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TELEGRAPHY

TELEGRAPH TRANSMISSION

CODE AND SPEED INDEPENDENT TDM SYSTEM FOR ANISOCHRONOUS TELEGRAPH AND DATA TRANSMISSION

ITU-T Recommendation R.111

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation R.111 was revised by the ITU-T Study Group IX (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

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

CONTENTS

Recommendation R.111

CODE AND SPEED INDEPENDENT TDM SYSTEM FOR ANISOCHRONOUS TELEGRAPH AND DATA TRANSMISSION

(Geneva, 1976; amended at Geneva, 1980, Malaga-Torremolinos, 1984 and at Helsinki, 1993)

The CCITT,

considering

(a) that the use of voice-frequency telegraph (VFT) equipment on voice channels provided by frequency division multiplexing of a primary group or by time slots in a pulse code modulation (PCM) transmission system may not always be the optimum solution for telegraph and low-speed data transmission, if aspects of transmission quality, equipment complexity, technological progress, miniaturization, power consumption and overall cost are globally considered;

(b) that the economic transmission of telegraph and low-speed anisochronous data signals requiring code- and speed-independent channels may be achieved by using time division techniques;

(c) that a relatively simple TDM (time division multiplex) system, even if less efficient in bandwidth utilization, might be preferred in some (e.g. short-haul) applications;

(d) that Administrations might be interested in conserving code and speed independence inherent in VFT systems when replacing them by TDM systems;

(e) that code and speed independent transmission systems are capable of transmitting any type of digital signal (anisochronous, isochronous, telegraph, data, signalling for switching purposes);

(f) that a code and speed independent TDM system can adapt its inherent telegraph distortion to the needs of a network, depending on the number of circuits connected in tandem;

(g) that a code and speed independent TDM system can adapt to a number of different types of channels (each being defined by its maximum modulation rate and inherent distortion);

(h) that a basic 64 kbit/s telegraph multiplexer may provide interfaces for remote submultiplexers if required. The submultiplexers may be associated in some applications with Recommendations X.50 [1] and X.51 [2] data multiplexers and with telephone channel modems and/or baseband modems,

unanimously declares the following views

1 64 kbit/s aggregate

1.1 General

1.1.1 Where code and speed independent TDM systems for transmission of telegraph and low-speed anisochronous data signals utilize the whole 64 kbit/s capacity (e.g. provided by a PCM time slot or a primary group), the equipment shall be manufactured to comply with the following standards.

1.2 Aggregate bearer channel

1.2.1 The aggregate bearer channel may be a 64 kbit/s PCM time slot or a 64 kbit/s synchronous data modem in accordance with the Recommendation cited in [3]. The nominal data signalling rate is 64 000 bit/s with a tolerance of ± 3 bit/s. However, it should be noted that if a synchronous data modem in accordance with [3] is used, a tolerance of ± 1 bit/s may be necessary.

1.2.2 The possibility of external signalling rate synchronization of the bearer channel should be provided to comply with the requirement of mutual aggregate bearer synchronization indicated in Recommendation R.100.

1.3 Frame structure

1.3.1 The frame consists of 240 bits for information plus 16 symmetrically distributed service bits for framing and other purposes. The 16th bit of the frame is the first service bit. The frame synchronization pattern comprises the first 12 service bits in the sequence 101001010101.

1.3.2 The 13th service bit is used to inform the opposite multiplexer terminal of bearer failure as follows: 1 = no bearer failure; 0 = bearer failure. A minimum of three consecutive 0 conditions is the criterion for an alarm indication.

1.3.3 The 14th service bit is used to inform the opposite multiplexer terminal of frame alignment loss as follows: 1 = no loss of frame alignment; 0 = frame alignment loss (this may be accompanied by bearer failure). A minimum of three consecutive 0 conditions is the criterion for an alarm indication.

1.3.4 The time delay between detection of a bearer failure or frame alignment loss and the sending of the 0 condition is for further study.

1.3.5 The 15th service bit is provisionally fixed to 1 and its use is left for further study.

1.3.6 The 16th service bit (last bit of the frame) may be used for possible justification and is fixed to 1. However, the justification strategy, if used, must be agreed bilaterally.

1.3.7 The channel numbering scheme is specified in Recommendation R.114.

1.4 Type of multiplexing

1.4.1 Channel interleaving shall be on a bit basis.

1.4.2 The coding method shall be the transition coding process in accordance with Annex A.

1.5 Allocation of information bits

1.5.1 The data signalling rate on the bearer for each multiplexed channel should be 250, 500, 1000, 2000 or 4000 bit/s corresponding to one, two, four, eight or sixteen bits per frame (symmetrically distributed) respectively.

1.5.2 The 64 kbit/s aggregate stream is divided into 60 kbit/s for information and 4 kbit/s for framing and other purposes.

1.5.3 The 60 kbit/s information bit stream may be subdivided into five bit streams of 12 kbit/s or, for national use or by bilateral agreement, into twenty bit streams of 3 kbit/s.

1.6 Telegraph and data channels

1.6.1 The nominal modulation rates are 50, 100, 200, 300, 600 and 1200 bauds. A mixture of these rates should be possible.

1.6.2 The maximum degree of inherent isochronous distortion due to the sampling process is 2.5, 5 or 7.5% according to the application as shown in Table 1, which gives the channel characteristics and full system capacity for various telegraph channel rates and for aggregate signalling rates of 64 kbit/s and below (see clause 2).

1.6.3 Where applicable, spurious elements with duration of 1.6 ms (= 8%) or less shall be rejected and elements longer than 2 ms shall be accepted at the 50 baud channel input. The element lengths to be rejected or accepted at higher channel modulation rates is for further study.

1.7 Frame alignment

1.7.1 Frame realignment is ensured within three correct consecutive frame synchronization patterns, i.e. within 12 to 16 ms. In the absence of frame realignment, the telegraph channel outputs of the demultiplexer should be locked in their start polarity state for switched applications.

NOTE – Stop polarity might be required by some Administrations on a per channel basis for leased applications.

TABLE 1/R.111

Channel characteristics and system capacities

Nominal modulation rate (bauds)	Maximum degree of isochronous distortion due to sampling (%)	Theoretical maximum modulation rate (bauds)	Data signalling rate on the bearer per channel (bit/s)	Shortest isolated element (ms)	Maximum number of channels for an integrated system of			
					64 kbit/s	9.6 kbit/s	4.8 kbit/s	2.4 kbit/s
50	5	83	250	4	240	32	16	8
	2.5	167	500	2	120	16	8	4
100	5	167	500	2	120	16	8	4
	2.5	333	1000	1	60	8	4	2
200	5	333	1000	1	60	8	4	2
300	7.5	333	1000	1	60	8	4	2
600[a)]	7.5	666	2000	0.5	30	4	2	–
1200[a)]	7.5	1333	4000	0.25	15	2	–	–

a) The number of channels indicated for modulation rates of 600 and 1200 bauds is for information only (homogeneous aggregates at these rates are not contemplated).

1.7.2 Three consecutive erroneous frame synchronization patterns should be regarded as the criterion for loss of frame alignment.

1.8 Loss of telegraph input

1.8.1 In the absence of any signal at a telegraph channel input, the multiplexer system should reproduce start polarity at the corresponding output.

NOTE – Stop polarity might be required by some Administrations on a per channel basis for leased applications.

1.9 Bearer interface

1.9.1 For the interface between the aggregate bearer and a PCM time slot, either a codirectional or contradirectional 64 kbit/s interface with the PCM equipment could be accepted. Even for a codirectional interface no stuffing device would be provided in the telegraph multiplexer, which would loop back the 64 kHz clock.

1.9.2 For the interface to a 64 kbit/s modem the interchange circuits of Table 2 should be provided (see the Recommendation cited in [4]).

1.10 Telegraph interface

1.10.1 The interface between the multiplexer and the telegraph circuits should be in accordance with national requirements.

TABLE 2/R.111

Circuit number (Recommendation V.24 [5])	Function
102[a)]	Signal ground or common return
102b[b)]	DCE common return
103[c)]	Transmitted data
104[c)]	Received data
109	Data channel received line signal detector
113[c) d)]	Transmitter signal element timing (DTE source)
114[c) d)]	Transmitter signal element timing (DCE source)
115[c)]	Receiver signal element timing

a) The provision of this conductor is optional.

b) This conductor is used in conjunction with interchange circuit 109.

c) The electrical characteristics of the interchange circuits marked with a c) should be in accordance with Recommendation X.27 [6]. The circuits not so marked should be in accordance with Recommendation X.26 [7].

d) Either circuit 113 or 114 is to be used.

2 Aggregate bearer rates lower than 64 kbit/s

2.1 General

2.1.1 Where code and speed independent TDM systems for transmission of telegraph and low speed anisochronous data signals make use of capacities lower than 64 kbit/s, the equipment shall be manufactured to comply with the following standards:

2.2 Aggregate bearer channels

2.2.1 Aggregate rates of 2.4, 4.8 and 9.6 kbit/s shall be used. These rates can be provided either using modems in accordance with the V-Series Recommendations or using data multiplexers in accordance with Recommendations X.50 [1] or X.51 [2].

2.3 Frame structure

2.3.1 The frame structure is independent of the frame structure of the 64 kbit/s data multiplexer or of the 64 kbit/s telegraph multiplexer. However, it must be designed to allow easy insertion of the carried telegraph channels on to the multiplexer defined in clause 1 above (see also clause 3 below).

2.3.2 For that purpose, one bit out of every six bits will carry framing information and other functions, which will result in effective binary rates of 2, 4 or 8 kbit/s with actual aggregate rates of 2.4, 4.8 and 9.6 kbit/s respectively.

2.3.3 The frame consists of 160 information bits plus 32 symmetrically distributed service bits for framing and other purposes. The sixth bit of the frame is the first service bit.

2.3.4 This frame is subdivided into two subframes each consisting of 80 information bits plus 16 symmetrically distributed service bits.

2.3.5 The subframe synchronization pattern comprises the first 12 service bits in the sequence 101001010101.

2.3.6 For the allocation of the 13th, 14th and 15th service bits, see 1.3.2 to 1.3.5 above. The 16th service bit is set at 0 for the first subframe and at 1 for the second subframe.

2.4 Type of multiplexing

2.4.1 See 1.4 above.

2.5 Allocation of information bits

2.5.1 The same data signalling rates as defined in 1.5 should be used (250, 500 and 1000 bit/s and, where applicable, 2000 and 4000 bit/s).

2.5.2 Table 3 shows the number of information bits per frame for the different data signalling rates on the bearer channel. These information bits are symmetrically distributed among the 160 information bits of the frame.

TABLE 3/R.111

Number of information bits per frame

Data signalling rate on the bearer per channel	Number of information per frame for each channel in an aggregate system of		
(bit/s)	9.6 kbit/s	4.8 kbit/s	2.4 kbit/s
250	5	10	20
500	10	20	40
1000	20	40	80
2000	40	80	–
4000	80	–	–

2.6 Telegraph and data channels

2.6.1 See 1.6 above.

2.7 Frame alignment

2.7.1 Frame realignment time is ensured within three correct consecutive subframe synchronization patterns. This frame realignment will be ensured within 40, 80 and 160 ms for aggregate rates of 9.6, 4.8 and 2.4 kbit/s respectively. In the absence of frame realignment the telegraph channel outputs of the demultiplexer should be locked in their start polarity state for switched applications.

NOTE – Stop polarity might be required by some Administrations on a per channel basis for leased applications.

2.7.2 See 1.7.2 above.

2.8 Loss of telegraph input

2.8.1 See 1.8 above.

2.9 Bearer interface

2.9.1 The interface between the telegraph aggregate and higher aggregate bearer channels should be as laid down in the relevant Recommendations for modems and data multiplexers.

2.10 Telegraph interface

2.10.1 See 1.10 above.

3 Compatibility

3.1 For the different subrates of 2, 4 and 8 kbit/s, there should be 8, 16 and 32 information bits respectively distributed symmetrically within the 64 kbit/s aggregate frame.

3.2 The 160 information bits of the 2.4, 4.8 and 9.6 kbit/s aggregate rates should correspond to 20 groups of 8 bits, 10 groups of 16 and 5 groups of 32 bits respectively. These 8, 16 and 32 information bits should be made to correspond to the 8, 16 and 32 information bits of the 64 kbit/s frame by means of a special padding/depadding unit.

3.3 Some examples of possible implementations are given in Figures 1, 2 and 3 for illustration purposes only.

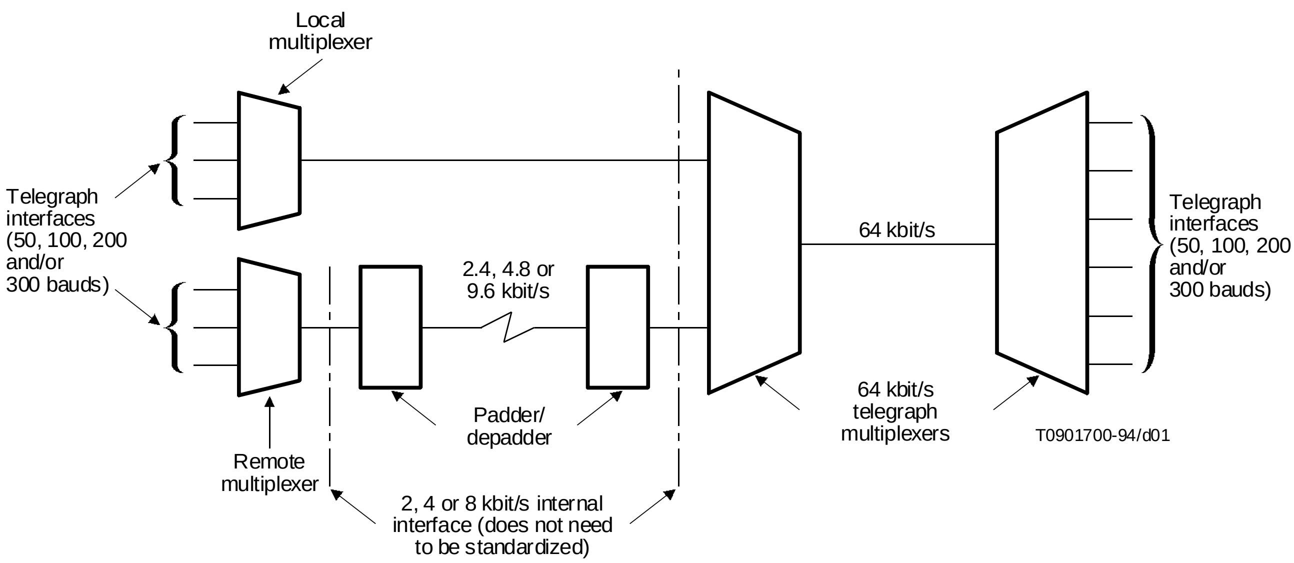

FIGURE 1/R.111

Integration of the lower aggregate rates defined in clause 2 using a 64 kbit/s telegraph multiplexer with a compatible frame structure

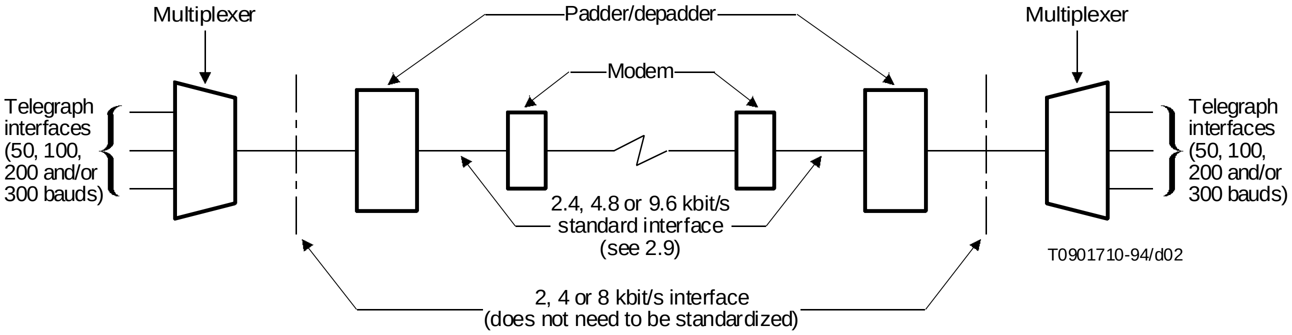

FIGURE 2/R.111

Routing of the lower aggregate rates by means of modems

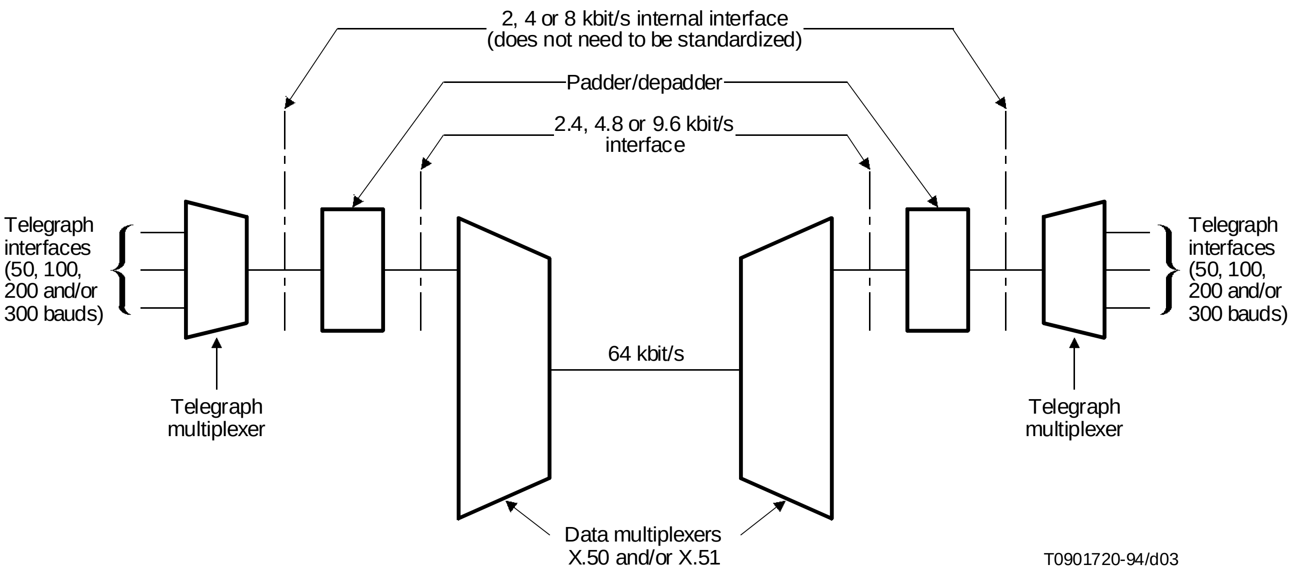

FIGURE 3/R.111

Routing of the lower aggregate rates over data multiplexers
(Recommendation X.50 [1] and/or X.51 [2])

Annex A

Transition coding process

(This annex forms an integral part of this Recommendation)

A.1 See Figure A.1.

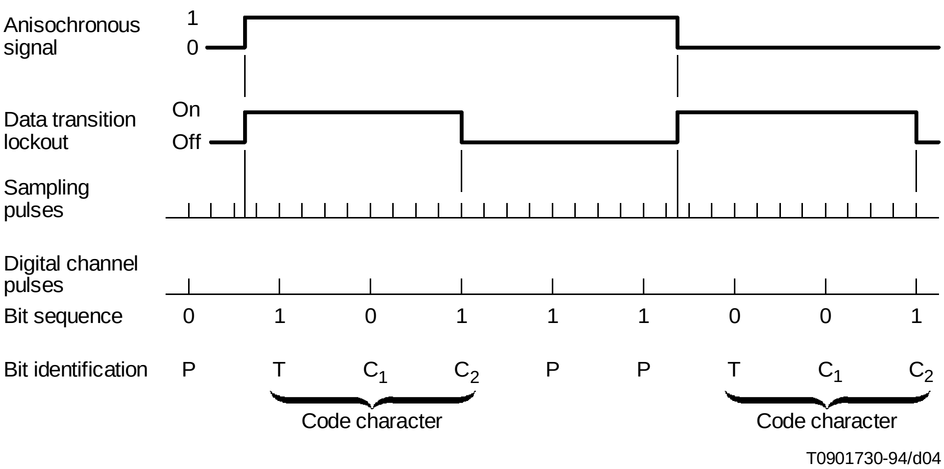

FIGURE A.1/R.111

Transition coding process

A.2 The sampling pulses are divided into groups of four and each transition of the anisochronous signal causes a code character of 3 bits to be generated at the rate of one bit for a group of 4 samples. The first T bit of this code character indicates the sense of transition while the two bits C_1 and C_2 translate into binary code the position of the transition in the relevant group.

A.3 Following the acceptance of a transition into the coding system, a "data transition lockout condition" which inhibits entry of further transitions shall persist until code characters T, C_1 and C_2 have been transmitted. Any transition which has been locked out in this manner shall enter the coder as soon as the lockout condition is removed and will be coded as if it had occurred in the first quarter of the next transmission period.

A.4 The code characters are transmitted over the digital channel at a rate of 1 bit per group of 4 sampling pulses and the subsequent bits P between the code characters confirm the polarity of the anisochronous signal at the relevant instant. The minimum number of P bits may be zero, so the maximum code character rate equals 1/3 of the maximum modulation rate allowed.

A.5 When the anisochronous signal has a permanent polarity, an error of one bit will never entail a continuous inversion of the decoded signal, but will cause a mutilation of this signal during a limited time. The duration of these mutilations is reduced to a minimum when the code characters are formed as shown in Table A.1.

TABLE A.1/R.111

Code character for a transition from 1 to 0 in the anisochronous signal			Code character for a transition from 0 to 1 in the anisochronous signal			Position of the transition in a group of four sampling pulses
T	C_1	C_2	T	C_1	C_2	
0	0	0	1	1	1	First quarter
0	0	1	1	1	0	Second quarter
0	1	0	1	0	1	Third quarter
0	1	1	1	0	0	Fourth quarter

References

[1] CCITT Recommendation *Fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks*, Rec. X.50.

[2] CCITT Recommendation *Fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks using 10-bit envelope structure*, Rec. X.51.

[3] CCITT Recommendation *Modems for synchronous data transmission using 60-108 kHz group band circuits*, Rec. V.36, clause 1, item f).

[4] *Ibid.*, clause 10.

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

[6] CCITT Recommendation *Electrical characteristics for balanced double-current interchange circuits for general use with integrated circuit equipment in the field of data communications*, Rec. X.27.

[7] CCITT Recommendation *Electrical characteristics for unbalanced double-current interchange circuits for general use with integrated circuit equipment in the field of data communications*, Rec. X.26.