INTERNATIONAL TELECOMMUNICATION UNION

ITU-T R.102

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(03/93)

TELEGRAPHY

TELEGRAPH TRANSMISSION

4800 bit/s CODE AND SPEED DEPENDENT AND HYBRID TDM SYSTEMS FOR ANISOCHRONOUS TELEGRAPH AND DATA TRANSMISSION USING BIT INTERLEAVING

ITU-T Recommendation R.102

(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.102 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 Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.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.

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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 and at Helsinki, 1993)

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.

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

TABLE 1/R.102

System capacity

Modulation Rate (bauds)	Code dependent channels			Code independent channels
	Character structure		Number of channels (homogeneous configuration)	Number of channels (homogeneous configuration)
	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.				

1.2.2 The TDM system shall be capable of multiplexing the eight modulation rates shown in Table 1 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 ± 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, 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 5/6 or 97 2/9 ms respectively.

2.4 There shall be no restriction on the continuous transmission of all characters specified in clause 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 Tables 2 and 3.

Table 4 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 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 and 3.)

NOTES

1 For all speeds other than 50 and 150 bauds, the second subframe in the fundamental frame is a repetition of the first subframe.

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:

$1 \times$ 75- or 100- or 110-baud channel	replaces $2 \times$ 50-baud channels
$1 \times$ 150- or 134.5-baud channel	replaces $3 \times$ 50-baud channels
$1 \times$ 200-baud channel	replaces $4 \times$ 50-baud channels
$1 \times$ 300-baud channel	replaces $6 \times$ 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.

6.9 Synchronism is defined as achieved when:

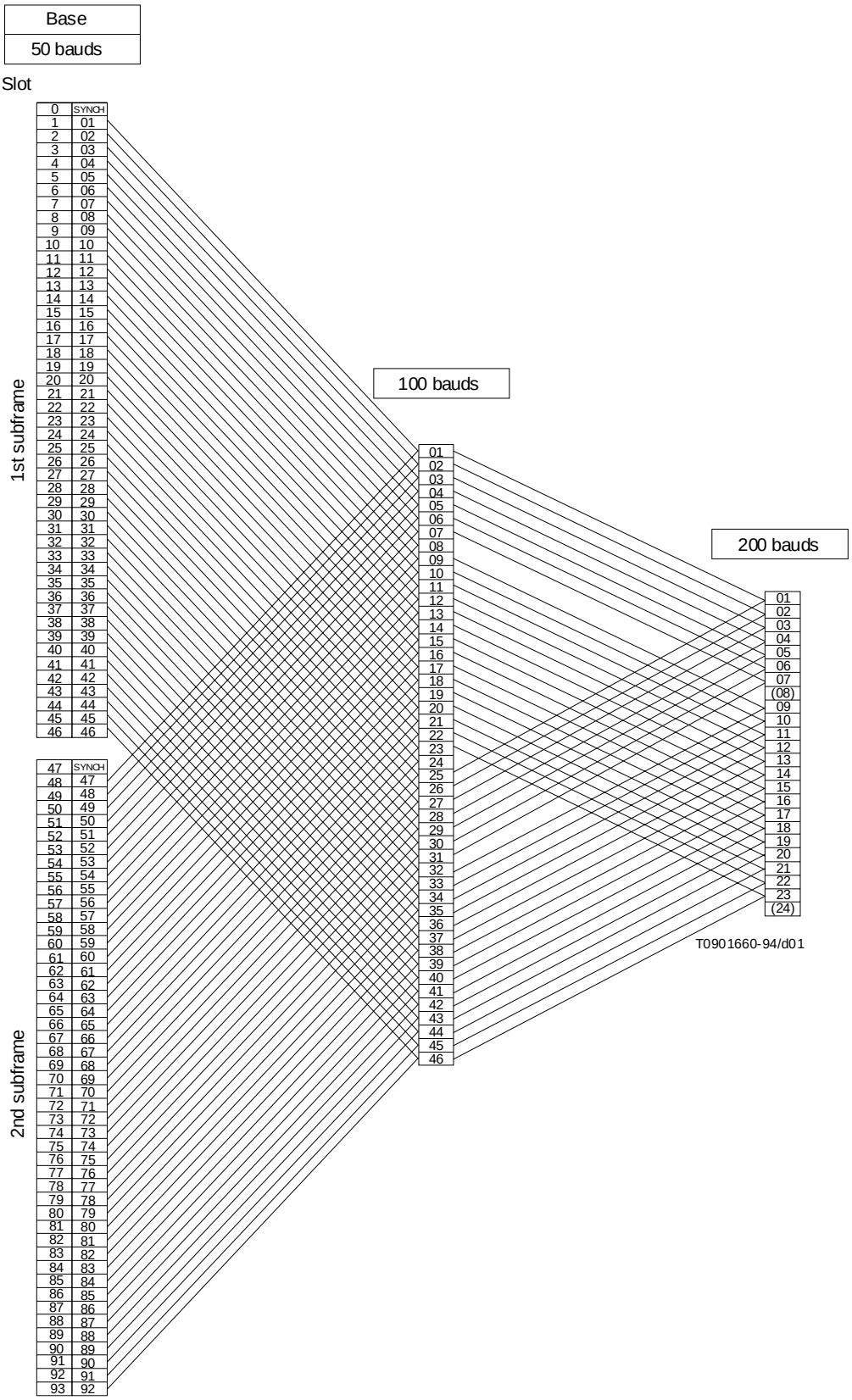
a) six identical synchronization patterns (i.e. six normal or six inverted synchronization patterns) have been consecutively received on a single bit position without error; and

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.

TABLE 2/R.102

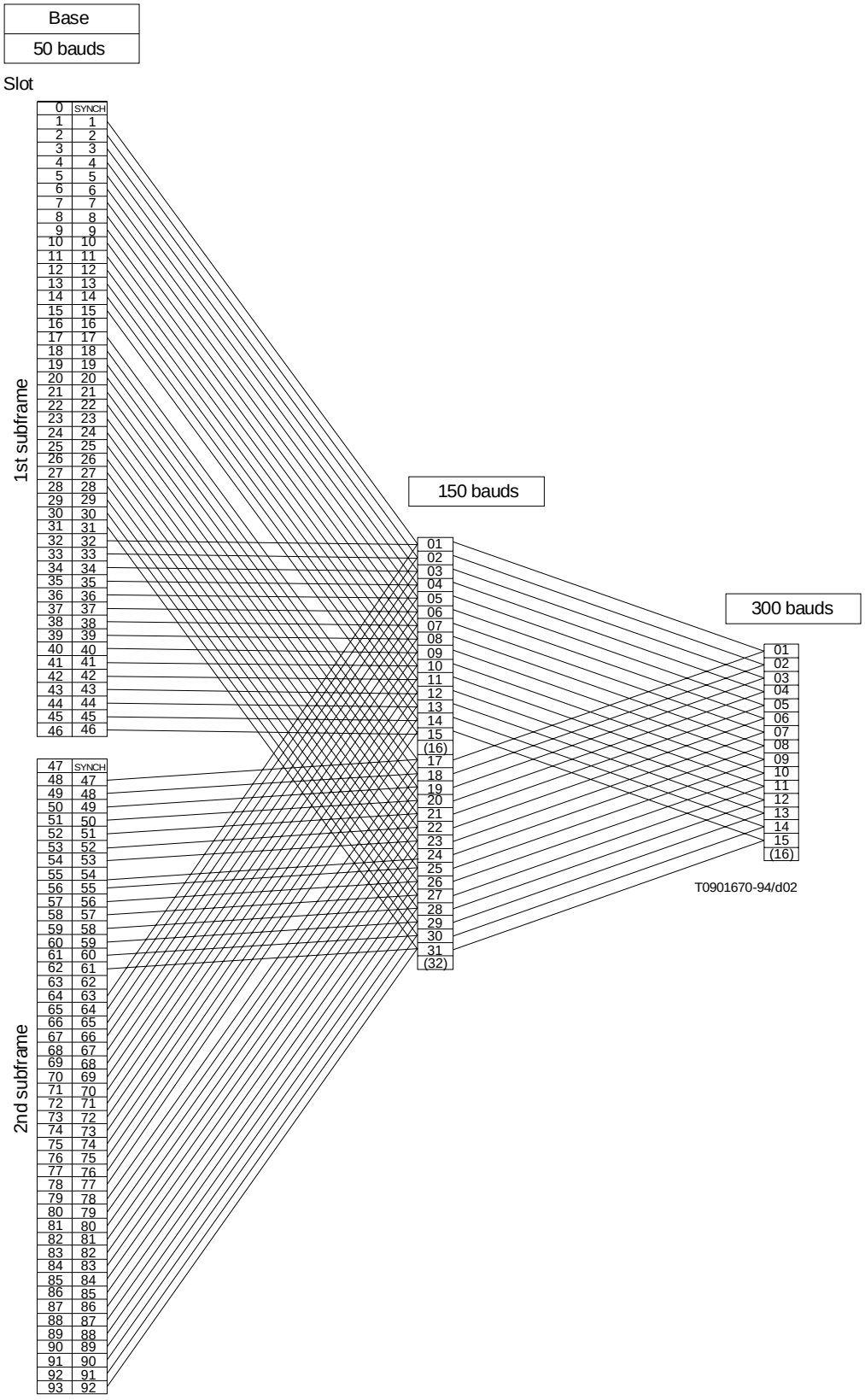
TDM-4800 channel allocation (50, 100 and 200 bauds)



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

TABLE 3/R.102

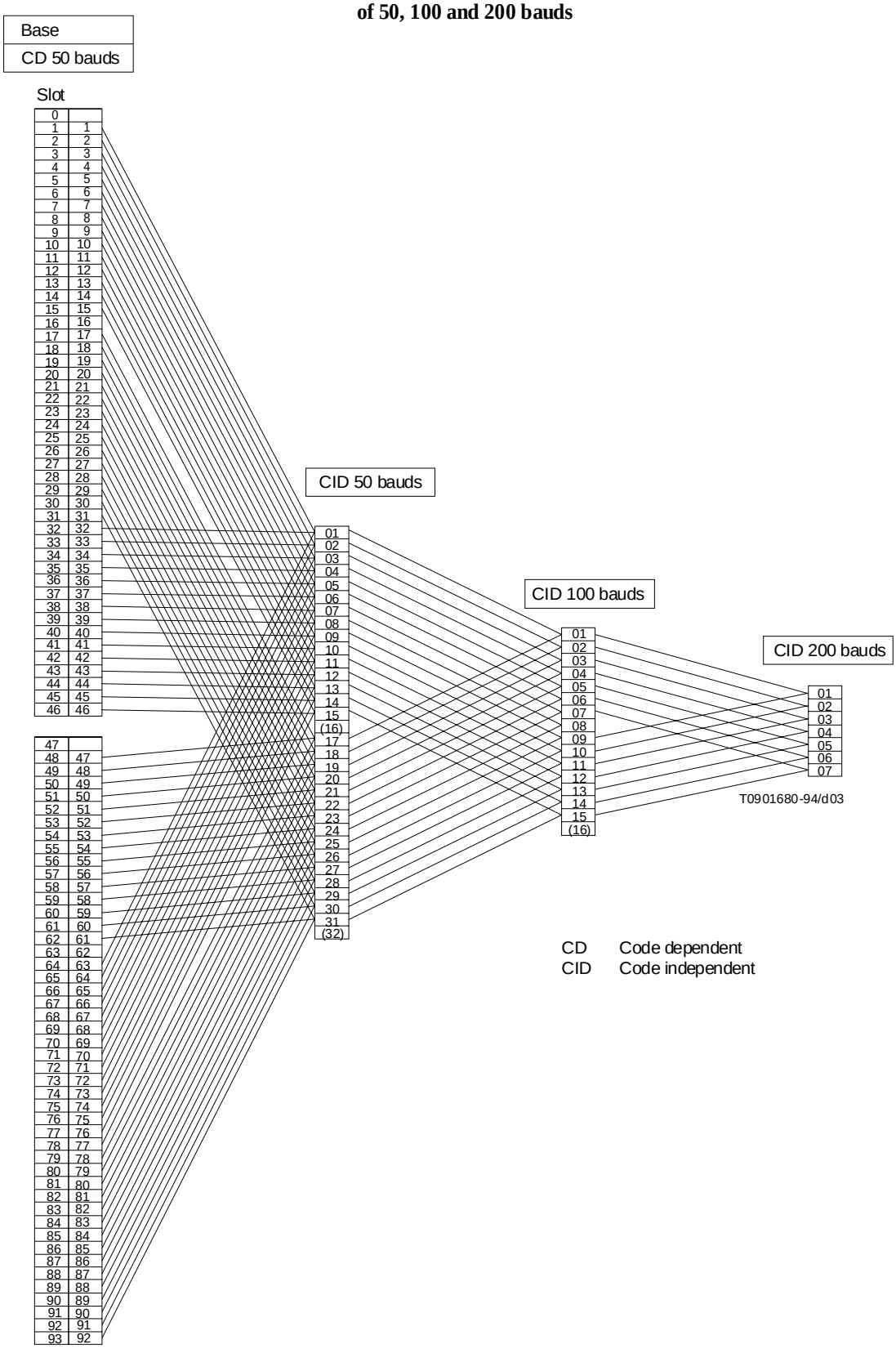
TDM-4800 channel allocation (50, 100 and 300 bauds)



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

TABLE 4/R.102

TDM-4800 channel allocation for code independent channels of 50, 100 and 200 bauds



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

TABLE 5/R.102

Channel allocation for each speed within the 94 bit frame

		Bit No.	Channel number Group 1						Bit No.	Channel number Group 2						Bit No.	Channel number Group 3						Bit No.	Channel number Group 4					
Channel speed (bauds)			50	100	200	–	150	300		50	100	200	–	150	300		50	100	200	–	150	300		50	100	200	–	150	300
Fundamental frame	First subframe	0	s	s	s	–	s	s	1	1	1	1	–	1	1	2	2	2	2	–	2	2	3	3	3	3	–	3	3
		4	4	4	4	–	4	4	5	5	5	5	–	5	5	6	6	6	6	–	6	6	7	7	7	7	–	7	7
		8	8	8	*x*	–	8	8	9	9	9	9	–	9	1	10	10	10	10	–	10	10	11	11	11	11	–	11	11
		12	12	12	12	–	12	12	13	13	13	13	–	13	13	14	14	14	14	–	14	14	15	15	15	15	–	15	15
		16	16	16	16	–	*x*	*x*	17	17	17	17	–	17	1	18	18	18	18	–	18	2	19	19	19	19	–	19	3
		20	20	20	20	–	20	4	21	21	21	21	–	21	5	22	22	22	22	–	22	6	23	23	23	23	–	23	7
		24	24	24	*x*	–	24	8	25	25	25	1	–	25	9	26	26	26	2	–	26	10	27	27	27	3	–	27	11
		28	28	28	4	–	28	12	29	29	29	5	–	29	13	30	30	30	6	–	30	14	31	31	31	7	–	31	15
					Skipped				32	32	32	9	–	1	1	33	33	33	10	–	2	2	34	34	34	11	–	3	3
		35	35	35	12	–	4	4	36	36	36	13	–	5	5	37	37	37	14	–	6	6	38	38	38	15	–	7	7
		39	39	39	16	–	8	8	40	40	40	17	–	9	9	41	41	41	18	–	10	10	42	42	42	19	–	11	11
		43	43	43	20	–	12	12	44	44	44	21	–	13	13	45	45	45	22	–	14	14	46	46	46	23	–	15	15
	Second subframe	47	s				5		48	47				17		49	48				18		50	49				19	
		51	50				20		52	51				21		53	52				22		54	53				23	
		55	54				24		56	55				25		57	56				26		58	57				27	
		59	58				28		60	59				29		61	60				30		62	61				31	
		63	62				*x*		64	63				1		65	64				2		66	65				3	
		67	66				4		68	67				5		69	68				6		70	69				7	
		71	70				8		72	71				9		73	72				10		74	73				11	
		75	74				12		76	75				13		77	76				14		78	77				15	
					Skipped				79	78				17		80	79				18		81	80				19	
		82	81				20		83	82				21		84	83				22		85	84				23	
		86	85				24		87	86				25		88	87				26		89	88				27	
		90	89				28		91	90				29		92	91				30		93	92				31	

NOTES

1 s = synchronizing bit.

2 *x* = Bit not available for corresponding channel speed.

3 75-, 110- and 134.5-baud signals shall be transmitted on 100-, 100- and 150-bit/s bearer channels, respectively, and restituted with appropriate speed at the channel output. See also 4.5, 4.6 and 4.7.

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 ± 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 4800 bit/s over an international analogue telephone-type circuit, it is preferred that a modem complying with the appropriate aspects of the V-Series 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.

11 Link performance and availability indicators

A system must be provided for monitoring performance and availability in accordance with Recommendation R.118.

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, subclause C8.