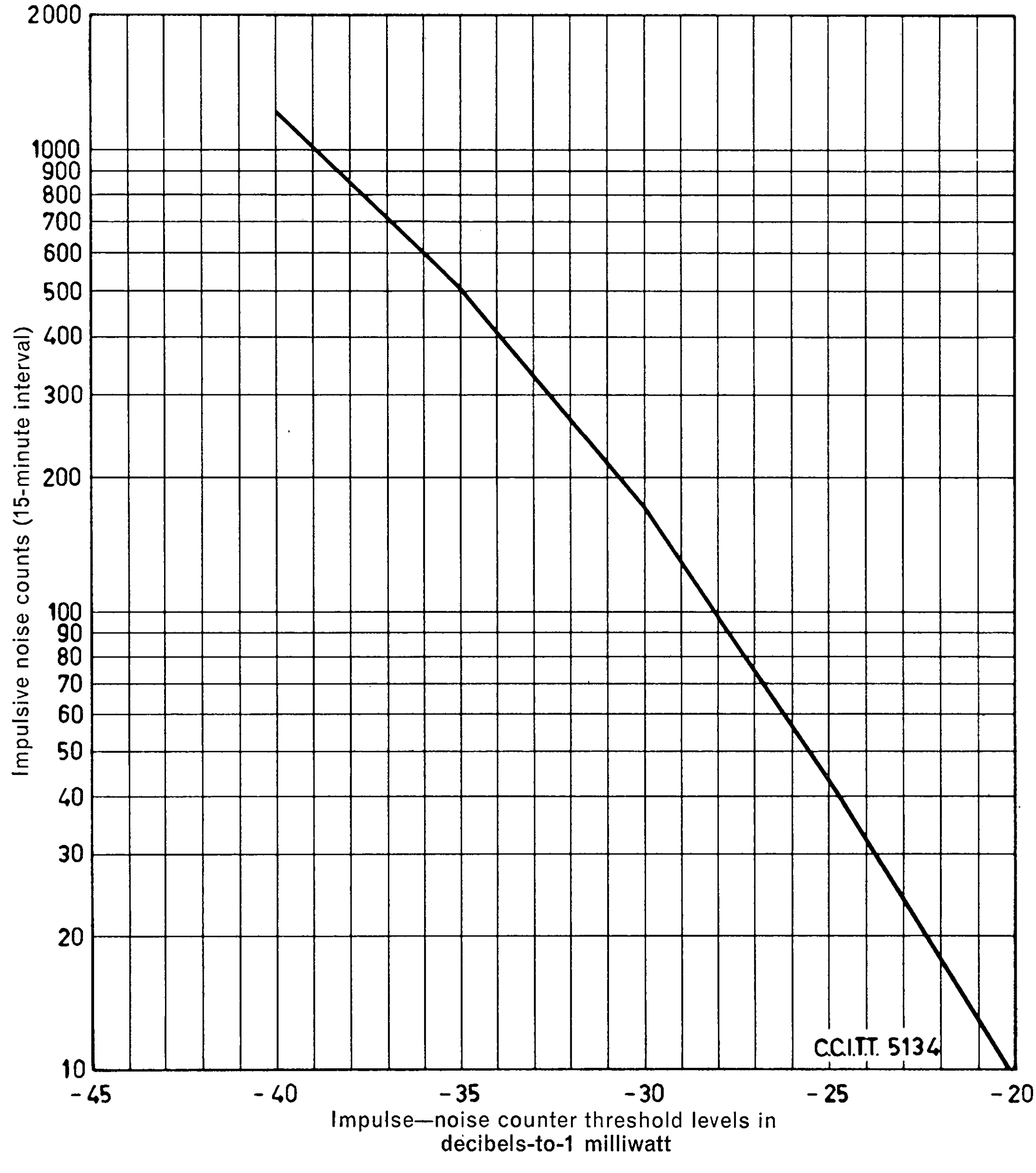
RC and DC = Four-wire switching facilities
TC and EO = Two-wire switching facilities

(1) long-distance circuit
(2) short-distance circuit
(3) loaded cable (about 15 km).

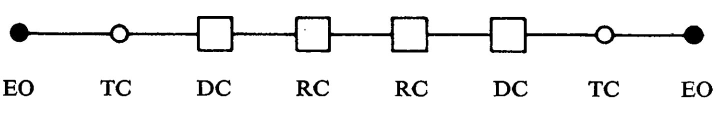
Note 2. — The curve is obtained by adding measured values of each circuit and switching point.

Note 3. — Sample size is about 50.

FIGURE 2. — **Average group delay distortion between local exchanges**



Note 1. — Assumed connection is as follows:



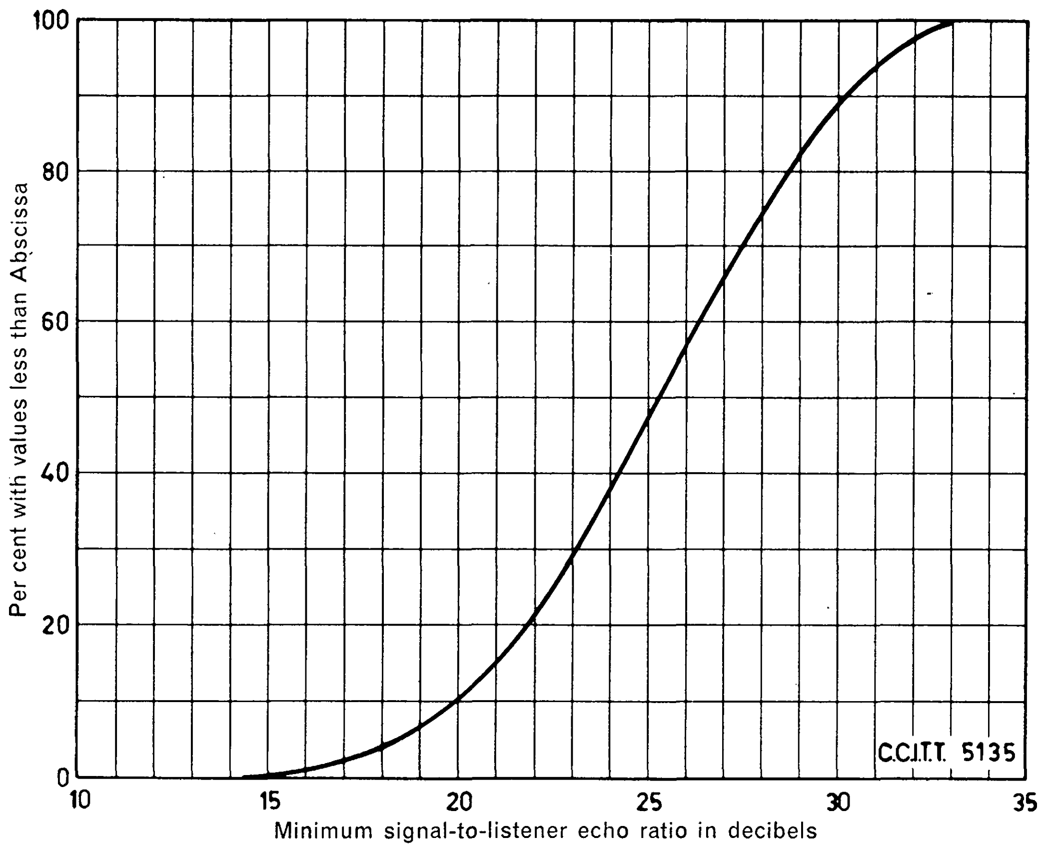
RC and DC = Four-wire cross-bar switching facilities
TC = Two-wire cross-bar switching facilities
EO = Two-wire cross-bar switching facilities or step-by-step switching facilities.

Note 2. — The curve is obtained by adding measured values of each circuit and switching point in reference to the receiving end (EO).

Note 3. — Sample size is about 50.

Note 4. — Impulsive noise of carrier circuits is not included because of their fewer counts.

FIGURE 3. — **Average impulsive noise counts between local exchanges**



Note 1. — Measurement frequency range is 300 Hz-3400 Hz.

Note 2. — Toll centres use 2-wire or 4-wire switching facilities.

Note 3. — Sample size is about 900.

Note 4. — Artificial subscribers' lines of various attenuation values are applied in the measurement.

FIGURE 4. — **Cumulative distribution curve of listener echo between subscribers**

Supplement No. 18

STUDY GROUP IV.—*(Reply to the Vth Plenary Assembly on Question 8/IV—Limits of impulsive noise for data transmission)*

LIMITS OF IMPULSIVE NOISE FOR DATA TRANSMISSION

1. *General*

In accordance with the proposals approved by Study Group IV at its meeting in May 1970, two series of tests of impulsive noise were organized in 1970, one on individual group channels between terminal repeater stations and the other on complete connections established between subscribers using the ordinary operational procedure in each relation concerned. Both programmes of tests were carried out quite independently of each other but the measuring device specified in Recommendation V.55 was used in each case.

2. *Limits of impulsive noise*

From information supplied by Special Study Group A, Study Group IV noted:

1) that the overall limits laid down in Recommendation V.53 are those specified in paragraph 4.1 of Recommendation V.53 in Volume VIII of the C.C.I.T.T. *White Book*;

2) that the limits refer to measurements made with the instrument specified in Recommendation V.55 used in the flat bandwidth condition and in accordance with the methods indicated in the Annex to Recommendation V.55;

3) that the limits apply to leased circuits and no limit is laid down for the general switched telephone network as specified in paragraph 4.2 of Recommendation V.53;

4) that the measurement points should be as shown in Recommendation V.51. They should be taken as closely as possible to the modem on the line side, but it should be noted that users' equipment may be placed between the modem and the line, in which case Administrations should determine the point of measurement.

3. *Tests on individual channels*

A number of international telephone channels were made available to repeater stations for several days so that they could count the number of noise pulses induced on the channels during periods of 15 minutes at different times.

The sensitivity threshold of the recording apparatus had been set at −18 dBm0 or −21 dBm0 or, in some cases, at lower values.

Results were submitted by the Administrations of Australia, Austria, France, Norway, Netherlands, Federal Republic of Germany, Hungarian People's Republic and the United Kingdom.

The results obtained on the percentage of tests during which no noise pulse, one noise pulse, 2 noise pulses, etc. were noted are shown in Tables 1 to 3 below. It was impossible to include the results submitted by Australia in these tables as they were given as the mean number of pulses per 15-minute observation period. The Australian results are therefore shown in a separate table (Table 4).

TABLE 1

SENSITIVITY THRESHOLD OF MEASURING APPARATUS: −18 dBm0

Channels tested	Number of tests	%	Percentage of 15-minute periods during which the following number of noise pulses was observed						
			0	1	2	3 to 5	6 to 10	11 to 18	> 18
Budapest-Vienna	168	100	91.0	4.2	1.8	1.2	0.6	0.6	0.6
Vienna-Budapest	61	100	63.9	13.1	6.6	8.2	6.6	1.6	0
Frankfurt/M-Paris	8	100	100	0	0	0	0	0	0
Paris-Frankfurt/M	16	100	62.5	25	6.3	6.2	0	0	0
London-Rotterdam	11	100	45.5	27.2	9.1	9.1	0	9.1	0
Rotterdam-London	677	100	99.2	0.6	0	0.2	0	0	0
Copenhagen-Oslo	46	100	93.5	6.5	0	0	0	0	0
Madrid-Paris	8	100	100	0	0	0	0	0	0
Brussels-Rotterdam	7	100	0	14.3	14.3	28.6	42.8	0	0
Copenhagen-Rotterdam	5	100	40	20	0	20	20	0	0
Copenhagen-Frankfurt/M	36	100	91.6	5.6	0	0	2.8	0	0
Vienna-Frankfurt/M	16	100	75	0	18.3	6.2	0	0	0
Brussels-London	680	100	98.5	1.2	0.3	0	0	0	0
Sydney-London	366	100	95.5	1.9	0.5	1.6	0.5	0	0
London-Sydney (Sat.) [a]	115	100	48	0	0	0	0	0	2
London-Sydney (Cable) [a]	101	100	34	0	0	0	0	0	14
Total	2105	—	2002	51	16	20	12	3	1
%		100	95.1	2.43	0.76	0.95	0.57	0.14	0.05
Global mean value		100	75.5	8.8	4.1	5.8	5.2	0.8	0.04

[a] These data were not taken into consideration in calculating mean values.

TABLE 2

SENSITIVITY THRESHOLD OF MEASURING APPARATUS: −21 dBm0

Channels tested	Number of tests	%	Percentage of 15-minute periods during which the following number of noise pulses was observed						
			0	1	2	3 to 5	6 to 10	11 to 18	> 18
Bonn-Paris	26	100	65.5	19.2	11.5		3.8		
Frankfurt/M-Paris	9	100	77.8	11.1		11.1			
Madrid-Paris	15	100	53.3	20	13.3	6.7		6.7	
Copenhagen-Oslo	42	100	80.9	11.9		4.8	2.4		
Copenhagen-Frankfurt/M	36	100	83.3	11.1	2.8	2.8			
Paris-Frankfurt/M	16	100	68.9	6.2	6.2	6.2		12.5	
Vienna-Frankfurt/M	16	100	81.3	12.5		6.2			
Rotterdam-London	173	100	98.3	1.7					
London-Sydney (Sat.) [a]	115	100	48						2
London-Sydney (Cable) [a]	101	100	34						14
Total	335	—	292	24	7	7	2	3	0
%		100	87.1	7.2	2.1	2.1	0.6	0.9	0
Mean %		100	76.1	11.7	4.2	4.8	0.8	2.4	

[a] These data were not taken into consideration in calculating mean values.

TABLE 3

SENSITIVITY THRESHOLD OF MEASURING APPARATUS: −24 dBm0

Channels tested	Total number of tests	%	Percentage of 15-minute periods during which the following number of noise pulses was observed						
			0	1	2	3 to 5	6 to 10	11 to 18	> 18
Frankfurt/M-Vienna	144	100	63.5	4.1	4.1	10.0	6.2	2.1	10.0
Madrid-Paris	10	100	20	20	20	20		20	
Total	154	—	92	8	8	17	9	5	15
%		100	59.8	5.2	5.2	11	5.9	3.2	9.7
Mean %		100	41.7	12.1	12.1	15	3.1	11	5

TABLE 4

RESULTS FURNISHED BY AUSTRALIA—IMPULSE NOISE TESTS

Row 1 shows average hourly percentage circuit occupancy from London, in terms of the busy hour occupancy which is shown as 100%. The remaining four rows show quarter-hourly average impulse noise counts, on the circuits and at the levels indicated. Readings were taken at different times over four days for each circuit, and the figures shown are averaged over between two and nine readings falling within that particular hourly period; the readings taken during the busy period exceeded four in each hourly period. A dash (—) indicates insufficient readings taken during a particular period. The times shown are GMT.

Circuit	Level	0800 to 0900	0900 to 1000	1000 to 1100	1100 to 1200	1200 to 1300	1300 to 1400	1400 to 1500	1500 to 1600	1600 to 1700	1700 to 1800	1800 to 1900	1900 to 2000	2000 to 2100	2100 to 2200	2200 to 2300	2300 to 2400	2400 to 0100	0100 to 0200	0200 to 0300	0300 to 0400	0400 to 0500	0500 to 0600	0600 to 0700	0700 to 0800
% Circuit occupancy		55	100	100	100	70	40	35	20	15	5	5	5	25	75	75	60	60	25	15	5	5	10	25	45
LON-SYD 30	−21 dBm0	17.7	2.9	4.6	12.3	0.8	0	0	0.6	4.7	3.6	4.7	12.0	0.3	0	5.0	2.3	3.3	0.5	0.5	0.8	6.3	2.2	0.8	3.6
	−18 dBm0	7.2	0.8	1.4	2.0	0.3	0	0	0.4	4.0	2.3	3.3	9.3	0.3	0	1.0	0	0.7	0	0	0.5	1.0	1.3	0.2	1.4
LON-SYD 30	−21 dBm0	1.3	55	14	5.0	4.5	4.5	—	4.0	0	—	—	0	0	—	10.5	7.7	2.0	0.8	—	1.3	5.8	7.0	8.0	93[a]
	−18 dBm0	1.2	46	0.3	0.8	3.0	2.0	—	1.5	0	—	—	0	0	—	4.5	3.2	0.6	0.5	—	0.8	3.8	5.5	4.7	84[a]

[a] There were a total of eight readings over the four days between these hours, including four successive readings on a particularly noisy day, where noise was caused by maintenance.

It will be seen from the above tables that, generally speaking, the telephone channels tested showed less than 18 noise pulses per 15-minute period, which meets the objective adopted by Special Study Group A.

The similarity between the results obtained with apparatus whose threshold was adjusted at -18 dBm0 and those whose threshold was adjusted at -21 dBm0 is somewhat surprising.

It is only with the threshold of -24 dBm0 that some impairment of quality is observed, but the number of samples available in this instance was insufficient for any valid conclusion to be drawn.

Some Administrations carried out measurements in which a data filter of the type defined in point h) of Recommendation V.55 was inserted in some cases. The results do not differ significantly from those obtained directly on international telephone-type channels.

4. *Tests on international switched connections*

These tests were carried out at the same time as the measurements made in connection with the reply to Question 21/IV.

The results are given as the mean number of pulses recorded with apparatus whose threshold was adjusted 18 dB below the received level when the normal generator at reference frequency (800 or 1000 Hz) is applied at the transmission end.

It is apparent from these results that the provision requiring less than 18 noise pulses per 15-minute period is satisfied only in a very small proportion of connections (probably 2 to 3%), the mean number of noise pulses recorded being more than 150 for 75% and more than 1000 for 25% of connections.

5. *Counts at the subscriber's station*

From the limited information available, it is noted that the noise impulse counts at the subscriber's station are considerably less than those measured on the international switched connections. As a tentative conclusion, this is due to the fact that, on national extensions, the threshold of the impulse counter could be set 18 dB below the *true* 0 dBm0 level at the subscriber's station. For measurements on international connections it has been mentioned elsewhere that the 0 dBm0 level at the receiving subscriber's station cannot *readily* be determined.

6. *Measurement results sent to Special Study Group A*

The results of the measurements, which are an integral part of the reply to Question 8/IV, have already been forwarded to Special Study Group A (Contribution COM Sp. A—No. 151/COM IV—No. 80) (see Annex 1 to Question 3/XVI of the *Green Book*, Vol. III).

7. *Conclusions*

It is certainly necessary to study the national extensions of international connections and no doubt special attention should be paid to switching equipment and local networks.

Furthermore, assuming that a further programme of tests will be carried out on international networks, it might be necessary to introduce additional measuring conditions either by adopting appropriate filters (which, if necessary, should be defined by Special Study Group A) or by using thresholds other than -18 dBm0.

Supplement No. 19

ITALIAN ADMINISTRATION *(Extract from Contribution COM Sp. A—No. 45, July 1970)*

WIDEBAND DATA TRANSMISSION TESTS

1. *Abstract*

We shall summarize here below the results of data transmission tests at 40 800 bit/s and measurements carried out over some circuits of the Italian wideband telephone network during 1969 by the Italian Administration in co-operation with S.I.P. (Italian Telephonic Operating Agency) and I.B.M. Italy.

The objectives of these tests were: to obtain the performance of various kinds of links existing in Italy in terms of error rate, to investigate, when possible, the factors which cause errors, to get statistics about transmission characteristics.

Total duration of tests was several hundred hours and for each link the sample was largely higher than the one proposed in Question 1/A, point L.

2. *Test programme*

The tests were performed at 40 800 bit/s with link set up in the basic group B. The programme covered the following connections:

— unloaded local cable;
— coaxial cable;
— coaxial cable GO and RETURN and radio link GO and RETURN;
— coaxial cable in tandem with radio link;
— coaxial cable in tandem with voice frequency cable;
— very-long-distance connection with different systems in tandem;
— very-long-distance connection with different systems in tandem with local cable at both ends.

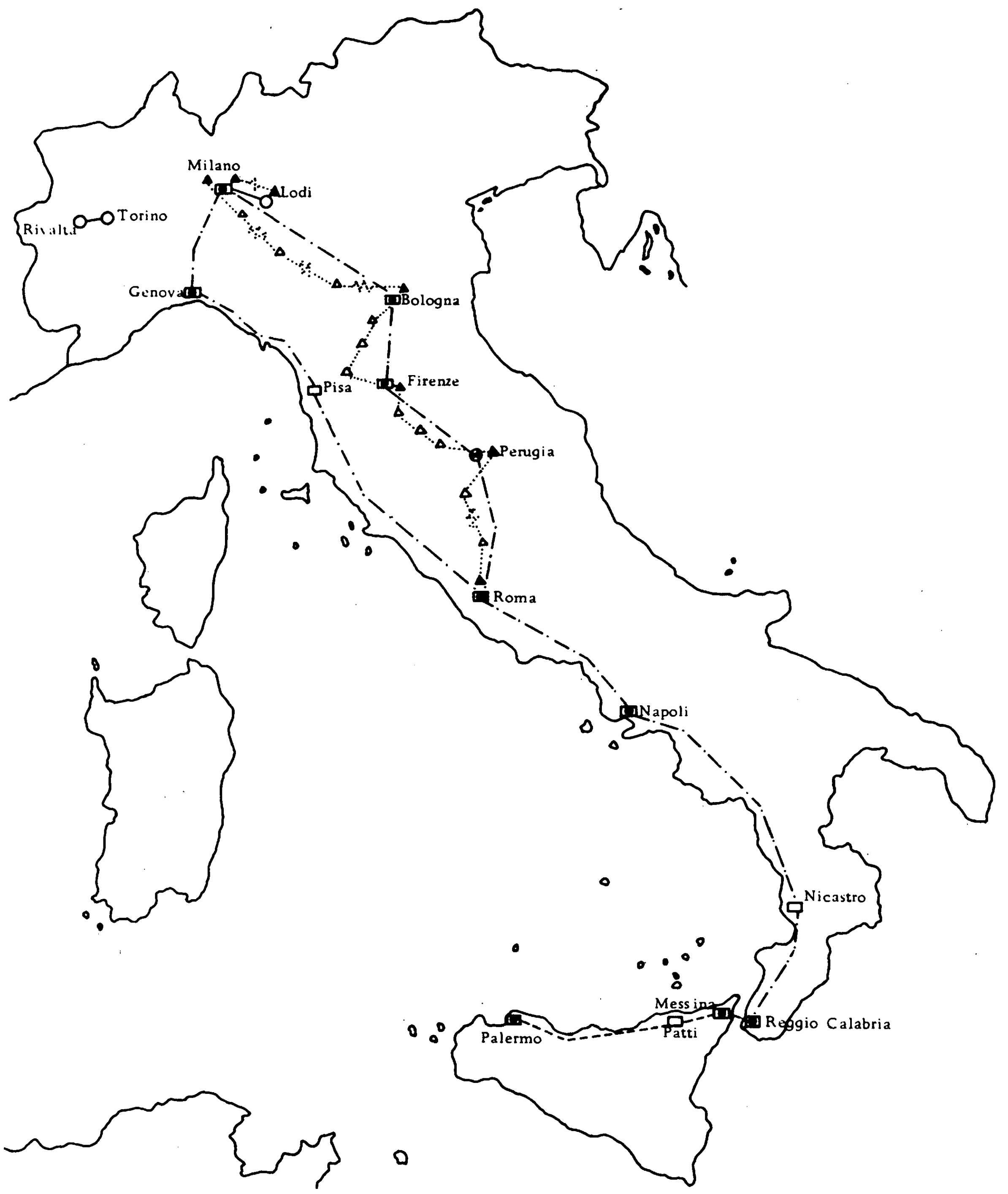
Transmission direction and test locations were selected in order to meet both the most significant transmission systems and the most likely potential customers in the country (Figure 1).

3. *Connection characteristics and set-up*

During the tests between terminal stations, the links were set up between group distribution frames and in every case the connection with data modems (D.C.E.) was implemented after through filters.

Normalized transmission and reception levels were respectively -30 dBm and -37 dBm, and during the tests carried out in the terminal repeater stations, external attenuators and amplifiers were equipped to meet the modem specifications.

During the tests on customers' premises the extension was realized via normal urban area local cables, and suitable wideband amplifiers and attenuation distortion equalizers were provided to guarantee the signal-to-noise ratio, the signal levels and the amplitude-frequency limit requested by D.C.E.



CCITT.3561

▣	Main terminal coaxial amplif. station	———	DM cable
▭	Terminal coaxial amplif. station	·····⋰⋱·····	Radio link
●	Main coaxial amplif. station with drop	— — —	4-MHz coaxial cable
▲	Radio link terminal station	— · —	12-MHz coaxial cable
△	Repeating station		

FIGURE 1. — Network

It was noticed that the most important share of group-delay distortion was due to through filters. In addition, we noticed that during loop tests and tests with two systems in tandem, it was possible to receive with three of the above filters without any trouble (the third one placed respectively at the loop point or at the input of second group link).

During the tests over the long-distance links the 84.08 kHz group pilot was disconnected without degrading the performances of the transmission. In fact, the level stability guaranteed by supergroup pilot was widely contained in the range of the D.C.E. AGC amplifier.

4. *Measurements and sample size*

The following measures have been performed in every connection:

— amplitude-frequency response;

— envelope delay-frequency response;

— near-end and far-end crosstalk;

— background noise after through filter;

— bit and block error rate (with on-line recording);

— impulse noise rate (with on-line recording).

A summary of methods followed regarding the impulse noise rate will be reported below in the test terminal equipments. This measure has been performed to investigate whether, for a given connection, a threshold exists for which the ratio of the time of impulse noise above this limit with respect to the test time, here defined as impulse noise ratio, and the bit error rate, are of the same order of magnitude. This is to try to establish a simple means of connecting quantitatively impulse noise and errors.

For each test the previous objective was to get at least 24 hours of consecutive transmission and of noise recording too during working days. In practice, we investigated also the effects of normal maintenance, signalling systems, circuit rerouting, system load, etc.

5. *Test terminal equipments*

The measuring apparatus is of the same type foreseen in Recommendation V.52. It is also equipped with a threshold amplifier to perform noise measurement. Data transmission and noise measurements are performed at different times. The threshold amplifier has an integration time of 25 μs; over-comings are sampled with a 200-kHz squared signal (resolution of 5 μs) and are cumulated on the same decade counter used for errors.

For each link, the threshold setting is performed trying to get an impulse noise ratio as close as possible to the previously detected bit error rate.

To reach this desired result, the first threshold value is fixed in accordance with the operator experience. Sample time is generally 15 minutes.

After analysing the first result, if necessary, threshold is corrected to reach the expected value. As soon as threshold is defined the measure, at least 24 hours long, will start.

The content of the counter, via an external buffered adapter, feeds, every 1, 10 or 20 seconds, a paper tape punch. The process by a computer (I.B.M. 1130) of these paper tapes provides the trend of errors and of noise.

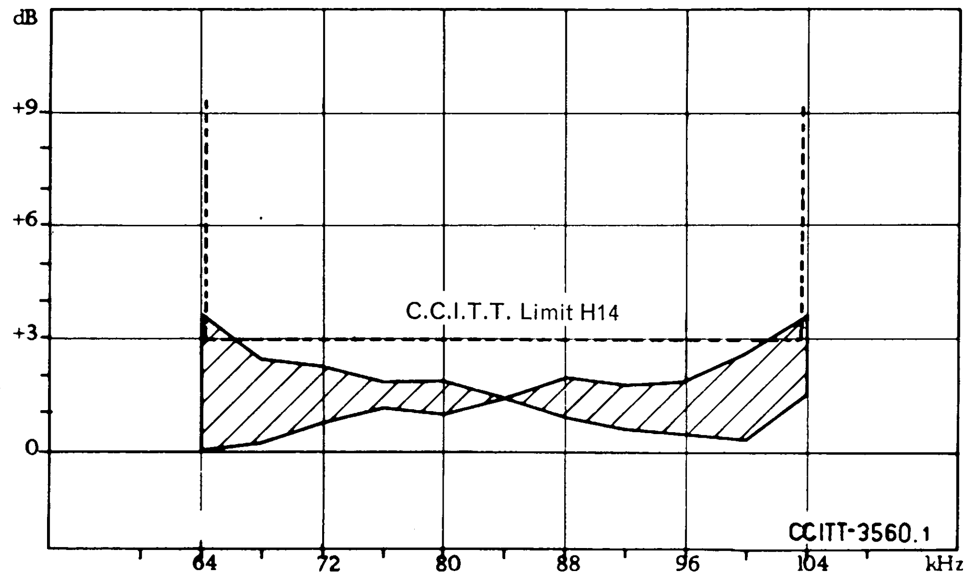
The D.C.E.s employed during the tests were the I.B.M. 3978 mod. 1 working at 40 800 bit/s. They are four-phase digital echo modulation modems with the transmission spectrum displaced on the 69.1-99.7 kHz band. More details and principles of operation can be found in Contribution COM Sp. A—No. 150, period 1964-1968.

6. *Results analysis and conclusions*

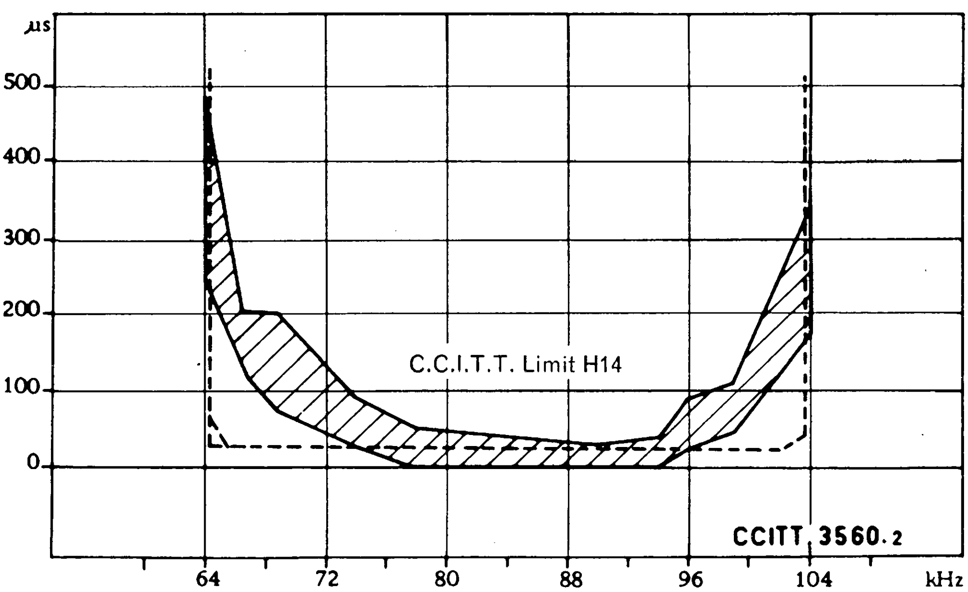
6.1 *Attenuation and phase distortion*

Statistics of all the characteristics taken during the tests are assumed as shown here below:

Attenuation distortion



Group delay distortion



Comparing the second diagram with the limit proposed in Recommendation H.14, we can notice that normal links do not entirely comply with the above specifications.

From this point of view, the results obtained, which comply with users' needs, have been reached without any submission to the limits of group delay distortion specified by Recommendation H.14.

This is quite an interesting point, because utilizing a well-defined type of D.C.E. transmitting at 40 800 bit/s, it is not necessary to modify any existing terminal station equipments to give a reliable data service.

6.2 *Pilot*

Group pilot equipments during tests over carrier systems were disconnected. To investigate its effect, a transmission was tried in the presence of pilot, but modems did not get synchronism.

This is because the pattern required by modem for synchronization purposes (101010 . . .) and its carrier (64 kHz) give a spectral component of 84.4 kHz closely near to 84.08 kHz pilot and the presence of pilot stop-filter introduces an unacceptable phase distortion.

6.3 *Error rate and noise*

General test results are reported in Table 1.

TABLE 1

GENERAL TEST RESULTS

Test	Block error rate	Bit error rate	Average error bits per block	Duration	Link type
1	1.07×10^{-5}	2.1×10^{-7}	10	51 h. 33′	Local cable
2	1.44×10^{-5}	4.3×10^{-6}	152	32 h.	Coaxial cable
2*	1.83×10^{-7}	2.14×10^{-9}	6	10 h.	” ”
3.1	7.7×10^{-5}	1.5×10^{-5}	104	56 h. 18′	Coaxial cable I GO and RETURN
3.2	2.5×10^{-5}	8.5×10^{-6}	173	32 h.	Radio link GO and RETURN
3.3	2.07×10^{-5}	7.2×10^{-6}	177	48 h. 3′	Coaxial cable II GO and RETURN
4.1	1.77×10^{-5}	1.16×10^{-6}	33	94 h. 48′	Coaxial cable + radio link
4.1*	6.5×10^{-6}	8.4×10^{-8}	6	25 h.	” ” ” ”
4.2, 4.3	6.91×10^{-5}	1.58×10^{-6}	12	95 h. 58′	Coaxial cable + V.F. cable
5.1	1.43×10^{-4}	5.84×10^{-6}	21	93 h. 1′	Two systems in tandem
5.2	1.78×10^{-4}	1.22×10^{-5}	35	169 h. 13′	Same + local connections

Note. — Test 2*, with a 900-channel block rerouted over another system.
Test 4.1* carried out only during night hours.

Bit error rate distribution diagrams (Annex 1, Figure 4 and following) show that, as for medium speed telephone links, the main share of errors happens during high traffic hours.

We can mainly consider two factors that cause errors to occur.

The first is the intermodulation noise. In terms of error rate we can see the influence of this noise comparing:

— in Test No. 4.1 * the night-time error rate against the whole test error rate;

— in Test No. 2 * the error rates of normal tests against those we got by rerouting a 900-channel block out of a 2700-channel system over another system.

The decrease of error rates has been of one and two orders of magnitude for Tests No. 4.1 * and No. 2 * respectively compared with Tests No. 4.1 and No. 2.

The second factor, which seems to cause the main share of errors, is more difficult to outline. It appears in the form of long bursts of noise pulses and we suppose it is due to different reasons such as: human intervention for reroutings, random failures over the system, recovery automatic switchings and so on.

Obviously to minimize the effects of the second factor on error statistics, it is very difficult to define the size of the test sample. In practice, analysing the on-line recordings and comparing the dispersion of block error rate and of bit error rate, it was found that there is a high error concentration in very short periods, the effects of which would be quite negligible on real data links, except in some very special applications.

6.4 *Impulse noise rate*

Some of the annexed diagrams show that in some cases it was possible to find a certain connection between bit error rate and noise rate defined as in point 4, and in others not.

The reason for which the trend of bit error rate and noise rate diagrams are not always similar is probably due to the fact that both rates change widely in the test time and there is no possibility of detecting such events simultaneously, while at the same time there are many difficulties in fixing the threshold at the proper value.

6.5 *Local connections*

The results of Tests 1 and 5.2 showed that it is possible to use urban local cables to implement connections between customers' premises and terminal stations, amplified and equalized, if necessary. This experience seems to exclude, for the modem used, the necessity to implement a special distribution network to furnish this class of service.

ANNEX

Figure 1: general view of test network.

From Figure 2 to Figure 43 and from Table 2 to Table 16 for each test are given:

a) the characteristics of the link such as:

- test locations,
- type of link,
- total length in m and km,
- transmitted and received levels,
- input and output impedance,
- amplitude and envelope delay frequency curves;

b) a table reporting:

- transmitted blocks and bits,
- erroneous blocks and bits,
- block and bit error rate,
- average number of erroneous bits within erroneous block,
- test duration in hours and minutes;

c) a distribution diagram of the bit error rate versus the hour of day integrated every 30 minutes;

d) a distribution diagram of the impulse noise rate versus the hour of day for a defined signal-to-noise ratio threshold, integrated every 30 minutes.

Items c) and d) are a synthesis obtained from the process of paper tapes.

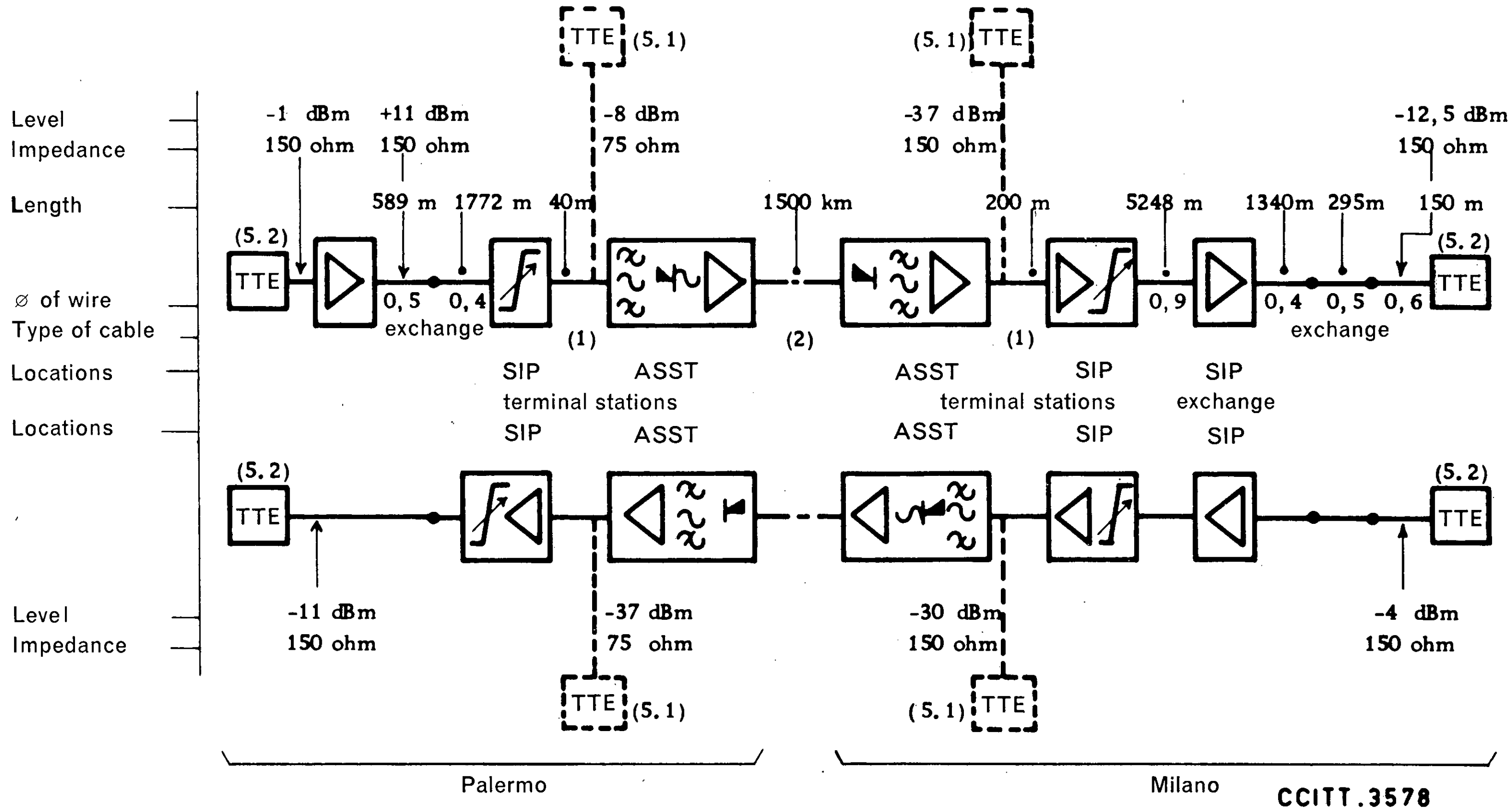
Furthermore, for tests 4 and 5 (Table 1), items b) c) and d) are repeated for both transmission directions.

Test 5

Link: Milano-Palermo

Type: 5.1 Very-long-distance connection with different systems in tandem
5.2 Very-long-distance connection with different systems in tandem with local cable at both ends

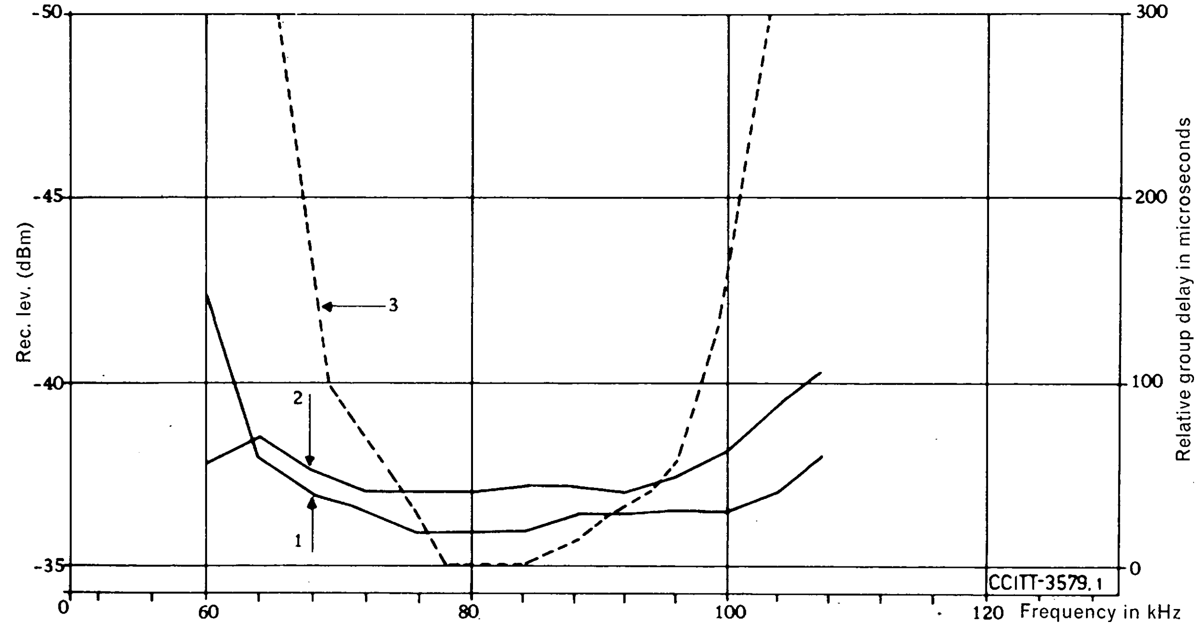
Total length: 1509.594 km



(1) = Connection cable between ASST-SIP terminal stations
(2) = Milano-Messina, 12 MHz coaxial cable with Milano to Roma GR 4—S/GR 3—BLOCK 1
Roma to Messina GR 4—S/GR 2—BLOCK 1
Messina-Palermo, 4 MHz coaxial cable with Messina to Patti GR 4—S/GR 14
Patti to Palermo GR 4—S/GR 16

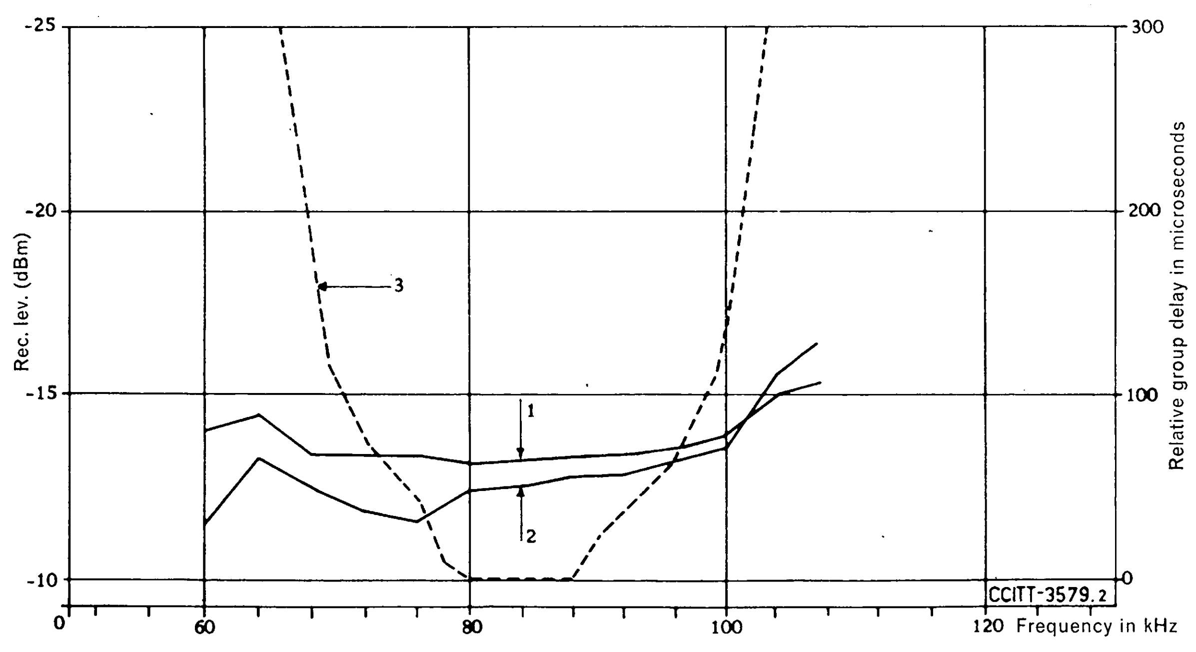
TTE = Test terminal equipment

FIGURE 33. — **Connection arrangement**



1-2 = Rec. lev. Milano to Palermo and Palermo to Milano
3 = Relative group delay, Palermo to Milano

FIGURE 34. — **Frequency response, with communication facility type 5.1**



1-2 = Rec. lev. Milano to Palermo and Palermo to Milano
3 = Relative group delay, Palermo to Milano

FIGURE 35. — **Frequency response, with communication facility type 5.2**

b) *Results in Palermo, with communication facility type 5.1*

TABLE 13

Transmitted		Erroneous		Error rate		Average error bits per block	Test duration
Blocks ($\times 10^3$)	Bits ($\times 10^6$)	Blocks	Bits	Block	Bit		
13 361	6827	264	19 695	1.9×10^{-5}	2.8×10^{-6}	74	46 h 29′

c) *Distribution of bit error rate versus hour of day*

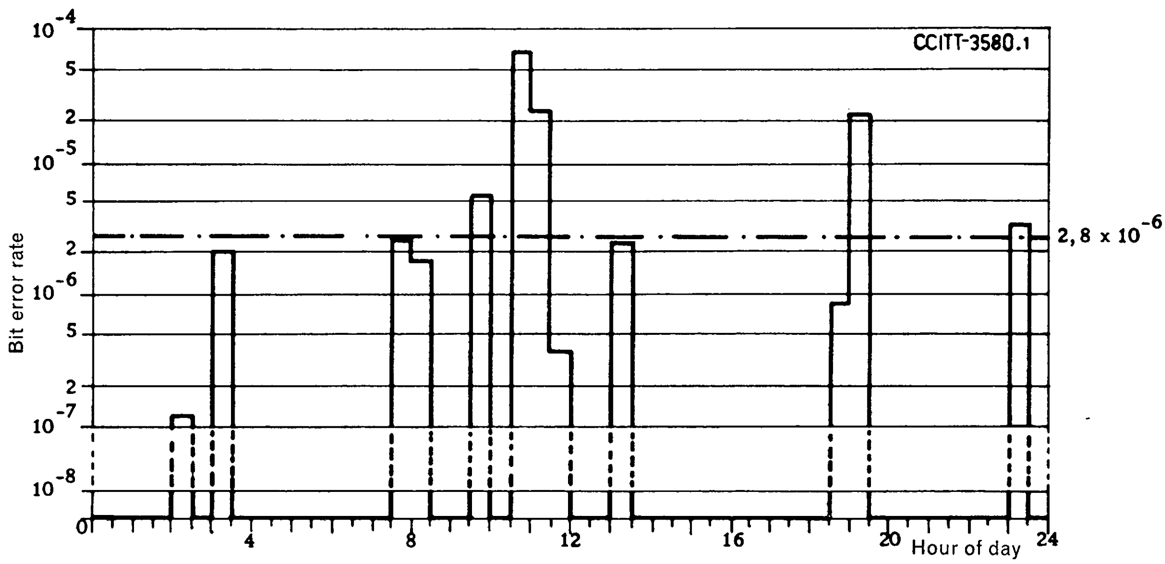


FIGURE 36

d) *Distribution of noise rate versus hour of day*

Threshold level: 10 dB

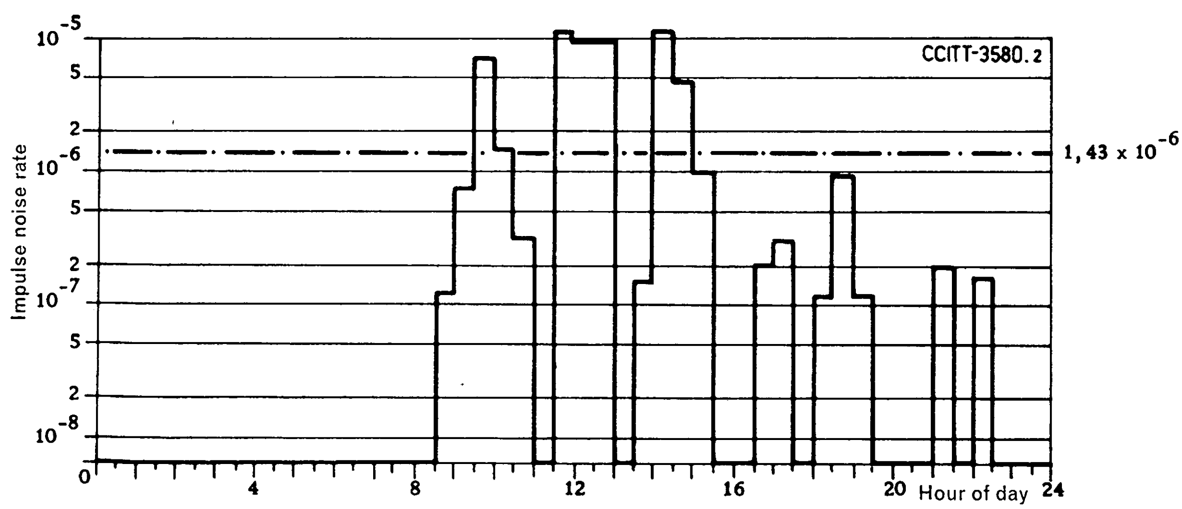


FIGURE 37

b) *Results in Milano, with communication facility type 5.1*

TABLE 14

Transmitted		Erroneous		Error rate		Average error bits per block	Test duration
Blocks (× 10^3)	Bits (× 10^6)	Blocks	Bits	Block	Bit		
13 375	6834	3577	60 104	2.6×10^{-4}	8.8×10^{-6}	16	46 h 32′

c) *Distribution of bit error rate versus hour of day*

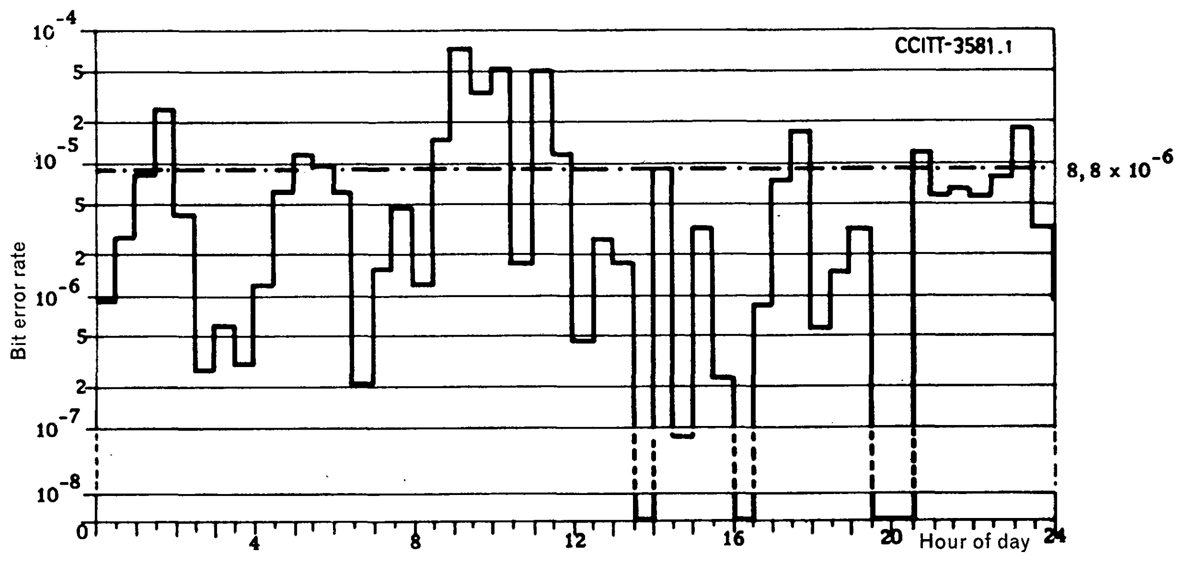


FIGURE 38

d) *Distribution of noise rate versus hour of day*

Threshold level: 10 dB

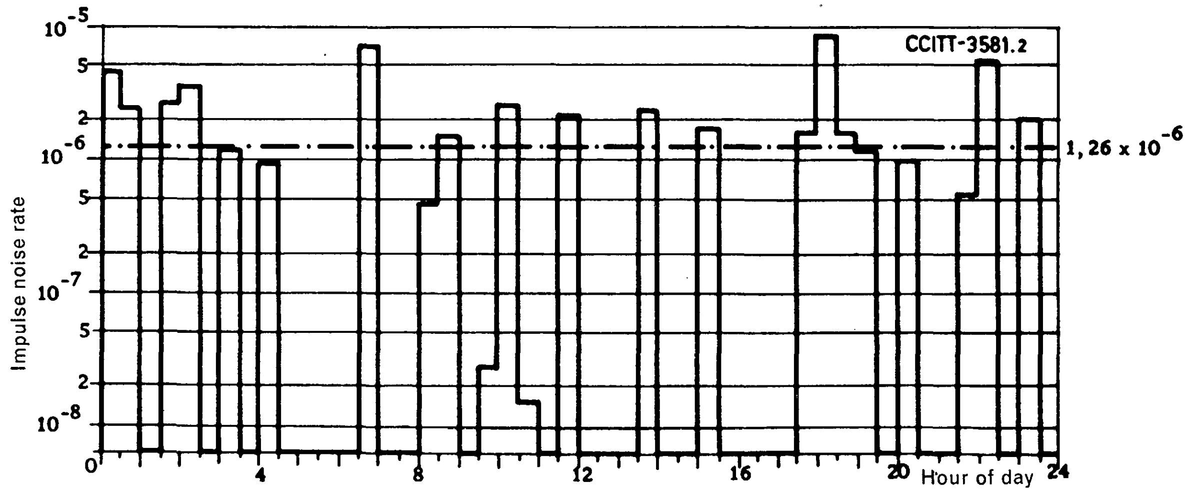


FIGURE 39

b) *Results in Palermo, with communication facility type 5.2*

TABLE 15

Transmitted		Erroneous		Error rate		Average error bits per block	Test duration
Blocks ($\times 10^3$)	Bits ($\times 10^6$)	Blocks	Bits	Block	Bit		
31 953	16 328	5448	76 086	1.7×10^{-4}	4.6×10^{-6}	14	111 h 10′

c) *Distribution of bit error rate versus hour of day*

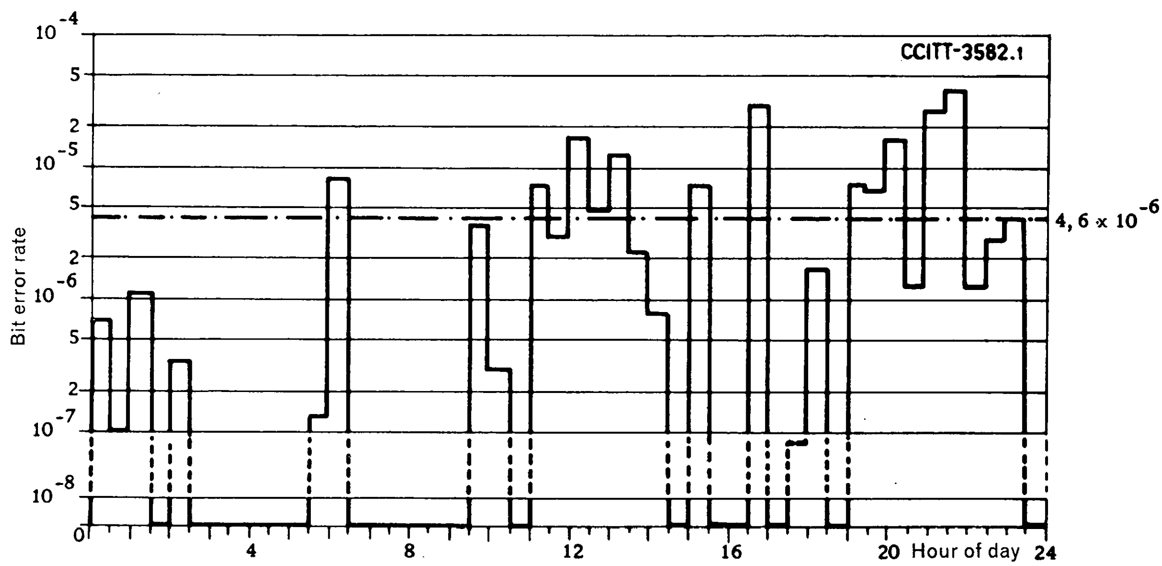


FIGURE 40

d) *Distribution of noise rate versus hour of day*

Threshold level: 10 dB

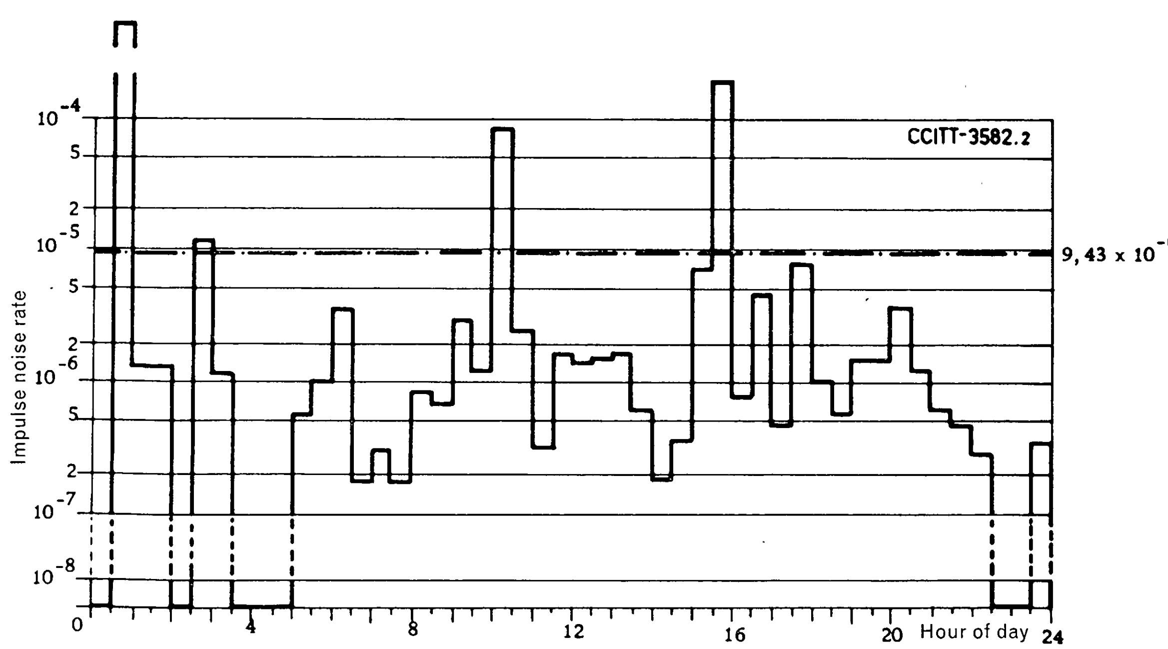


FIGURE 41

b) *Results in Milano, with communication facility type 5.2*

TABLE 16

Transmitted		Erroneous		Error rate		Average error bits per block	Test duration
Blocks (× 10^3)	Bits (× 10^6)	Blocks	Bits	Block	Bit		
16 685	8526	3254	228 443	1.9×10^{-4}	2.6×10^{-5}	70	58 h 3′

c) *Distribution of bit error rate versus hour of day*

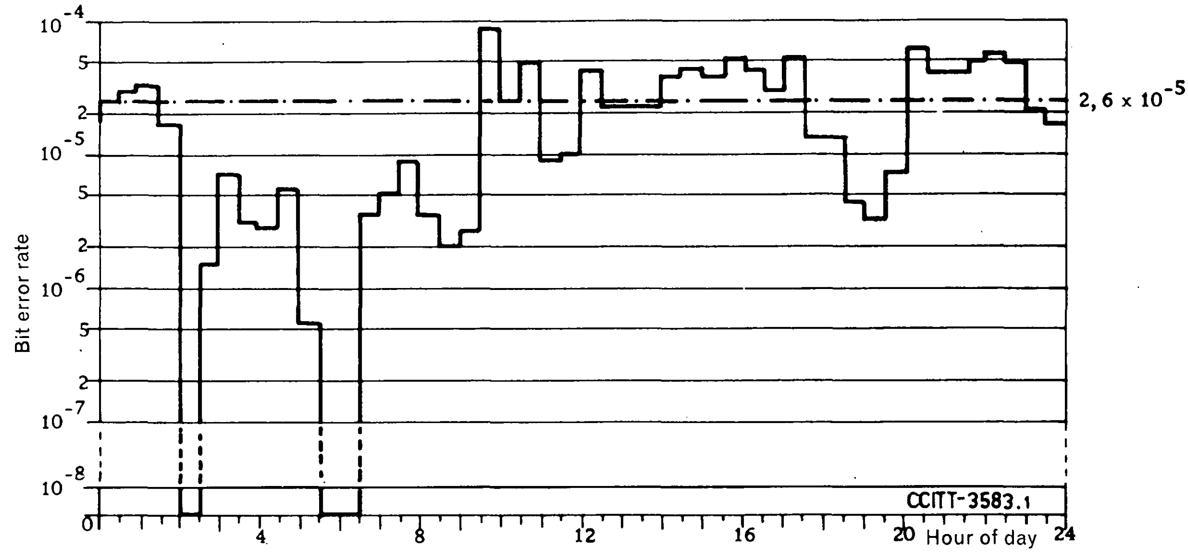


FIGURE 42

d) *Distribution of noise rate versus hour of day*

Threshold level: 8 dB

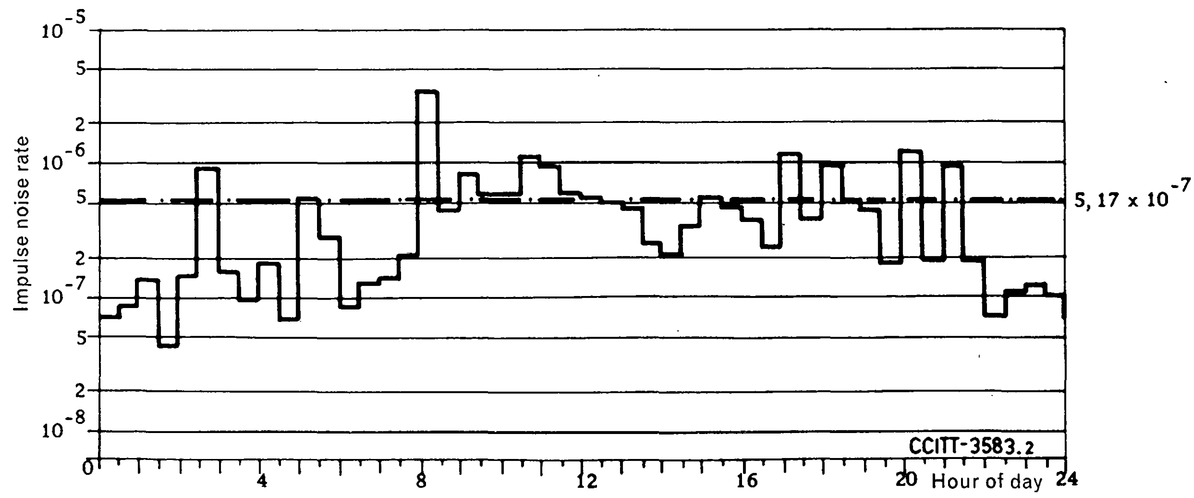


FIGURE 43

Supplement No. 20

THE U.S.S.R. TELECOMMUNICATIONS ADMINISTRATION.—*(Contribution COM Sp. A—No. 97 October 1970)*

TESTS OF A DATA TRANSMISSION SYSTEM OVER WIDEBAND CIRCUITS

The U.S.S.R. Telecommunications Administration has already proposed to standardize the 72 kbit/s modem for operation over 48-kHz bandwidth channel. Characteristics of this modem are described in Annex 2 to point Z of the Study Programme of Special Study Group A. Some results of laboratory and line tests of the modem were given there.

This paper summarizes the results of new line tests of the modem carried out in September-December 1969.

Arrangement of the test connection

The test connection was set up on a loop-shaped circuit.

Data signalling rate

72 kbit/s. The 8-phase modulation method was used in the modem; therefore, the modulation rate in the channel was 72 : 3 = 24 kilobauds.

The signal level was −5 dBm0.

Transmitted information—a pseudorandom sequence length of 370 bits.

The data transmission system tested

In addition to the modem described in Annex 2 to Question 1/A-point Z, an automatic fine equalizer was used for equalizing attenuation distortion of a wideband circuit.

Information on connections used for tests

The 60-108-kHz circuits were equipped at terminals with a channel translating equipment comprising channel filters, an adjusted pre-equalizer and rejection filters. The through-connection equipment comprising through-connection filters and their phase equalizers was inserted into the dropping-off points in the 60-108 frequency range.

Two circuits with the following characteristics were used for measurements:

Circuits No.	No. 1	No. 2
Carrier system	60-channel system	60-channel and 1920-channel systems
Group used	No. 2 and No. 4	No. 2 and No. 4
Supergroups used	—	No. 3
Number of links	4	10
Circuit length (km)	1000	3500
Frequency characteristics distortion in the 66-102-kHz frequency band:		
a) after equalization with the pre-equalizer	2 dB 50 microseconds	8 dB 100 microseconds
b) after additional equalization with the fine equalizer	1.5 dB 15 microseconds	1.5 dB 20 microseconds

When carrying out the tests, rejection filters for operation at a frequency of about 84 kHz were absent in the circuit (the effect of such rejection filters is still being studied). For the tests, rejection filters operating at frequencies of about 64 and 104 kHz were inserted into the circuit.

The time of tests

The tests were carried out during the daylight hours.

Breaks of a connection used for a test

When evaluating error rates, circuit breaks the duration of which exceeded a certain value were ignored. In such cases the circuit was considered to be " out-of-service ".

Method of tests

All the errors were recorded on a magnetic tape and then were put into a computer which processed the results of measurements.

Results of tests—Test stage No. 1

Channel No. 1 was used. Thirty measurements were made. During each measurement (about 4 hours and 15 minutes) 1 100 000 000 bits approximately were transmitted; 32 419 313 106 bits were transmitted in total (about 125 hours). From one measurement to another, bit error rate varied from 8.1×10^{-6} to 2.4×10^{-3}. During 30 measurements 13 993 940 erroneous bits were detected. Hence, average bit error rate was 4.6×10^{-4}.

When processing experimental data, circuit breaks the duration of which exceeded 2 minutes were ignored.

During the same measurements block error rate was determined. Forty-one measurements were made. During each measurement 3 500 000 blocks of 370 bits length were transmitted. From one measurement to another, block error rate varied from 1.5×10^{-4} to 1.7×10^{-2}. During 41 measurements (about 204 hours) 142 679 000 blocks were transmitted in total and 498 163 erroneous blocks were detected. Hence, average block error rate was 3.5×10^{-3}.

A block containing even only one erroneous bit was regarded as an erroneous one.

Test stage No. 2

Channel No. 1 was employed. There were transmitted 3 572 340 660 bits (about 14 hours). 122 663 errors were detected. Hence, average bit error rate was 3.4×10^{-5}.

When processing experimental data, circuit breaks the duration of which exceeded 300 milliseconds were ignored.

Test stage No. 3

Fifteen measurements were carried out over channel No. 2 having a great number of links. During each measurement 11 465 800 bits (about 2 minutes and 40 seconds) were transmitted, 171 987 000 bits were transmitted in total (about 40 minutes). From one measurement to another the number of erroneous bits varied from 2 to 409. Therefore, bit error rate varied from 1.7×10^{-7} to 3.6×10^{-5}. During 15 measurements 2 332 erroneous bits were detected. Hence, average bit error rate was 1.4×10^{-5}.

During 15 measurements 491 520 blocks with the length of 350 bits each were transmitted. 84 erroneous blocks were received. Hence, average block error rate was 1.7×10^{-4}.

When processing experimental data, circuit breaks the duration of which exceeded 300 milliseconds were discarded.

Supplement No. 21

FRENCH ADMINISTRATION.—*(Contribution COM Sp. A—No. 136, February 1971)*.

CHARACTERISTICS OF GROUP LINKS FOR WIDEBAND SIGNAL TRANSMISSION

1. *Introduction*

This contribution describes tests carried out in France with data transmission at 48 kbit/s on group links for the purpose of determining those characteristics of group links which permit good quality transmission of data signals.

The proposals for amending Recommendation H.14 are to be found at the end of this document.

2. *Measurement principle*

The quality of the data transmission on the group link being tested was characterized by the variation of the error rate on bits as a function of the corrected signal/noise ratio:

$$\frac{E}{N} = \frac{\text{signal power}}{\text{noise power}} \cdot \frac{\text{passband (Hz)}}{\text{speed (bit/s)}}$$

The signal and noise powers were measured at the output of the receiving filter of the modem. Noise was inserted at the receiver input by means of a white noise generator (see measuring assembly in Figure 1).

This method is useful because comparison between the different tests is possible.

Furthermore, counts were taken of errors of long duration on certain circuits.

3. *Modem used*

The modem used was a 48-kbit/s modem conforming to C.C.I.T.T. Recommendation V.35. Only the lower sideband of the modulation was transmitted.

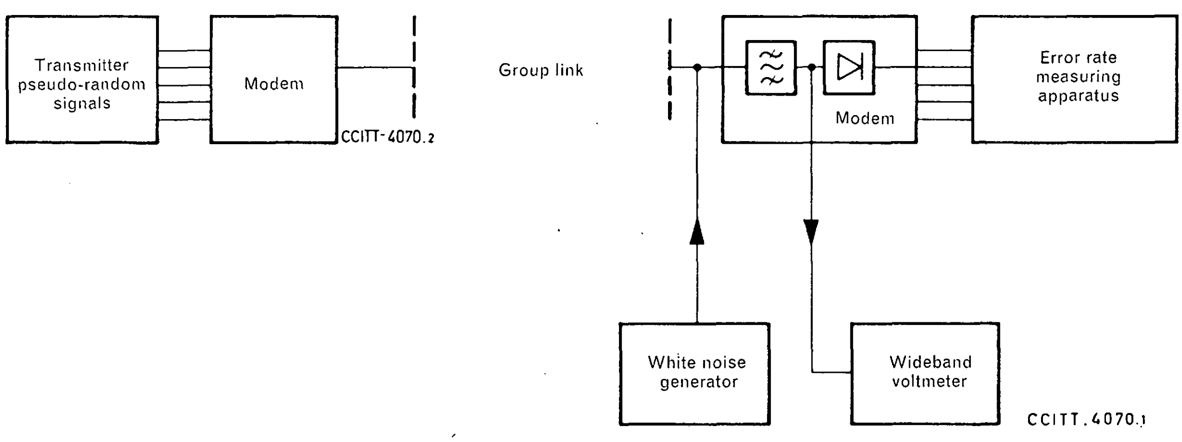


FIGURE 1. — **Measurement assembly**

4. *Measurements*

Two types of test were arranged: on local equipment and on line equipment.

1) *Back-to-back tests*

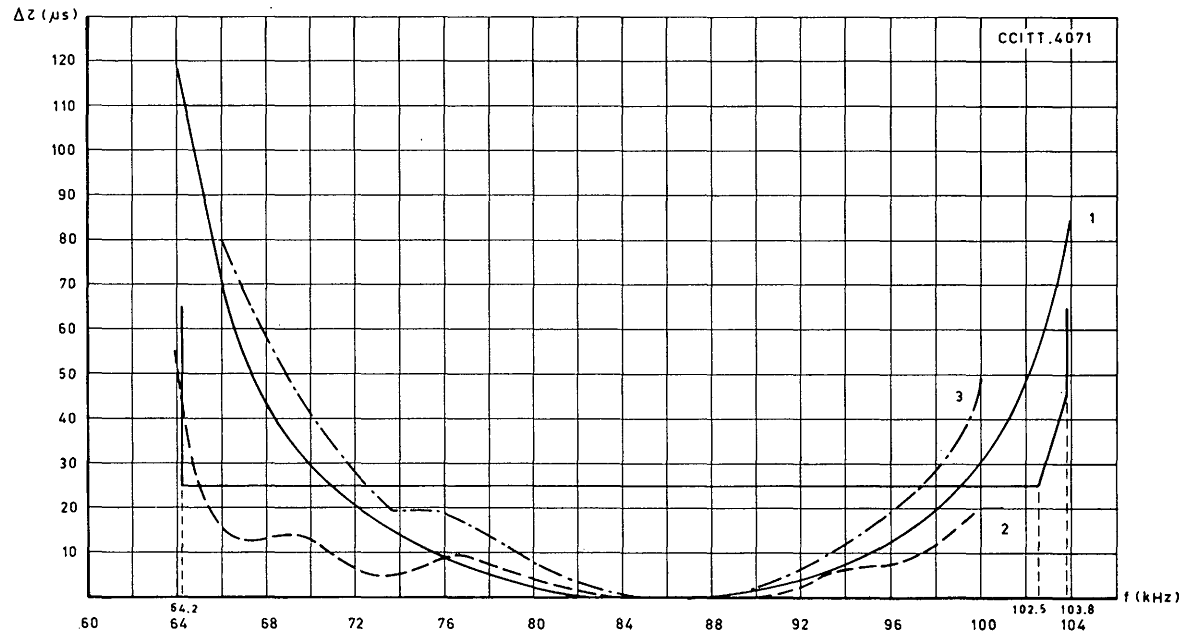
These tests consisted of looping successively the transmitter and receiver of the modem through:

— a through group filter;

— a through group filter summarily phase corrected;

— a through group filter summarily corrected plus a non-corrected through filter.

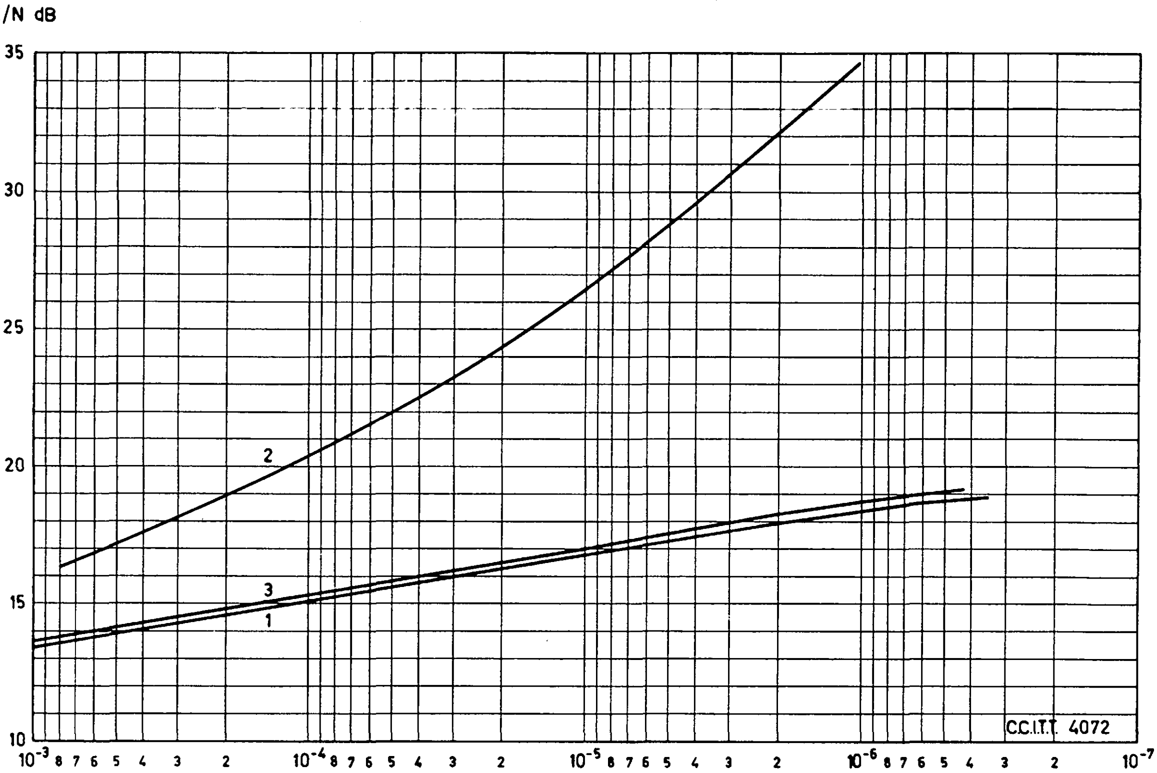
The group delay distortions of these different networks are given in Figure 2.



1 ———— = through group filter
2 — — — = through group filter corrected
3 —.—.— = through group filter corrected + second through filter

FIGURE 2. — **Group delay distortion**

The error rates obtained as a function of the signal/noise ratio are shown in Figure 3. On the network consisting of two through filters and a corrector, transmission was not possible. The tests therefore point to an initial limitation on the phase distortion permissible on a group.



Curve 1 = modem looped
Curve 2 = modem looped through filter
Curve 3 = modem looped through filter corrected

FIGURE 3. — **Error rate—back-to-back tests**

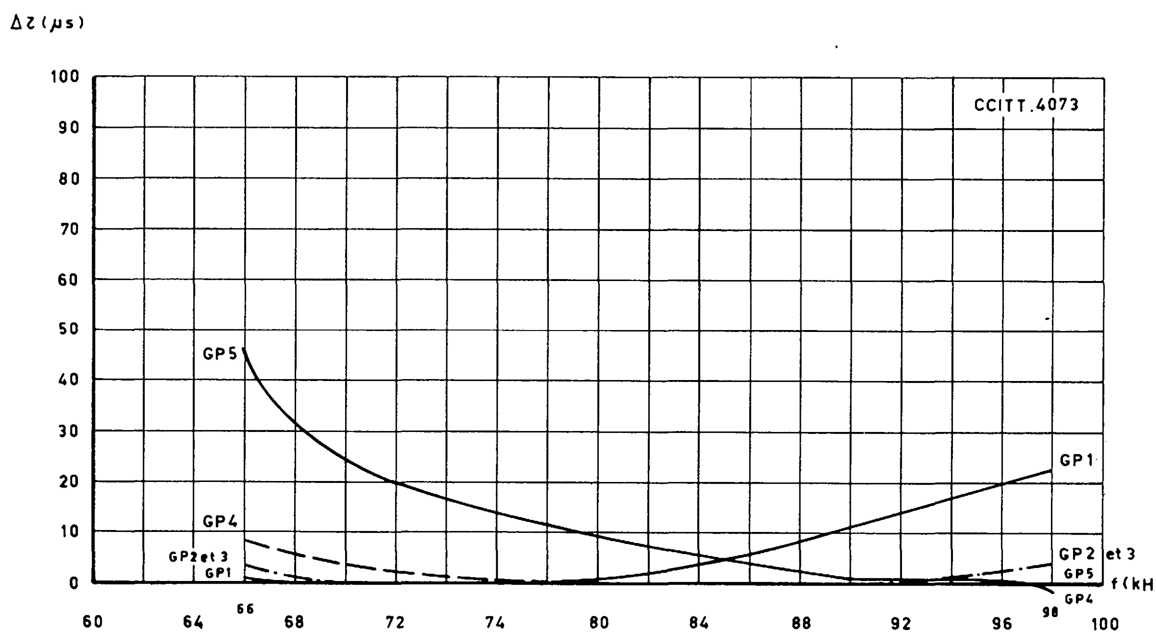


FIGURE 4. — **Group delay distortion of the five groups of the supergroup link**

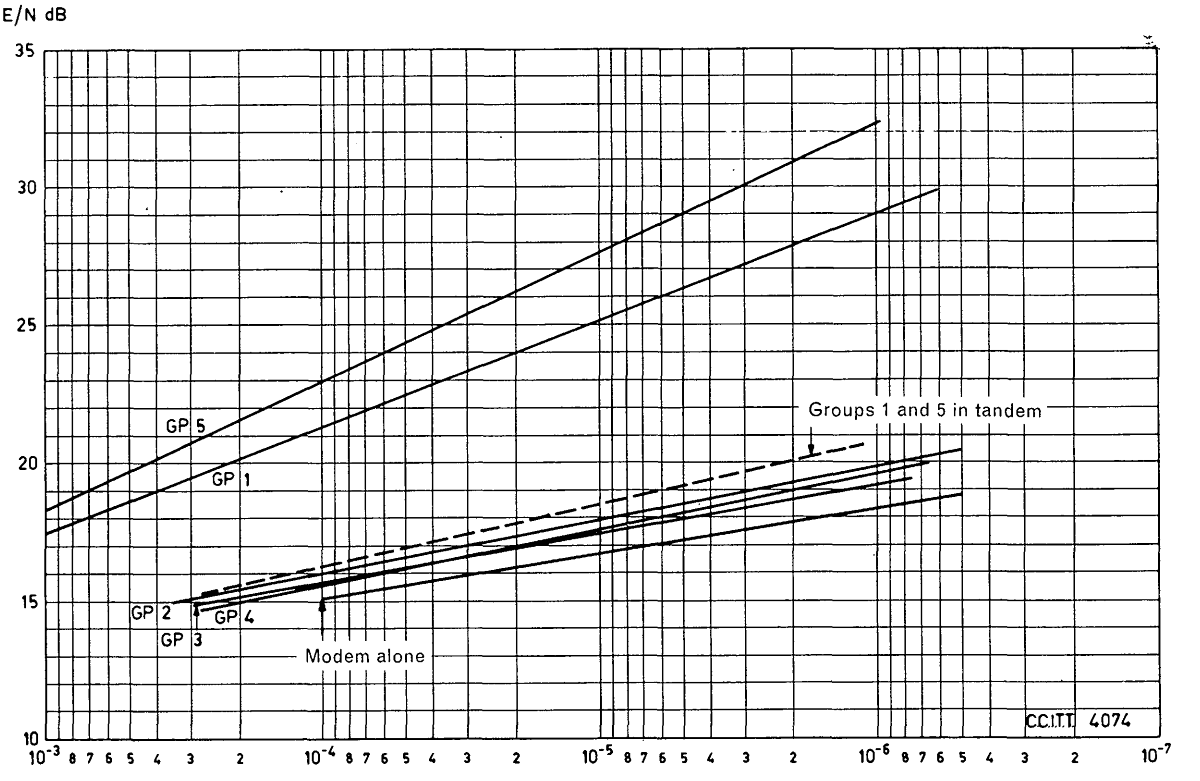


FIGURE 5. — Error rate on groups 1 to 5 of a supergroup link

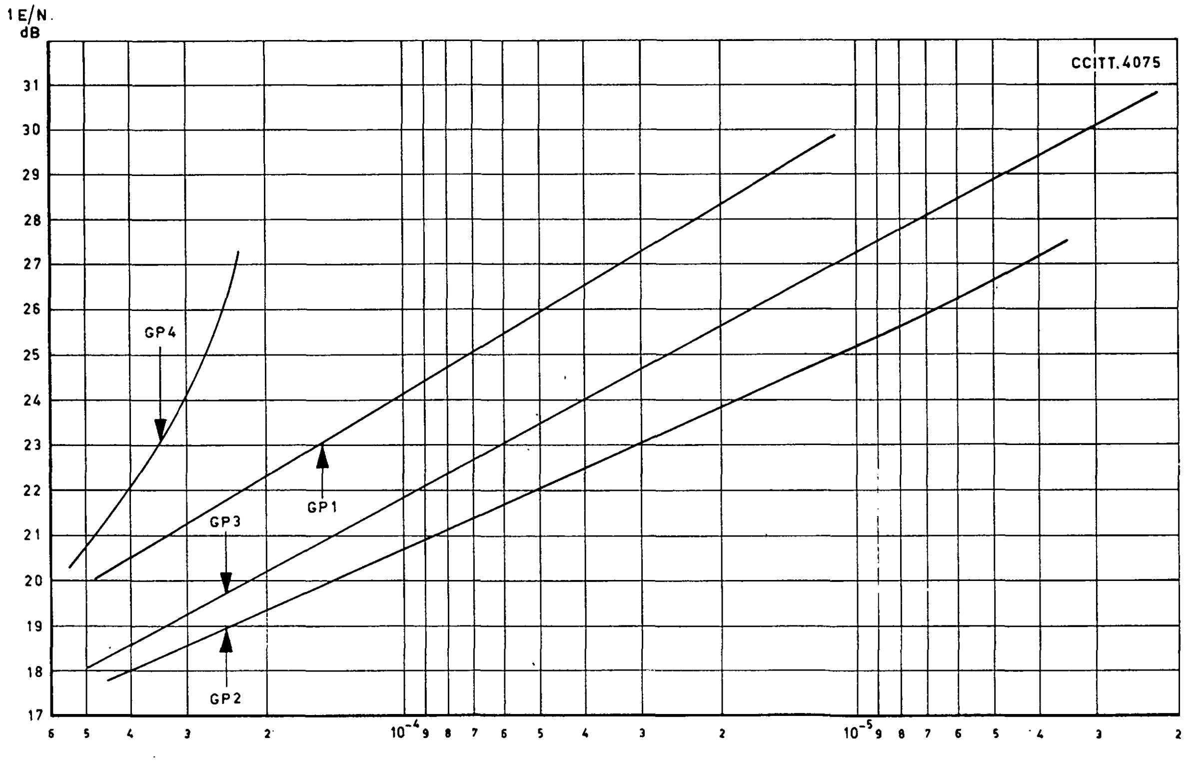


FIGURE 6. — Error rate on group links with one through filter in series

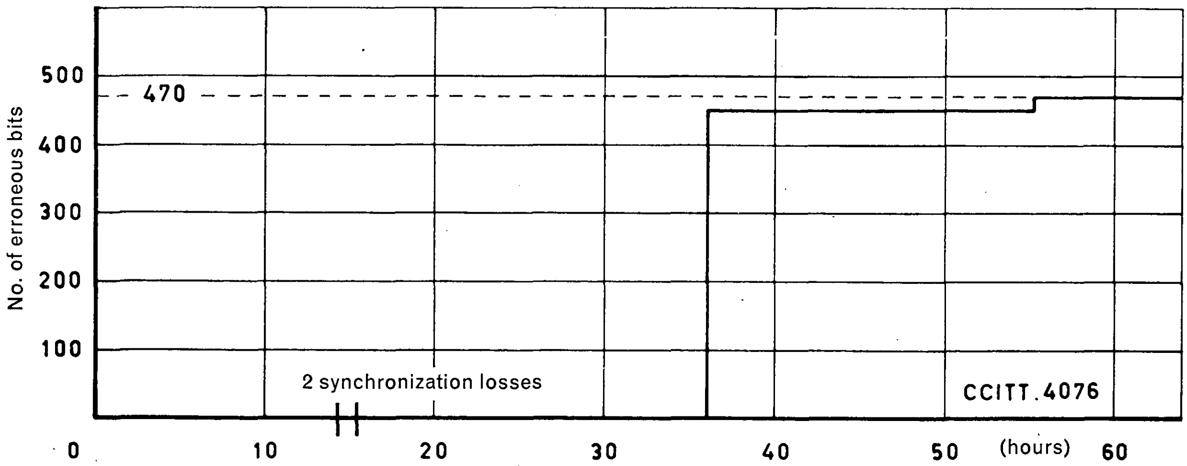


FIGURE 7. — **Number of erroneous bits on group 3 with a through filter on receiving side**

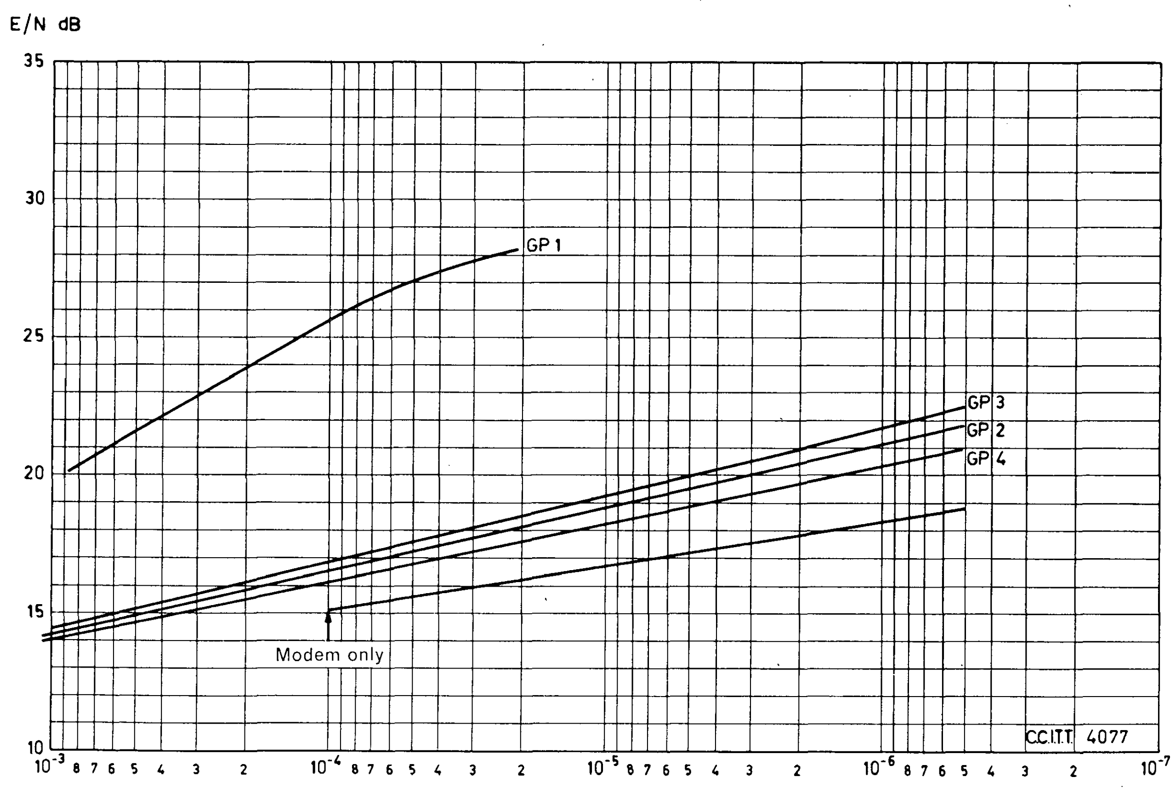


FIGURE 8. — **Error rate on group links with one corrected through filter in series**

2) *Line tests*

First series

The measurements were carried out on the five groups of a supergroup link about 600 km long comprising a through supergroup filter in the three following cases:

a) without through group filter in series

The group delay distortions of these five links are indicated in Figure 4. Figure 5 shows the error rates obtained. On groups 1 and 5 the group delay/frequency distortion results in a marked reduction in transmission quality. If group 1 is through-connected to group 5, which has the effect of making the group delay distortion more symmetrical, transmission becomes almost as good as with groups 2, 3 and 4.

b) with through filter inserted on the receiving side

The error rates obtained are shown in Figure 6. For groups 2 and 3 they are almost identical with those obtained in the back-to-back tests with a through filter. For the three other groups they are worse and especially on group 5 transmission is no longer possible.

In addition, on group 3 we recorded errors during a continuous 64-hour period. The recording is reproduced in Figure 7. The mean error rate on bits was 0.4×10^{-7}.

c) with corrected through filter inserted on the receiving side

The error rates obtained are indicated in Figure 8. For groups 2, 3 and 4 the results are only very slightly different from those in case a) (connection without through filter). Transmission is not possible on group 5.

Second series

The group links this time had two through supergroup connections.

On groups 2, 3 and 4 the results obtained were very close to the preceding tests.

On groups 1 and 5 the group delay distortion being noticeably larger, transmission was impossible.

Third series

The test link was made up of two rank 3 group links and one corrected through filter. (The adjacent group links were in service.)

The results obtained were practically identical with those in the first series (group links with corrected through filters).

5. *Conclusion* [1]

These tests show that 48 kbits modems can tolerate larger group delay distortions than is indicated in Recommendation H.14. We therefore propose amending the group delay characteristics of group links and replacing it by that shown in Figure 9. We also propose modifying the attenuation/frequency distortion characteristic and limiting the frequency band for which the attenuation distortion must be less than 3 dB to 68 and 98 kHz.

[1] See also the revised Recommendation H.14 published in the *Green Book*, Vol. III.

The tests we have carried out showed that transmission quality could vary with the form of the group delay/frequency distortion. A particularly bad case would be one in which this characteristic is undulating. It might be necessary to fix a limit for these undulations.

The characteristics we propose for the group link would be acceptable for data transmission, at rates above 48 kbit/s. We performed identical tests to those described above with a synchronous modem at 72 kbit/s, single sideband. The results were at least as good as with 48 kbit/s.

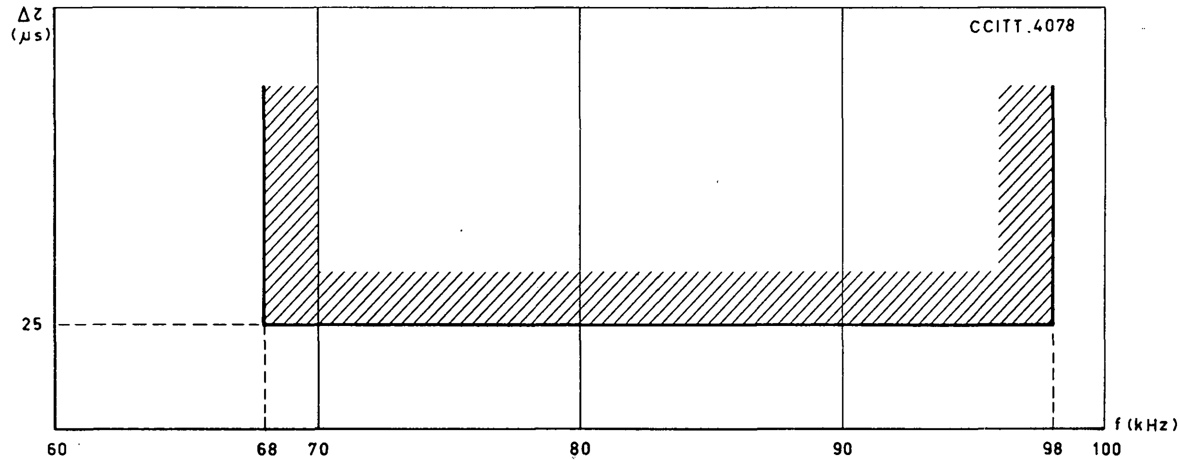


FIGURE 9. — **Group delay distortion proposed for group links**

Supplement No. 22

FRENCH ADMINISTRATION.—*(Contribution COM Sp. A—No. 158, September 1971)*

WIDEBAND MODEM TESTS

1. *Introduction*

This contribution describes the results of tests carried out on a 72-kbit/s modem.

These tests were conducted in response to the request in Annex 4, "Wideband modem tests", to the Report of Special Study Group A on its meeting in Geneva, 7-17 December 1970 (see Annex 5 to Question 1/A—point Z).

2. *Description of the modem used*

— *Data-signalling rate:* 72 kbit/s in synchronous mode or, optionally, 48 kbit/s.

— *Encoding:* Data scrambled by a device in accordance with Recommendation V.35.

— *Baseband signal:* Limitation of the spectrum in the band 0.5 to 35 kHz by bipolar encoding of the second order.

— *Modulation:* Single sideband amplitude modulation with reduced carrier.

— *Signal sent to line:* limited to the band 64-100 kHz.
Power of the signal emitted at the group modem distribution frame (signal + carrier) = −5 dBm0.

— *Demodulation:* homochronous demodulation.

— *Carrier recovery:* by VCXO phase lock circuit from the received signal.

— *Reconstitution of time base:* by VCXO phase lock circuit from the demodulated signal.

— *Decoding:* after sampling, the data are decoded by a device in accordance with Recommendation V.35.

A more detailed description of this modem is given in Document COM Sp. A—No. 117 (December 1970).

Improvement of the pilot recovery and time base reconstitution circuits has resulted in appreciably better modem performance, which explains the differences between Document COM Sp. A—No. 117 and the present contribution.

It should be noted that the service speech channel and the reception level regulator were not used for these tests.

Note. — The modem was operated at a rate of 48 kbit/s simply by substitution of the timing oscillators and the band limiting low-pass filters.

3. *Measurement results*

Two types of tests were carried out:

— Back-to-back;

— On actual circuits.

3.1 *Back-to-back tests*

The arrangement used is shown in Figure 1.

Condition 1 is permanently imposed on access 103. Circuit 104, conditioned by the clock, is used to count the number of erroneous bits.

White noise is measured after the limiting filter (60 to 108 kHz).

Figure 2 shows the error rate for various looping quadripoles.

Curve 1: Looping via a through filter.

Curve 2: Looping via a through filter corrected by two types of correctors.

Curve 3: Looping via a resistive line.

Figures 3 and 4 show the characteristics of the various looping quadripoles.

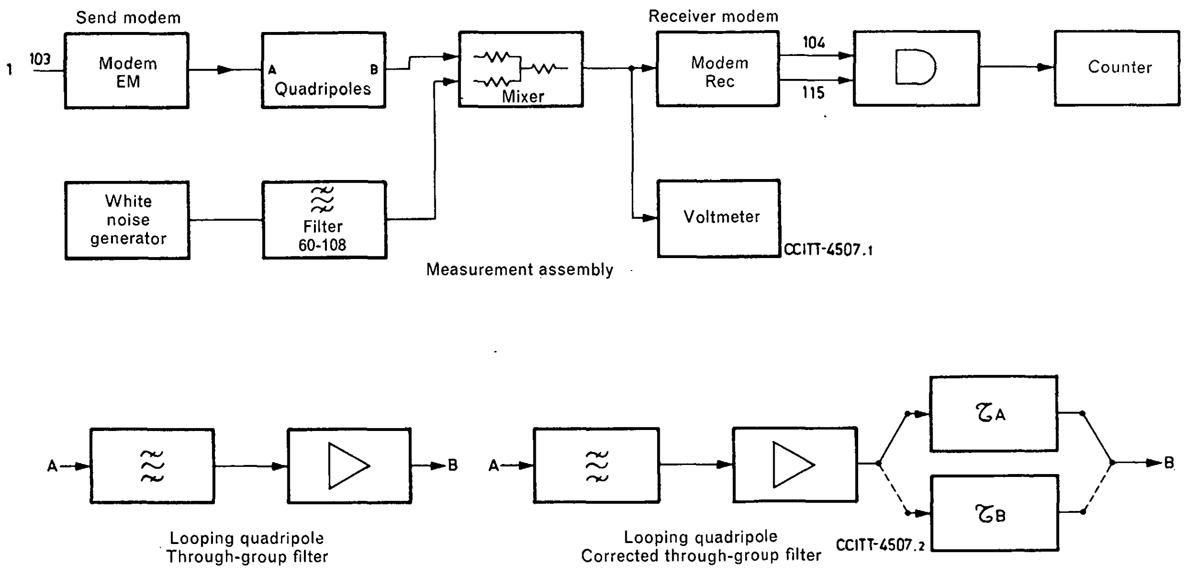
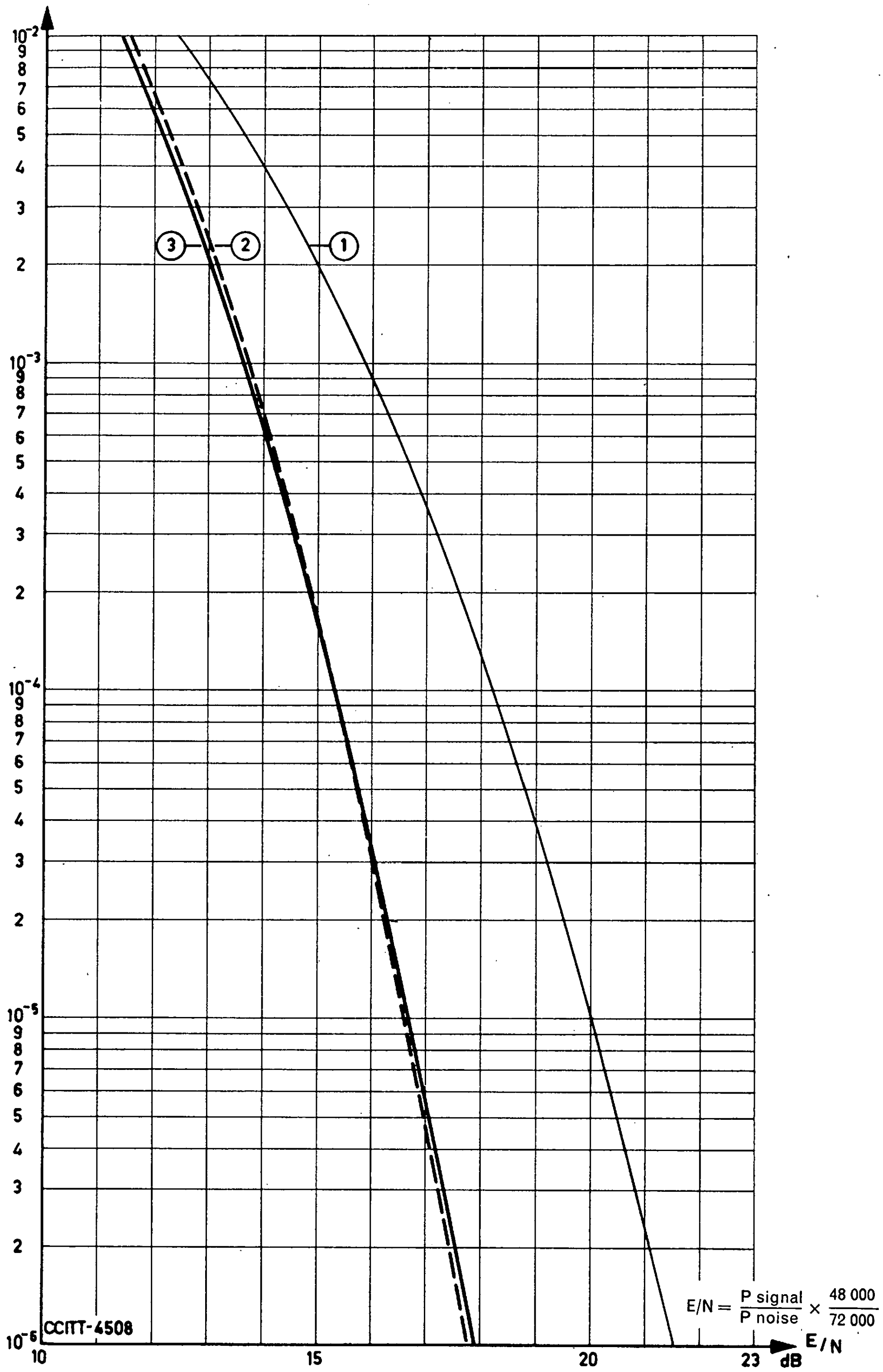


FIGURE 1. — **Back-to-back tests**



(1) = Looping via a through group filter
(2) = Looping via a corrected through filter
(3) = Looping via a resistive line

FIGURE 2. — **Error rate in back-to-back tests**

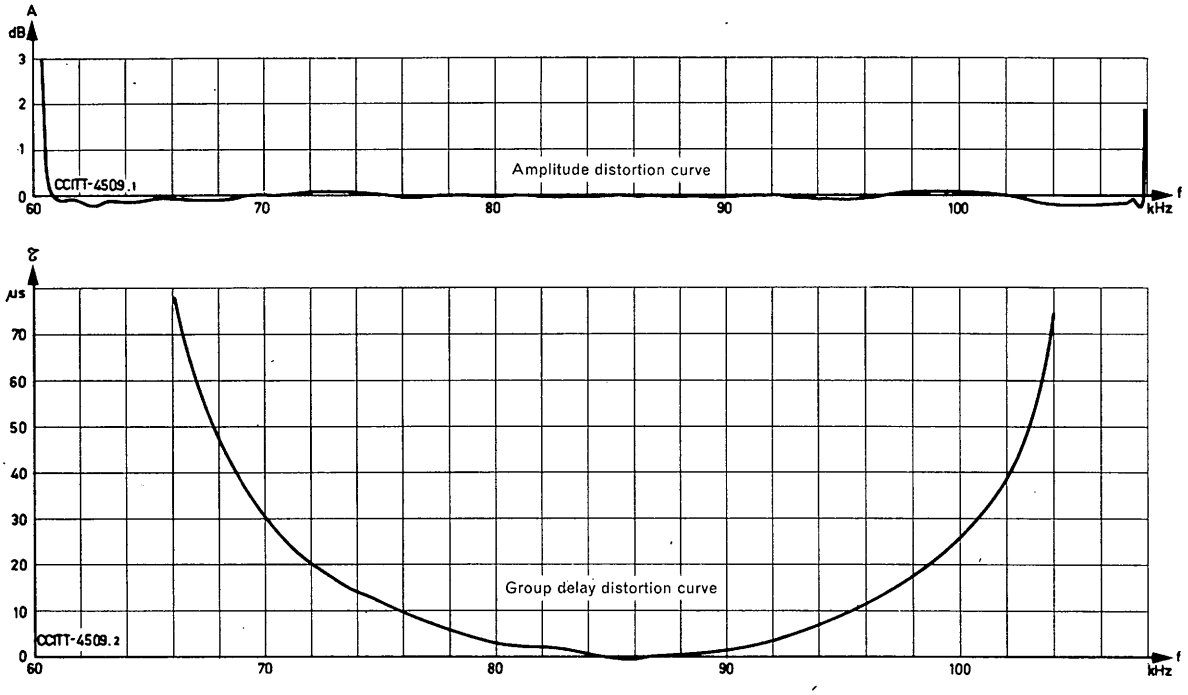


FIGURE 3. — **Characteristics of the non-compensated group modem through filter**

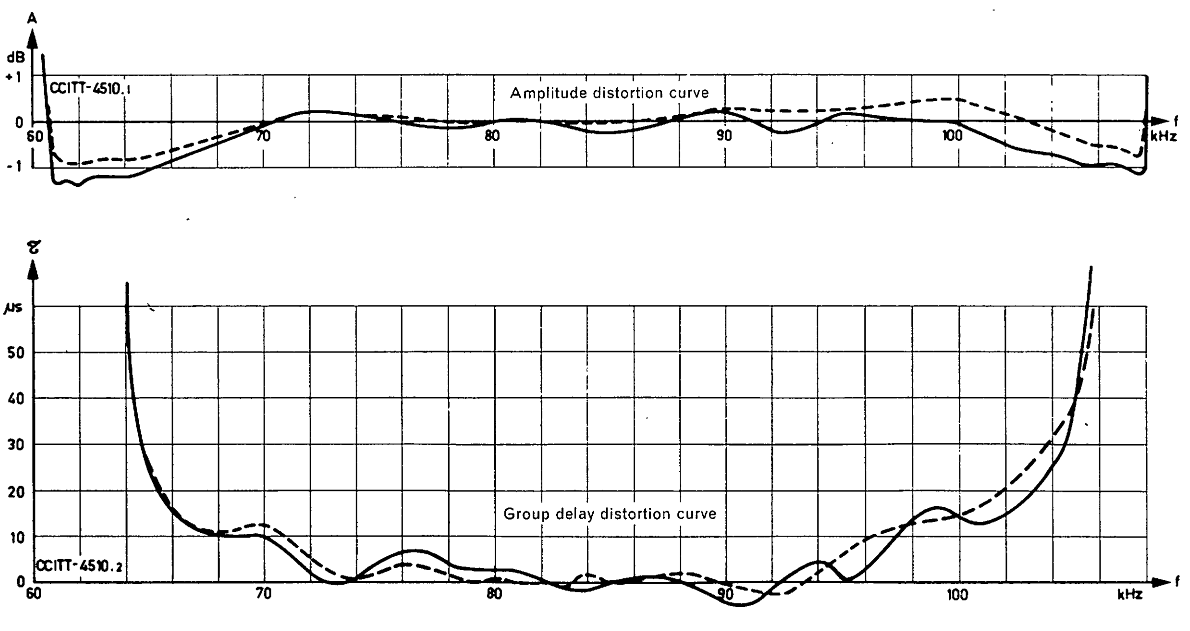


FIGURE 4. — **Characteristics of a compensated through filter, with two types of correctors**

- - - type A ——— type B

3.2 *Tests on acual circuits*

First series of measurements

These measurements were carried out on two groups of a supergroup through-filtered and looped at about 500 km from the point of measurement.

Figure 5 shows the circuit arrangement used.

Figure 6 shows the error rate for different circuits.

Curve 1: Looping via group modem 2, a through filter and group modem 4.

Curve 2: Looping via group modem 2, a through filter, group modem 4, a through filter and the two correctors in tandem.

Curve 3: Looping via group modem 4 alone.

Only group modems 2 and 4 were used in order to avoid interference from adjacent group modems.

Figures 7 and 8 give the characteristics of the various looping quadripoles.

The noise level measured after the through filter is of the order of −39 dBm0 for these group modems, with carrier leaks at 96 kHz, of −65 dBm0 for group modem 2 and −48 dBm0 for group modem 4.

Second series of measurements

This series of measurements was conducted on an H.14 circuit.

Figure 9 shows the circuit arrangement.

Figures 10 and 11 give the curves representing the error rate and the circuit characteristics respectively.

The noise level measured after the through filter ranges from −25 to −35 dBm0, depending on the loading of the adjacent circuits.

The highest harmonic noises are: 68 kHz at −35 dBm0; 84 kHz at −61 dBm0; 96 kHz at −29 dBm0 and 104 kHz at −48 dBm0.

Figure 12 shows the error distribution for a long period of measurement.

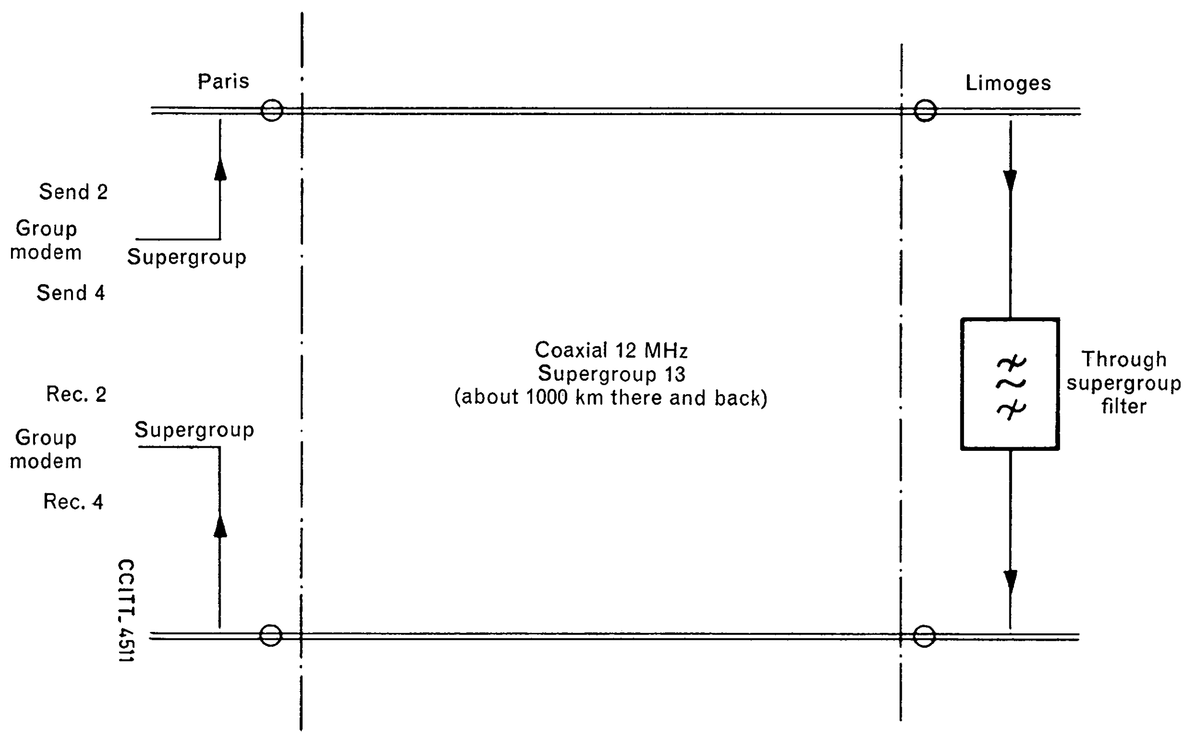
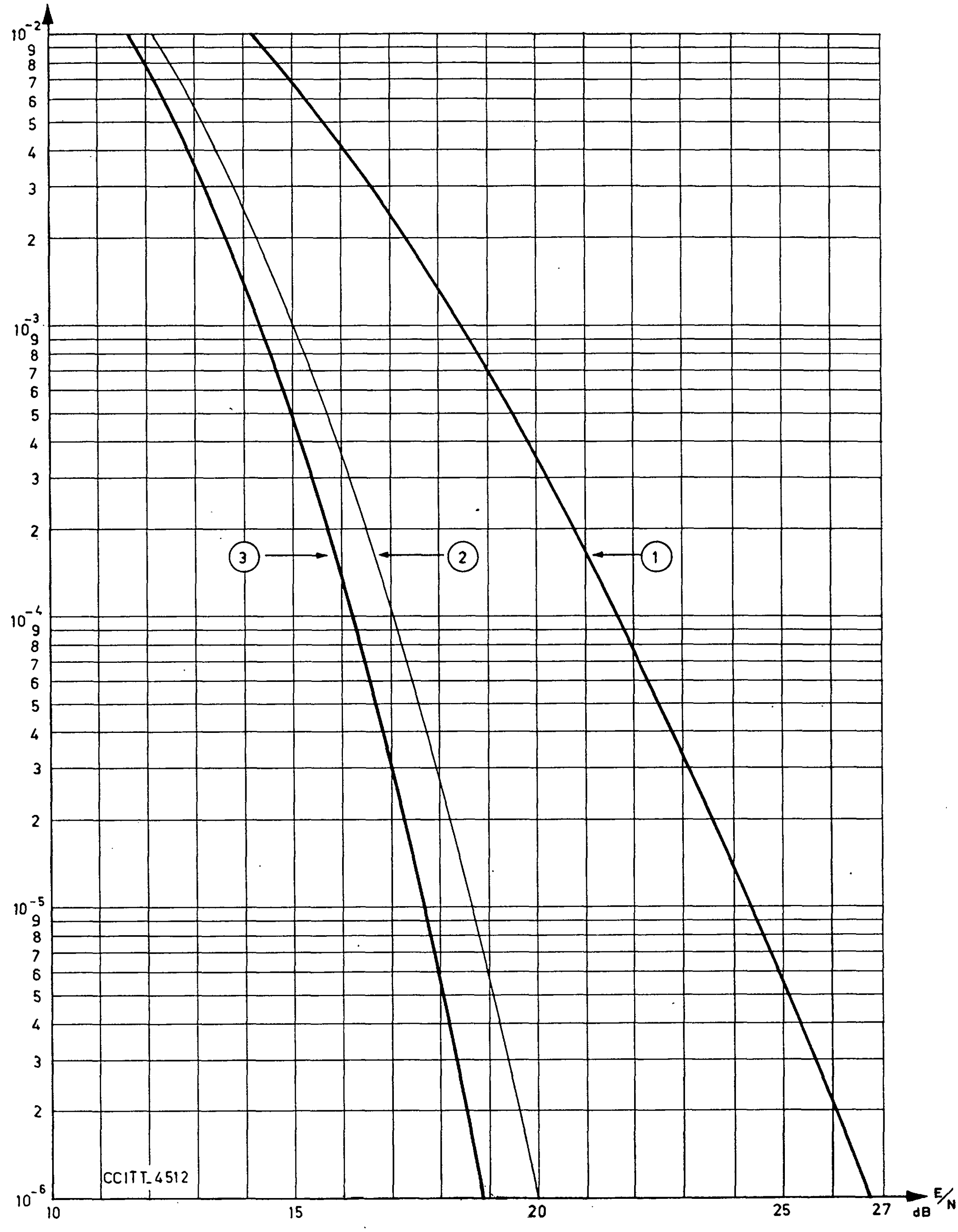


FIGURE 5. — **Tests on actual circuits—First series of measurements—Supergroup loop**



$$E/N = \frac{P\ \text{signal}}{P\ \text{noise}} \times \frac{48\,000}{72\,000}$$

(1) = Looping via a group modem, a through filter, a group modem
(2) = Looping via a group modem, a through filter, a group modem, a through filter and two correctors
(3) = Looping via a group modem only

FIGURE 6. — **Tests on actual circuits—First series of measurements**

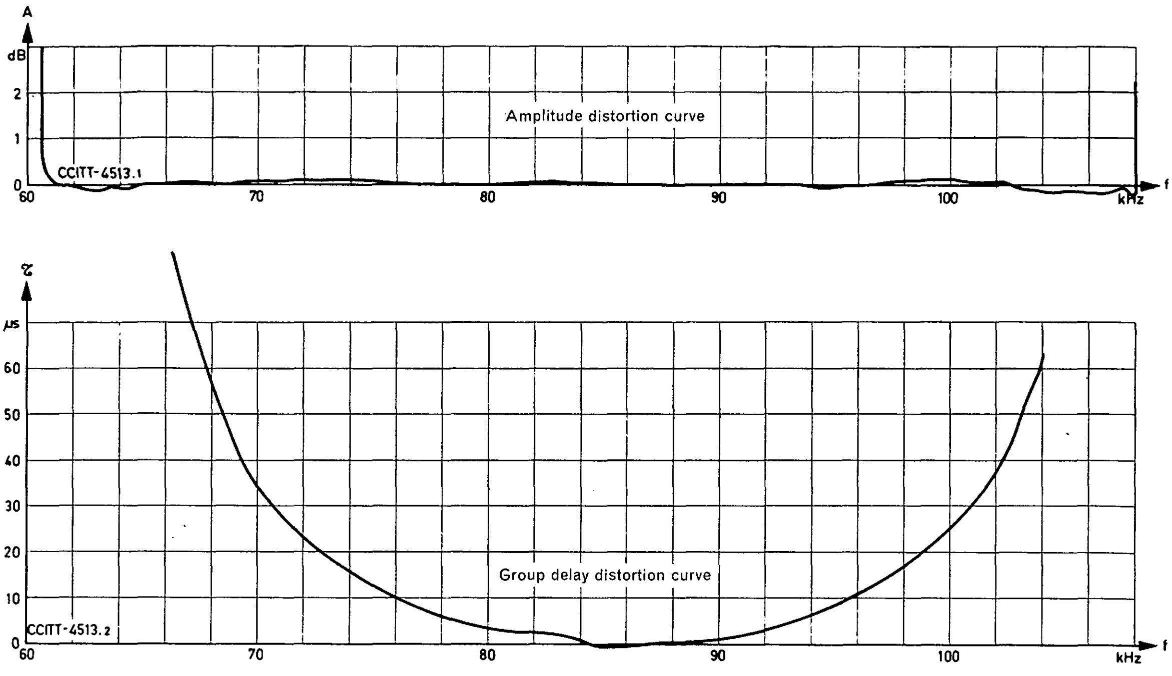


FIGURE 7. — **Circuit characteristics—Group modem 2 + through filter + group modem 4**

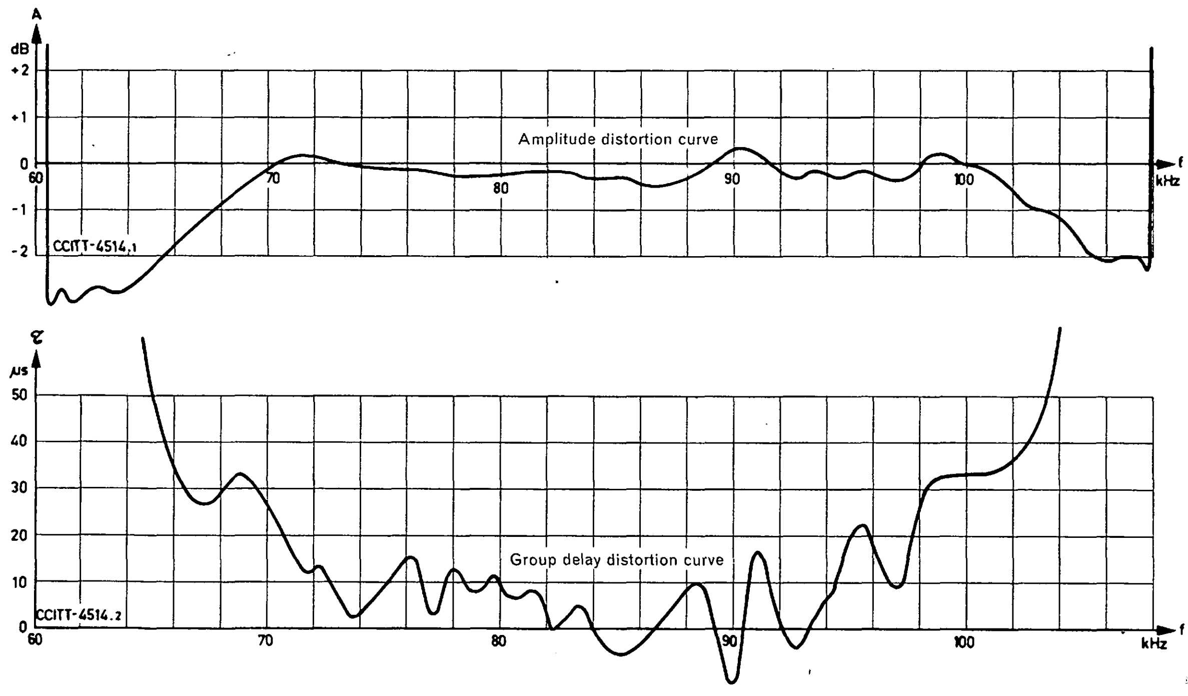


FIGURE 8. — **Circuit characteristics: Group modem 2 + through filter + group modem 4 + through filter + two correctors**

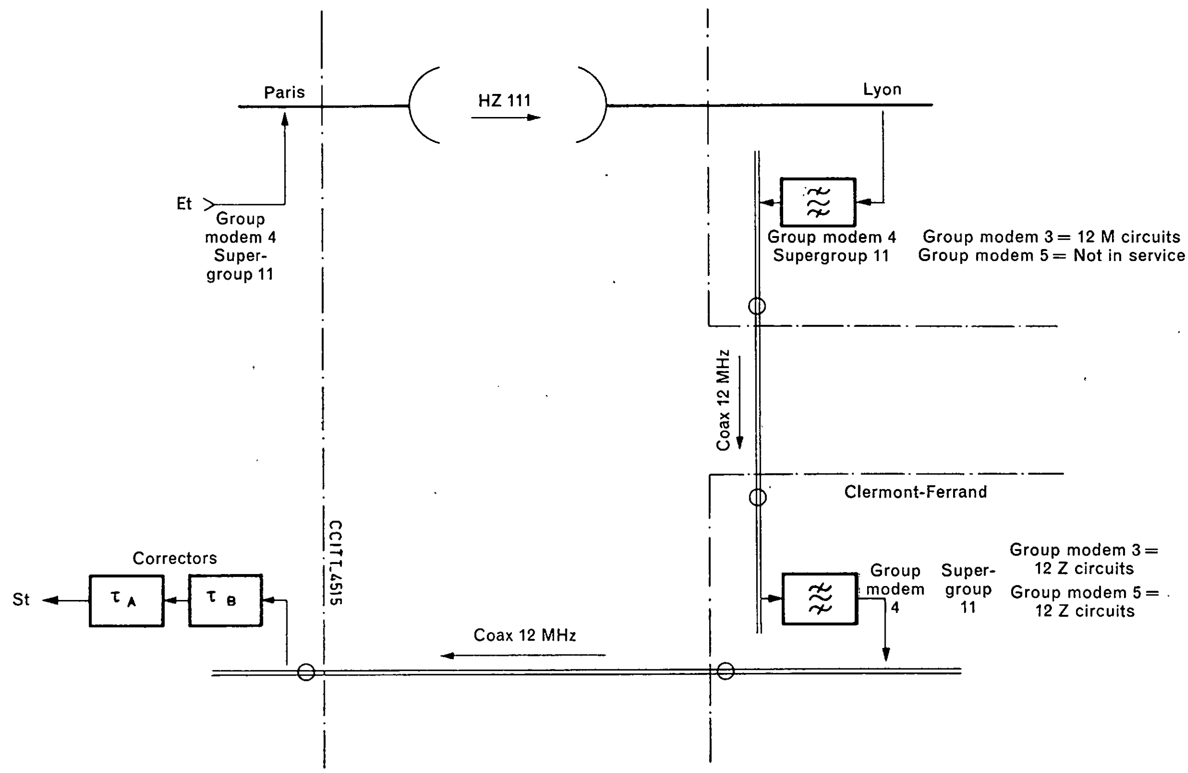
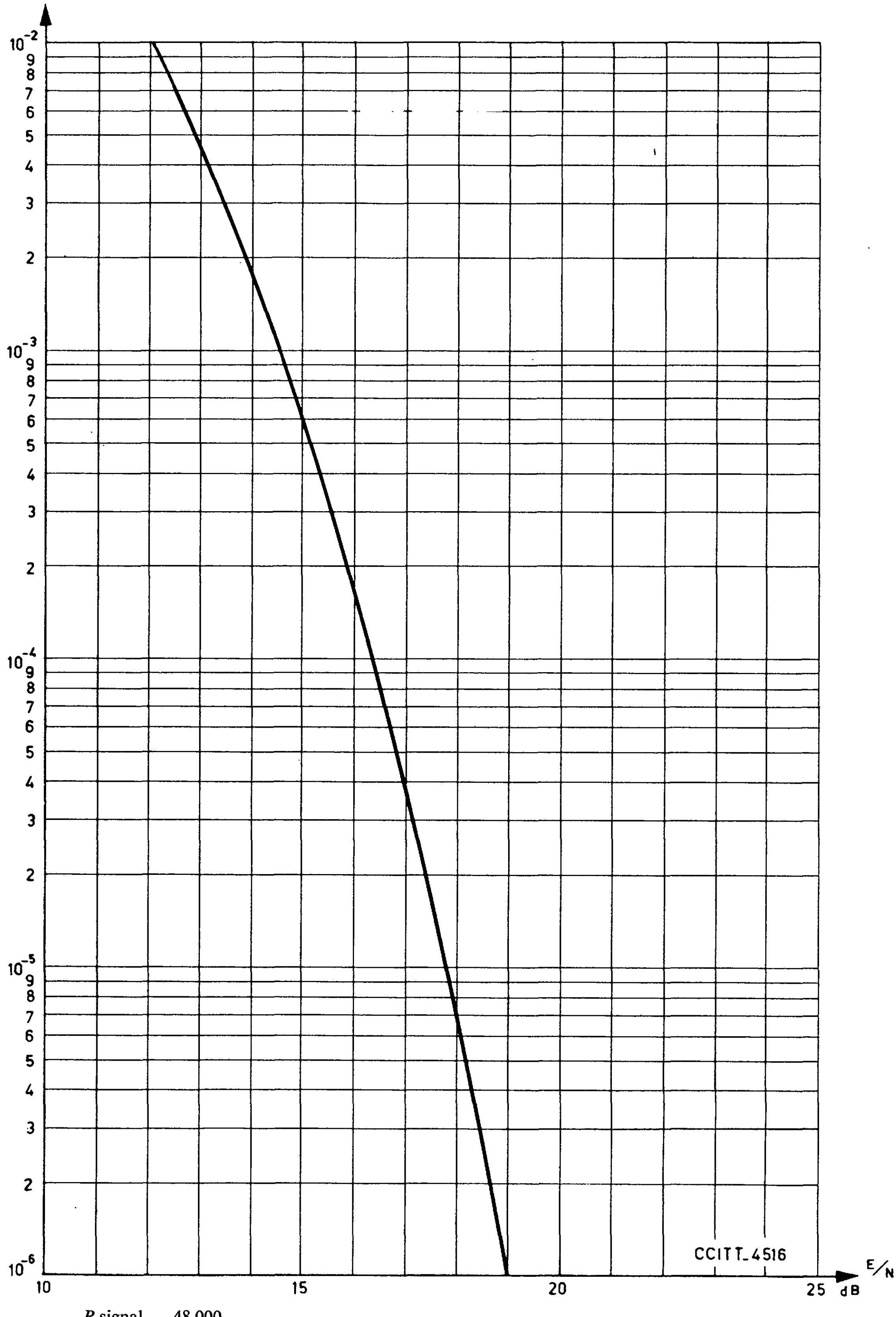


FIGURE 9. — **Tests on actual circuits—Diagram of circuit H14 (about 1200 km)**



$$E/N = \frac{P \text{ signal}}{P \text{ noise}} \times \frac{48\,000}{72\,000}$$

FIGURE 10. — **Tests on H14 circuits**

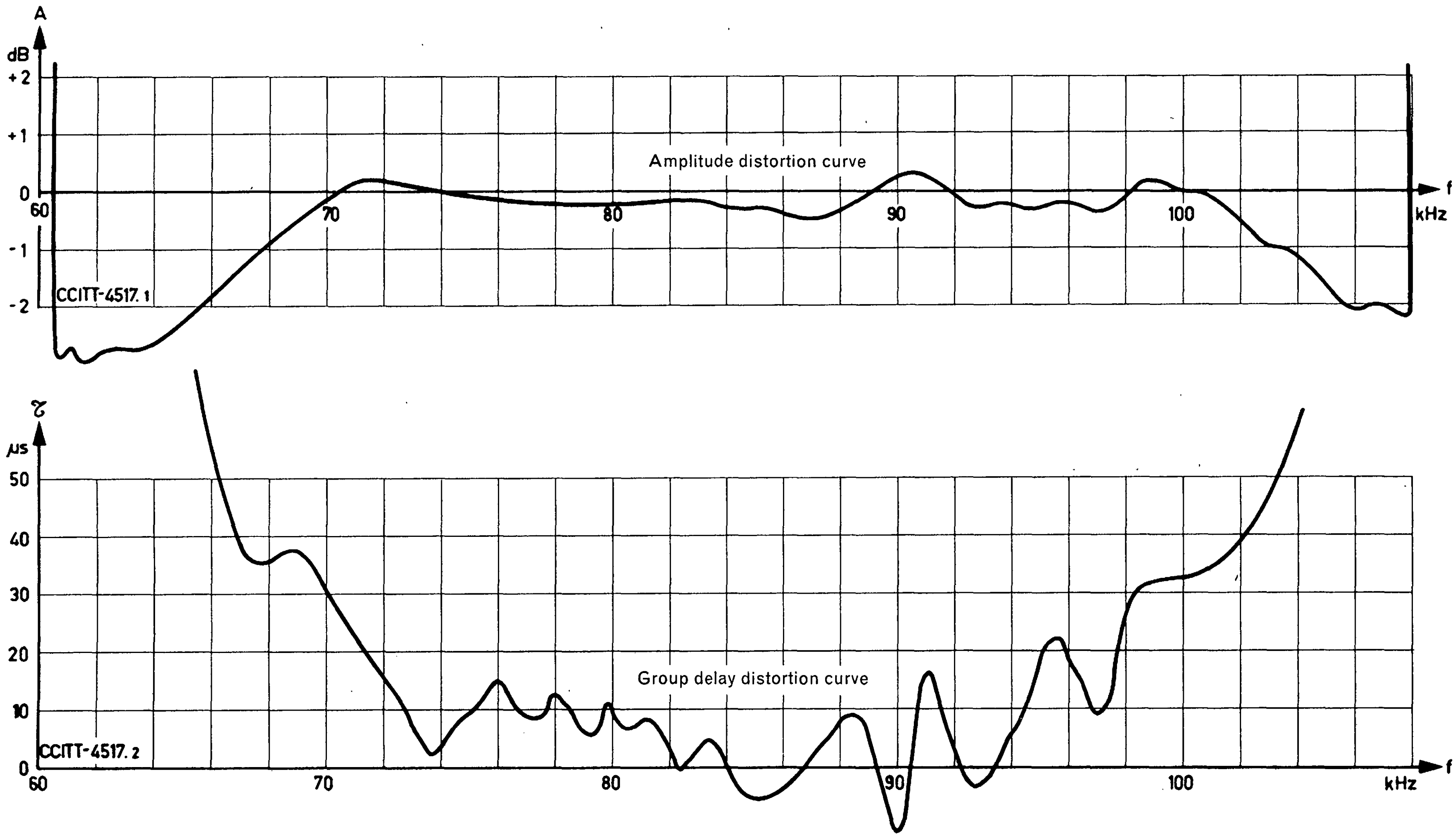


FIGURE 11. — **Characteristics of H14 measuring circuit**

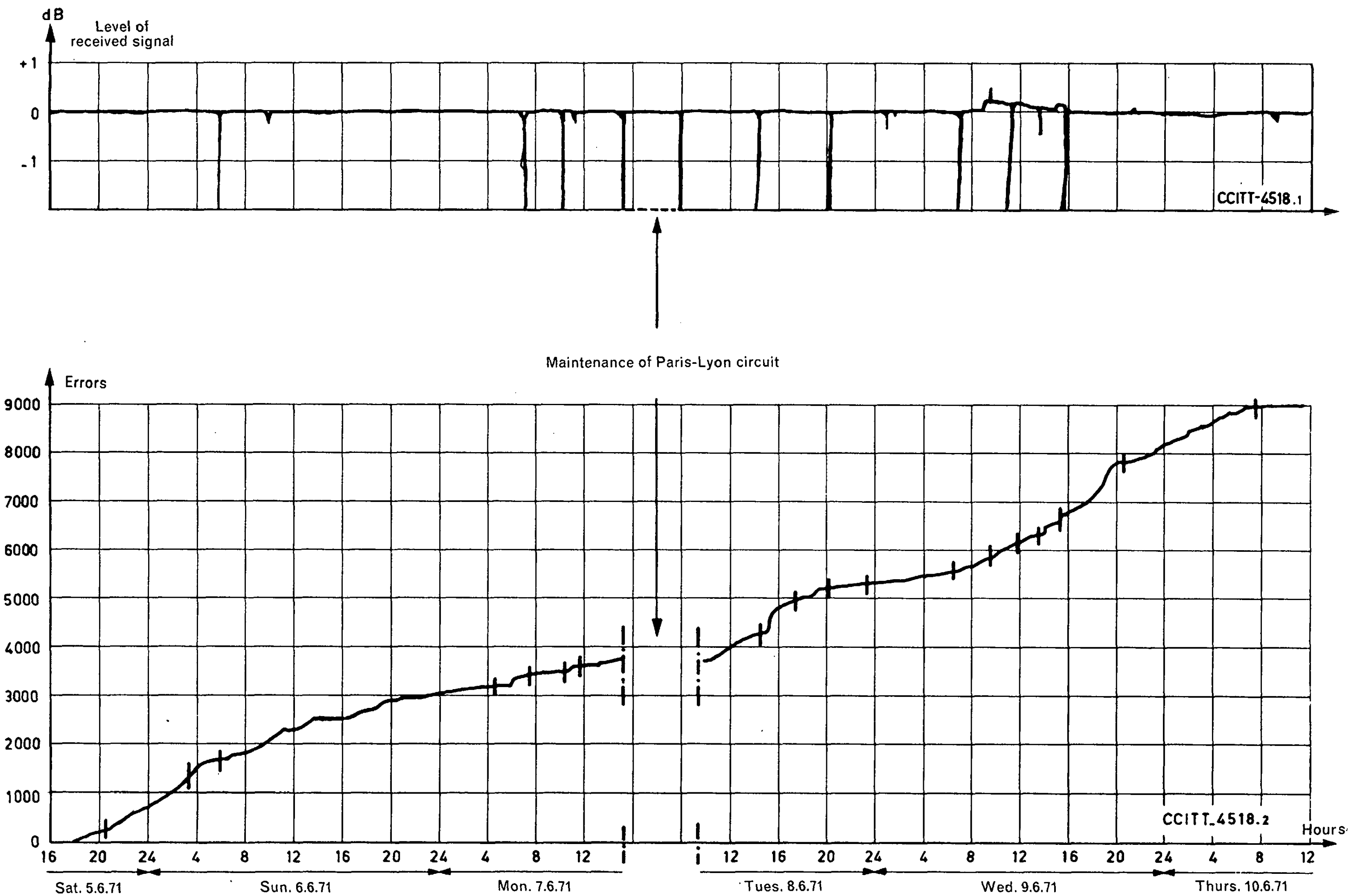


FIGURE 12. — Tests on H14 circuit—Recording of errors and level of received signal versus time

4. *Additional measurements*

4.1 *Measurement of out-of-band energy levels*

Figure 13 shows the signal power distribution in 4-kHz bands at the send modem output.

4.2 *Measurement of protection against unwanted phase modulation*

The curves in Figure 14 show the error rate as a function of the shift in the receiving group modem carrier for different modulation frequencies.

The shift is expressed in degrees peak-to-peak.

Figure 15 reproduces the error rate as a function of a white noise, the group modem carrier being phase-modulated at 200 Hz with a shift of $\pm$ 6 and $\pm$ 12 degrees peak-to-peak.

5. *Conclusion*

These tests show that the quality of data transmission at 72 kbit/s is highly satisfactory in a circuit having the characteristics proposed in the report on the meeting of the LTG Joint Working Party (November 1970). (See the revised Recommendation H.14.)

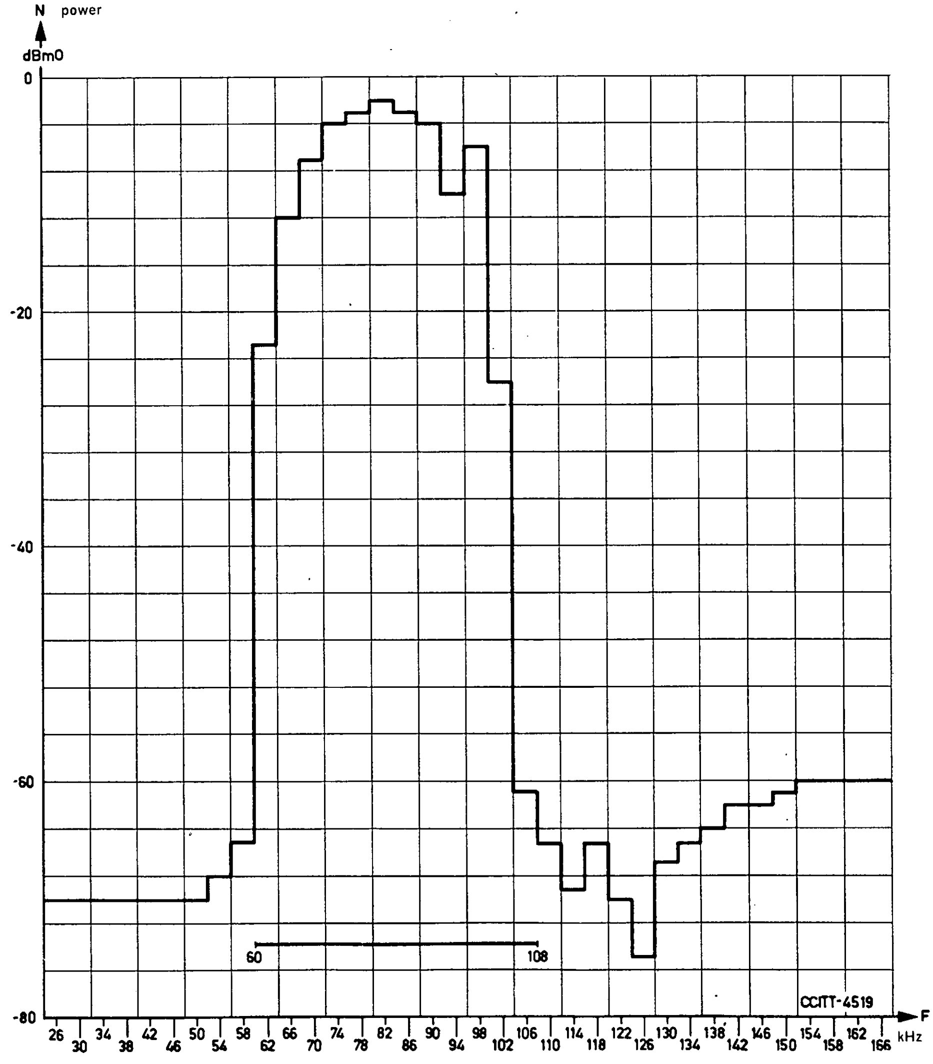
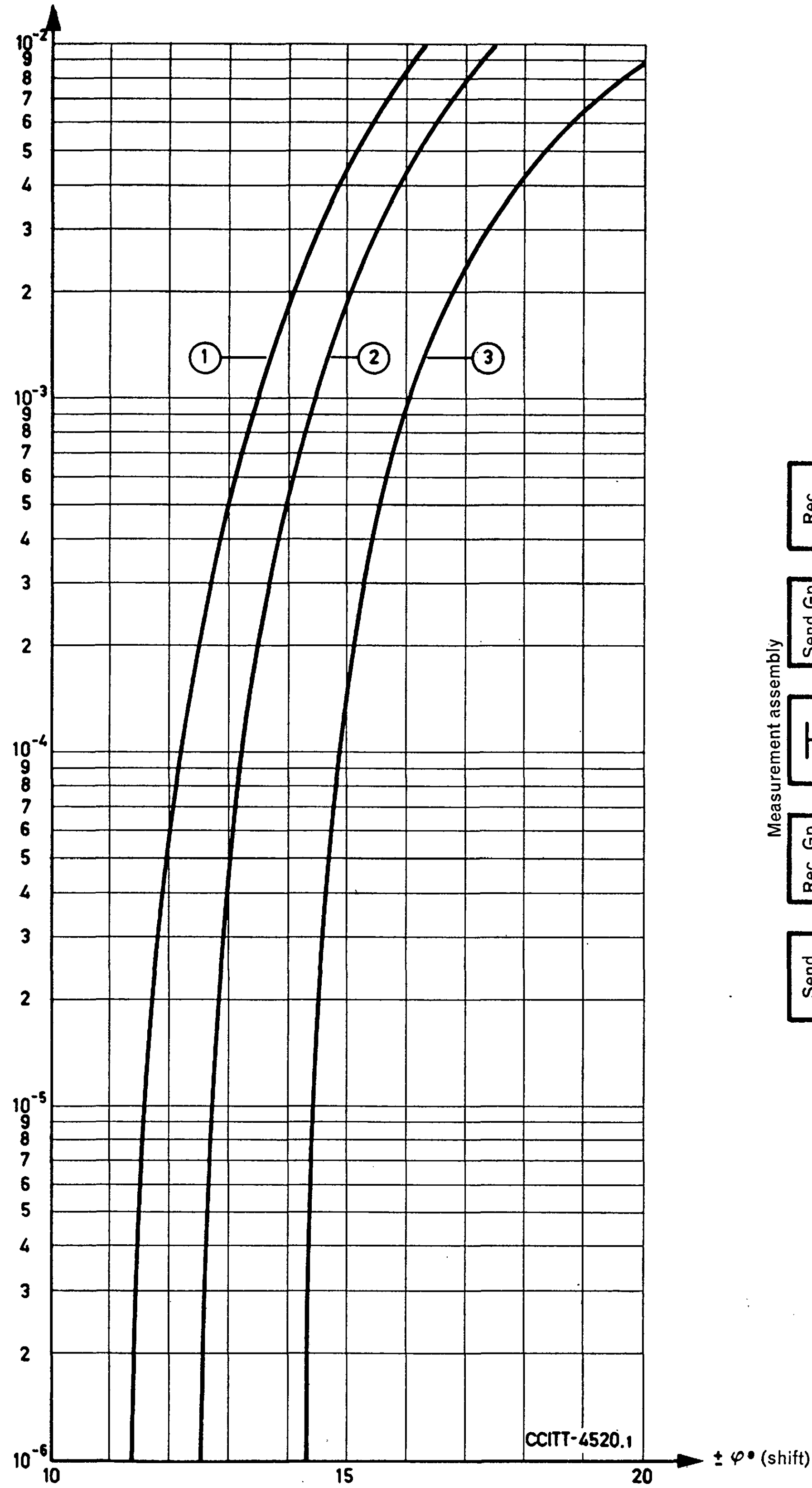


FIGURE 13. — **Sent signal spectrum measured in 4-kHz bands**



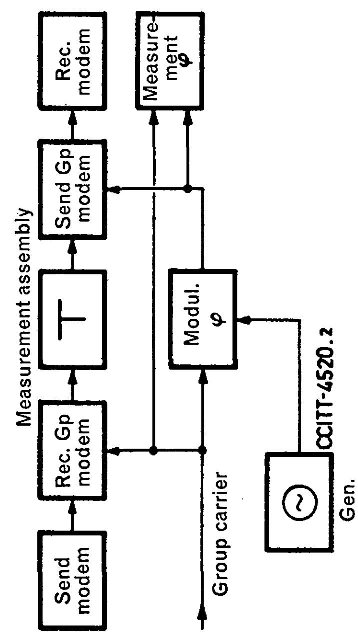
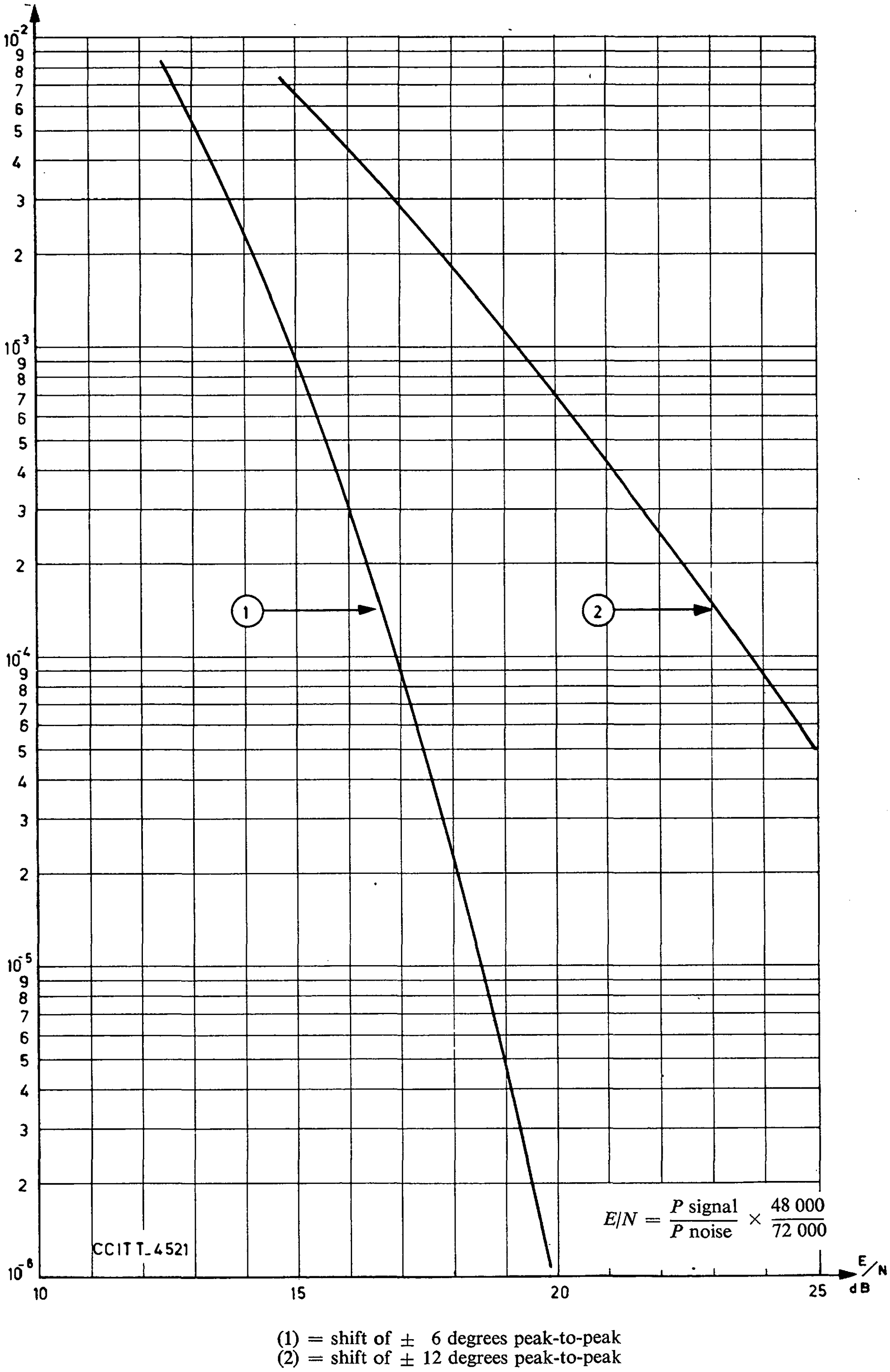


FIGURE 14. — **Behaviour with wave-form phase modulation at (1) = 1000 Hz (2) = 200 Hz (3) = 2 Hz**



(1) = shift of ± 6 degrees peak-to-peak
(2) = shift of ± 12 degrees peak-to-peak

FIGURE 15. — **Behaviour with sine-wave phase modulation at 200 Hz**

Supplement No. 23

UNITED KINGDOM POST OFFICE.—*(Contribution COM Sp. A—No. 180, December 1971)*

48-KBIT/S TRANSMISSION TESTS

Introduction

The United Kingdom Post Office has set up an experimental, manually switched 48-kbit/s network, having switching centres located in London, Birmingham and Manchester—joined by single group links. This contribution gives results of routine tests at 48 kbit/s carried out on the network over the period June 1970 to September 1971.

Description of tests

The modems used comply fully with C.C.I.T.T. Recommendation V.35. Tests were performed between each of the three switching centres, using both cable and radio circuits. All other groups in the supergroups used were loaded with normal live traffic.

Each route was tested weekly for a 15-minute period, usually during the busy hours. Element and block error rates were measured, the test pattern and block size being 511 bits. A total of 261 tests were done.

The results are shown below for the various routes. Figure 1 shows cumulative distributions of element and block error rates.

LONDON–MANCHESTER

Radio circuits

Probability of:	London-Manchester	Manchester-London	Average
a) element errors	1.90×10^{-7}	6.92×10^{-7}	4.60×10^{-7}
b) block errors	1.77×10^{-5}	6.73×10^{-5}	4.45×10^{-5}

Cable circuits

Probability of:	London-Manchester	Manchester-London	Average
a) element errors	0.97×10^{-7}	0.34×10^{-7}	0.63×10^{-7}
b) block errors	1.20×10^{-5}	0.30×10^{-5}	$0.71 \times 10^{-}$

Probability of element errors for route: 2.98×10^{-7}
Probability of block errors for route: 2.56×10^{-5}

LONDON–BIRMINGHAM

Radio circuit

Probability of:	London-Birmingham	Birmingham-London	Average
a) element errors	2.97×10^{-7}	0.25×10^{-7}	1.34×10^{-7}
b) block errors	2.98×10^{-5}	0.25×10^{-5}	1.34×10^{-5}

Cable circuits

Probability of:	London-Birmingham	Birmingham-London	Average
a) element errors	10.77×10^{-7}	0.72×10^{-7}	4.49×10^{-7}
b) block errors	15.17×10^{-5}	0.24×10^{-5}	5.84×10^{-5}

Probability of element errors for route: 2.72×10^{-7}
Probability of block errors for route: 3.15×10^{-5}

BIRMINGHAM–MANCHESTER

Radio circuits

Probability of:	Birmingham-Manchester	Manchester-Birmingham	Average
a) element errors	1.06×10^{-7}	34.65×10^{-7}	15.99×10^{-7}
b) block errors	0.75×10^{-5}	50.61×10^{-5}	22.91×10^{-5}

Cable circuits

Probability of:	Birmingham-Manchester	Manchester-Birmingham	Average
a) element errors	3.69×10^{-7}	0.20×10^{-7}	1.94×10^{-7}
b) block errors	1.99×10^{-5}	0.28×10^{-5}	1.14×10^{-5}

Probability of element errors for route: 8.80×10^{-7}
Probability of block errors for route: 10.76×10^{-5}

SYNOPSIS

Element error probability for radio circuits:	6.78×10^{-7}
Block error probability for radio circuits:	8.67×10^{-5}
Element error probability for cable circuits:	2.05×10^{-7}
Block error probability for cable circuits:	2.17×10^{-5}
Element error probability for all circuits:	4.78×10^{-7}
Block error probability for all circuits:	5.35×10^{-5}

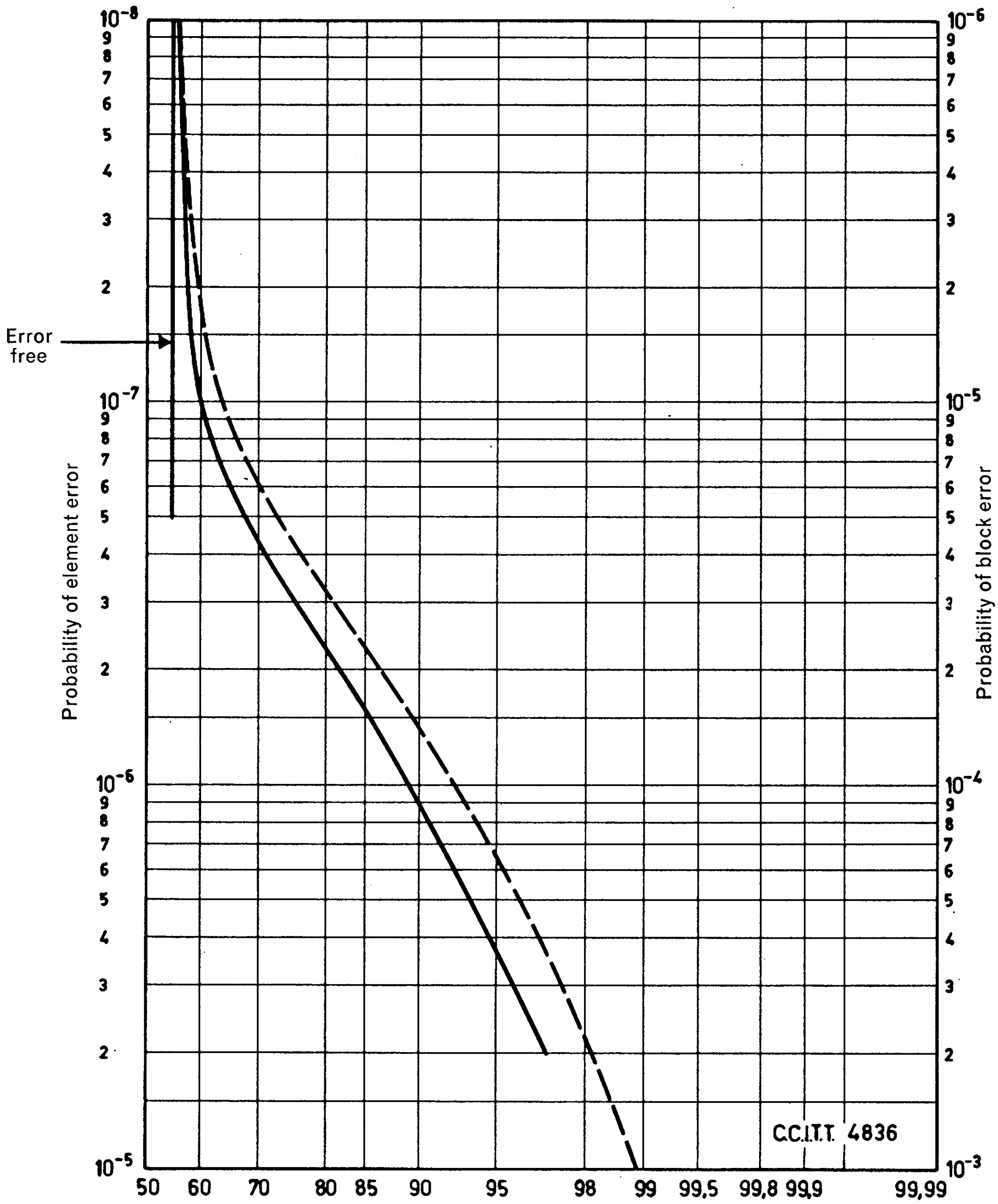


FIGURE 1. — Percentage of calls having element/block error rate better than value shown

Supplement No. 24

COMMUNICATIONS SATELLITE CORPORATION.—*(Contributions COM Sp. A—No. 120, December 1970, and No. 277, August 1972)*

CONSIDERATIONS IN THE TRANSMISSION OF DATA VIA SATELLITE-LINKED CONNECTIONS

Summary

At the IVth Plenary Assembly of the C.C.I.T.T. in 1968, the study programme of Special Study Group A (data Transmission) included, in its four-year effort, the study of all aspects of data transmission by means of satellite-linked connections.

It is the purpose of this contribution to provide general background information on satellite communications technology and its capability in enhancing the transmission of data in domestic, regional, and intercontinental links. Performance objectives of COMSAT's satellite services are presented for voice-band and wide-band data transmission. A discussion of the advantages offered by satellite transmission is followed by a treatment of the influence of propagation delay upon such transmissions.

The error characterization and control of a data channel is a very important parameter in the design of digital data transmission systems. The contribution discusses common error-control techniques and their applicability to satellite links. Preliminary results of a COMSAT/INTELSAT programme directed towards characterization of ES-ES links are also presented.

Introduction

The communications satellite is unique as a telecommunications medium because it offers to its users a transmission medium, the cost of which is not a function of the distance between terminals. Similarly, the noise in the channel is not a function of the distance between communicating terminals.

With the introduction of the SPADE system into the INTELSAT networks in 1971, [1] this demand-assigned pulse-code-modulation approach will enable the offering of on-demand voice-band data channels to one or more terminals also having SPADE equipment. The impact of the availability of on-demand data service on a point-to-point or broadcast basis will have significant impact on long-haul data transmission growth. The extension of this service to wideband data can be expected when sufficient requirement for such service appears. Provision already exists for incorporation of teletype service into SPADE terminals [2].

While the SPADE system is oriented towards networks having a great many terminals but relatively light per terminal traffic loads, the probable introduction of time-division multiple-access (TDMA) systems in the 1974-75 period will be oriented towards those stations having medium to heavy traffic [1]. Featuring bit-rates in excess of 60 Mbit/s in global-coverage antenna beams, such TDMA systems will make full use of advantages which PCM/TDM techniques can provide for data transmission services, particularly flexibility and economy.

Satellite channel performance objectives

The foregoing paragraphs have been emphasizing the future and near-future digital satellite communications systems. This is not meant to indicate that the existing satellite services are not capable of providing excellent grades of data transmission service. In general, the INTELSAT earth stations receive their terrestrial plant signals in frequency-division multiplexed channel assemblies, principally 12-channel groups (60-108 kHz), and nominal 4-kHz VF channels (0-4-kHz).

The performance objectives for nominal 4-kHz voice-grade VF channels suitable for data (0.3 to 3.4 kHz) as measured between INTELSAT earth station terminals are :

1. *Amplitude/frequency response*

The amplitude/frequency response of a voice-grade VF channel with respect to a reference frequency of 1 kHz should be better than:

Frequency band	*Loss variation*
500-2800 Hz	+0.5 to −0.5 dB
300-3000 Hz	+1.0 to −0.5 dB
3000-3400 Hz	+1.5 to −0.5 dB

2. *Channel weighted noise*

The hourly mean weighted noise level of an idle channel terminating in an earth station should not exceed −50 dBm0p.

3. *Intelligible crosstalk between adjacent channels*

a) *Far end*

The crosstalk coupling loss as measured on any/all channels at the receive station, except the channel sending at 1-kHz test tone at 0 dBm0 should be greater than 65 dB.

b) *Near end*

The crosstalk coupling loss as measured in any/all channels at the transmit station except the channel sending the 1-kHz test tone at 0 dBm0 should be greater than 65 dB.

4. *Delay distortion*

Voice channel group delay distortion characteristics:

1000-2600 Hz	170 microseconds
600-2600 Hz	500 microseconds
500-2800 Hz	1000 microseconds

The minimum group delay point in the voice-frequency band should be regarded as the reference frequency.

5. *Impulse noise*

Impulse noise counts for VF circuits should not be more than 6 counts per 15 minutes at a level of −21 dBm0.

6. *Phase jitter*

The peak-to-peak phase jitter in any channel should not exceed 3 degrees.

Performance objectives for a 48-kHz group data channel as measured between INTELSAT earth stations are :

1. *Amplitude/frequency response*

The amplitude/frequency response of a basic group (60-108 kHz) with respect to the 104.08-kHz group pilot frequency should be better than:

Frequency band	
60.0-107.7 kHz	±1.0 dB

2. *Envelope delay distortion*

Envelope delay distortion characteristics should not exceed:

65.5-102.5 kHz	25 microseconds
64.2-65.5 kHz	65 microseconds
102.5-103.8 kHz	45 microseconds

The minimum group delay point in the basic group frequency band should be regarded as the reference frequency. The minimum group delay point shall lie between 66 kHz and 102 kHz. The ripple cycle should not exceed 2.5 kHz.

3. *Intelligible crosstalk between adjacent groups*

Far and near end crosstalk coupling loss should be better than 70 dB. The coupling loss should be measured for all groups in the baseband.

4. *Impulse noise*

The impulse noise counts for a data group circuit (48 kHz) should not be more than 60 counts per 30 minutes at a level of −8 dBm0.

Data transmission test programme

In order to provide more accurate information to the data transmission community on satellite service and potential uses, and better monitor the performance of the services that COMSAT and INTELSAT are providing, a data transmission test programme has been initiated. The objective of this continuing effort will be to:

1) Characterize the satellite services in such a fashion as to be meaningful to the potential user. This is to include voice channel data transmission and wideband data transmission.

2) Monitor satellite circuit performance with a view towards detecting and correcting such degrading factors as may be present, as well as upgrading specified minimum performance levels.

3) Determine the error model of satellite data transmission facilities. In the initial stages of the programme, the bit error rate measurements will be taken on various links. With the passage of time, such measurements will be expanded to enable a probabilistic error model to be obtained for satellite links. The correlation of this model with that of the terrestrial facilities will then enable optimized error-control systems to be designed for overall end-to-end operation.

While COMSAT has participated in a number of co-operative efforts requested by potential customers in order to evaluate the performance of certain types of data transmission equipment on an end-to-end basis over a satellite-established link, it is COMSAT's opinion that the characteristics of the terrestrial terminations masked the performance of the earth station-to-earth station portion of the connection and did not provide an accurate representation of the merits of the satellite link.

Since COMSAT has no control over the characteristics and performance of the associated terrestrial facilities, the data transmission test programme will be directed solely at the earth station to earth station performance of satellite links. By presenting the results of such tests to the data transmission community, it is hoped to encourage the use of data transmission over satellite-established links; these being the only intercontinental links capable of meeting the broad spectrum of requirements now being considered by the Study Groups Special A and Special D.

The first results of the data transmission test programme are presented in Annex A and Annex B to this contribution. Further annexes will be appended as the test programme proceeds.

Effects of satellite propagation delay

The influence of propagation delay upon satellite communications is one of the more controversial issues associated with that field. This concern is exhibited by the wording of C.C.I.T.T. Recommendation G.114 which indicates that circuits with one-way propagation times above 400 ms are unacceptable " except under the most exceptional circumstances ". This would tend to rule out the use of multiple-hop satellite-established links for voice-communication and, thereby, data communications.

Subsequent tests have indicated, however, that delay itself is not reason for user dissatisfaction with multiple-hop satellite links; rather, the critical factor appears to be that of echo control [3]. Studies in the United Kingdom and Japan now indicate that single-hop and double-hop satellite connections are equally acceptable when the echo return loss is greater than 31 dB. With improved echo control techniques, the availability of serviceable multiple-hop satellite connections for data transmission will be enhanced. This will enable a data link to be established between almost any two points on the Earth.

The longer propagation delays associated with satellite-established connections, while introducing no difficulties to users of computers in " conversational " modes, do have a dramatic effect on data throughput due to certain error control techniques. This will be discussed in the next section.

It is for the knowledgeable data communications user to avail himself of the advantages of satellite-established connections while avoiding the pitfalls which may be encountered and could be easily avoided.

Error-detection and retransmission (ARQ)

The most basic form of ARQ system is one in which the block of data bits is transmitted and no further blocks are transmitted until an acknowledgement or retransmission request is received from the other terminal. This method has been called an idle-RQ system, and because the throughput is a direct function of channel error rate and round-trip delay, its use over satellite circuits [1] is deprecated because of the loss of throughput resulting from the waiting period. Figure 1 indicates the per cent throughput as a function of block length. The satellite single-hop round-trip propagation delay is assumed to be 700 ms to which has been added 40 ms for modem delay, 50 ms for the detection of the RQ signal, and 25 ms for the terrestrial facility delay in each end circuit. The equation for determining this throughput efficiency is:

$$n_i = \frac{B}{B + TR} \tag{1}$$

where

B is the block length in bits

T is the total round-trip delay (815 ms), and

R is the input data rate (bit/s).

[1] Throughout this contribution it is assumed that the data circuit has its go *and* return channels over a geostationary satellite link.

A more convenient normalized form of this equation is:

$$n_i = \frac{\frac{B}{R}}{\frac{B}{R} + T} \tag{2}$$

where $\frac{B}{R}$ is the time required to transmit a single block of data.

From Figure 1 and considering equation (2) it is clear that if the time of transmitting a block is equal to 815 ms, then the noiseless throughput is reduced by fifty per cent as a result of the path delays. The addition of real-channel noise will reduce the throughput still further. Hence, the utilization of an error-control system based upon the idle-RQ principle over satellite circuits is to be deprecated. The throughput loss more than offsets the simplicity of implementation which is the prime advantage of the idle-RQ method.

With the cost of low-speed sequential digital storage decreasing at a very rapid rate, the second form of ARQ systems, called " dual-RQ " or " go-back-n " systems, is much more appealing to satellite applications, since the noiseless throughput is 100%.

Recommendation V.41 of C.C.I.T.T. Study Group Sp. A has been formulated for those applications in which the two-block storage (" go-back-2 ") is sufficient to accommodate the path delay specification. Table 1 of Recommendation V.41 indicates certain maximum total path delays which can be accommodated by the recommended error-control system for certain ranges of data rates and those prescribed block lengths.

A more meaningful description of the influence of total path delay upon go-back-n retransmission systems can be seen in Figure 2, and is based upon the values of T being constrained to:

$$(n-1)\left(\frac{B}{R}\right) \geq T \geq (n-2)\left(\frac{B}{R}\right)$$

where n is the available blocks of storage and has values of 2, 3, 4, etc., and T is the total of all elements of path delay, including round-trip propagation delay, modem delay, RQ recognition delay, etc.

From Figure 2, and for given values of total path delay, the permissible values of n are given for the block transmission time $\left(\frac{B}{R}\right)$. It can also be seen that, where the total path delay may take on a rather broad range of time, care must be exercised in the selection of a value of n for a fixed value of $\frac{B}{R}$. This is especially true for circuits established via satellites. Since earth stations are situated in widely dispersed fashion within the antenna coverage of a satellite, the one-way ES-satellite-ES delay may take on a value of 238 ms for a station located directly beneath the satellite, or a value of 280 ms for those stations at beam-edge. Hence, the delay associated with an ES-satellite-ES connection can have a range of 476 to 560 ms. If one then adds the delay associated with the terrestrial facilities, modem delay, etc., a range of 580 to 790 ms can be expected for the total possible round-trip path delay of a single-hop satellite circuit. A range of 1070 to 1410 ms may be expected with a double-hop satellite circuit. The variation of this delay because of the station-keeping instabilities is an insignificant component of the total delay, e.g., the daily peak-to-peak variation of the range of INTELSAT III (F-4) is about 250 μs.

Figure 3 is identical to Figure 2 but shows the single-hop and double-hop delay ranges. The areas within each " go-back-n " zone wherein a fixed value of $\frac{B}{R}$ will satisfy any probable delay for randomly chosen end-to-end connections are indicated. It would appear desirable to employ the same general error

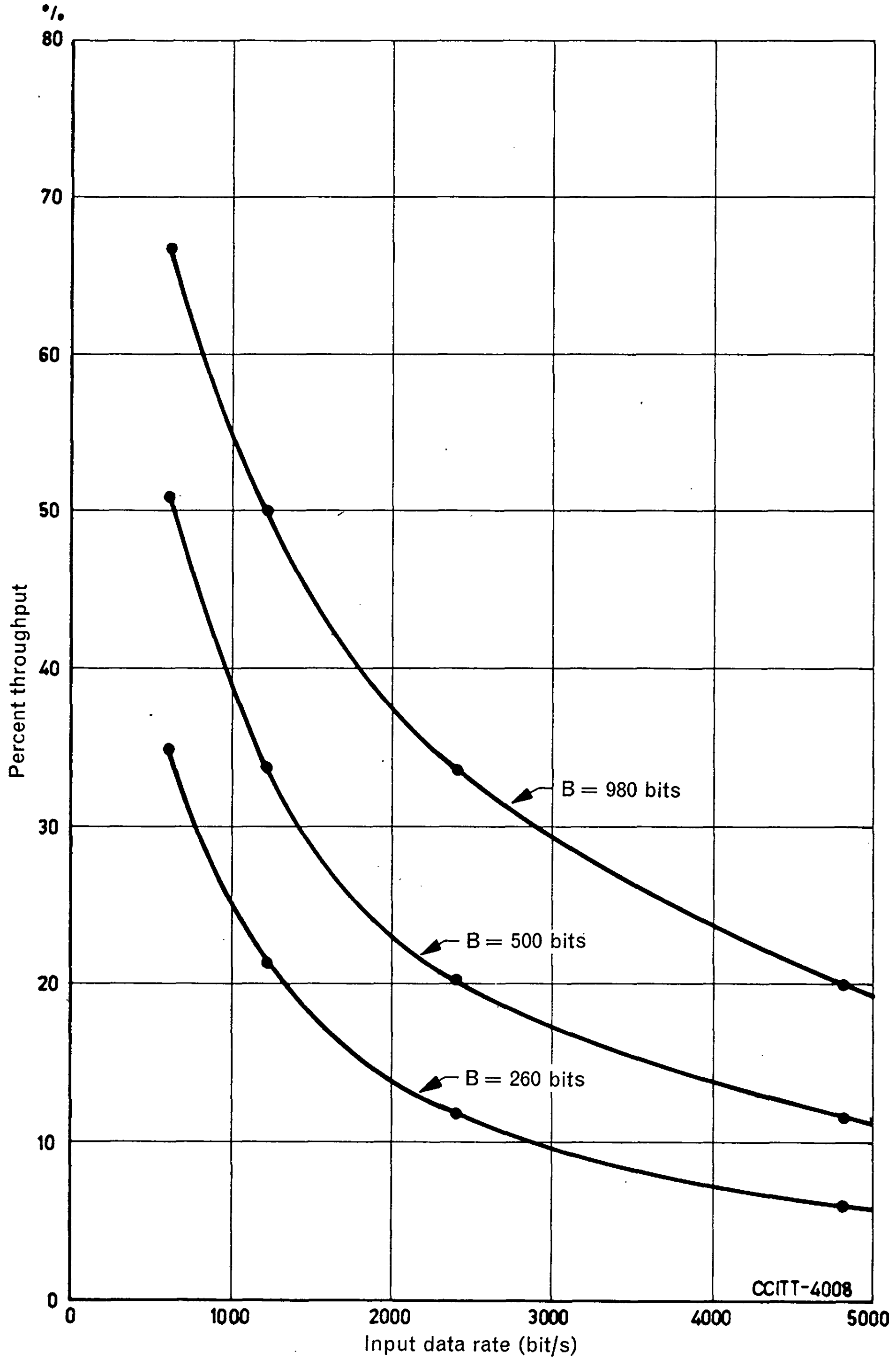


FIGURE 1. — **Idle-RQ throughput loss**

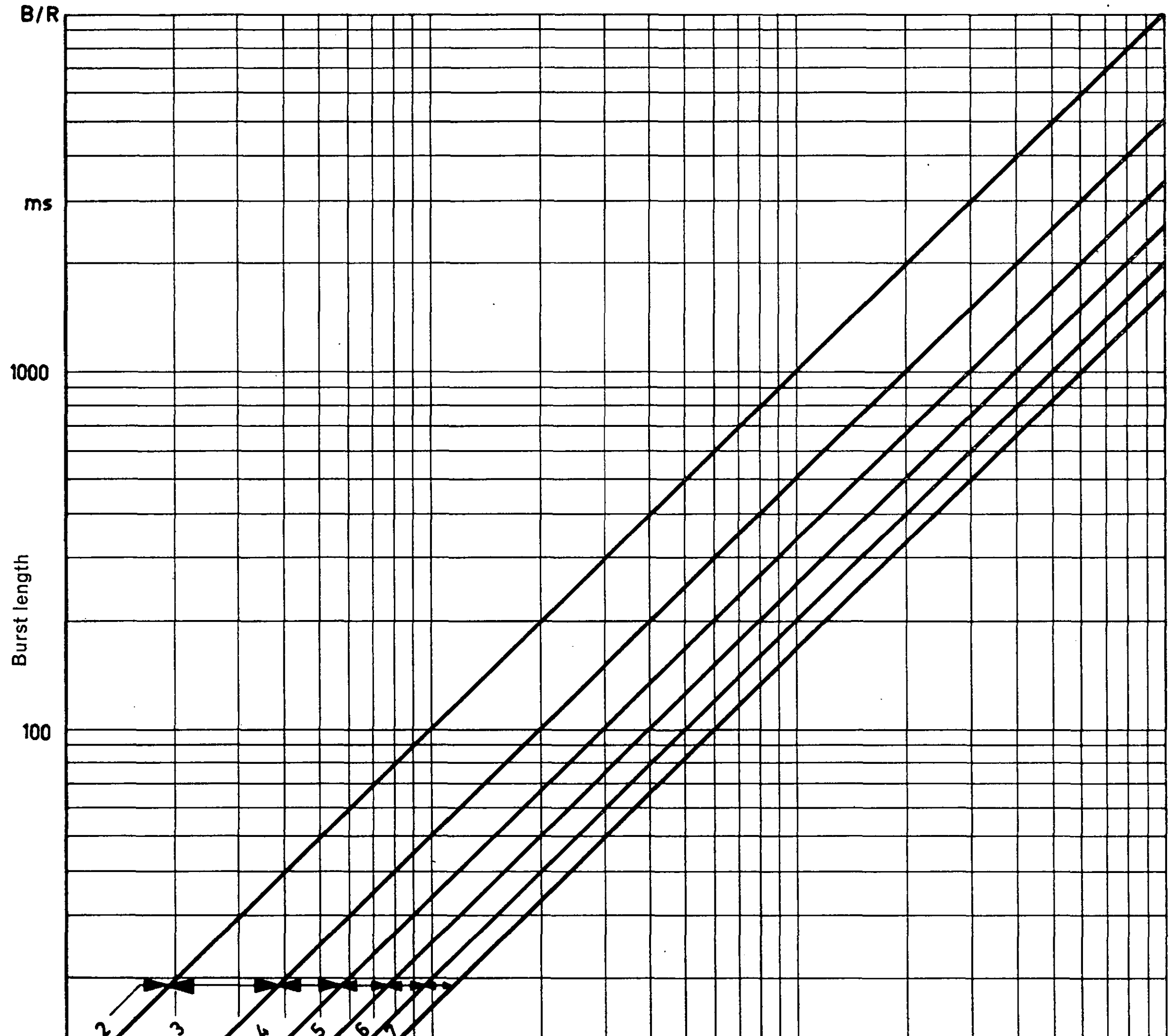


FIGURE 2. — **Go-back-n delay limits**

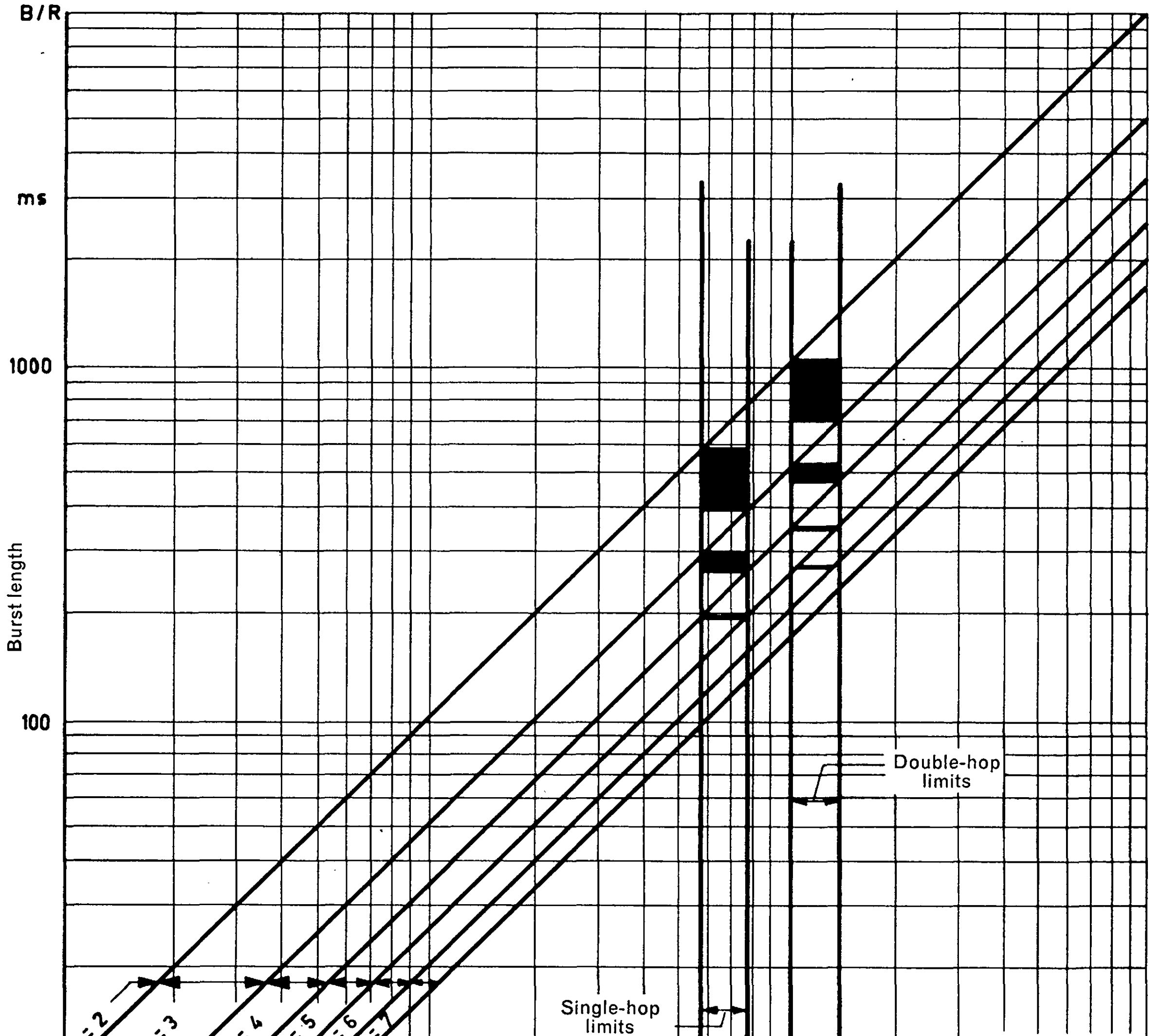


FIGURE 3 — Go-back-n delay limit with satellite operating possibilities

control system for all intercontinental, regional, and domestic facilities with modular optional equipment to enhance its capability over a broader range of transmission facilities. The $\frac{B}{R}$ values which appear suitable for both single-hop and double-hop satellite circuits are:

Category I 460-520 ms $n = 3$ and 4

Category II 270 ms $n = 4$ and 6

The first category is also applicable, for $n = 2$, to terrestrial and/or submarine cable transmissions leading to total path delays of less than 460 ms while the second category permits similar applications involving less than 270 ms delay.

Forward-acting error correction

In the ARQ systems cited previously, for each error of one or more bits in a transmission group, the throughput associated with a time period of length equal to the total loop delay is lost. For example, a single-bit error occurring once every T seconds will reduce the throughput to zero.

Using forward-acting error correction (FAEC) it is possible to guarantee a certain level of throughput for a given statistical channel error model as well as reducing the storage requirement at the transmitter. The price for such improvement is paid at the receiver where not only does decoder complexity increase but a general loss of overall throughput is incurred because the redundancy required for error correction is significantly greater than that required for mere error detection.

The most promising form of forward-acting error correction for the class of data transmission currently under consideration is believed to be that which uses convolutional coding with threshold decoding. More study and experimentation will be required to determine whether FAEC is economically competitive with go-back-n ARQ systems.

A further difficulty with the design of FAEC systems is the fact that the error model for landline facilities appears to be quite different from that of satellite connections. Hence, an error control technique which is very efficient in handling the terrestrial channel model may be incapable of similar performance with a satellite channel model [4].

BIBLIOGRAPHY

[1] C.C.I.T.T. Study Group Special D, Contribution No. 5, period 1968-1972: The Planning for the INTELSAT Digital International/Intercontinental Networks.

[2] C.C.I.T.T. Study Group Special A, Contribution No. 121, period 1968-1972: Demand-assigned Data Transmission Using the SPADE System for Satellite-linked Connections (see Supplement No. 25, *Green Book*, Volume VIII).

[3] C.C.I.T.T. Study Group XII, Contribution No. 37, period 1968-1972: User Tolerance of Connections including Two Single-hop Satellite Links in Tandem.

[4] Burton, H. O.: A Survey of Error Correcting Techniques for Data on Telephone Facilities, presented at the 1970 International Conference on Communications, San Francisco, California.

ANNEX A

Measurement of 4800-bit/s transmission performance over the Pacific Ocean INTELSAT III (F-4) between Jamesburg (U.S.) Earth Station and Paumalu (U.S.) Earth Station

Purpose of test

To measure the bit error rate (BER) of a 4800-bit/s data transmission over a 4-kHz satellite channel in operational status.

Test plan

Jamesburg (JA) and Paumalu (PA) message carriers were selected for this test as follows within the JA-PA 1203 Supergroup 1/Group 3:

Channel 4—in operational use;
Channel 5—to be used for the 4800-bit/s transmission;
Channel 6—in operational use;
Channel 8—to be used for impulse noise measurement.

Channels 5 and 8 were looped back at the Paumalu station. Out-of-band noise (OBN) was maintained at the nominal levels of $-52/-53$ dBm0p during the test period. Station C/Ts were maintained at their normal value of -148.6 dBW/°K.

Test results

a) Data transmission level	-17 dBm0
b) Noise level	-61.5 dBm0
c) Signal-to-noise ratio	$+44.5$ dB
d) Phase jitter	$<1.0°$ (peak-to-peak)
e) Phase hits	None / 5° threshold
f) Attenuation vs. freq. (1600 Hz reference)	± 0.2 dB/300-3400 Hz
g) Impulse noise bits (for 70-hour period)	22 counts/-22 dBm0
h) Bit error rate	2.9×10^{-8}

ANNEX B

Measurement of channel performance over the Pacific Ocean INTELSAT III (F-4) between Jamesburg (U.S.) Earth Station and various other Pacific area Earth Stations

Purpose of test

To make short-term measurements of channel performance of randomly selected spare satellite channels between the Jamesburg station and other Pacific area stations on a straightaway and looped-back basis.

Test plan

With earth station C/Ts at normal values, 15-minute tests were conducted between Jamesburg and the distant stations, first on a straightaway basis and then on a looped-back basis, at which time a bit error rate check was made using a 4800-bit/s data modem.

Where station equipment configuration prohibited a direct measurement and loop-back at the station and the channel included terrestrial facilities for the measurement and loop-back at the ITMC, those channels are indicated by an asterisk.

Test results

See Table B-1 for test results.

Remark

The short duration of these tests should be noted and the results indicated considered in the light of this factor.

TABLE B-1a

Stations		Receive: Jamesburg (U.S.)				
	Transmit	Hong Kong	Guam	Carnarvon	Manila	Tokyo
Test-tone/noise (dB flat)		58 [a]	56	49	49 [a]	61.5 [a]
Phase jitter (peak-peak)		1.5° [a]	2.0°	2.0°	8.0°-15.0° [a]	2.0° [a]
Phase hits		None/5° [a]	None/5°	None/5° [a]	158/10° [a]	None/5° [a]
Amplitude hits (1.0 dB threshold)		0 [a]	0	0	0 [a]	0 [a]
Dropouts (>350 ms)		0 [a]	0	0	0 [a]	0 [a]
Level stability (±dB)		<0.1 [a]	<0.1	<0.1	<0.1 [a]	<0.1 [a]
Impulse noise (counts in 15 min) −22 dBm0		0 [a]	0	0	0 [a]	0 [a]
Bit error hits per 15-minute test period		0 [a]	0	0	0 [a]	39 [a] (Unequalized)

[a] Indicates connection with terrestrial segment in addition to satellite link.

TABLE B-1b

Stations		Receive: Jamesburg (U.S.)			
	Transmit	Sydney	Bartlett (Alaska)	Honolulu	Paumalu
Test-tone/noise (dB flat)		50 [a]	61.0	50.5 [a]	61.5
Phase jitter (peak-peak)		2.0° [a]	0.3°	10° [a]	0.5
Phase hits		None/5° [a]	None/5°	2264/5° [a]	0/10°
Amplitude hits (1.0 dB threshold)		0 [a]	0	2 [a]	0
Dropouts (>350 ms)		0 [a]	0	0 [a]	0
Level stability (±dB)		<0.1 [a]	<0.1	<0.1 [a]	<0.1 dB
Impulse noise (counts in 15 min) −22 dBm0		0 [a]	0	0 [a]	0
Bit error hits per 15-minute test period		0 [a]	7	6 [a]	0

[a] Indicates connection with terrestrial segment in addition to satellite link.

ANNEX C

Measurement of 4800-bit/s transmission performance over the Atlantic Ocean INTELSAT III (F-6) using the Etam (U.S.) Earth Station with a non-operational carrier

Purpose of test

To measure the bit error rate (BER) of a 4800-bit/s data transmission in the 4-kHz top and bottom frequency baseband channels of an INTELSAT III 24-channel carrier in a non-operational status.

Test plan

A non-operational noise-loaded carrier was used for these tests because this permitted variation of the carrier power to noise temperature ratio (C/T) at the receive site.

Group A, channel 1—Test channel (lowest frequency baseband channel)
Group A, channel 2—Impulse noise monitoring channel when Group A, channel 1, is under test
Group B, channel 2—Impulse noise monitoring channel when Group B, channel 1, is under test
Group B, channel 1—Test channel (highest frequency baseband channel)

Test results

1. The channel performance summary is shown in Table C-1 for C/T 1 dB below nominal.
2. The data performance summary is shown in Table C-2 for C/T 2 dB below nominal.
3. The bit error rate in each channel as a function of C/T is shown in Figure C-1.
4. The impulse noise counts per minute as a function of C/T and threshold are shown in Figure C-2 for the bottom channel and in Figure C-3 for the top channel.

Remarks

1. The transponder in which this noise-loaded group is located is not fully loaded.

2. The error model for the channel with C/T settings from 4 to 6 dB below nominal was impulsive while random hits predominated as the C/T setting approached nominal.

TABLE C-1

CHANNEL PERFORMANCE SUMMARY

Test route	Phase jitter p-p/avg. deg.	Loss variation (dB)		Impulse noise counts/15 min			S/N[a] (dB)	Phase hits/ 15 min (>5°)	Ampl. hits/ 15 min (>1 dB)
		0.3-3.0 kHz	1.5-2.8 kHz	−22 dBm0	−26 dBm0	−30 dBm0			
Etam-to-Etam									
24-channel noise-loaded carrier									
Gp. A, channel 1	1.0/0.5	+0.2 to −0.6	+0.1 to −0.3	4.5	45	150	41	0	0
Gp. B, channel 1	1.0/0.5	+0.1 to −0.3	+0.1 to −0.0	0.0	0.3	10.5	37	0	0

[a] Transmission level was −13 dBm0, C/T 1 dB below nominal.

TABLE C-2

DATA PERFORMANCE SUMMARY

Test route	Length of test	Avg. BER	Avg. block error rate (2000 bits/block)	Avg. number of erroneous bits [a] per erroneous block
Etam-to-Etam				
24-channel noise-loaded carrier				
Gp. A, channel 1	30 min	$<1 \times 10^{-7}$ (No hits)	$<1 \times 10^{-8}$ (No hits)	—
Gp. B, channel 1	30 min	$<1 \times 10^{-7}$ (No hits)	$<1 \times 10^{-8}$ (No hits)	—

[a] With differentially coded PSK demodulation, a value of 2.0 is minimum.

Note. — C/T is 2 dB below nominal.

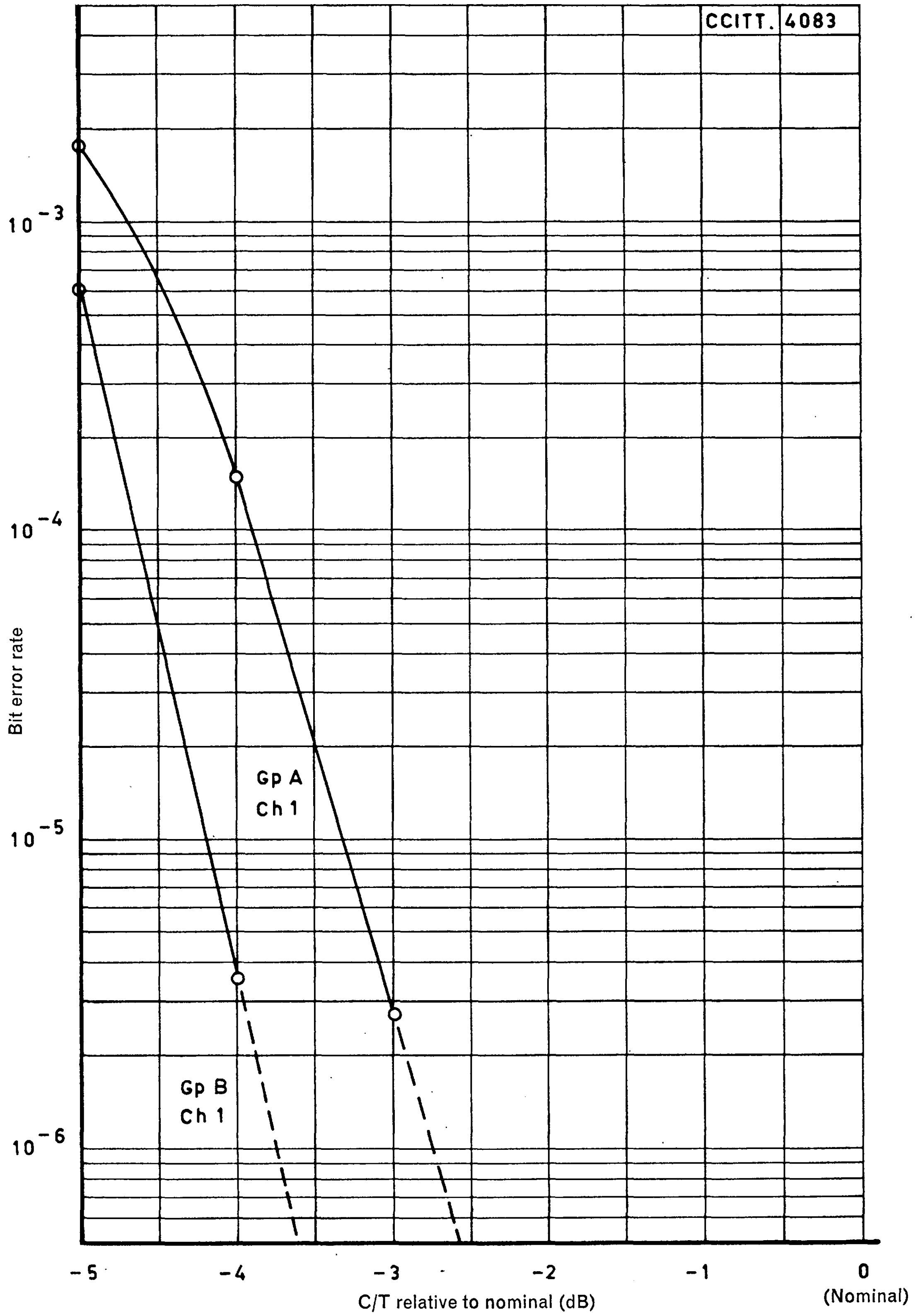


FIGURE C-1. — **Bit error rate vs. C/T** (24-channel noise-loaded carrier)

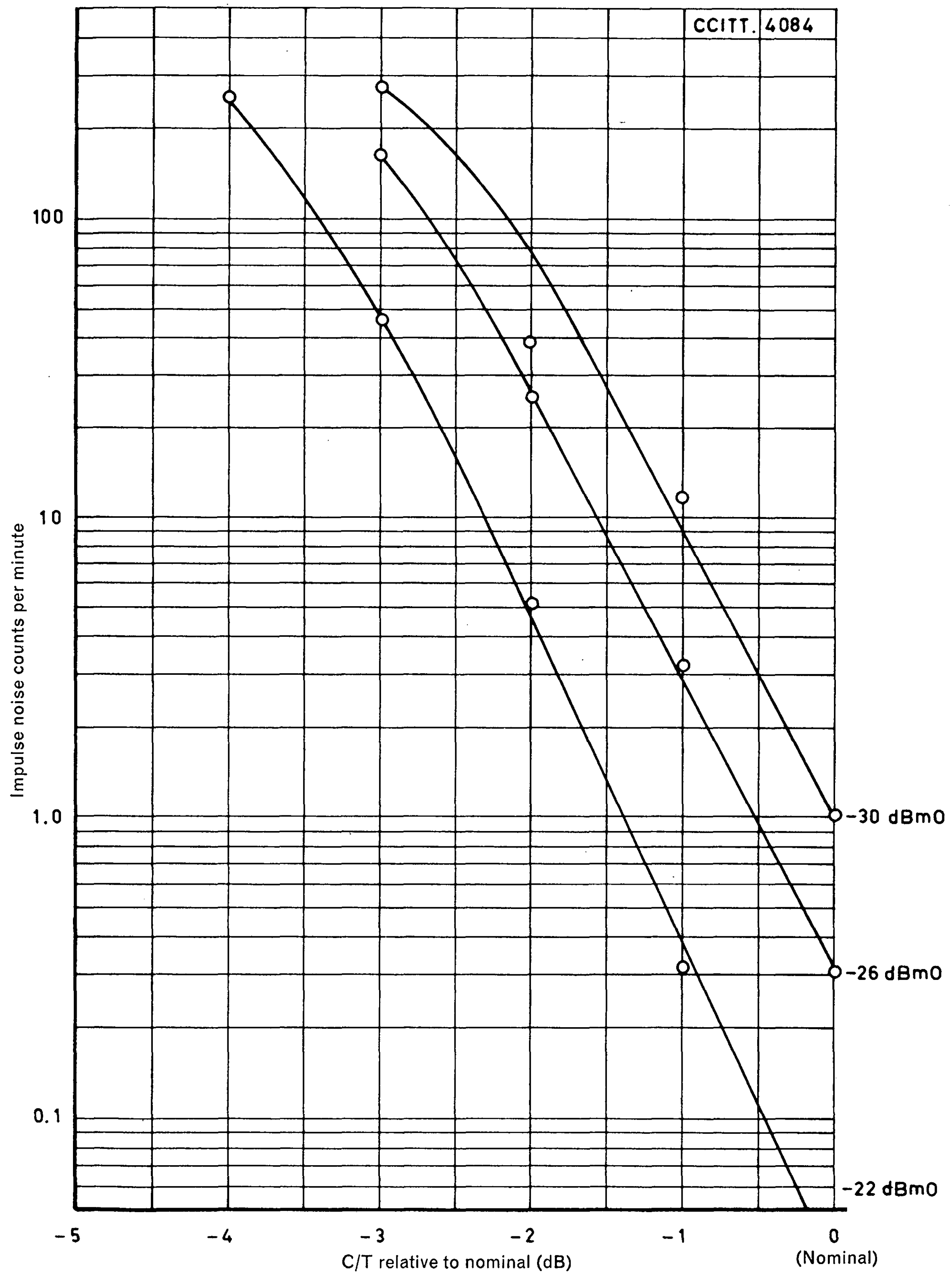


FIGURE C-2. — **Impulse noise counts vs. C/T** (group A, channel 1)
24-channel noise-loaded carrier

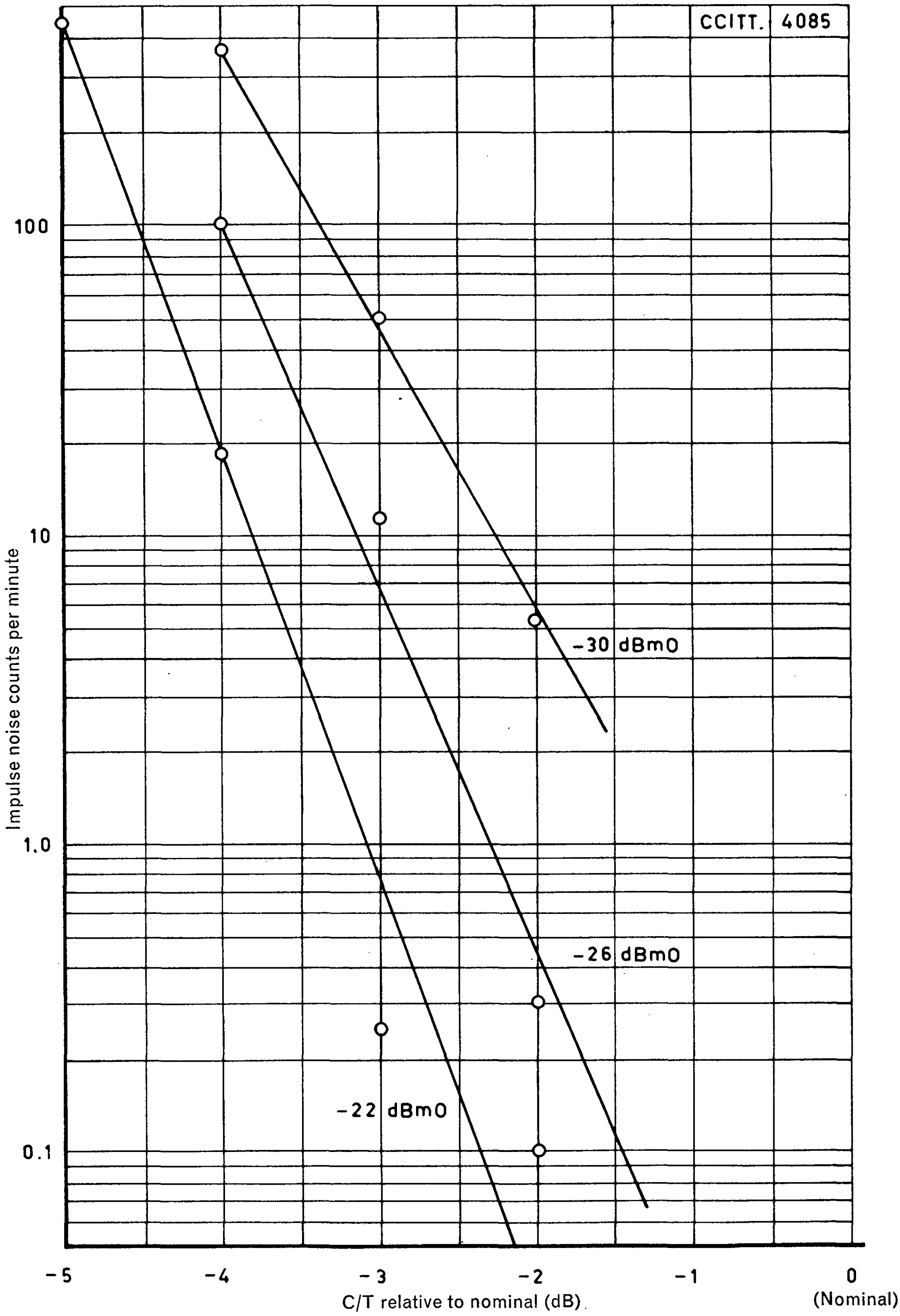


FIGURE C-3. — **Impulse noise counts vs. C/T** (group B, channel 1)
24-channel noise-loaded carrier

ANNEX D

Measurement of 4800-bit/s transmission performance over the Atlantic Ocean INTELSAT III (F-6) using the Etam (U.S.) and Cayey (U.S.) Earth Stations with operational carriers

Purpose of test

To measure the bit error rate (BER) of a 4800-bit/s data transmission over 4-kHz satellite channels of an INTELSAT III 192 channel carrier in operational status.

Test plan

Because of the desirability of collecting data between earth stations only, and because only United States earth stations in the Atlantic region have channel bank multiplex equipment, the only available channel loopback station to work with Etam, West Virginia (U.S.A.) was Cayey, Puerto Rico (U.S.A.). The Etam-Cayey-Etam tests were performed on Gp 1 of SGp 2 of a 192-channel carrier.

Channel 9—test channel, looped at Cayey

Channel 10—simultaneous monitoring channel

Channel 11—test channel, looped at Cayey.

The transponder used for this test is not the same as was used for the Annex C test. The same satellite was used, however.

Test results

1. The channel performance summary is shown in Table D-1.
2. The data performance summary is shown in Table D-2.

Notes

1. The transponder in which the carriers under test were located is heavily loaded with other carriers.
2. In contrast to all prior BER satellite channel tests (see Annexes A, B, and C), the bit errors occurring in this test displayed burst tendencies; the frequency of the bursts correlated with the traffic (fewer bursts with lighter traffic).
3. The burst errors were almost always marked by simultaneous phase and amplitude hits.
4. The cause of the burst errors is now under investigation.

TABLE D-1

CHANNEL PERFORMANCE SUMMARY

Test route	Phase jitter p-p/avg. deg.	Loss variation (dB)		Impulse noise counts/15 min			S/N [a] (dB)	Phase hits/ 15 min (>5°)	Ampl. hits/ 15 min (>1 dB)
		0.3-3.0 kHz	1.5-2.8 kHz	−22 dBm0	−26 dBm0	−30 dBm0			
Etam-Cayey-Etam loop									
Ch. 11 — Test 1	1.0/0.5	0.0 to −0.7	0.0 to −0.1	3.0	6.0	128	+38	0.0	0.0
Ch. 11 — Test 2	1.0/0.3	0.0 to −0.7	0.0 to −0.1	2.7	13.5	113	+37	0.3	0.1
Ch. 9 — Test 1	2.0/0.5	+0.2 to −0.5	+0.2 to −0.1	3.0	13.5	88.5	+37	0.2	0.0
Ch. 9 — Test 2	1.8/0.5	+0.2 to −0.5	+0.2 to −0.1	8.0	24.0	179	+37	0.8	0.2

[a] Transmission level was −13 dBm0.

TABLE D-2

DATA PERFORMANCE SUMMARY

Test route	Length of test	Avg. BER	Avg. block error rate (2000 bits/block)	Avg. number of erroneous bits per erroneous block [a]
Etam-Cayey-Etam loop				
Ch. 11 — Test 1	14.9 hours	8.5×10^{-6}	7.3×10^{-3}	2.34
Ch. 11 — Test 2	12.7 hours	6.7×10^{-6}	7.2×10^{-4}	21.6
Ch. 9 — Test 1	1.2 hours	5.5×10^{-6}	1.1×10^{-3}	10.0
Ch. 9 — Test 2	1.3 hours	1.5×10^{-5}	3.2×10^{-3}	9.6

[a] With differentially encoded PSK modems, the minimum value is 2.0 bits.

ANNEX E

Measurement of data transmission performance and channel characteristics

Purpose of the tests

To obtain data on bit error rate (BER) and corresponding channel characteristics for a variety of conditions.

Test plan

1. *Andover (U.S.)—December 1970*

Measurements were performed on a voice channel loop over operational carriers with the loop being made at the Goonhilly Earth Station (U.K.). Other tests were performed on a 24-channel noise-loaded carrier, transmitted and received at Andover.

These tests employed the INTELSAT III (F-7) satellite.

2. *Etam (U.S.)—March 1971*

Measurements were performed on a voice channel loop over operational carriers with the loop being made at the Cayey Earth Station (Puerto Rico).

These tests employed the INTELSAT III (F-6) satellite.

3. *Jamesburg (U.S.)—March 1971*

Measurements were performed on group-band channel loops over operational carriers with the loops being made at the Paumalu (U.S.) and Moree (Australia) Earth Stations. Other tests were performed on a 132-channel noise-loaded carrier transmitted and received at Jamesburg.

These tests employed the INTELSAT III (F-4) satellite.

4. *Cayey (Puerto Rico)—July 1971*

Measurements were performed on voice and group-band channel loops. All test loops were derived from noise-loaded carriers transmitted and received at Cayey.

These tests employed the INTELSAT IV (F-2) satellite.

Test results

1. The voice channel characteristics are given in Table E-1.
2. The data transmission error rates for voice channels are given in Table E-2.
3. The group-band channel characteristics are given in Table E-3.
4. The group-band data transmission error rates are given in Table E-4.

TABLE E-1. — VOICE BAND CHANNEL CHARACTERISTICS

Test route	Circuit	Attenuation-dB Ref. — 1000 Hz			Impulse noise counts/15 min ⩾ dBm0			Phase jitter p-p (deg)	Phase jitter ave. (deg)	Phase hits (>5°/15 min)	Amp. hits (>1 dB/15 min)	Coinc. hits	Noise (dBm0)
		500-2800 Hz	300-3000 Hz	3000-3400 Hz	−22	−26	−30						
* Etam-CY loop	SG2/G1 Ch 11	0.4	0.7	1.8									−49.0
* CY-Etam	SG2/G1 Ch 9				2.0	4.6	7.8						−51.5
* CY-Etam	SG2/G1 Ch 10							1.0	0.3	1.0	1.5	0.4	
* AN-GH loop	GA-Ch 2	0.3	0.6	0.9	1.4			0.2	<0.1	0.7			−50.0
CY loop	GA-Ch 2	0.15	0.5	1.2	0	0	0	0.4	0.1	0	0	0	−59.0

TABLE E-2. — VOICE BAND ERROR RATES

Test route	Circuit	Length of test (h)	Data rec. level (dBm0)	S/N (dB)	Bit errors	Bit errors per burst	Average BER
* Etam-CY loop * Etam-CY loop * Etam-CY loop	SG2/G1/Ch 11 SG2/G1/Ch 11 SG2/G1/Ch 11	5.5 6.0 5.5	−13 −13 −13	36.0 35.5 36.0	28 12 16	8 4 4.4	2.9×10^{-7} 1.5×10^{-7} 1.7×10^{-7}
* AN-GH loop * AN-GH loop	GA-Ch 2 GA-Ch 2	20.0 17.0	−13 −13	36.5 37.0	133 1029 [a]	79, 42, 8 1001 [a], 14	5×10^{-6} 4×10^{-7} [a]
AN-loop AN-loop	GB/Ch 1 GA/Ch 1		−13 −13				$<1 \times 10^{-7}$ $<1 \times 10^{-7}$
CY-loop	GA/Ch 2		−13	46			$<2 \times 10^{-7}$

All tests made with Milgo 4400 at 4800 bit/s. * Tests over operational carriers.
[a] Average BER reflects the bit error per burst and bit error results.

TABLE E-3. — GROUP BAND CHANNEL CHARACTERISTICS

Test route	Circuit	Attenuation-dB Ref. — 104 kHz 60.0-107.7 kHz	Impulse noise counts/15 min ⩾dBm0			Phase jitter p-p (deg)	Phase jitter ave. (deg)	Phase hits (>5°/15 min)	Amp. hits (>1 dB/15 min)	Coinc. hits	Noise (dBm0)
			−22	−26	−30						
* JA-PA loop	SG1/G3	−1.6 to +1.0	11.25	37.5	—	3.5	1.0	0	0	0	−38.5
* JA-MO loop	SG2/G1	−0.8 to +1.0	6.0	105	—	3.5	0.8	0	0	0	−36.5
** JA loop	GA	−0.4 to +1.0	0	0	0	1.5	0.5	0	0	0	−38.0
** JA loop	SG1/G2	−0.8 to 0.0	0	0	37.5	1.5	0.5	0	0	0	−40.0
** JA loop	SG2/G5	−0.3 to +0.4	0	0	0	1.5	0.5	0	0	0	−36.0
** CY loop	SG1/G4	−0.1 to +1.0	0	0	0						−37.0

TABLE E-4. — GROUP BAND ERROR RATES

Test route	Circuit	Length of test (h)	Data rec. level (dBm0)	S/N (dB)	Average BER
* JA-PA loop	SG1/G3	12.0	−5	33.0	0.9×10^{-8}
* JA-MO loop * JA-MO loop * JA-MO loop	SG2/G1 SG2/G1 SG2/G1	0.7 2.8 11.8	−8 −5 −5	30.0 33.0 33.0	1.3×10^{-7} 3.9×10^{-7} 2.3×10^{-7}
JA loop JA loop JA loop	GA SG1/G2 SG2/G5		−5 −5 −5	33.0 35.0 31.0	$<1 \times 10^{-7}$ $<1 \times 10^{-7}$ $<1 \times 10^{-8}$
CY loop	SG1/G4		−5	32.0	$<2 \times 10^{-8}$

All tests made with GE diginet 422 at 50 kbit/s.

* Tests over operational carriers.
** Impulse noise count thresholds are −10, −14, and −18 dBm0.

5. Channel envelope delay measurements were made for the tests over operational carriers. The results follow.

Etam/Cayey loop

SG2/G1/Ch 11	1000-2600 Hz	160 μs
	600-2600 Hz	1160
	500-2800 Hz	1730
	500-3000 Hz	1730

Andover/Goonhilly loop

GA/Ch 2	1000-2600 Hz	370 μs
	600-2600 Hz	1100
	500-2800 Hz	1400
	500-3000 Hz	1400

Jamesburg/Paumalu loop

SG1/G3	65.5-102.5 kHz	10 μs
	64.2- 65.5 kHz	10
	102.5-103.8 kHz	5

Jamesburg/Moree Loop [1]

SG2/G1	65.5-102.5 kHz	90 μs
	64.2- 65.5 kHz	150
	102.5-103.8 kHz	100

Remarks

The tests reported here include tests over operational carriers and tests over noise-loaded carriers. For clarity, all tests over operational carriers are indicated by an asterisk in the " Test route " column of Tables E-1 to E-4.

2. 2.1 Previous measurements over the Etam-CY voice channel loop were made in October of 1970 and are reported in Annex D. These previous measurements indicated an unexpected incidence of burst errors and correspondingly high error rates. Investigations revealed that these error bursts occurred in coincidence with signalling in a channel adjacent to the super-group pilot. This signalling resulted in interference with the normal operation of the supergroup automatic gain regulator (SG/AGR).

2.2 The tests reported here were performed with the SG/AGR in manual mode to eliminate the interference.

2.3 The tests performed at Etam in March 1971 (labelled " Etam-CY loop " in Tables E-1 and E-2) should be compared with the tests reported in Annex D. The greatly improved performance obtained indicates the validity of the findings discussed above.

2.4 All U.S. earth stations now have modified their equipment to correct the SG/ARG problem.

3. All tests reported were made with the earth station received C/T at nominal value (—147.8 dBW/°K for INTELSAT IV and —148.5 dBW/°K for INTELSAT III).

4. The measurement of data transmission error rates and channel characteristics is a continuing effort at COMSAT. Additional data will be reported as it is obtained.

[1] Results not typical owing to improper delay equalization at Moree Earth Station.

Supplement No. 25

COMMUNICATIONS SATELLITE CORPORATION.—*(Contribution COM Sp. A—No. 121, December 1970)*

DEMAND-ASSIGNED DATA TRANSMISSION USING THE SPADE SYSTEM FOR SATELLITE-LINKED CONNECTIONS

Summary

A digital satellite communications system such as SPADE provides a wide range of on-demand traffic service using an efficient and modular design. The basic voice channel unit can transmit 24-30 telegraphy channels or one alternate voice/data channel directly and, with the addition of multiplex equipment, can expand the normal throughput of telegraphy by as much as sixty times the normal single channel rate and of voiceband data by a factor of ten to forty. A single wideband data channel (48 kbit/s) can be transmitted with minimal additional equipment either directly or with forward-acting error correction using the same power and bandwidth as single-channel-per-carrier voice channel.

Introduction

SPADE is a demand assignment system which utilizes single-channel per-voice-carrier transmissions over satellite communications facilities. In the planned INTELSAT operational configuration the transmitted channel bit rate is 64 kbit/s and voice-activated four-phase coherent phase-shift keyed modulation will be used. The signalling interface with the SPADE equipment can be made compatible with all C.C.I.T.T. signalling systems.

The intent of this contribution is to describe the different types of service that can be transmitted via the SPADE system, namely: voice, record (TTY), voiceband data, wideband data, and alternate voice/data (AVD).

General system considerations

The SPADE system concept provides for a flexible and efficient mode of satellite multiple-point to multiple-point communications. The application of SPADE to demand assignment voice traffic has already been well documented [1, 2, 3]. Demand assigned multiple access systems provide for the sharing of satellite circuits by a large number of terrestrial users. In effect the network earth stations that are in common view of a satellite share a pool of satellite circuits. The circuits are then assigned on demand, forming a temporary connection between any two earth stations within the region covered by the satellite. When no longer required, the circuits are returned to the satellite demand assignment pool. The application of SPADE to other traffic services provides the same demand assignment flexibility and efficiency for data, alternate voice/data and record traffic.

The Communications Satellite Corporation has demonstrated in the laboratory, as well as in field tests, that alternate voice/data can be transmitted over the standard SPADE channel configuration. Experiments have also been conducted whereby wideband data (40.8 or 48 kbit/s) has been transmitted over a single SPADE channel utilizing the same power and bandwidth as required for PCM-encoded voice transmissions. In addition, tests have been conducted showing that forward-acting error correction can be provided at modest additional implementation cost enabling significant performance enhancement of the wideband data transmissions and maintaining the same power and bandwidth requirements as used in standard single-channel-per-carrier voice transmissions [4].

COMSAT is currently procuring for INTELSAT prototype SPADE terminal equipment which will transmit and receive telegraph signals using a high-speed TDM multiplex in conjunction with a single SPADE channel to provide high capacity point-to-multipoint service, as well as to transmit and receive telegraph signals from a satellite broadcast channel using time division multiple access (TDMA) to provide efficient telegraphy service for light traffic links.

Description of service implementation

a) *Alternate voice/data*

Normal voiceband data rates such as 1200 bit/s, 2400 bit/s and 4800 bit/s can be sampled directly (as are analogue voice inputs) by the 7-bit voice channel PCM encoder included in the SPADE terminal. Laboratory and satellite tests have demonstrated that no significant degradation was introduced by using the PCM encoder to sample the voiceband data inputs.

An alternate approach is to demodulate the voiceband data to baseband and use a time division multiplex with a single SPADE channel unit (bypassing the PCM encoder) which would allow, for example, the transmission of ten 4800-bit/s signals using the standard power and bandwidth required for single-channel-per carrier voice. This service would be available for traffic routes on a point-to-multipoint basis.

b) *Wideband data*

Wideband data (40.8 or 48 kbit/s) can be transmitted directly over a single SPADE channel utilizing the same peak power and bandwidth as required for single-channel-per-carrier voice. The input data stream can be bit-filled to make it compatible with the desired SPADE channel unit input rate at 56 kbit/s.

Instead of bit-filling, advantage can be taken of the available excess bandwidth and add forward-acting error correction, thus enhancing the performance of the data channel by 3 to 5 orders of magnitude above the specified minimum of $P_{BE} = 1 \times 10^{-4}$ for voice operation. Equipment of this type has been developed and successfully tested at COMSAT both in the laboratory and over the INTELSAT III (F-6) satellite.

c) *TTY*

INTELSAT is planning to incorporate into the SPADE system two types of equipment for transmission and reception of telegraph signals over the SPADE equipment. Present techniques allocate 24 to 30 fifty-baud telegraphy channels to a single voice-frequency bearer channel. The purpose of this developmental equipment is to take advantage of the digital communications channels and to increase the efficiency and flexibility of TTY satellite transmissions.

The first equipment consists of a TDM multiplex that will work in conjunction with a SPADE channel to provide high capacity point-to-multipoint service. This equipment shall accept start-stop telegraph signals using either 5, 7, or 8 level codes at speeds between 50 and 200 bauds. The equipment shall have an output channel bit rate of 48 000 bit/s. It shall have a maximum capacity of at least 1100 fifty-baud channels or the equivalent in higher-speed channels. It will also be capable of accepting any mixture of rates, so long as the aggregate input rate is within the capabilities of the channel. This system will be required to carry telex traffic as well as message traffic. The 48 000 bit/s output rate will then be bit-filled to 56 000 bit/s and be compatible with the input data rate of the standard SPADE channel.

The second equipment is for transmission and reception of telegraph signals from a satellite *broadcast* channel using time division multiple access (TDMA). The purpose of this system is to provide efficient telegraphy service for light traffic links over an INTELSAT satellite. The equipment shall accept telegraph signals using either 5 or 8 level codes at speeds between 50 and 110 bauds. The number of telegraph channels that may be transmitted or received by any one earth station will vary from station to station with traffic requirements. However, this system is capable of providing at least 40 fifty-baud channels (or the equivalent in higher-rate channels) per multiplex terminal. The system accommodates up to 60 multiplex terminals and all terminals have identical channel capacity.

System modes of operation

Depending on the data service and traffic requirements, several different modes of operation are available using the SPADE system.

1. Multiple-point to multiple-point service is available for voice, alternate-voice/data and wideband data whereby the users share a common pool of frequencies and the circuit assignments are made on demand. Thus, any station can establish a satellite connection with any other station in the network on demand, utilizing the satellite resources only when communications are actually needed. This system configuration benefits those links where occasional voice and data communications are required. An example of occasional data transmission is the transfer of stored computer programmes from one locale to others a wideband data link. A central location could transmit programme revisions over a single wideband channel to a multiplicity of users. Only one frequency is required since it is operating as a *broadcast* channel whereby all stations in the network can receive the channel and utilize the transmitted information. Another example can be the transmission of newspaper copy from a central office to multiple geographical locations for simultaneous printing.

2. Point to multiple-point transmission suggested for high density alternate voice/data and TTY links provide for an optimum utilization of channel power and bandwidth. The throughput capability of a single SPADE channel can be significantly increased for high density traffic links by providing a TDM multiplex at the transmitter channel, deriving up to ten 4800 bit/s (AVD) transmissions and up to 110 fifty-baud TTY channels per SPADE channel.

3. Time division multiple access transmissions are available for light traffic links transmitting TTY signals. This broadcast channel enables those users with light traffic requirements to obtain efficient multiple-point to multiple-point TTY communications with other earth stations in the network.

System performance

The SPADE system can guarantee earth station to earth station bit error rate performance to any degree desired. In the SPADE signalling channel error rates of 10^{-11} to 10^{-12} are nominal. The nominal error rate in the voice channels is 10^{-7}. Through the use of coding the voice channel nominal error rate is on the order of 10^{-10}.

BIBLIOGRAPHY

[1] Puente, J. G.: " A PCM-FDMA Demand-assigned Satellite Multiple Access Experiment," *I.T.U. Telecommunication Journal*, Volume 36, No. IV, April 1969.

[2] C.C.I.T.T. " The Planning for the International Telecommunications Satellite Consortium Digital International/Intercontinental Networks," Special Study Group D—Contribution No. 5, Period 1968/1972.

[3] WERTH, A. M.: " SPADE: A PCM/FDMA Demand Assignment System for Satellite Communications," *Proceedings of the INTELSAT/IEE International Conference on Digital Satellite Communications*, London, November 1969.

[4] CACCIAMANI, E. R.: " The SPADE Concept Applied to a Network of Large and Small Earth Stations ", AIAA 3rd Communications Satellite System Conference, Los Angeles, California, AIAA Paper No. 70-420, April 1970.

Supplement No. 26

AUSTRIAN POSTAL AND TELEGRAPH ADMINISTRATION.—*(Contribution COM Sp. A—No. 222, April 1972)*

RANDOM NOISE SIMULATOR

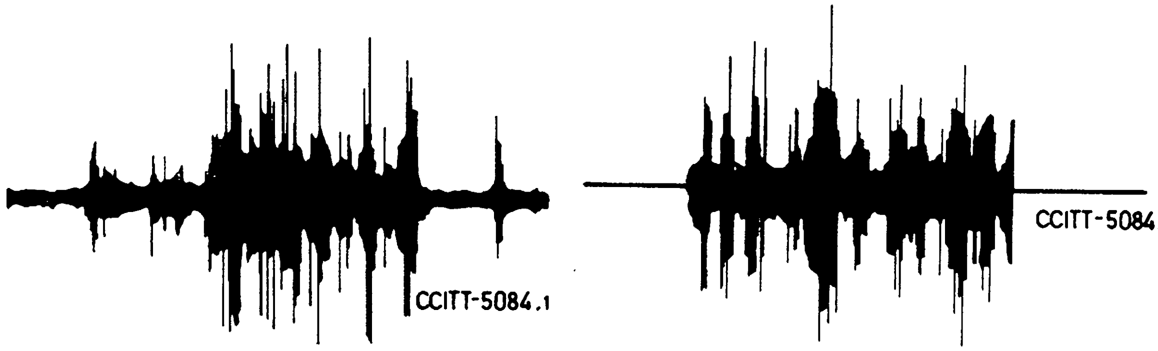
1. *Introduction*

In simulating line noise, the use of Gaussian noise is common practice. Considering that the characteristics of many types of noise (e.g. impulse noise) differ essentially from those of Gaussian noise, a more appropriate method of simulation is often desirable. The generator described below allows of a simulation of various types of noise by random generation of Gaussian noise and it can be used to advantage in all test procedures involving line noise.

In comparative modem tests, the generator can serve as an impulse noise source. The simulated noise reproduces the major properties of real impulse noise, thus permitting a reliable evaluation of the modem performance.

A significant property of impulse noise is the occurrence of intermittent noise bursts. Therefore, the generator produces a random sequence of bursts and noise-free intervals. As regards the statistical distribution of both the burst and the interval duration, an exponential distribution is used, which agrees well with line noise measurements; this distribution offers the added advantage of a relatively easy electronic realization.

The contents of the generated burst is Gaussian noise of which the noise level is commutated between a high and a low level on a random basis. Thus, the noise produced consists of low-level noise interrupted by high-level noise. By using Gaussian noise that alternates between these two levels, the internal structure of bursts (Figure 1) as well as the amplitude distribution of real impulse noise is approximated.



Oscillogram of a real burst. Scale: 0.1 s/cm
30 mV/cm

Oscillogram of a simulated burst. Scale: 0.1 s/cm
30 mV/cm

FIGURE 1

2. *Characteristics of the random noise simulator*

a) The simulated noise is a random sequence of bursts alternating with noise-free intervals. The duration of both the bursts and the intervals is exponentially distributed.

b) The mean values of both the burst duration and the interval duration can be chosen independently between 0.1 s and 10 s.

c) The contents of the bursts is Gaussian noise, commutated at random between a high and a low level. The periods during which a high or low level of noise prevails are exponentially distributed.

d) The two mean values of the periods during which the noise is at a high and a low level, respectively, can be chosen independently between 1 ms and 100 ms.

e) The difference between the high and the low level of noise can be set by an attenuator.

f) The simulator can also produce noise without intervals (burst length infinite), thus permitting the simulation of non-burst noise types.

3. *Block diagram of the random noise simulator*

Figure 2 shows the block diagram of the generator and an example of the time dependence of the noise level.

A Gaussian noise signal whose level can be adjusted by the attenuator A1 is fed into the generator. The electronic switch S1 selects one of two paths, the one leading over attenuator A2, the other one bypassing it, thus generating noise of either a low or a high level. The switch S1 is controlled by a random time base T1, by means of which the average duration of the high-level condition and the low-level condition can be set.

The electronic switch S2 produces the sequence of bursts and intervals. It is controlled by the random time base T2, by means of which the average duration of the bursts and intervals can be set. The two switches can be fixed in both of their positions so that the noise levels can be conveniently checked at the output.

By setting the parameters of the generator, the statistical distribution of time and amplitude of various types of noise can be simulated. In particular, if the amplitude of the low level noise is reduced to zero, the generator produces noise pulses at random intervals.

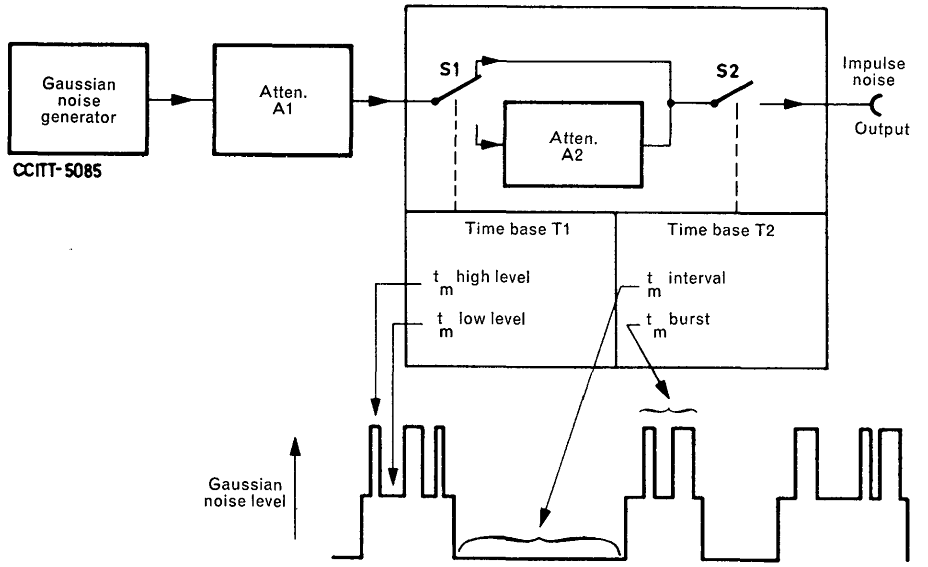


FIGURE 2. — **Block diagram of the noise simulator and an example of the time dependence of the noise level**

t_m . . . are the average time values to be set.

AMERICAN TELEPHONE AND TELEGRAPH CO.—*(Contribution COM Sp. A—No. 128, December 1970)*

MEDICAL DATA SETS

General

Much interest has been expressed in the telephone transmission of various medical data such as electrocardiograms, electromyograms and electroencephalograms. Numerous applications for this service suggest themselves. Consultation by telephone can apparently be of real use to practitioners in remote areas as well as to hospitals and medical centres. Increased interest in the computer diagnosis of certain medical data such as the electrocardiogram indicates further promise for the usefulness of this transmission capability. Many physiological signals of clinical significance are well within the information-carrying capacity of telephone channels.

U.S. common carrier data sets have been developed to transmit medical analogue data such as electrocardiograms, electroencephalograms, etc., with frequency spectra extending from dc to 100 Hz. This family of sets includes a portable (acoustically coupled) transmitting-only set, an electrically connected transmitting-only set, and an electrically connected receiving-only set. Other sets, experimental and under development, provide for the transmission of more than one simultaneous signal with different frequency spectra.

The data sets provide the capability for alternate voice and data. Generally, switching between the TALK and DATA modes is done by means of pushbuttons on the data set. When in the TALK mode, these sets permit normal voice communication over dialled-up telephone facilities. When in the DATA mode, they provide for analogue data transmission in the forward direction and co-ordination signalling in the reverse direction. Some of the sets under development may include a low-speed digital data capability in the reverse direction.

Electrically connected common carrier data sets typically contain telephone sets integrated into them for establishing connections and for normal voice communication. The portable battery-powered data set mentioned previously can be used with standard telephone sets. The handset is placed in the chamber of the data set. The data set delivers its output signal to the telephone line by means of acoustic coupling to the transmitter of the telephone set with which it is used. Similarly, the reverse channel signal is received acoustically from the telephone set receiver.

Typical installation options provided in non-portable transmitters and receivers include automatic answering, use with automatic calling units, 600 or 900 ohm telephone line termination and telephone line output levels. No installation options are provided on the portable transmitter.

The main data channel for the single channel data sets uses telephone line signals in the range from 1725 Hz to 2250 Hz. The frequency is a direct analogue of the voltage on the send data lead. The reverse channel signalling circuit uses telephone line signals of 387 Hz. An ON (alarm) condition is signalled by the absence of 387 Hz, the OFF by the presence of 387 Hz. Other sets under development use other modulation schemes and signal formats.

The circuitry of the single channel data set typically employs similar techniques to those in facsimile data sets. A differential amplifier drives an astable multivibrator in the transmitter while zero crossing detection is used in the receiving data set. The transmitting reverse channel circuitry in the receiver data set consists of a 387-Hz oscillator and a tuned hybrid filter. The tuned hybrid filter serves to isolate reverse channel signals from the main data channel. The reverse channel receiver in the non-portable transmitter uses a tuned amplifier to reject data signals which might otherwise operate the reverse channel detector, which is a simple level detector. The reverse channel receiver in the portable reverse channel unit employs acoustic coupling from the receiver of the telephone set with which the unit is used. A tuned amplifier follows the microphone and drives the detector circuit. The detector output is used to control a multivibrator which is turned on whenever the 387-Hz line signal is absent. The multivibrator drives the indicator lamp, which blinks on and off whenever the multivibrator is running.

Interface signals

The following is a listing of some typical interface leads and appropriate signal requirements for current common carrier data sets. A number of electrocardiograph equipment manufacturers are at present developing adapter circuitry to make existing and new electrocardiograph equipment compatible with interfaces of this type. The interface characteristics of these sets have been chosen to simplify this adapter circuitry as much as possible.

SD 1 and SD 2—Send Data 1 and 2

The Send Data 1 and 2 leads are balanced with respect to the Signal Ground lead. They are the balanced input connections to a differential amplifier. These two leads accept balanced input signals of $\pm$ 1 volt or $\pm$ 1.25 volts with respect to the Signal Ground lead, depending on the data set. The maximum potential difference between the SD 1 and SD 2 leads can be, therefore, 2 volts or 2.5 volts.

SG—Signal Ground

The Signal Ground lead serves as the reference for control and data signals. It may be connected directly or through a current-limiting network to Frame Ground.

FG—Frame Ground

The Frame Ground is common with the ac power service ground and the data set chassis. The Signal Ground lead may be connected directly to the Frame Ground by an installation option. When this option is not used, the Signal Ground lead assumes a potential with respect to the ac power ground which is determined by the signal leads (connected to SD 1 and SD 2 on the data set) of the connecting customer equipment.

IT—Interlock, or DSR—Data Set Ready

The Data Set Ready (or Interlock) ON signal is dependent upon primary power being on at the data set and the data set being in the data mode. An OFF signal is presented by the Data Set Ready circuit when the data set is not in the data mode. The signals may be voltages or contact closures to Signal Ground, depending on the data set.

RCR—Reverse Channel Receive

Indication of the ON status of the Reverse Channel Receive circuit is made by means of a lamp or tone from the data set as well as a contact closure between the RCR and Signal Ground leads or RCR1 and RCR2 leads, depending on the data set. These signals are activated by means of an ON condition (contact closure) at the Reverse Channel Send circuitry of the receiving data set at the other end of the telephone connection. This Reverse Channel ON signal is used to indicate a return to the TALK mode of operation at the transmitting data station. Some experimental sets can receive low-speed digital data on this lead.

RR—Remote Release or DTR—Data Terminal Ready

The Data Terminal Ready (or Remote Release) lead allows or does not allow the data set to go into the data mode, depending on whether the lead is placed in the ON or OFF condition. A closure between DTR and Signal Ground or RR and Remote Control Common (RC) constitutes the ON condition, whereas an open between these leads constitutes the OFF condition. Opening the closure while the data set is in the data mode will terminate the call. In automatic operation, this is the recommended mode of terminating a call.

RY—Ready or AA—Automatic Answer

When unattended features are provided, a contact closure between the Ready Lead and the Remote Control Common lead (or between Automatic Answer and Signal Ground leads), provided by the connecting medical electronic equipment, will enable the data station to answer calls on an unattended basis. If a contact closure is not provided between these leads the telephone associated with the data set will ring but the call will not be automatically answered.

RI-1 and RI-2—Ring Indicator 1 and Ring Indicator 2

A contact closure between the Ring Indicator 1 and Ring Indicator 2 occurs whenever ringing current is detected if the data set has been arranged for the possibility of automatic answering. The Ring Indicator circuit can be used to prepare the business machine for data reception before the call is automatically answered.

RD—Receive Data

The RD lead presents an analogue signal which varies from −2 to + 2 volts (or −2.5 to + 2.5, depending on the data set), with respect to the Signal Ground lead in accordance with the input signal presented to the Send Data circuit of either the non-portable or portable transmitter. The source impedance presented by the RD circuit to the connecting equipment is less than 1000 ohms.

RCS—Reverse Channel Send

A contact closure between the RCS and Signal Ground leads, or the depressing of the RCS button on the data set, will give an ON indication at the RCR and/or the lamp or tone on the transmitter at the other end of the telephone connection. This contact closure is used as an alarm to indicate to the attendant at the transmitting location that voice co-ordination is necessary and that he should go to the TALK mode of operation. In some experimental data sets, the lead is activated by voltages representing low-speed digital data.

Supplement No. 28

JOINT WORKING PARTY NRD *(Extract from the report to the Vth Plenary Assembly, document APV/No. 21, June 1972)*

DATA SERVICE REQUIREMENTS

1. *User facilities*

. . . .

i) *Facsimile (including phototelegraph) service on data networks*

The representative of the I.P.T.C. raised a question whether or not the facsimile service could be implemented in a new data network. After discussion, the Joint Working Party concluded that as far as facsimile transmission in digital form is concerned, it would readily be acceptable to a new data network, because an item on " bit sequence independence " has been listed in the user facilities.

As for analogue facsimile transmission it would be admitted to users as long as they were prepared to provide analogue/digital conversion, if necessary.

ii) *Voice co-ordination as a data user requirement*

The Joint Working Party noted the following comment on this subject made by I.S.O.:

" There is no requirement for the network to provide voice and transmit this over the network, even though the transmission rate is adequate."

Some delegates pointed out that, although this facility could be useful under certain or special circumstances (e.g. setting-up of calls, maintenance service, etc.), it is likely to be diminished and should not be listed in the user requirements.

It was also noted that if such a facility is required it could be provided by means of analogue/digital conversion.

iii) *User requirements for computer communications 1980 and beyond*

a) In the Annex to Question 1/A, point H (Question 9 of Study Group X) the following supplementary question is indicated:

" What new facilities for data transmission are likely to be asked from us in the next 5, 10 and 20 years? "

b) Noting that there were an increasing number of scientific and multi-disciplinary conferences and publications in many countries on different aspects of computer communication requirements for the more distant future, the meeting considered that it would be useful for members to make contributions on this subject concerning user requirements foreseen for the 1980's and beyond.

These points left for further study have been incorporated in the study programme for the period 1973-1976 as Question 1/NRD—points A, B and C with a detailed indication of study points.

2. *Network parameters*

. . . .

3. *Regulations and tariffs for data services*

3.1 *Introduction*

Although the Joint Working Party NRD is not responsible for tariff principles, the NRD consulted the Chairman of Study Group III, who agreed that it would be helpful if NRD would indicate any factors which they feel might assist Study Group III in formulating tariff structures for new data network services. Furthermore, GM/NRD considered whether there is a need to include provisions for data transmission services in the I.T.U. Regulations.

3.2 *Regulations*

3.2.1 The documents which relate to the international telecommunications services are:

a) articles in the International Telecommunications Convention which contain general provisions concerning telecommunications services;

b) Telegraph, Telephone and Radio Regulations which are annexed to the Convention and contain provisions governing the procedures to be followed;

c) C.C.I.T.T. Recommendations which supplement the Regulations and contain detailed technical, operational, tariff and accounting procedures.

The provisions of the Regulations are binding on the signatories unless they specifically state their intention not to observe certain provisions. In effect, Regulations are mandatory whereas C.C.I.T.T. Recommendations are not. The responsibility for amending or revising the Regulations rests with I.T.U. World Administrative Conferences which meet very infrequently; hence provisions in Regulations are not appropriate for new services in the early stages of development. Moreover, on the instructions of the Plenipotentiary Conference, Resolution No. 36, C.C.I.T.T. has been considering simplification of the existing Telegraph and Telephone Regulations by transferring as much detail as possible to C.C.I.T.T. Recommendations. As a result, proposals will be put to the next C.C.I.T.T. Plenary Assembly which will restrict the content of the Regulations to provisions containing only broad principles. For example, in the provisions of the proposed revised Telegraph Regulations covering services to users, the telex, phototelegraph and leased circuit services are referred to in the following terms:

> " Administrations may provide or authorize telex, phototelegraph, or other telegraph services and may place international circuits at the exclusive disposal of users . . ."

The provisions in the proposed revised Telephone Regulations dealing with services to users state:

> " The Administrations shall determine by mutual agreement the classes of calls, the special facilities, and the special transmission using telephone circuits to be admitted in their reciprocal international telephone relations . . ."

3.2.2 GM/NRD suggests that data transmission service is one of the many international telecommunications services offered by Administrations and does not justify a specific set of Regulations. It agreed that Study Group I and Study Group II should be asked to consider including a reference to data transmission service in the revised Telegraph and Telephone Regulations respectively.

3.2.3 One of the more important aspects of a data transmission service is the need to ensure privacy of a communication; for example, safeguarding against unauthorized access to data banks. How far this should be the responsibility of the telecommunications authorities is open to question. There is a provision in Article 35 of the Convention which covers secrecy of telecommunications as follows:

> " Members and Associate Members agree to take all possible measures, compatible with the system of telecommunication used, with a view to ensuring the secrecy of international correspondence.
>
> " Nevertheless, they reserve the right to communicate such correspondence to the competent authorities in order to ensure the application of their internal laws on the execution of international conventions to which they are parties."

GM/NRD suggests that the C.C.I.T.T. might wish to seek the opinion of the I.T.U. as to whether this provision is thought to be sufficient in the context of data transmission service.

3.2.4 Existing C.C.I.T.T. Recommendations for data transmission are mainly technical in nature and contain very few references to operational procedures and service matters. To some extent this is because, unlike most other telecommunications services, Administrations do not provide the facilities for a complete user-to-user service. There may, however, be scope for including more information on operational procedures and service aspects in C.C.I.T.T. Recommendations and GM/NRD suggests that this question could be examined.

3.3 *Tariffs* [1]

3.3.1 The majority of international data transmission services are at present carried either on the public switched telephone or telex networks or on leased circuits. The present tariff structure for both telephone and telex services is based on the conventional " duration and distance " method. The same basic principle applies to a telephone-type leased circuit which is used as a reference unit for deriving charges for other uses of telephone-type circuits and for telegraph-type circuits at specified modulation rates.

3.3.2 It should be appreciated that C.C.I.T.T.'s responsibility in the tariff field is concerned with the principles and establishment of international accounting rates. The charge to the user is entirely a matter for each national Administration.

3.3.3 The advent of dedicated networks for data transmission services allows the possibility of adopting different call charges from those applied to data transmission services on the telephone and telex networks and consideration of tariff principles based on methods other than the duration and distance concept as the latter would be inappropriate or impracticable for some data transmission applications.

3.3.4 GM/NRD has considered what information could be conveyed to Study Group III at this stage to assist in its deliberations. In this connection the chairman indicated the following list for consideration:

Some points to be further resolved within appropriate Study Groups include:

1) What rate structure ought to be recommended to take account of slow- and high-speed transmission and higher performance characteristics?

2) Should the rate be in a linear relationship with the call duration or should short calls be charged differently?

3) How should the different classes of service be charged for (e.g. closed network facility, identification by the network, short setting-up and clearing time, delayed delivery, etc.)?

4) Simplified international tariff structure (e.g. distance independence or for packet switching connect-time independence).

5) How will international accounting be effected (with due regard to short calls), e.g. accuracy of time recording, beginning of chargeable duration?

6) Peak and off-peak rates.

7) Transfer of charge.

8) Interworking between networks of different kinds may involve new tariff principles.

GM/NRD has come to the conclusion that this list would not be of much practical value to Study Group III without more detailed information of the services and facilities to be provided in the

[1] See also Question 9/III in the *Green Book*, Vol. IIA.

international data transmission service, the computer processing applications involved, the charging facilities which are likely to be provided in national and international networks and some indication of the cost of providing the basic services and additional facilities.

It is to be hoped that some of this information will soon be available when NRD has decided on the services and facilities to be provided internationally but information on charging facilities and costs is more likely to be available from the studies of national network design at this stage.

3.3.5 GM/NRD feels that the main difficulty for Study Group III in formulating tariff structures will be to take account of all the implications of data transmission as compared with the traditional telecommunications services and it seems necessary for a considerable interchange of information between NRD and Study Group III. This might be achieved in two ways: by national consultations between NRD and Study Group III delegates or the attendance of selected representatives from NRD at future meetings of Study Group III to explain in detail the technical and operational consideration of the NRD proposals, or a combination of both approaches.

Supplement No. 29

JOINT WORKING PARTY NRD *(Extract from the report to the Vth Plenary Assembly, document APV/No. 112, December 1972)*

INFORMATION GIVEN BY CERTAIN ADMINISTRATIONS AND RECOGNIZED PRIVATE OPERATING AGENCIES REGARDING THE CUSTOMER INTERFACE IN RECOMMENDATION X.21

1. During the next study period as synchronized networks begin to be implemented, other international standards bodies will be dealing with related standards. In addition computer and terminal manufacturers will be designing equipment for attachment to these new networks. It is important, therefore, that some specific advice be given to I.S.O., E.C.M.A., other Administrations (or R.P.O.A.s) and manufacturers of the intentions where known of Administrations (or R.P.O.A.s) regarding the customer interface in Recommendation X.21.

2. The following countries intend to implement as part of their standard interface for synchronous classes in synchronized networks the character alignment method employing SYN characters as indicated in paragraph 3.a) of Recommendation X.21: U.S.A. (A.T. & T.) and Canada.

3. The following countries intend to implement as part of their standard interface for synchronous classes in synchronized networks the character alignment method employing byte timing as indicated in paragraph 3.b) of Recommendation X.21: Denmark, Finland, Federal Republic of Germany, Norway, Sweden and United Kingdom.

Note. — In addition with this arrangement, during the customers' data phase, the byte timing signal will be presented over the interface but the customer may ignore this signal.

4. The following countries intend to implement as part of their standard interface for synchronous classes in synchronized networks both of the character alignment methods indicated in paragraphs 3.a) and 3.b) of Recommendation X. 21: Italy and France.