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SERIES R: TELEGRAPH TRANSMISSION

Time division multiplexing

CODE AND SPEED DEPENDENT TDM SYSTEM FOR ANISOCHRONOUS TELEGRAPH AND DATA TRANSMISSION USING BIT INTERLEAVING

Reedition of CCITT Recommendation R.101 published in the Blue Book, Fascicle VII.1 (1988)

NOTES

1 CCITT Recommendation R.101 was published in Fascicle VII.1 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression “Administration” is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Recommendation R.101

CODE AND SPEED DEPENDENT TDM SYSTEM FOR ANISOCHRONOUS TELEGRAPH AND DATA TRANSMISSION USING BIT INTERLEAVING

(Geneva, 1976; amended at Geneva, 1980, Málaga-Torremolinos, 1984 and Melbourne, 1988)

The CCITT,

considering

(a) that the economic transmission of large numbers of anisochronous telegraph and data services over a single telephone-type circuit may be achieved by using ςtime-division multiplexing (TDM) techniques;

(b) that the multiplexing system should be capable of operating as a sub-multiplexer within a higher order TDM hierarchy as well as on an analogue telephone-type circuit in association with standard data modems;

(c) that the codes and speeds used for anisochronous telegraph and data transmission are well defined, permitting the application of simple code-dependent multiplexing techniques;

(d) that code-dependent multiplexing provides inherent regeneration of start-stop signals carried by the system;

(e) that, while it is foreseen that the main application would be for telex traffic, the multiplexing system should be capable of simultaneously transmitting the complete range of standard anisochronous speeds and codes likely to be required by users;

(f) that the multiplexing system should be capable of accepting for transmission all types of telex signals and of regenerating those signals at the channel outputs within the tolerances specified in the relevant CCITT Recommendations;

(g) that the multiplexing system should permit the efficient mixing of various combinations of anisochronous speeds, codes and signalling types in the same transmission system;

(h) that the minimum duration of signal transfer delay through the TDM system could be achieved by the transmission of interleaved elements;

unanimously declares the view

that, where bit-interleaved code and speed dependent TDM systems are used for anisochronous telegraph and data transmission with an aggregate bit rate of 2400 bit/s carried either by an analogue telephone-type circuit or by a higher order TDM, the equipment shall be constructed to comply with the following standard:

1 System capacity

1.1 The capacity of the system shall be 46 channels at 50 bauds (7.5 units including a stop element of 1.5 units).

1.2 For other modulation rates two alternatives are allowed.

1.2.1 *Alternative A*

1.2.1.1 Channels at 75 bauds (7.5 units including a stop element of 1.5 units) shall be accommodated. See § 5.5.2 below.

1.2.1.2 Further study is needed to accommodate other modulation rates.

1.2.2 *Alternative B*

1.2.2.1 The modulation rates and character structures shown in Table 1/R.101 shall be accommodated with the capacities indicated for homogeneous configurations.

1.2.2.2 The TDM system shall be capable of multiplexing the eight modulation rates shown in Table 1/R.101 simultaneously.

TABLE 1/R.101

System capacity (alternative B)

Modulation rate (bauds)	Character structure		Number of channels (homogeneous configuration)
	Character length (units)	Stop element (units)	
50	7.5	1.5	46
75	7.5	1.5	30
100	7.5 or 10	1.5 1	22
110	11	2	22
134.5	9	1	15
150	10	1	15
200	7.5, 10 or 11	1.5 1 2	10
300	10 or 11	1 2	7

2 Start-stop channel inputs

2.1 The modulation rate tolerance that shall be accepted on continuous incoming 50- and 75-baud start-stop signals with a stop element of 1.4 units shall be at least ± 1.4%.

2.2 When receiving characters at 50 or 75 bauds having nominally 1.5-unit stop elements, the system shall be capable of transmitting without error, isolated incoming characters that have a one-unit stop element, occurring at a maximum rate of one per second.

2.3 The minimum interval between start elements of undistorted successive continuous characters that may be presented at the channel input when the nominal modulation rate is 50 or 75 bauds shall be 145 5/6 or 97 2/9 ms respectively.

2.4 There shall be no restriction on the continuous transmission of all characters specified in § 1 above (e.g. combination No. 32 of International Telegraph Alphabet No. 2) when they are presented at the maximum permitted rate.

2.5 The effective net margin on all channel inputs when undistorted signals are received from a transmitter having a nominal character length and rate shall be at least 40%.

2.6 At the nominal signalling rate, an input character start element shall be rejected if equal to or less than 0.4 units duration and shall be accepted if equal to or more than 0.6 units duration.

2.7 Elements corresponding to start polarity (at the distant multiplexer output) shall be inserted in the aggregate stream in the case of:

a) unequipped channels;

b) equipped but unallocated channels;

c) open-circuit line condition at the local start-stop channel input.

2.8 The maximum tolerance on modulation rates other than 50 and 75 bauds shall be 1.8%.

3 Start-stop channel outputs

3.1 The maximum degree of gross start-stop distortion shall be 3% for all permitted modulation rates.

3.2 The maximum difference possible between the mean modulation rate of the channel output signals and the nominal modulation rate shall be 0.2%.

3.3 When characters having a nominal 1.5-unit stop element are presented at any input rate within the specified range of this Recommendation, the minimum stop element duration released at the output shall be 1.25 units.

3.4 When characters having a nominal 1- or 2-unit stop element are presented at any input rate within the specified range of this Recommendation, the minimum stop element duration released at the output shall be 0.8 or 1.8 units respectively.

3.5 Channel output shall be controlled as specified below in the event of recognition of any of the following failure conditions:

a) carrier loss signalled by the modem (OFF condition of received line signal detector – circuit CT109, Recommendation V.24 [1]);

b) loss of aggregate signal (defined as a period of 280 ms without a transition on the aggregate);

c) loss of synchronization.

3.6 Within 4 ms of the recognition of the failures described in § 3.5, the following shall occur to the channel outputs of the affected TDM:

3.6.1 Leased channels – two options shall be possible on a per channel basis:

a) set to steady start polarity;

b) set to steady stop polarity;

3.6.2 Circuit-switched service – two options shall be possible on a per channel basis:

a) steady start polarity at the channel output;

b) loopback of the channel towards the local end for a period of 5 ± 1 seconds, after which channel outputs shall revert to steady start polarity. Additionally for alternative B, the traffic path shall be maintained towards the distant multiplexer terminal during this loopback interval.

Note – The actions taken in case 3.6.2 a) shall ensure that, after recognition of failure, no 50-baud channel used for circuit-switched service shall produce an output pulse of stop polarity of longer than 20 ms or a series of 20-ms pulses of stop polarity. It should be noted that 20-ms pulses can cause difficulty with some switching equipment. The loopback option in 3.6.2 b) is provided in order to avoid clearance of established connections during short breaks and thus avoid excessive recall attempts.

3.7 The affected terminal shall signal its synchronization status to the distant terminal in accordance with §§ 6.3.5 for alternative A and 6.4.2 for alternative B. The distant terminal shall control its channel outputs in accordance with § 3.6 above with a delay that shall not exceed 600 ms (measured from the instant of failure), ignoring the propagation time of the bearer circuit. Alternatively, for alternative B, leased channels have the option, at the customer's request, of maintaining the traffic path in the unaffected direction.

4 Multiplexing details

4.1 Channel interleaving shall be on a bit basis.

4.2 Both start and stop elements of each input character shall be transmitted through the aggregate.

4.3 The transfer delay for 50- and 75-baud signals through a pair of terminals connected back-to-back (excluding the modems) shall not exceed 2.5 units. This delay shall be measured from the reception of the start element of a character at an input channel of one terminal until the corresponding start element is delivered from the output channel of the second terminal.

4.4 *Alternative A*

4.4.1 Multiplexing details for higher modulation rates remain for study.

4.5 *Alternative B*

4.5.1 The maximum transfer delay for all other permitted channel speeds for back-to-back terminals shall not exceed 3.5 units.

4.5.2 110-baud characters are conveyed on a 100-bit/s bearer channel by transmitting at least one stop element in the aggregate signal.

4.5.3 134.5-baud characters are conveyed on a 150-bit/s bearer channel by transmitting the necessary filling bits of stop polarity before the character start elements in the aggregate signal.

5 Frame structure

5.1 A unique subframe of 47 bits shall be used.

5.2 A 47-bit subframe shall consist of one synchronization bit in the first bit position and 46 traffic bits.

5.3 A fundamental frame consisting of two consecutive subframes shall be used.

5.4 Two alternative framing arrangements are allowed; however, the channel numbers used throughout this Recommendation represent the last two digits of a 4-digit numbering scheme – and are shown in Recommendation R.114. This channel numbering scheme (see Tables 3/R.101, 4/R.101 and 5/R.101) covers both framing arrangements.

5.5 *Alternative A*

5.5.1 Two scrambling techniques are used:

5.5.1.1 Alternate frame slots have inverted signal polarity. The chart of frame structure (see Table 2/R.101) indicates the pattern used. Channels not equipped are transmitted as A (start) polarity.

5.5.1.2 The channels are arranged for external interconnection with assignment of a sequence of channel numbers (channel 1 through channel 46). These channel numbers are distinct from frame slot assignment. (This is comparable to a VFT's having both a frequency assignment and a channel number.) The channel numbering sequence is scrambled with respect to the frame slot sequence. This technique is useful not only for ensuring a good distribution of transitions, but also for simplifying mixed speed programming.

TABLE 2/R.101

Frame for forty-six 50-baud channels with provision for 75-baud channels (Alternative A)

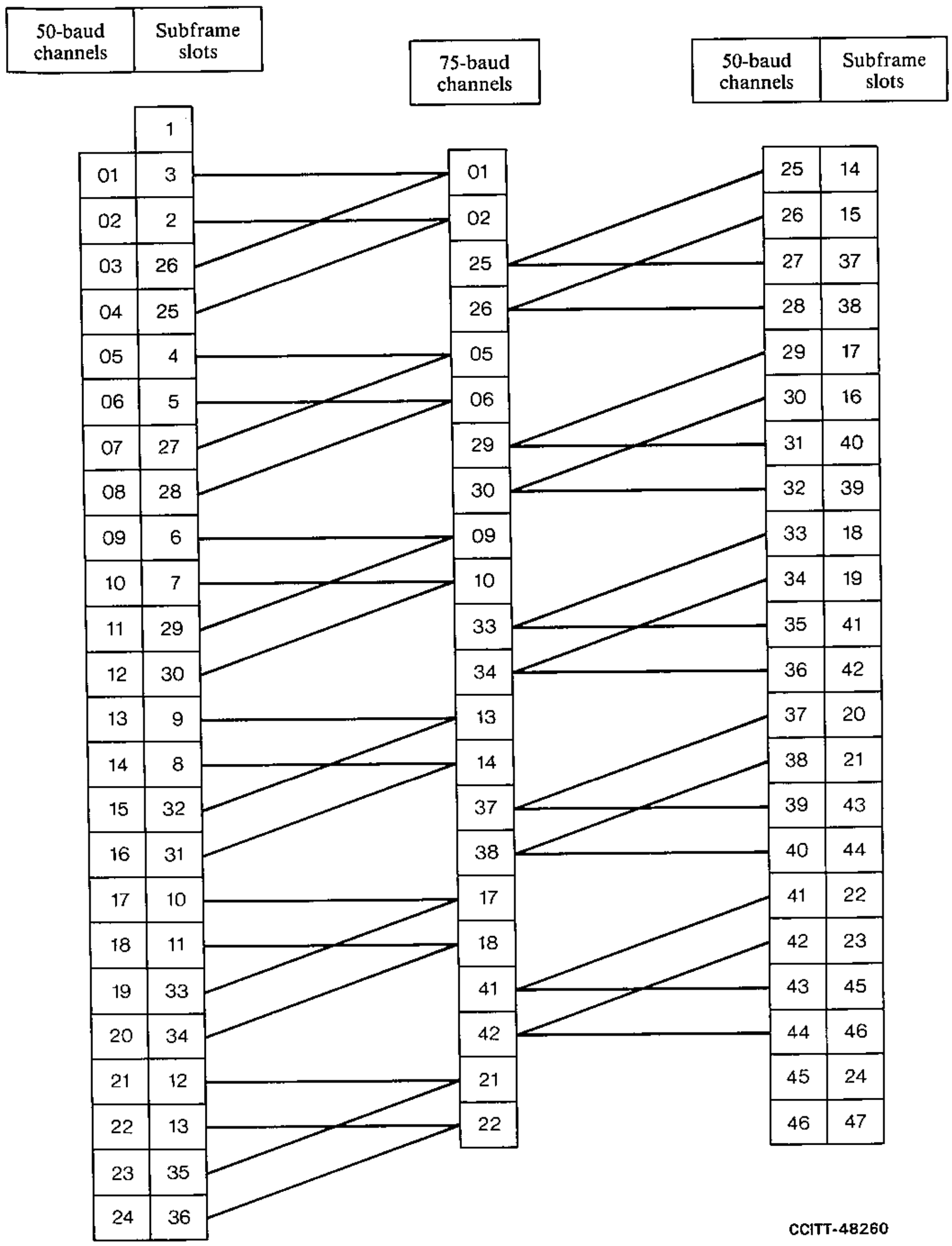
Subframe slot	Channel number	Aggregate polarity corresponding to Z polarity on low-speed channel	Channel speed	Subframe slot	Channel number	Aggregate polarity corresponding to Z polarity on low-speed channel	Channel speed
1	Not applicable		SYNC	24	45	Z	50
2	02	A	50 [a)]	25	04	A	50 [a)]
3	01	Z	50	26	03	Z	50
4	05	A	50	27	07	A	50
5	06	Z	50	28	08	Z	50
6	09	A	50	29	11	A	50
7	10	Z	50	30	12	Z	50
8	14	A	50	31	16	A	50
9	13	Z	50	32	15	Z	50
10	17	A	50	33	19	A	50
11	18	Z	50	34	20	Z	50
12	21	A	50	35	23	A	50
13	22	Z	50	36	24	Z	50
14	25	A	50	37	27	A	50
15	26	Z	50	38	28	Z	50
16	30	A	50	39	32	A	50
17	29	Z	50	40	31	Z	50
18	33	A	50	41	35	A	50
19	34	Z	50	42	36	Z	50
20	37	A	50	43	39	A	50
21	38	Z	50	44	40	Z	50
22	41	A	50	45	43	A	50
23	42	Z	50	46	44	Z	50
				47	46	A	50

[a)] Any horizontal pair, such as channels 02 and 04 (i.e. subframe slots 2 and 25), may be replaced by a 75-baud channel. (Slots 1, 24 and 47 excepted.) In this case "fill" pulses of A polarity must be inserted in each character following element numbers 2 and 5 (see Recommendation cited in [2] for element numbers with International Telegraph Alphabet No.2).

5.5.2 In Table 2/R.101, higher speed channels may be substituted for multiple low-speed channels. The resulting channel should bear the number of the lowest channel replaced. For example, when channels 02 and 04 are replaced by a 75-baud channel, the 75-baud channel should be known as channel 02. (See Table 3/R.101 for the relative numbering of 50- and 75-baud channels.)

TABLE 3/R.101

Channel allocation scheme for Alternative A

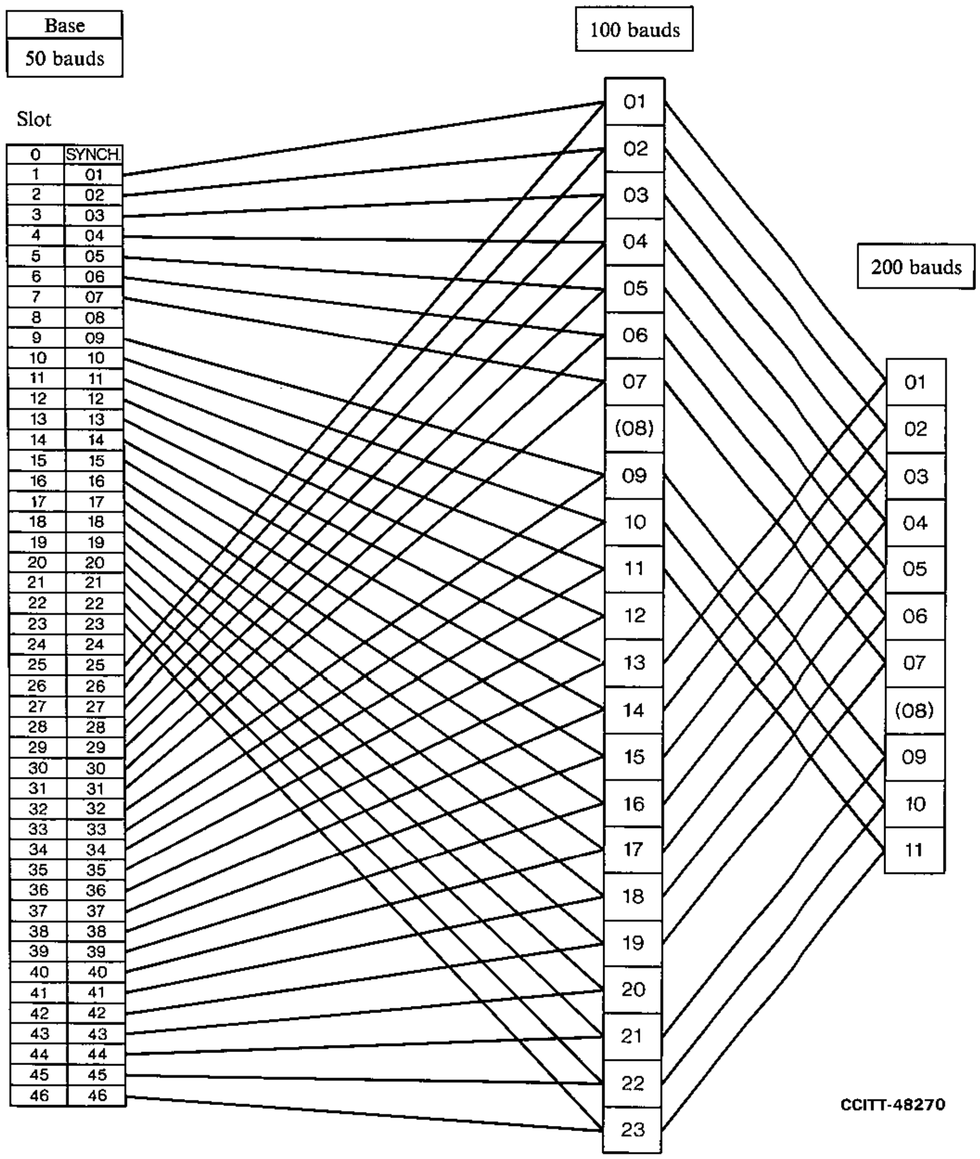


5.6 *Alternative B*

5.6.1 The channel allocation in the fundamental frame is shown in Table 6/R.101 in matrix form giving the relationship between individual low-speed channels and the corresponding traffic bits. The fundamental frame is represented as divided into four groups of 24 positions. The correspondence between positions in the matrix structure and bit numbers within the fundamental frame is shown in the bit number columns. The table also shows the distribution of positions within the specific groups for channels of different speeds and the corresponding channel numbering. (See also Tables 4/R.101 and 5/R.101.)

TABLE 4/R.101

TDM channel allocation for Alternative B (50, 100 and 200 bauds)

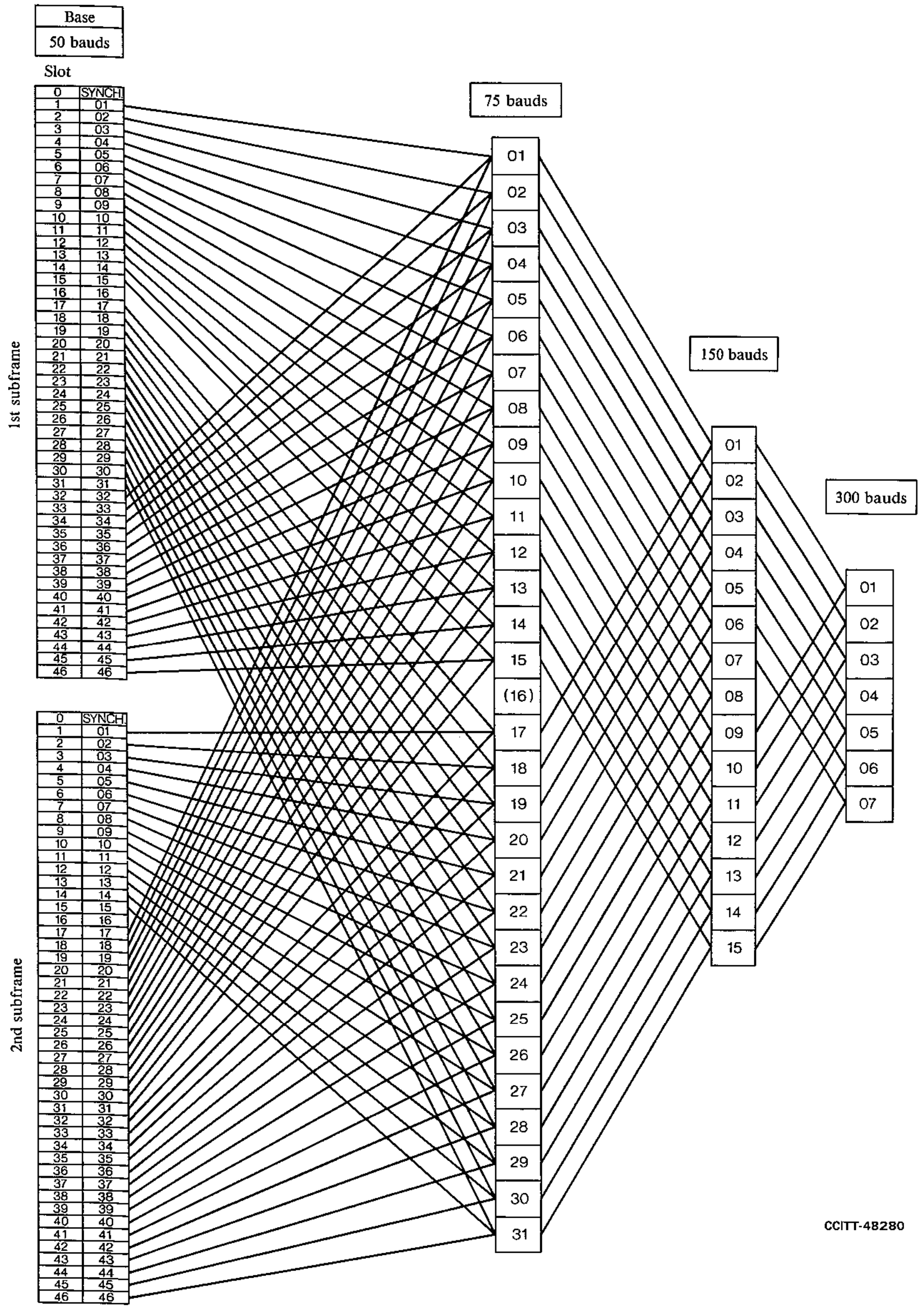


Note 1 – A higher rate channel cancels the use of all other channel numbers connected across to that channel number.

Note 2 – The allocation of 50-baud channel 16 for maintenance purpose cancels the possibility to set up 100-baud channel 16 and 200-baud channel 04.

TABLE 5/R.101

TDM channel allocation for Alternative B (50, 75, 150 and 300 bauds)



Note 1 – A higher rate channel cancels the use of all other channel numbers connected across to that channel number.

Note 2 – The allocation of 50-baud channel 24 for maintenance purpose cancels the possibility to set up 75-baud channel 24 and 150-baud channel 08.

TABLE 6/R.101

Frame structure for Alternative B

		Subframe slot	Channel number Group 1						Subframe slot	Channel number Group 2						Subframe slot	Channel number Group 3						Subframe slot	Channel number Group 4					
Channel rate (bauds)			50	100	200	75	150	300		50	100	200	75	150	300		50	100	200	75	150	300		50	100	200	75	150	300
Fundamental frame	First subframe	0	Synchronization bit						1	01	01	01	01	01	01	2	02	02	02	02	02	02	3	03	03	03	03	03	03
		4	04	04	04	04	04	04	5	05	05	05	05	05	05	6	06	06	06	06	06	06	7	07	07	07	07	07	07
		8	08	x	x	08	08	x	9	09	09	09	09	09	01	10	10	10	10	10	10	02	11	11	11	11	11	11	03
		12	12	12	x	12	12	04	13	13	13	01	13	13	05	14	14	14	02	14	14	06	15	15	15	03	15	15	07
		16	16	16	04	x	x	x	17	17	17	05	17	01	01	18	18	18	06	18	02	02	19	19	19	07	19	03	03
		20	20	20	x	20	04	04	21	21	21	09	21	05	05	22	22	22	10	22	06	06	23	23	23	11	23	07	07
		24	24	x	x	24	08	x	25	25	01	01	25	09	01	26	26	02	02	26	10	02	27	27	03	03	27	11	03
		28	28	04	04	28	12	04	29	29	05	05	29	13	05	30	30	06	06	30	14	06	31	31	07	07	31	15	07
			Skipped						32	32	09	09	01	01	01	33	33	10	10	02	02	02	34	34	11	11	03	03	03
		35	35	12	x	04	04	04	36	36	13	01	05	05	05	37	37	14	02	06	06	06	38	38	15	03	07	07	07
		39	39	16	04	08	08	x	40	40	17	05	09	09	01	41	41	18	06	10	10	02	42	42	19	07	11	11	03
		43	43	20	x	12	12	04	44	44	21	09	13	13	05	45	45	22	10	14	14	06	46	46	23	11	15	15	07
	Second subframe	0	Synchronization bit						1				17			2				18			3				19		
		4				20			5				21			6				22			7				23		
		8				24			9				25			10				26			11				27		
		12				28			13				29			14				30			15				31		
		16				x			17				01			18				02			19				03		
		20				04			21				05			22				06			23				07		
		24				08			25				09			26				10			27				11		
		28				12			29				13			30				14			31				15		
			Skipped						32				17			33				18			34				19		
		35				20			36				21			37				22			38				23		
		39				24			40				25			41				26			42				27		
		43				28			44				29			45				30			46				31		

Note 1 – Blank slots in second subframe are as first subframe.

Note 2 – x = bit not available for corresponding channel bit rate.

Note 3 – 110-and 134.5-baud signals shall be transmitted on 100 and 150 bit/s bearer channels respectively and restitued with appropriate rate at the channel output. See also §§ 4.5.2 and 4.5.3 (Alternative B).

TABLE 7/R.101

Alternative B channel numbering

Channel rate (bauds)	Range of channel number *n*	Subframe slot(s) allocated to channel number *n*	
50	01-46	*n*	
75	01-15	*n* and ($n + 31$) from first subframe and ($n + 16$) from second subframe	See Notes 1 and 2
	17-31	*n* from first subframe and ($n - 16$) and ($n + 15$) from second subframe	
100	01-07	*n* and ($n + 24$)	See Note 3
	09-23	*n* and ($n + 23$)	
150	01-15	*n* and ($n + 16$) and ($n + 31$)	
200	01-07	*n* and ($n + 12$) and ($n + 24$) and ($n + 35$)	See Note 3
	09-11	*n* and ($n + 12$) and ($n + 23$) and ($n + 35$)	
300	01-07	*n* and ($n + 8$) and ($n + 16$) and ($n + 24$) and ($n + 31$) and ($n + 39$)	

Note 1 – At 75 bauds, channel number *n* and $n + 16$ are interdependent, i.e. when channel *n* is used for 75 baud traffic, channel $n + 16$ must also be used for 75 bauds or remain unallocated.

Note 2 – Channel number 16 not used.

Note 3 – Channel number 08 not used.

Note 4 – 110 and 134.5-baud signals shall be transmitted on 100 and 150 bit/s bearer channels respectively and restituted with appropriate rate at the channel output. See also §§ 4.5.2 and 4.5.3 (Alternative B).

Note 1 – For all speeds other than 75 bauds, the second subframe in the fundamental frame is a repetition of the first subframe.

Note 2 – In each subframe one position within group 1 is skipped, i.e. allocated zero time in the aggregate signal.

5.6.2 Substitution of higher speed channels into a homogeneous 50-baud system configuration shall be made as follows:

2 × 75-baud channels	replaces 3 × 50-baud channels
1 × 100- or 110-baud channel	replaces 2 × 50-baud channels
1 × 150- or 134.5-baud channel	replaces 3 × 50-baud channels
1 × 200-baud channel	replaces 4 × 50-baud channels
1 × 300-baud channel	replaces 6 × 50-baud channels

5.6.3 All bits from groups 3 and 4 shall give inverted polarity.

5.6.4 The first, third and fifth bits of the synchronization pattern are contained in the first subframe. The second, fourth and sixth bits are contained in the second subframe (see § 6.4.2).

6 Synchronizing

6.1 The system shall not lose synchronism more than once per hour for a randomly distributed error rate of one part in 10^3.

6.2 Two synchronizing arrangements are allowed as follows on §§ 6.3 and 6.4.

6.3 *Alternative A*

6.3.1 The synchronizing bits shall be alternated between 1 and 0 in successive subframes during normal traffic periods.

6.3.2 The system shall declare loss of synchronism when 7 synchronizing bits are detected in error during a period of 1.5 to 2 seconds.

6.3.3 With two terminals connected back-to-back (excluding the modems), one terminal shall be capable of detecting loss of synchronism within 280 ms when its received aggregate signals are replaced by either steady start or steady stop polarity.

6.3.4 Under the conditions in § 6.1 above, after loss of synchronism has been recognized and the receive aggregate signals have been restored, the average time that may be taken for the terminal concerned to resynchronize and to connect normal data through to the low-speed channel outputs shall be less than 900 ms.

6.3.5 When one terminal recognizes loss of synchronism:

a) traffic transmitted to the other terminal shall be interrupted immediately;

b) the changes shown in Figures 1/R.101 and 2/R.101 shall occur in the synchronizing pattern.

6.4 *Alternative B*

6.4.1 A sync frame is defined as a sequence of three consecutive fundamental frames (i.e. six consecutive subframes) containing a synchronization word that consists of six equidistantly spaced bits.

6.4.2 The normal sync pattern transmitted when the TDM terminal receiver is correctly synchronized will be 100010. When the receiver is out of synchronism the transmitted pattern shall be 011101 (see § 6.4.5 below). The changeover shall only occur at the end of a sync frame.

6.4.3 Loss of synchronism is defined when three consecutive synchronization patterns are received in error.

6.4.4 When the received aggregate signal is replaced by steady start or steady stop polarity, the receiver terminal shall be capable of detecting loss of synchronism within 280 ms.

6.4.5 With two terminals connected back-to-back, loss of synchronism in one terminal shall be indicated at the other terminal within 240 ms, by inversion of the normal synchronization pattern. (See § 6.4.2 above.)

6.5 Receipt of the inverted sync pattern shall cause the terminal to force the aggregate traffic bits to the polarities corresponding to:

a) steady start at the start-stop channel input for channels that are used for circuit-switched service and that are in the free-line condition;

b) steady stop at the start-stop channel input for all other channels,

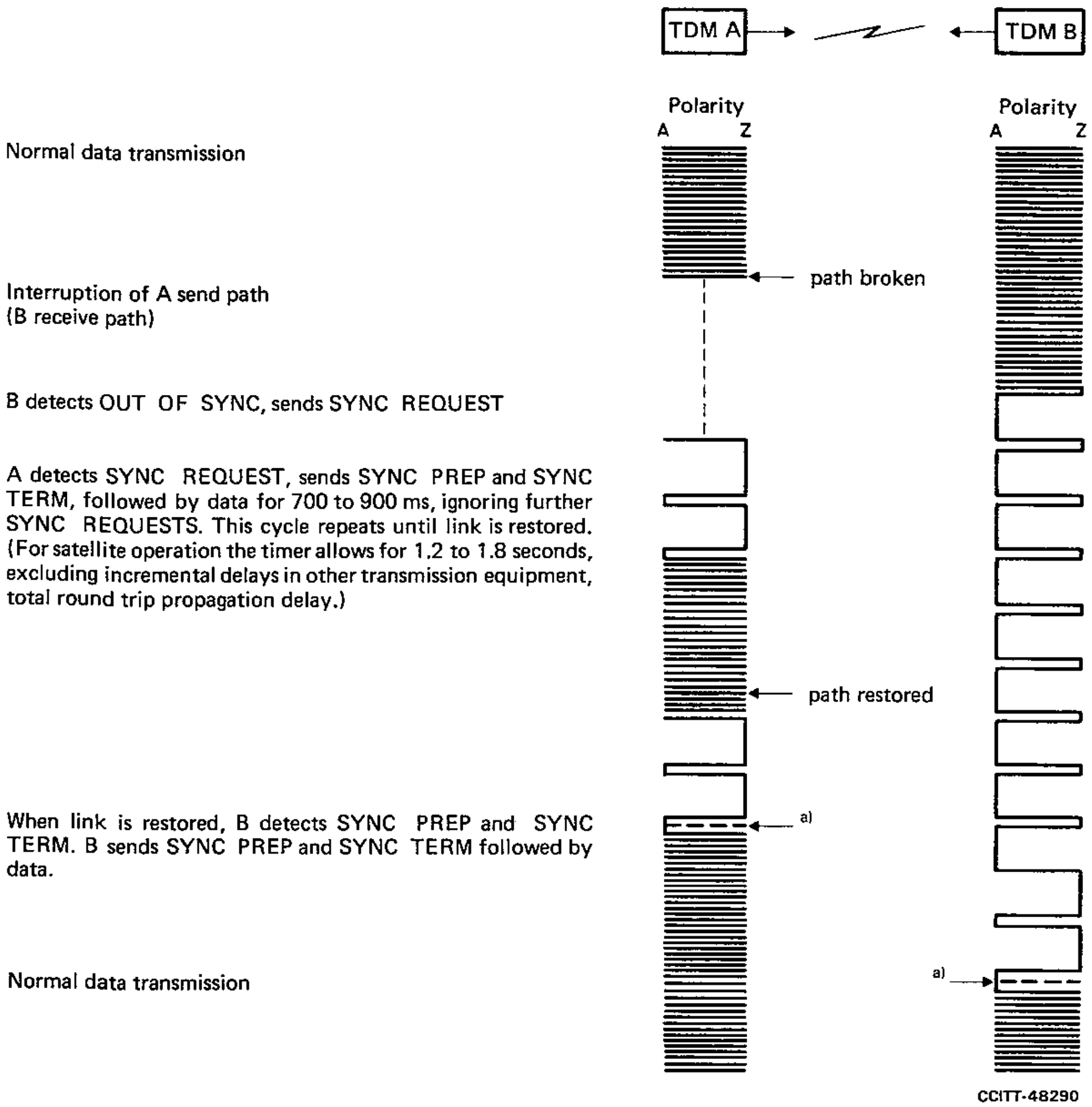
that is, both transmitted in accordance with § 5.6.3 above.

6.6 Synchronism is defined as achieved when:

a) six identical synchronization patterns (i.e. six normal or six inverted synchronization patterns) have been consecutively received on a single bit position without error; and

b) within the same period, two or more consecutive identical synchronization patterns (i.e. normal or inverted sense) have not been received on any of the other bit positions in the 47-bit subframe.

The sense of the patterns in a) and b) may be different.

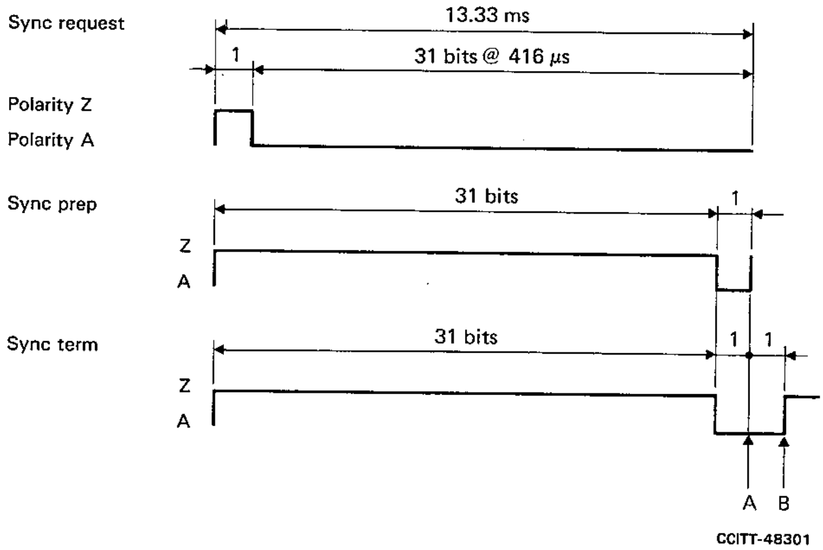


[a] Aggregate time slot counters are reset to zero upon receipt of SYNC TERM. FRAME SYNC is the next bit transmitted. See description of SYNC TERM, which follows in Figure 2R/101.

Note – It should be noted that there is equipment (corresponding to Alternative A) in use that applies SYNC signals that are of inverted polarity to those shown in this Recommendation.

FIGURE 1/R.101

TDM synchronization procedure (Alternative A)



Note 1 – When synchronization is achieved, point A represents the time when aggregate time slot counters are reset to zero. The interval from A to B represents the frame SYNC pulse of the first subframe to be released after synchronization.

Note 2 – It should be noted that there is equipment (corresponding to Alternative A) in use that applies SYNC signals that are of inverted polarity to those shown in this Recommendation.

FIGURE 2/R.101

Synchronization signals (Alternative A)

6.7 If condition a) in § 6.6 above is fulfilled while condition b) is not:

a) the search for synchronism is continued in the terminal concerned; and

b) this terminal shall force the transmitted aggregate traffic bits to the polarities indicated in § 6.5 above.

6.8 Under the conditions in § 6.1 above, after loss of synchronism has been recognized and the aggregate signals have been restored, the average time that may be taken for the terminal concerned to resynchronize and to connect normal data through to the low-speed channel outputs shall be less than 960 ms, excluding all transmission delays external to the R.101 TDM terminal equipment.

7 Telex signalling

7.1 Specifications for the signals used to establish, to clear and to control telex calls are laid down in Recommendations U.1 (types A and B), U.11 (type C) and U.12 (type D). Recommendation U.25 lists the modes of both-way telex signalling on a single circuit and the signalling combinations on a given aggregate that a TDM terminal shall be capable of handling.

7.2 Recommendation U.25 also lays down the tolerances on the control signals from a TDM terminal to telex and vice versa.

8 Aggregate signals and interface

8.1 The tolerance on the modulation rate of the send aggregate signals of the TDM system shall be ± 0.01%.

8.2 The maximum degree of isochronous distortion of the send aggregate signals of the TDM system shall be 4%.

8.3 The effective net margin of the aggregate receiver of the TDM system shall be at least 40%.

8.4 When the TDM system is operated with an aggregate speed of 2400 bit/s over an international analogue telephone-type circuit, it is preferred that a modem complying with the appropriate aspects of the Series V Recommendations be employed.

8.5 The electrical interface conditions and control signals between the TDM system and the bearer circuit shall comply with the appropriate Recommendations in the V and X Series.

9 System clock arrangements

9.1 The TDM system shall be capable of operating with either an internal or external transmit clock.

9.2 In the event of the failure of an external clock that may be used for the TDM transmit, the TDM shall continue to function locally for maintenance purposes using its own internal clock.

9.3 The receive clock for the TDM terminal shall be provided by the bearer circuit or higher order multiplex.

9.4 In the event of the failure of an external clock that may be used for the TDM receive, the TDM shall continue to function locally for maintenance purposes using its own internal clock.

9.5 The internal clock provided in the TDM terminal should have an accuracy of 0.01%.

10 System maintenance, control and alarms

10.1 One 50-baud channel may be allocated (on an optional basis) for maintenance purposes, where possible on a separate system using a parallel route. Where this option is exercised, channels 16 or 24 (subframe slots 16 or 24) in alternative B equipment or channel 45 (subframe slot 24) in alternative A equipment are preferred to minimize the effect on the derivation of higher-rate channels.

10.2 If the internal (logic) power supply of the TDM terminal fails and an external telegraph battery supply is employed, all local start-stop channel outputs shall be controlled to start polarity.

10.3 It shall be possible to reallocate individual start-stop channels for different services without removing the TDM terminal from service.

11 Link transmission system quality indicator

11.1 The synchronizing bits in the alternative A or B structures shall be monitored (on an optional basis) to provide information on the error rate of the aggregate.

The implementation of this optional mesurement should be such that the error rate on the synchronizing bits is supervised continuously and an alarm is issued when a preselected limit has been reached.

The alarm limits should be at least one faulty bit every 10^3, 10^4 or 10^5 bits.

11.2 For alternative A, the occurrence of an incorrect synchronizing bit (when the TDM is in synchronism) should be signalled to an internal or external equipment (see Note 1). Alternative B is for further study.

11.3 The interface between the telegraph muldex and the measuring equipment should be in accordance with national requirements.

11.4 Between the moment at which the TDM system has declared loss of synchronism and restoration of the latter, the invalid synchronization pulse shall not be generated.

12 Link transmission system availability indicator

12.1 The loss of synchronism of a synchronized TDM in alternative A or B shall be monitored (on an optional basis) to provide an indication of the transmission system availability.

12.2 The interface between the telegraph muldex and the measuring equipment (see Note 2) giving the out-of-service status should be in accordance with national requirements.

Note 1 – The external equipment may take the form of a simple indicating device or a computer system. The “dead time” of the device may be 20 ms, 150 ms, 1000 ms or a multiple of the (sub) frame length, this value being left for further study.

Wherever possible the error count values should be compared with the Recommendation R.54 requirement (one character in error for the complete transmission system in 100 000, characters).

Alarm values of a high count number in excess of the above criteria or a large deviation from a normal count value shall be advised to the corresponding Administration.

Note 2 – A measurement of unavailability (with respect to transmission system quality) includes breaks due to failure of transmission equipment and transmission propagation anomalies. The external equipment may take the form of a simple indicating device or a computer system. The “dead time” of the equipment shall be 300 ms or 1000 ms, the value being left for further study.

Wherever possible the long term availability shall be in accordance with CCIR Recommendation 557, namely 99.7%. It is recognized in this CCIR Recommendation, that in practice the objectives may fall in the range 99.5 to 99.9%, this value being left for further study.

References

[1] CCITT Recommendation *List of definitions for interchange circuits between data terminal equipment and data circuit terminating equipment*, Rec. V.24.

[2] CCITT Recommendation *Operational provisions for the international public telegram service*, Rec. F.1, § C8.

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