SECTION 7

TIME DIVISION MULTIPLEXING

Recommendation R.100

TRANSMISSION CHARACTERISTICS OF INTERNATIONAL TDM LINKS

(Geneva, 1980, modified at Melbourne, 1988)

Note — The application of TDM systems providing code- and speed-independent channels in addition to code- and speed-dependent channels is a subject for further study.

1 Analogue path links

1.1 Standard telephone carrier systems with 4-kHz and 3-kHz spaced channels permit homogeneous time division multiplex (TDM) telegraph systems, operated in association with 2400-bit/s data modems, to provide the capacities of telegraph channels shown in Table 1/R.100.

H.T. [T1.100]
TABLE 1/R.100
Channel capacities of homogeneous TMD systems

TDM system type (see Note 1)	{					
	50 baud	75 baud	100 baud	150 baud	200 baud	300 baud
Recommandation						
R.101, Alternative A	46	22	—	—	—	—
R.101, Alternative B	46	30	22	15	10	7
R.111	8	(see Note 2)	4	(see Note 2)	2	2

Note 1 — TDM systems complying with Recommendation R.101 provide code-and speed-dependent channels involving inherent regeneration of output signals. The provision of channels above 75 bauds for Recommendation R.101, Alternative A systems, is the subject of further study.

TDM systems complying with Recommendation R.111 provide code-and speed-independent channels by a transition coding process that does not include regeneration of the output signals. Furthermore. these systems may have aggregate signalling rates of either 2.4, 4.8, 9.6 or 64 kbit/s.

Note 2 — The Recommendation R.111 homogeneous system configurations shown involve an aggregate rate of 2400 bit/s and 5% maximum isochronous distortion per channel due to sampling. 75-and 150-baud signals may be carried on nominal 100-and 200-baud channels respectively with proportionally less distortion.

TABLE 1/R.100 [T1.100], p.

1.2 A 4-wire link is required in association with the data modem employed to provide satisfactory transmission for the 2400-bit/s duplex aggregate signals of an international TDM system.

1.3 The data modem employed should preferably comply with the appropriate aspects of the Series V Recommendations. Multiple 2400-bit/s aggregates may be multiplexed onto the same 4-wire link using the appropriate internal multiplexing facilities of a Recommendation V.29 [1] modem. The reliability and availability of derived telegraph channels will, however, be highly dependent on the stability and characteristics of the bearer, modem and system arrangements adopted.

1.4 The conditions of use of international TDM links are generally similar to those for VFT links, described in Recommendation H.22 [2]. The requirements of the actual V-Series modem employed however, should be additionally respected.

Note — This subject is under study in Joint Working Party LTG, Study Group IV and Study Group IX.

1.5 PCM (pulse code modulation) telephone channels complying with Recommendation G.712 [3] are also generally suitable as bearers for TDM telegraph systems associated with modems complying with the Series V Recommendations. However, possible transmission arrangements involving tandem connection of a number of PCM channels require further study.

1.6 Recommendation R.111, in § 1.2.1, provides for the use of modems complying with the Recommendation cited in [4].

2 Digital path links

2.1 64 kbit/s international digital transmission circuits are realized by PCM time slots or via TDMA satellite systems. SCPC (single channel per carrier) satellite systems provide 56 kbit/s channels. Primary groups (60-108 kHz) in conjunction with V.36 [4] modems may also be used.

2.2 *64 kbit/s TDM link*

2.2.1 Recommendation R.111, § 1 defines the telegraph TDM systems at 64 kbit/s.

2.2.2 Recommendations X.50 [5] and X.51 [6] set out the parameters of envelope interleaving TDM systems at 64 kbit/s, which provide 0.6, 2.4, 4.8 and 9.6 kbit/s tributary data channels. These data channels can be used to transfer the aggregate signals of TDM systems at 0.6 kbit/s (Recommendation R.103), 2.4 kbit/s (Recommendations R.101, R.105, R.112 and R.111, § 2), 4.8 kbit/s (Recommendations R.102 and R.111, § 2) and 9.6 kbit/s (Recommendation R.111, § 2).

2.3 56 kbit/s TDM links are realized using envelope interleaving TDM systems which are defined in Recommendations X.55 [7] and X.56 [8]. These systems provide the same tributary channels as in 2.2.2.

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2.4 Figure 1/R.100 shows a typical multiplex hierarchy .

Figure 1/R.100, p.

2.5 The capacities of 50 baud channels of 64 and 56 kbit/s TDM systems are shown in Table 2/R.100.

H.T. [T2.100]
TABLE 2/R.100
50 baud channel capacities of homogeneous TDM systems

{	{ Transparent	Non-transparent	
R.111, § 1 (64 kbit/s)	240	—	
{	20 × R.101 (2.4 kbit/s)	—	920
	20 × R.112 (2.4 kbit/s)	300	920
	160	—	{
	160	—	{
	160	—	20 × R.105 (2.4 kbit/s)

Note — Virtual channels.

TABLE 2/R.100 [T2.100], p.

2.6 The characteristics of 64 and 56 kbit/s digital circuit interfaces are described in Recommendations G.703 [9] and V.36 [4].

References

[1] CCITT Recommendation *9600 bits per second modem standardized for use on point-to-point 4-wire leased telephone-type circuits* , Rec. V.29.

[2] CCITT Recommendation *Transmission requirements of international voice-frequency telegraph links (at 50, 100 and 200 bauds)* , Rec. H.22.

[3] CCITT Recommendation *Performance characteristics of PCM channels between 4-wire interfaces at audio frequencies* , Rec. G.712.

[4] CCITT Recommendation *Modems for synchronous data transmission using 60-108 kHz group band circuits* , Rec. V.36.

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

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

[7] CCITT Recommendation *Interface between synchronous data networks using a 6 + 2 envelope structure and single channel per carrier (SCPC) satellite channels* , Rec. X.55.

[8] CCITT Recommendation *Interface between synchronous data networks using an 8 + 2 envelope structure and single channel per carrier (SCPC) satellite channels* , Rec. X.56.

[9] CCITT Recommendation *Physical/electrical characteristics of hierarchical digital interfaces* , Rec. G.703.

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

USING BIT INTERLEAVING

(Geneva, 1976; amended at Geneva, 1980, M´alaga-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 time-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.

H.T. [T1.101]

TABLE 1/R.101

System capacity (alternative B)

Modulation rate (bauds)	Character structure		{
	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

TABLE 1/R.101 [T1.101], p.

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 ± | .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 | /6 or 97 | /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.

H.T. [T2.101]

TABLE 2/R.101

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

Subframe slot Aggregate polarity corresponding to Z polarity on low-speed channel }	Channel number Channel speed	{	
1	Not applicable	SYNC	
2	02	A	50 | ua)
3	01	Z	50
4	05	A	50
5	06	Z	50
6	09	A	50
7	10	Z	50
8	14	A	50
9	13	Z	50
10	17	A	50
11	18	Z	50
12	21	A	50
13	22	Z	50
14	25	A	50
15	26	Z	50
16	30	A	50
17	29	Z	50
18	33	A	50
19	34	Z	50
20	37	A	50
21	38	Z	50
22	41	A	50
23	42	Z	50

TABLE 2/R.101 [T2.101], p.

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, p.

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, p.

Table 5/R.101, p.

H.T. [T3.101]

lw(38p) | lw(10p) | lw(66p) | lw(10p) | lw(66p) | lw(10p) | lw(66p) | lw(10p) | lw(66p) . lw(38p) | lw(10p) | lw(66p) | lw(10p) | lw(66p) | lw(10p) | lw(66p) | lw(10p) | lw(66p) .

{ MONTAGE Channel number Group 1 MONTAGE Channel number Group 2 MONTAGE Channel number Group 3 MONTAGE Channel number Group 4
}

lw(38p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . 50 100 200 75 150 300 50 100 200 75 150 300 50 100 200 75 150 300 50 100 200 75 150 300 lw(22p) | lw(16p) | cw(10p) | lw(66p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) .

0 { Synchronization bit 1 01 01 01 01 01 01 2 02 02 02 02 02 02 3 03 03 03 03 03 03
}

lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 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
}

lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 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
}

lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 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
}

lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 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
}

lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 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
}

lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 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
}

lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 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
}

lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 32 32 09 09 01 01 01 33 33 10 10 02 02 02 34 34 11 11 03 03 03
}

lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 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
}

lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 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
}

lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 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
}

Table 6/R.101 [T3.101] (à l'italienne), p.

H.T. [T4.101]

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 { See Notes 1 and 2 17-31 {	
100	01-07 { See Note 3 09-23 {	
150	01-15 {	*n* and (*n* + 16) and (*n* + 31) }
200	01-07 { See Note 3 09-11 {	
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).

Table 7/R.101 [T4.101], p.

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.

FIGURE 1/R.101, p.

FIGURE 2/R.101, p.

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 ± | .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 | 00, 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.

Recommendation R.102

4800 BIT/S CODE AND SPEED DEPENDENT AND HYBRID TDM SYSTEMS FOR ANISOCHRONOUS

TELEGRAPH AND DATA TRANSMISSION USING BIT INTERLEAVING

(Malaga-Torremolinos, 1984; modified at Melbourne, 1988)

The CCITT,

considering

(a) that there is a demand for a bit-interleaved code and speed dependent TDM system for anisochronous telegraph and data transmission using an aggregate bit rate of 4800 bit/s;

(b) that an increase of the economical transmission of large numbers of anisochronous telegraph and data signals, especially those of higher modulation rates e.g. 300 bauds, can be achieved by doubling the system capacity normally carried over a code and speed dependent TDM using an aggregate bit rate of 2400 bit/s;

(c) that the doubling of system capacity should be based on the already well defined time division multiplexing (TDM) technique used for the multiplexing system according to Recommendation R.101 retaining the frame structure of alternative B;

(d) that unit modularity, operation and maintenance should best be rationalized for both the basic Recommendation R.101 (alternative B) TDM and the expanded multiplexing system with the higher aggregate bit rate;

(e) that the expanded multiplexing system should permit the accommodation of code-dependent and code-independent (transparent) channels using the TDM hybrid technique according to Recommendation R.112;

(f) that the expanded multiplexing system should permit the accommodation of new facilities emerging in the future,

unanimously declares the view

that, where bit-interleaved code and speed dependent TDM systems with the provision for a limited use of code-independent (transparent) channels are used for anisochronous telegraph and data transmission with an aggregate bit rate of 4800 bit/s carried either by an analogue telephone-type circuit or by a higher order TDM, the equipment shall be constructed as an expanded multiplexing system to the basic Recommendation R.101 (alternative B) TDM to comply with the following standard:

1 System capacity

1.1 The capacity of the system shall be 92 channels at 50 bauds (7.5 units including a stop element of 1.5 units).

1.2 For other modulation rates see Table 1/R.102.

1.2.1 The modulation rates and character structures shown in Table 1/R.102 shall be accommodated with the capacities indicated for homogeneous configurations.

H.T. [T1.102]
TABLE 1/R.102
System capacity

Modulation Rate (bauds)	Code dependent channels			Code independent channels
	Character length (units) {	Stop element (units)	{	
50	7.5	1.5	92	30
75	7.5	1.5	46	—
100	7.5 or 10	1.5 1	46	15
110	11	2	46	—
134.5	9	1	30	—
150	10	1	30	—
200	7.5, 10 or 11	1.5 1 2	22	7
300	10 or 11	1 2	15	—

Note — The system capacity for code-independent channels using the TDM hybrid technique according to Recommendation R.112 is not covered by this table.

Table 1/R.102 [T1.102], p.

1.2.2 The TDM system shall be capable of multiplexing the eight modulation rates shown in Table 1/R.102 simultaneously.

1.2.3 The TDM system shall provide for a limited use of transparent channels. In using the TDM hybrid technique, the system capacity and the overall characteristics of the code-independent channel from the channel input to the channel output shall be in accordance with Recommendation R.112.

Note — The overall characteristics of code- and speed-dependent channels are the subject of this Recommendation and are specified in the following clauses.

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 ± | .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, occuring 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 | /6 or 97 | /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, 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 § 6.4. The distant terminal shall control its 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, 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 The maximum transfer delay for all other permitted channel speeds for back-to-back terminals shall not exceed 3.5 units.

4.5 75-baud characters are conveyed on a 100-bit/s bearer channel by transmitting filling bits in each character following element numbers 2 and 5 [2].

4.6 110-baud characters are conveyed on a 100-bit/s bearer channel by transmitting at least one stop element in the aggregate signal.

4.7 134.5-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 One framing arrangement is allowed. The channel numbers used throughout this Recommendation represent the last two digits of a 4-digit numbering scheme — the first two digits are shown in Recommendation R.114. This channel allocation scheme is shown in Table 2/R.102 and in Table 3/R.102.

Table 4/R.102 shows the channel allocation of 50, 100 and 200 baud code independent channels using the TDM hybrid technique according to Recommendation R.112.

5.5 The channel allocation in the fundamental frame is shown in Table 5/R.102 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 2/R.102 and 3/R.102.)

Note 1 — For all speeds other than 50 and 150 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 Substitution of higher speed channels into a homogeneous 50-baud system configuration shall be made as follows:

1 × 75- or 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

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

5.8 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).

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 One synchronizing arrangement is allowed as described in §§ 6.3 through 6.11.

6.3 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 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 § 6.7 below). The changeover shall only occur at the end of a sync frame.

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

6.6 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 140 ms.

6.7 With two terminals connected back-to-back, loss of synchronism in one terminal shall be indicated at the other terminal within 120 ms, by inversion of the normal synchronization pattern. (See § 6.4 above.)

6.8 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 § 5.7 above.

Table 2/R.102, p.

Table 3/R.102, p.

Table 4/R.102, p.

H.T. [T2.102]

lw(38p) | lw(10p) | lw(66p) | lw(10p) | lw(66p) | lw(10p) | lw(66p) | lw(10p) | lw(66p) . lw(38p) | lw(10p) | lw(66p) | lw(10p) | lw(66p) | lw(10p) | lw(66p) | lw(10p) | lw(66p) .

{ Bit No. Channel number Group 1 Bit No. Channel number Group 2 Bit No. Channel number Group 3 Bit No. Channel number Group 4
}
lw(38p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . 50 100 200 — 150 300 50 100 200 — 150 300 50 100 200 — 150 300 50 100 200 — 150 300 lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 0 s s s — s s 1 1 1 1 — 1 1 2 2 2 2 — 2 2 3 3 3 3 — 3 3
}
lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 4 4 4 4 — 4 4 5 5 5 5 — 5 5 6 6 6 6 — 6 6 7 7 7 7 — 7 7
}
lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 8 8 8 *x* — 8 8 9 9 9 9 — 9 9 10 10 10 10 — 10 10 11 11 11 11 — 11 11
}
lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 12 12 12 12 — 12 12 13 13 13 13 — 13 13 14 14 14 14 — 14 14 15 15 15 15 — 15 15
}
lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 16 16 16 16 — *x x* 17 17 17 17 — 17 1 18 18 18 18 — 18 2 19 19 19 19 — 19 3
}
lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 20 20 20 20 — 20 4 21 21 21 21 — 21 5 22 22 22 22 — 22 6 23 23 23 23 — 23 7
}
lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 24 24 24 *x* — 24 8 25 25 25 1 — 25 9 26 26 26 2 — 26 10 27 27 27 3 — 27 11
}
lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 28 28 28 4 — 28 12 29 29 29 5 — 29 13 30 30 30 6 — 30 14 31 31 31 7 — 31 15
}
lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 32 32 32 9 — 1 1 33 33 33 10 — 2 2 34 34 34 11 — 3 3
}
lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 35 35 35 12 — 4 4 36 36 36 13 — 5 5 37 37 37 14 — 6 6 38 38 38 15 — 7 7
}
lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 39 39 39 16 — 8 8 40 40 40 17 — 9 9 41 41 41 18 — 10 10 42 42 42 19 — 11 11
}
lw(22p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(16p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) | lw(10p) . { 43 43 43 20 — 12 12 44 44 44 21 — 13 13 45 45 45 22 — 14 14 46 46 46 23 — 15 15
}

Table 5/R.102 [T2.102] A L'ITALIENNE, p.

6.9 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.

6.10 If condition a) in § 6.9 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 § 6.8 above.

6.11 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 480 ms, excluding all transmission delays external to the Recommendation R.102 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 ± | .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 4800 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) 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.

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.

MONTAGE: Recommandation R.103 sur le reste de cette page.