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Foreword

This ETSI Technical Report (ETR) was produced by the Transmission and Multiplexing (TM) Technical Committee of the European Telecommunications Standards Institute (ETSI).

ETRs are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim European Telecommunication Standard (I-ETS) status. An ETR may be used to publish material which is either of an informative nature, relating to the use or the application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or an I-ETS.

This ETR gives guidance to network operators and equipment manufacturers on the possible standard bit rate adaptation and optional multiplexing function of signals having bit rates not greater than 56 kbit/s and signalling rate not greater 57,6 kbauds when interconnecting digital leased line networks. It is limited to the consideration of synchronous signals while additional asynchronous to synchronous conversion is presented and may be implemented according to relevant standards.

This ETR has a corresponding European Telecommunication Standard (ETS) for the multiplexing function of signals having 64 and n x 64 bit rates, ETS 300 167.

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1 Scope

This ETSI Technical Report (ETR) describes network reference configurations and functional requirements for the interconnection of digital leased line networks when sub-64 kbit/s leased line are considered. It provides a standard way for the bit rate adaptation and optional multiplexing function of sub-64 kbit/s signals on 64 kbit/s links based on ITU-T Recommendation V.110 [4]. Alternative methods for the mapping of sub-64 kbit/s signals on 64 kbit/s or 2 048 kbit/s links may have already been deployed and their main characteristics are given in Annexes A to D.

As an example, this ETR also presents in Annexe E essential functions which should be implemented at the interconnection point when an alternative mapping standard and the recommended one are used.

2 References

This ETR incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETR only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] ITU-T Recommendation V.14: "Transmission of start-stop characters over synchronous bearer channels".

[2] ITU-T Recommendation V.24: "List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)".

[3] ITU-T Recommendation V.34: "A modem operating at data signalling rates of up to 28 800 bit/s for use on the general switched telephone network and on leased point-to-point 2-wire telephone type circuits".

[4] ITU-T Recommendation V.110: "Support of data terminal equipments with V-Series type interfaces by an integrated services digital network".

[5] CCITT Recommendation X.24: "List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) on public data networks".

[6] ITU-T Recommendation X.25: "Interface between data terminal equipment (DTE) and data circuit terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit".

[7] ITU-T Recommendation X.30: "Support of X.21, X.21 bis and X.20 bis based data terminal equipments (DTEs) by an integrated services digital network (ISDN)".

[8] CCITT Recommendation X.50: "Fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks".

[9] CCITT Recommendation X.50 bis: "Fundamental parameters of a 48-kbit/s user data signalling rate transmission scheme for the international interface between synchronous data networks".

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

[11] CCITT Recommendation X.54: "Allocation of channels on international multiplex links at 64 kbit/s".

[12] CCITT Recommendation X.58: "Fundamental parameters of a multiplexing scheme for the international interface between synchronous non-switched data networks using no envelope structure".

[13] CCITT Recommendation G.704: "Synchronous frame structures used at primary and secondary hierarchical levels".

[14] ITU-T Recommendation G.736: "Characteristics of a synchronous digital multiplex equipment operating at 2 048 kbit/s".

[15] CCITT Recommendation G.796: "Characteristics of a 64 kbit/s cross connect equipment with 2 048 kbit/s access ports".

[16] ITU-T Recommendation G.797: "Characteristics of a flexible multiplexer in a PDH environment".

[17] CCITT Recommendation I.460: "Multiplexing, rate adaptation and support of existing interfaces".

[18] ITU-T Recommendation O.153: "Basic parameters for the measurement of error performance at bit rates below the primary rate".

[19] ETS 300 167: "Transmission and multiplexing - Functional characteristics of 2 048 kbit/s interfaces".

[20] ETS 300 010-1: "Synchronous cross connect equipment - 64 and n x 64 kbit/s cross connection rate - 2 048 kbit/s access ports - Part 1: Core functions and characteristics".

[21] prETS 300 244-1: "Synchronous cross connect equipment - sub 64 kbit/s cross connection rate - 64 or 2 048 kbit/s access ports - Part 1: Core functions and characteristics". {DELETED REFERENCE - WORK ITEM STOPPED}

3 Symbols and abbreviations

B	a 64 kbit/s channel of the ISDN basic access or primary rate access
BBDCE	Base Band DCE
CRC	Cyclic Redundancy Check
DISC	DISConnect
DM	Disconnect Mode
Dn	sub 64 kbit/s data in the ITU-T Recommendation V.110 [4] frame
DTE	Data Terminal Equipment
DXC	Digital Cross Connect equipment
En	user rate identifier
HEX	HEXadecimal number
ID	IDentification
LAPB	Link Access Protocol Balanced
LSB	Least Siginificant Bit
MSB	Most Significant Bit
MULDEX	digital multiplexing/demultiplexing equipment
R	Reference point for a non-ISDN user interface
RA0	Rate adaptor (asynchronous to synchronous)
RA1	Rate adaptor (sub-64 kbit/s to intermediate bit rate)
RA2	Rate adaptor (intermediate bit rate to 64 kbit/s)
RR	Receive Ready
RNR	Receive Not Ready
SA	group of Sn bits
SABM	Set Asynchronous Balanced Mode
SB	group of Sn bits
Sn	Status bit in the ITU-T Recommendation V.110 [4] frame
S/T	coincident S and T reference points (see ITU-T Recommendation I.411)
TA	Terminal Adaptor
TS	Time Slot (of a 2 048 kbit/s CCITT Recommendation G.704 [13] frame)

UA	Unnumbered Acknowledgement
X	frame alignment indicator
XID	Exchange IDentification
108	connect data set to line/Data terminal ready
107	data set ready
105	request to send
109	data channel received line signal detector

4 Network reference configuration

Figure 1 depicts general structure for a digital leased line network. It shows the two standard levels of multiplexing schemes at 64 kbit/s and 2 048 kbit/s which may occur in any network supporting digital leased line services.

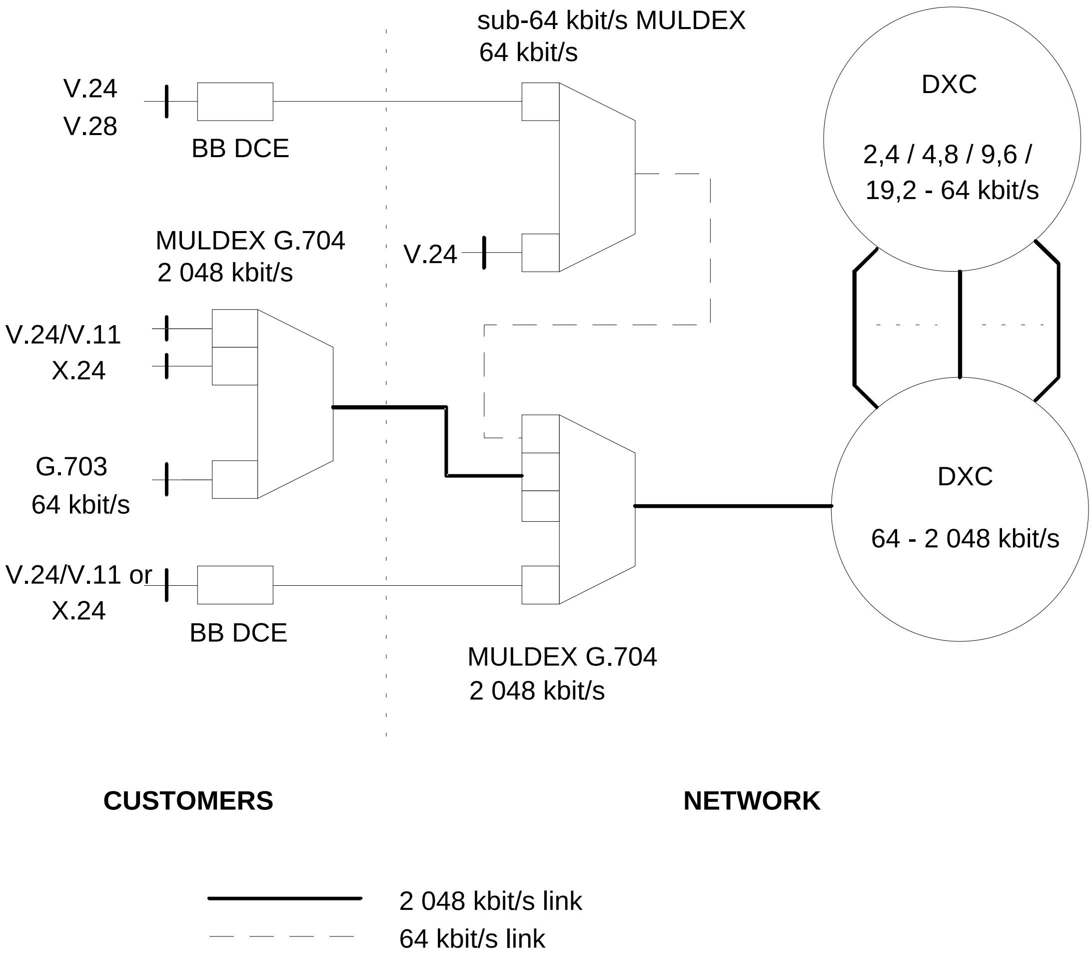


Figure 1: Structure of a digital leased line network

There is no existing standard covering the functional requirements for sub-64 kbit/s multiplexing equipment. The first order multiplexing equipment may be complying to ITU-T Recommendation G.736 [14] or to ITU-T Recommendation G.797 [16]. The 64 kbit/s cross connect equipment is specified in CCITT Recommendation G.796 [15] and in ETS 300 010-1 [20].

Figure 2 presents possible network implementation in case of interconnection of two digital leased line networks assuming that they are logically connected at the 2 048 kbit/s level. In figure 2, it is assumed that the two involved networks are using the same adaptation/multiplexing scheme based on ITU-T Recommendation V.110 [4]. Annexes A to E provide additional information for leased line networks using alternative multiplexing schemes.

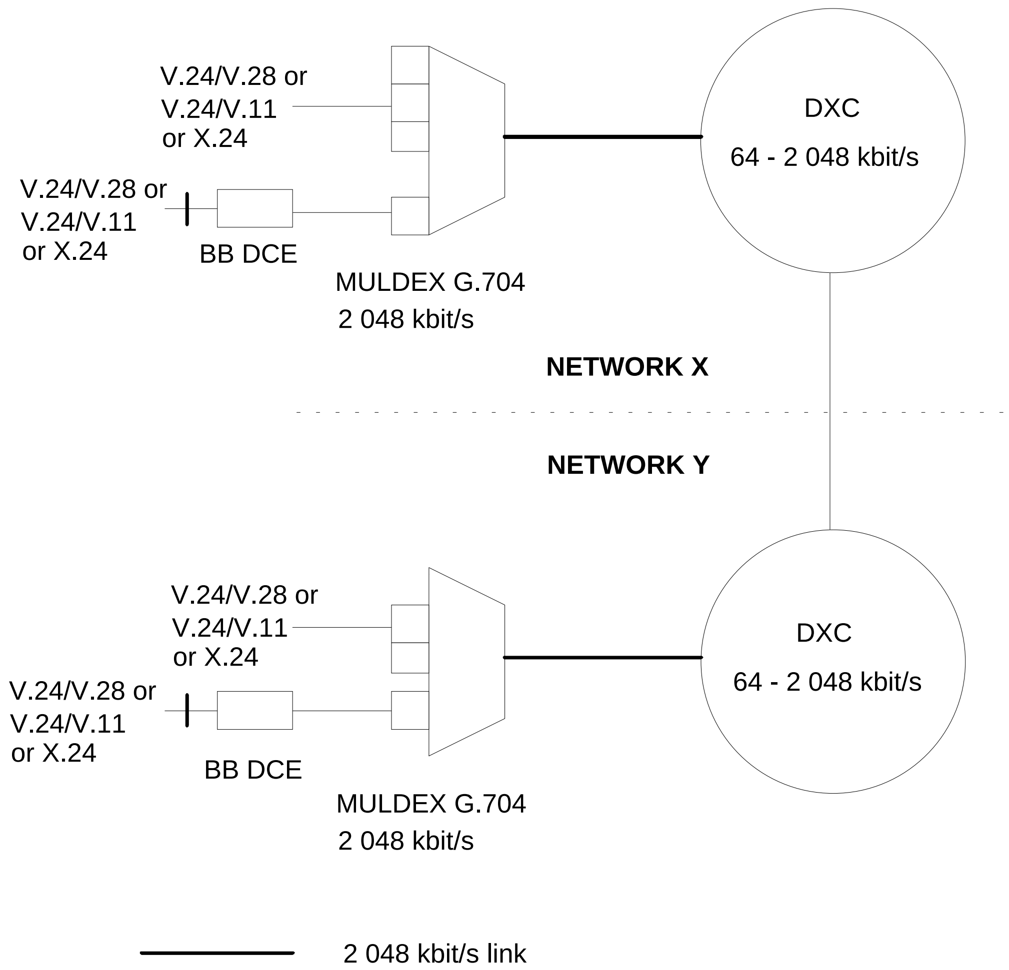


Figure 2: Digital leased line network interconnection

5 Reference model

The reference model for bit rate adaptation is taken from ITU-T Recommendation V.110 [4] and describes the two standard stages necessary for bit rate adaptation from any bit rate in the range from 600 bit/s to 19,2 kbit/s to the 64 kbit/s bit rate. The reference model for bit rate adaptation is given in figure 3.

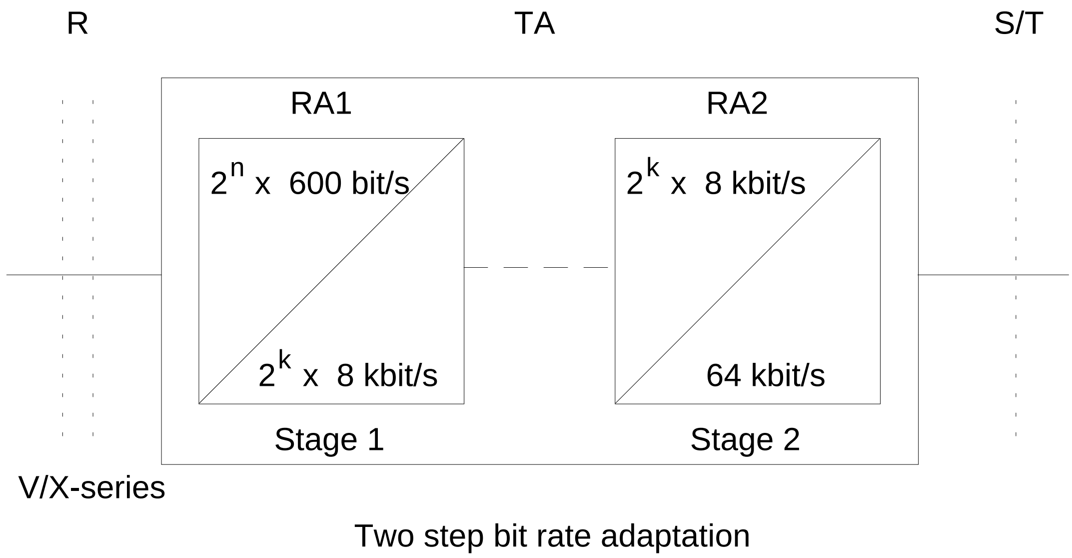


Figure 3: Reference model for bit rate adaptation

The reference model contains the following functional blocks:

- the R interface adaptation. The interface considered at the R reference point may be a ITU-T Recommendation V.24 [2] type interface, or, alternatively, a CCITT Recommendation X.24 [5] type interface;

- a two-stage bit rate adaptation functional block. The first stage, RA1, provides adaptation from one of the following bit rates 600 bit/s, 1,2 kbit/s, 2,4 kbit/s, 4,8 kbit/s, 7,2 kbit/s, 9,6 kbit/s, 12 kbit/s, 14,4 kbit/s or 19,2 kbit/s to n x 8 kbit/s (see NOTE 2). The second stage, RA2, provides adaptation from n x 8 kbit/s to 64 kbit/s;

  NOTE 1: ITU-T Study Group 14 is currently expanding the range of bit rates to consider in ITU-T Recommendation V.110 [4] to those covered by (or derived from) ITU-T Recommendation V.34 [3] under development. The additional bit rates of ITU-T Recommendation V.34 [3] are 21,6 kbit/s, 24 kbit/s, 26,4 kbit/s and 28,8 kbit/s. 38,4 kbit/s and asynchronous 57,6 kbaud signalling rates are also intended to be considered in ITU-T Recommendation V.110 [4]. This ETR includes requirements corresponding to synchronous 24 kbit/s, 28,8 kbit/s and 38,4 kbit/s bit rates and to asynchronous 57,6 kbaud signalling rate. Consideration of synchronous 21,6 kbit/s and 26,4 kbit/s bit rates is for further study.

  NOTE 2: For synchronous 24 kbit/s, 28,8 kbit/s and 38,4 kbit/s signals, RA1 functional block provides direct adaptation function to 64 kbit/s and consequently the RA2 functional block from figure 3 does not exist.

- the coincident S and T reference points (S/T) interface adaptation. This functional block is not to be provided in the leased line application. This ETR concerns applications where only 64 kbit/s circuits have to provide transport of one sub-rate signal (when simple rate adaptation is performed) or multiplexed sub-rate signals (when a complementary multiplexing function according to CCITT Recommendation I.460 [17] is implemented).

A complementary functional block to figure 3 may be considered for the case where signal at R reference point is asynchronous. In this case the functional block RA0 performs an asynchronous to synchronous conversion. The corresponding reference model is given in figure 4. When the application concerns asynchronous 57,6 kbaud signalling rate two options are considered, either:

- the RA0 functional block convert the 57,6kbaud asynchronous signal into 64 kbit/s synchronous signal and consequently RA1 and RA2 functional blocks from figure 4 do not exist; or

- the RA0 functional block convert the 57,6 kbaud asynchronous signal into 56 kbit/s synchronous signal and consequently the RA1 functional block provides direct adaptation function to 64 kbit/s and the RA2 functional block from figure 4 does not exist.

The second alternative allows provision for end-to-end signalling according to table 8.

Principles of asynchronous to synchronous conversion are given in ITU-T Recommendation V.14 [1] and in ITU-T Recommendation V.110 [4], § 2.3.

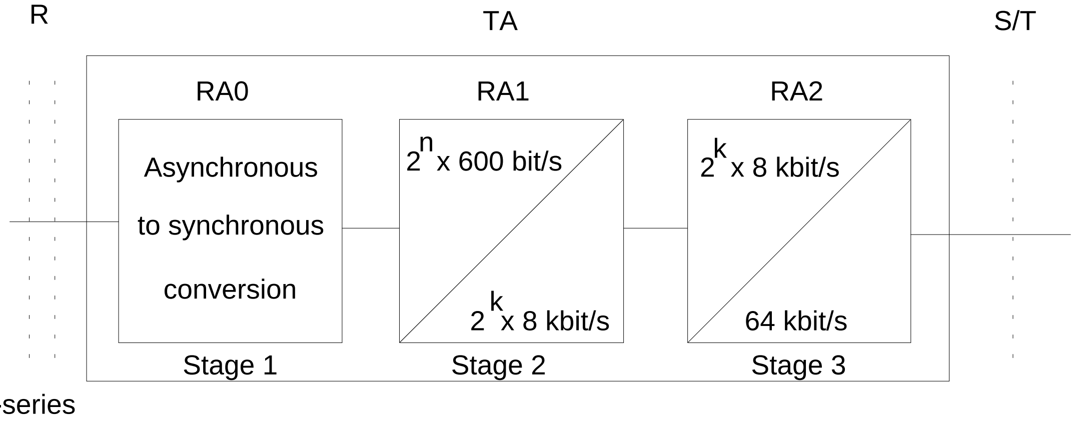


Figure 4: Reference model for asynchronous DTE

6 Functional requirements

The bit rate adaptation is composed of a two or three-stage mechanism as described in Clause 5. Considering the synchronous case, the RA1 functional block transforms the initial bit rate to a bit rate expressed as n x 8 kbit/s where n = 2k (k = 0, 1, 2 or 3). When necessary, RA2 functional block adapts the n x 8 kbit/s signal provided by the RA1 functional block to 64 kbit/s when n not equal to 3. The detailed requirements are given here-in-after.

6.1 Structure of the ITU-T Recommendation V.110 frame

The first stage for the bit rate adaptation process elaborates a 80-bit frame organised in ten 8-bit envelopes. For an intermediate 8 kbit/s bit rate, 100 frames per second are generated and there are 200, 400 and 800 frames per second for the intermediate (or final) 16, 32 or 64 kbit/s bit rates respectively. General structure of ITU-T Recommendation V.110 [4] frame is given in table 1. The transmission order is from left to right and from top to down directions.

Table 1: General ITU-T Recommendation V.110 [4] frame structure

Octet number	bit number							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
0	0	0	0	0	0	0	0	0
1	1	D1	D2	D3	D4	D5	D6	S1
2	1	D7	D8	D9	D10	D11	D12	X
3	1	D13	D14	D15	D16	D17	D18	S3
4	1	D19	D20	D21	D22	D23	D24	S4
5	1	E1	E2	E3	E4	E5	E6	E7
6	1	D25	D26	D27	D28	D29	D30	S6
7	1	D31	D32	D33	D34	D35	D36	X
8	1	D37	D38	D39	D40	D41	D42	S8
9	1	D43	D44	D45	D46	D47	D48	S9

As presented in table 1, Octet 0 only contains "0" bits and the first bit of other octets is always set to "1". This constitutes the 17-bit frame alignment signal. The following categories of information are present in the frame:

- data bits Dn with n ranging from 1 to 48;

- status bits Sn and X on bit 8 of each octet excluding octet 0;

- En bits, n ranging from 1 to 7 indicating the user bit rate, and complementary information on the channel operation.

6.2 Use of status bits (Sn and X)

Bits S1, S3, S4, S6, S8, S9 and X are used for the transmission of signalling information associated to data bits. The S-bits are organised in 2 groups SA and SB, each group having the capability of transferring the information associated to one particular control circuit of the DTE-DCE interface:

108 → S1, S3, S6, S8 = SA → 107;

105 → S4, S9 = SB → 109.

NOTE: The transfer of control signal from 108 to 107 circuits and from 105 to 109 circuits is required in switched circuit application. In the leased circuit application the use of SA and SB groups may be considered as a simple mean of end to end transfer of information. Consequently, 107 and 109 circuits do not reproduce SA and SB information.

There is a co-ordination between S bits and data bits. Any S bit is corresponding to a set of 8 data bits as indicated in table 2.

Table 2: Co-ordination between the S and D bits

S bit	D bit
S1	D1 to D8
S3	D9 to D16
S4	D17 to D24
S6	D25 to D32
S8	D33 to D40
S9	D41 to D48

The X bit (frame alignment indicator) is used for end to end transfer of information on loss or recovery of the ITU-T Recommendation V.110 [4] frame alignment. In case of loss of ITU-T Recommendation V.110 [4] frame alignment, X = "1". In case of recovery of ITU-T Recommendation V.110 [4] frame alignment, X = "0".

6.3 Use of E bits

E1, E2 and E3 bits allow the user bit rate identification, the corresponding coding is given in table 3.

Table 3: Use of E bits for bit rate coding

E bits			Intermediate/final bit rate			
E1	**E2**	**E3**	**8 kbit/s**	**16 kbit/s**	**32 kbit/s**	**64 kbit/s**
1	0	0	600 bit/s			
0	1	0	1,2 kbit/s			
1	1	0	2,4 kbit/s			
0	1	1	4,8 kbit/s	9,6 kbit/s	19,2 kbit/s	38,4 kbit/s
1	0	1		7,2 kbit/s	14,4 kbit/s	28,8 kbit/s
0	0	1			12 kbit/s	24 kbit/s

E4, E5 and E6 bits transmit information related to the user synchronisation alignment when it is independent from the network.

NOTE: In the context of synchronous digital leased line network this information is no more relevant. In consequence, E4, E5 and E6 may be allocated for another use. A new allocation for E4, E5 and E5 bits is being determined in ITU-T Study Group 14. Example of application of E4, E5 and E6 is the transfer of loopbacks commands and corresponding acknowledgements.

E7 bit is used for inter working capability with systems having ITU-T Recommendation X.30 [7] process implemented and this bit concerns the multiframe information. For this purpose, the E7 bit of each fourth ITU-T Recommendation V.110 [4] frame is set to "0".

6.4 Frame alignment

The frame alignment signal is described in subclause 6.1. It contains 17 bits: the 8 bits of octet 0 set to "0" and bits 1 of octet 1 to octet 9 are set to "1". This configuration cannot be reproduced within the frame which makes the frame recovery process easier. Table 4 reproduces the position of the frame alignment signal in the ITU-T Recommendation V.110 [4] frame.

Table 4: Frame alignment signal

octet number	**bit number**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
0	0	0	0	0	0	0	0	0
1	1							
2	1							
3	1							
4	1							
5	1							
6	1							
7	1							
8	1							
9	1							

The process for recovery of frame alignment operates on the 17-bit distributed frame alignment signal:

00000000 1XXXXXXX 1XXXXXXX 1XXXXXXX 1XXXXXXX 1XXXXXXX
1XXXXXXX 1XXXXXXX 1XXXXXXX 1XXXXXXX

To ensure a reliable alignment, it is suggested that at least two 17-bit alignment signals in consecutive frames are detected before declaring this state.

The frame alignment signal should be continuously monitored. The loss of frame alignment is determined by the occurrence of at least three consecutive frames each of them containing at least one errored bit in the frame alignment signal.

6.5 data bits mapping

Data is transmitted on the Dn bits. There are 48 bits per frame. Depending on the user data rate, filling bits (F bits in table 6) or bit duplication will be needed. Six different formats are specified in the bit rate ranging from 600 bit/s to 38,4 kbit/s. Some of them, e.g.:

- 7,2 kbit/s, 14,4 kbit/s and 28,8 kbit/s;

- 4,8 kbit/s, 9,6 kbit/s, 19,2 kbit/s and 38,4 kbit/s;

- 12 kbit/s and 24 kbit/s,

use the same format for data bits mapping but with a different recurrence due to the corresponding intermediate or final bit rate.

Table 5 gives the specified format for data bits mapping in function of user bit rate.

Table 5: Framing format versus user bit rate

Mapping format	Intermediate/final bit rate			
	8 kbit/s	**16 kbit/s**	**32 kbit/s**	**64 kbit/s**
table 6.a	600 bit/s			
table 6.b	1,2 kbit/s			
table 6.c	2,4 kbit/s			
table 6.e	4,8 kbit/s	9,6 kbit/s	19,2 kbit/s	38,4 kbit/s
table 6.d		7,2 kbit/s	14,4 kbit/s	28,8 kbit/s
table 6.f			12 kbit/s	24 kbit/s

Table 6 details the bits assignment for each specified format.

Table 6: Bits assignment versus framing format

Table 6.a

0	0	0	0	0	0	0	0
1	D1	D1	D1	D1	D1	D1	S1
1	D1	D1	D2	D2	D2	D2	X
1	D2	D2	D2	D2	D3	D3	S3
1	D3	D3	D3	D3	D3	D3	S4
1	1	0	0	E4	E5	E6	E7
1	D4	D4	D4	D4	D4	D4	S6
1	D4	D4	D5	D5	D5	D5	X
1	D5	D5	D5	D5	D6	D6	S8
1	D6	D6	D6	D6	D6	D6	S9

Adaptation of 600 bit/s user bit rate
to 8 kbit/s intermediate bit rate

Table 6.b

0	0	0	0	0	0	0	0
1	D1	D1	D1	D1	D2	D2	S1
1	D2	D2	D3	D3	D3	D3	X
1	D4	D4	D4	D4	D5	D5	S3
1	D5	D5	D6	D6	D6	D6	S4
1	0	1	0	E4	E5	E6	E7
1	D7	D7	D7	D7	D8	D8	S6
1	D8	D8	D9	D9	D9	D9	X
1	D10	D10	D10	D10	D11	D11	S8
1	D11	D11	D12	D12	D12	D12	S9

Adaptation of 1,2 kbit/s user bit rate
to 8 kbit/s intermediate bit rate

Table 6.c

0	0	0	0	0	0	0	0
1	D1	D1	D2	D2	D3	D3	S1
1	D4	D4	D5	D5	D6	D6	X
1	D7	D7	D8	D8	D9	D9	S3
1	D10	D10	D11	D11	D12	D12	S4
1	1	1	0	E4	E5	E6	E7
1	D13	D13	D14	D14	D15	D15	S6
1	D16	D16	D17	D17	D18	D18	X
1	D19	D19	D20	D20	D21	D21	S8
1	D22	D22	D23	D23	D24	D24	S9

Adaptation of 2,4 kbit/s user bit rate
to 8 kbit/s intermediate bit rate

Table 6.d

0	0	0	0	0	0	0	0
1	D1	D2	D3	D4	D5	D6	S1
1	D7	D8	D9	D10	F	F	X
1	D11	D12	F	F	D13	D14	S3
1	F	F	D15	D16	D17	D18	S4
1	1	0	1	E4	E5	E6	E7
1	D19	D20	D21	D22	D23	D24	S6
1	D25	D26	D27	D28	F	F	X
1	D29	D30	F	F	D31	D32	S8
1	F	F	D33	D34	D35	D36	S9

Adaptation of N x 3,6 kbit/s user bit rate to
intermediate/final bit rate
F = filling bit, N = 2, 4 or 8 only

Table 6.e

0	0	0	0	0	0	0	0
1	D1	D2	D3	D4	D5	D6	S1
1	D7	D8	D9	D10	D11	D12	X
1	D13	D14	D15	D16	D17	D18	S3
1	D19	D20	D21	D22	D23	D24	S4
1	0	1	1	E4	E5	E6	E7
1	D25	D26	D27	D28	D29	D30	S6
1	D31	D32	D33	D34	D35	D36	X
1	D37	D38	D39	D40	D41	D42	S8
1	D43	D44	D45	D46	D47	D48	S9

Adaptation of N x 4,8 kbit/s user bit rate to intermediate/final bit rate
N = 1, 2, 4 or 8 only

Table 6.f

0	0	0	0	0	0	0	0
1	D1	D2	D3	D4	D5	D6	S1
1	D7	D8	D9	D10	F	F	X
1	D11	D12	F	F	D13	D14	S3
1	F	F	D15	F	F	F	S4
1	0	0	1	E4	E5	E6	E7
1	D16	D17	D18	D19	D20	D21	S6
1	D22	D23	D24	D25	F	F	X
1	D26	D27	F	F	D28	D29	S8
1	F	F	D30	F	F	F	S9

Adaptation of N x 12 kbit/s user bit rate to intermediate/ final bit rate, F = filling bit
N = 1 and 2 only

6.6 Adaptation of intermediate bit rate to 64 kbit/s

When necessary, the second stage of bit rate adaptation adapts the intermediate bit rate to 64 kbit/s corresponding to the transmission capacity of a channel in the 64 kbit/s based digital leased line network (i.e. the transmission capacity associated to any TS of a CCITT Recommendation G.704 [13] frame). The following method is used: a 8 kbit/s signal will be mapped on the first bit of a given TS, a 16 kbit/s signal will be mapped on bits 1 and 2 of a given TS and a 32 kbit/s signal will be mapped on bits 1, 2, 3 and 4 of a given TS. The free bits of the TS will be set to "1".

NOTE: It may be possible to allocate the free bits of a TS for additional intermediate bit rate signals. Two formats may be considered as described in CCITT Recommendation I.460 [17]:

- fixed multiplexing format requiring that 16 kbit/s intermediate bit rate signals are mapped into bit numbers 1, 2 or 3, 4 or 5, 6 or 7, 8 and that 32 kbit/s intermediate bit rate signals are mapped into bit numbers 1, 2, 3, 4 or 5, 6, 7, 8;

- flexible multiplexing format which allows to create a new channel starting on the first free bit of the TS.

6.7 Adaptation of 48 kbit/s and 56 kbit/s user bit rates

The adaptation of a 48 kbit/s user signal is performed by mapping the data bits according to the structure given in table 7. The use of S1, S3, S4 and X bits is described in subclause 6.2.

For this application, the ITU-T Recommendation V.110 [4] frame is reduced to 32 bits. The frame alignment signal:may be functionally required or ignored depending on the application in the perspective of the maintaining the 8 kHz octet integrity within the network. When frame alignment signal is ignored the X bit should be set to "1".

1XXXXXXX 0XXXXXXX 1XXXXXXX 1XXXXXXX

Table 7: Bits assignment for 48 kbit/s user signal

octet number	bit number							
	1	2	3	4	5	6	7	8
1	1	D1	D2	D3	D4	D5	D6	S1
2	0	D7	D8	D9	D10	D11	D12	X
3	1	D13	D14	D15	D16	D17	D18	S3
4	1	D19	D20	D21	D22	D23	D24	S4

The adaptation of a 56 kbit/s user signal is performed by following the mapping of the data bits in the structure given in table 8. The use of S3, S4 and X bits is described in subclause 6.2.

Table 8: Recommended bits assignment for 56 kbit/s user signal

octet number	**bit number**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	D1	D2	D3	D4	D5	D6	D7	0
2	D8	D9	D10	D11	D12	D13	D14	X
3	D15	D16	D17	D18	D19	D20	D21	S3
4	D22	D23	D24	D25	D26	D27	D28	S4
5	D29	D30	D31	D32	D33	D34	D35	1
6	D36	D37	D38	D39	D40	D41	D42	1
7	D43	D44	D45	D46	D47	D48	D49	1
8	D50	D51	D52	D53	D54	D55	D56	1

For this application, the ITU-T Recommendation V.110 [4] frame is reduced to 64 bits. If required (i.e. when the digital leased line network does not provide 8 kHz octet integrity), the frame alignment may be based on the following distributed sequence on bit 8:

XXXXXXX0 XXXXXXXX XXXXXXXS3 XXXXXXXS4
XXXXXXX1 XXXXXXX1 XXXXXXX1 XXXXXXX1

When frame alignment signal is ignored the X bit should be set to "1".

NOTE: ITU-T Recommendation V.110 [4] presents an alternative table for the bit assignment of 56 kbit/s user signals. Attention is drawn on the lack of status bits and frame alignment signal in table 9.

Table 9: Alternative bits assignment for 56 kbit/s user signal

octet number	**bit number**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	D1	D2	D3	D4	D5	D6	D7	1
2	D8	D9	D10	D11	D12	D13	D14	1
3	D15	D16	D17	D18	D19	D20	D21	1
4	D22	D23	D24	D25	D26	D27	D28	1
5	D29	D30	D31	D32	D33	D34	D35	1
6	D36	D37	D38	D39	D40	D41	D42	1
7	D43	D44	D45	D46	D47	D48	D49	1
8	D50	D51	D52	D53	D54	D55	D56	1

Annex A: Mapping of signals based on CCITT Recommendation X.50, division 2

This Annex describes a multiplexing method for sub-64 kbit/s signals based on CCITT Recommendation X.50 [8], division 2. It should be noted that other existing implementations of CCITT Recommendation X.50 [8], division 2 may diverge from the description given in this Annex.

A.1 Frame structure

The frame structure is according to CCITT Recommendation X.50 [8], § 2.3. Data bits are structured in 8-bit envelopes and multiplexed in a 80-octet frame. Any octet has the following structure:

F D1 D2 D3 D4 D5 D6 S

where:

F bit is used as a distributed Frame Alignment Signal (FAS);
D1 to D6 bits are data bits;
S bit is a status bit associated to the corresponding data channel.

The frame alignment signal is carried on F bit and has the following configuration:

A	1	0	0	0	1	1	1	1	1	B	1	0	0	0	0	1	1	1	0
C	1	1	1	0	0	1	0	1	1	D	0	1	0	0	1	0	0	0	0
E	0	1	0	0	0	1	0	0	1	F	0	0	0	1	0	1	1	1	0
G	0	1	1	0	1	1	0	0	0	H	0	1	1	0	0	1	1	0	1

The 7 last bits of the sequence, 1001101, correspond to the loading sequence of the FAS generator.

A-bit is used as Loss of Frame Alignment (LFA) defect indicator to the remote end with A = "0" in case of loss of frame alignment.

B-bit is used as Alarm Indication Signal (AIS) defect indicator to the remote end with B = "0" in case of reception of the AIS.

Assignation of the other reserved bits in the FAS is as follows:

C = 1, D = "0", E = "0", F = 1, G = 1, H ="0"

Bits C to H are international spare bits.

A.2 Octet allocation

Octets are allocated in order to provide transport of sub-64 kbit/s data channels. Bit rates which are considered are 2,4 kbit/s, 4,8 kbit/s, 9,6 kbit/s and 19,2 kbit/s.

NOTE: The provision of 19,2 kbit/s user bit rate is not specified in CCITT Recommendation X.50 [8] and is considered as an additional function for the frame while the specified 600 bit/s bit rate is not considered.

Correspondence between bit rate and number of octets allocated to a channel is:

2,4 kbit/s	4 octets of the 80-octet frame;
4,8 kbit/s	8 octets of the 80-octet frame;
9,6 kbit/s	16 octets of the 80-octet frame;
19,2 kbit/s	32 octets of the 80-octet frame.

Octets associated to sub-64 kbit/s channels are mapped in the 80-octet frame according to an equidistant allocation rule as specified in CCITT Recommendation X.54 [11]. This does not apply to the 19,2 kbit/s channels where signals use the transmission capacity of two adjacent 9,6 kbit/s channels.

A.3 Strategy for frame alignment

A.3.1 Frame alignment

The strategy for recovery of frame alignment is the reception of 16 consecutive F bits without error (following the first reception of the 7-bit loading sequence, A, B, C, D, E, F, G and H bits are not taken into account in this process).

A.3.2 Loss of frame alignment

The strategy for loss of frame alignment is the reception of more than 8 errored F bits in one frame (A, B, C, D, E, F, G and H bits are not taken into account in this process).

A.4 Other framing aspects

The status bit S is used as an embedded monitoring and maintenance channel for the corresponding sub-64 kbit/s channel.

S = "0" indicates a normal status for the sub-64 kbit/s channel.

S = 1 indicates a defect or failure condition for the sub-64 kbit/s channel.

During a sub-64 kbit/s channel diagnostic or maintenance phase the corresponding S bit is framed (S-frame) as follows:

X T DS M1 LL M2 RL 1

with:

X	S-frame alignment signal (1 and "0" alternated);
T	Test activation (T = "0") or test acknowledgement (T = 1);
DS	Detection of line signal on the local loop (DS = ON if signal present);
M1, M2	Coding of the local loop condition (Normal; BBDCE failure/loopback activated, line failure in local loop, BBDCE out of power or under test);
LL	Local loopback control (LL = ON if loopback required);
RL	Remote loopback control (RL = ON if loopback required).

A.4.1 Strategy for S-frame alignment

The S-frame alignment is declared after the reception of 4 x 1/"0" (or "0"/1) on the X bit without error.

The loss of S-frame is declared after the reception of 3 consecutive identical X-bit.

Under S-frame alignment condition, any of the T, DS, M1, LL, M2 or RL bit is considered only if in 4 following S-frames they have been received with the same value in 3 x S-frames.

A.4.2 Detection of stable S state

S-bit is declared as "0" or "1" in case of loss of S-frame condition and under the reception of 5 consecutive "0's" or 6 consecutive "1's" respectively in any set of 8 x S-bit.

Annex B: Mapping of signals based on CCITT Recommendation X.50, division 3

This Annex describes a multiplexing method for sub-64 kbit/s signals based on CCITT Recommendation X.50 [8], division 3.

NOTE: Other existing implementations of CCITT Recommendation X.50 [8], division 3 may diverge from the description given in this Annex.

B.1 Frame structure

The frame structure is according to CCITT Recommendation X.50 [8], § 3. Data bits are structured in 8-bit envelopes and multiplexed in a 20-octet frame. Any octet has the following structure:

F D1 D2 D3 D4 D5 D6 S

where:

F bit is used as a distributed frame alignment signal (FAS);
D1 to D6 bits are data bits;
S bit is a status bit associated to the corresponding data channel.

The frame alignment signal is carried on F bit and has the following configuration:

A 1 1 0 1 0 0 1 0 0 0 0 1 0 1 0 1 1 1 0

The 5 last bits of the sequence, 01110, correspond to the loading sequence of the FAS generator.

A-bit is used as defect indicator to the remote end with A = "0" in case of defect occurrence.

B.2 Octet allocation

Octets are allocated in order to provide transport of sub-64 kbit/s data channels. Bit rates which are considered are 2,4 kbit/s, 4,8 kbit/s, 9,6 kbit/s according to CCITT Recommendation X.50 [8] and, in addition 14,4 kbit/s, 19,2 kbit/s and 48 kbit/s. The last bit rate is according to CCITT Recommendation X.50 bis [9].

B.2.1 CCITT Recommendation X.50 bit rates

Octets related to sub-64 kbit/s channels are mapped in the 20-octet frame according to an equidistant allocation rule as specified in CCITT Recommendation X.54 [11] for 2,4 kbit/s, 4,8 kbit/s and 9,6 kbit/s.

B.2.2 14,4 kbit/s

Two 14,4 kbit/s channels may be provided with the following octet allocation:

channel 1: octets 1, 2, 6, 11, 12, 16
channel 2: octets 3, 4, 8, 13, 14, 18

B.2.3 19,2 kbit/s

Two 19,2 kbit/s channels may be provided with the following octet allocation:

channel 1: octets 1, 2, 6, 7, 11, 12, 16, 17
channel 2: octets 3, 4, 8, 9, 13, 14, 18, 19

B.2.4 48 kbit/s

Any of the octets in the 20-octet frame are allocated to provide transmission capacity of the 48 kbit/s channel. This is according to CCITT Recommendation X.50 bis [9].

B.3 Strategy for frame alignment

The associated state diagram for loss and recovery of frame alignment is shown in figure B.1.

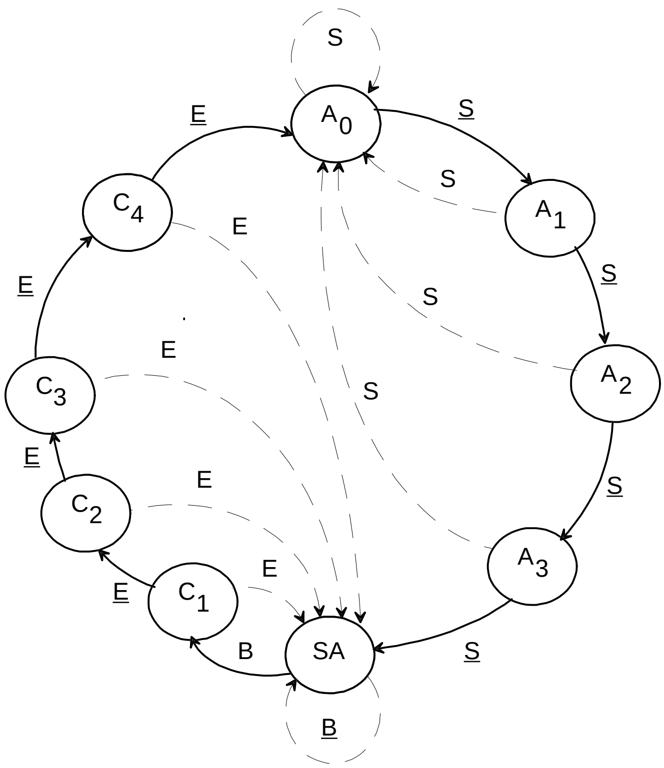
The alignment process, based on the received F bits (refer to CCITT Recommendation X.50, division 3), declares a loss of frame alignment condition upon detection of 4 consecutive sections (a section is defined as 10 consecutive F alignment bits) each of them with at least 1 error (**S** event).

In the above conditions, the process goes from state **A0** to state **SA**.

One section correctly received (**S** event) brings the process from a generic **Ai** state to **A0** state. The recovery of frame alignment contains two phases:

- during a first phase the reception of any 7 consecutive alignment bits without error (**B** event) brings to state **C1**;
- during a second phase the successive 4 received bits are checked against 4 locally generated bits according to the estimated alignment signal (**E** event if positive check, **E** event if negative check).

The failure of the above check brings the process into the **SA** state again. During this phase the value of the "A" bit (refer to CCITT Recommendation X.50 [8], division 3) is ignored.



Ai = Alignment states i = 0, 1, 2, 3
Cj = Confirmation states j = 1, 2, 3, 4
SA = Search for Frame Alignment

Figure B.1: Alignment strategy for the 64 kbit/s (structured according to X.50 [8], division 3) signal

Annex C: Mapping of signals based on CCITT Recommendation X.51

This Annex describes two versions of a multiplexing method for sub-64 kbit/s signals based on CCITT Recommendation X.51 [10].

NOTE: Other existing implementations of CCITT Recommendation X.51 [10] may diverge from the description given in this Annex.

C.1 Frame structures

C.1.1 Version 1

The frame structure is according to CCITT Recommendation X.51 [10], § 2. Data bits may be structured in 10-bit envelopes or carried transparently in 10-bit TS unstructured. The 10-bit TS are multiplexed on a fundamental 60 kbit/s signal. Any envelope has the following structure:

S A D1 D2 D3 D4 D5 D6 D7 D8

where:

A bit is used as an envelope alignment bit;
D1 to D8 bits are data bits;
S bit is a status bit associated to the corresponding data channel.

The justification mechanism as described in CCITT Recommendation X.51 [10], § 4 is not used.

The error check as described in CCITT Recommendation X.51 [10], § 5.2 is not used.

The frame length is 2 560 bits containing 240 TS or envelopes (2,4 kbits) and 160 padding bits (Pn). One padding bit is inserted after every set of 15 of the 2,4 kbits. The CCITT Recommendation X.51 [10] frame is organised in four sub-frames each containing 640 bits. The frame duration is 40 ms.

The use of padding bits (Pn, n ranging from 1 to 40 per sub-frame) is given below:

- P21 to P36 are used according to CCITT Recommendation X.51 [10], § 6.

The use of all other padding bits is free. Generally, any padding bit may be set to "1" or "0". Possible use of other padding bits is described here-in-after:

- P1: remote alarm indicator (or A-bit) or tributary data channel (n x 100 bit/s);

- P2 to P8: international housekeeping bits or tributary data channel (n x 100 bit/s);

- P37 to P40: international housekeeping bits or tributary data channel (n x 100 bit/s);

- P9 to P20: split up into two groups - group A for sub-frames 1 and 3 - group B for sub-frames 2 and 4 - used for tributary data channel (50 bit/s or n x 100 bit/s).

C.1.2 Version 2

The frame is octet oriented and signal is octet interleaved. One service octet and the nine following data octets form a sub-frame. Two following sub-frames form the fundamental frame.

Octets carrying data channels appear in the fundamental frame as follows:

- every third data octet constitute a 24 kbit/s channel;

- every sixth data octet constitute a 12 kbit/s channel.

Figure C.1 provides a general description of the version 2 of the CCITT Recommendation X.51 [10] derived frame.

Fundamental frame, T = 2,5 ms

sub-frame 1										sub-frame 2									
1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
D1	A1	B1	C1	A2	B2	C2	A3	B3	C3	D2	A4	B4	C4	A5	B5	C5	A6	B6	C6

octet D1

1	2	3	4	5	6	7	8
P01	P02	P03	P04	P05	Sa1	Sb1	Sc1

octet D2

1	2	3	4	5	6	7	8
P06	P07	P08	P09	P10	Sa4	Sb4	Sc4

data octet, A1 to C6

d1	d2	d3	d4	d5	d6	d7	d8

D1, D2: service octets
A1 to C6: data octets
d1 to d8: data bits
P01 to P10: padding bits
Sa to Sc: status bits

Figure C.1: Fundamental frame structure, version 2

The two service octets of a fundamental frame are used for padding information and status information.

The frame alignment signal is distributed in the first bit of eight consecutive service octets. The frame alignment signal is 1 1 0 0 1 0 0 1.

The use of other bits from the service octets is as follows:

- P01 and P06: frame alignment signal bits;
- P02: remote alarm indicator (or A-bit) or housekeeping bit;
- P03 to P05: housekeeping bits (400 bit/s);
- P07 to P10: housekeeping bits (400 bit/s);
- Sa1 to Sc6: status bits for tributary data channels.

C.2 Channel allocation

C.2.1 Version 1

Considering the 10-bit TS, and in extension of CCITT Recommendation X.54 [11] the five phases need not to be structured homogeneously. For a 12 kbit/s bearer channel tributary data channels having different bit rates may be allocated as indicated in table C.1. For a 19,2 kbit/s tributary data channel a bearer channel is provided by the aggregation of the two phases 1 and 3 or 2 and 4.

Table C.1: Example of envelope TS allocation versus bit rate

Phases	**envelope TS number**															
1	01	06	11	16	21	26	31	36	41	46	51	56	61	66	71	76
2	02	07	12	17	22	27	32	37	42	47	52	57	62	67	72	77
3	03	08	13	18	23	28	33	38	43	48	53	58	63	68	73	78
4	04	09	14	19	24	29	34	39	44	49	54	59	64	69	74	79
5	05	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80

12 kbit/s	--1--|
6 kbit/s	------2-----|
3 kbit/s	------------4------------|
1,5 kbit/s	--------------------------8-------------------------|
750 bit/s	---16---
TS bit rate	number of channels per phase homogeneously mapped

Examples for phase 3:
(According to ITU-T Recommendation X.53)

channel 403 (2,4 kbit/s);
channel 508 (4,8 kbit/s);
channel 413 (2,4 kbit/s).

In the same way, it is possible to allocate the padding bits to the transmission of data channels. These are carrying asynchronous data up to 1,2 kbaud. For channels having a n x 100 baud modulation rate the distribution of TS is not arranged in an equidistant manner. Tables C.2, C.3 and C.4 give the padding bits allocation function of the data channel modulation rate.

Table C.2: Example of padding bits allocation versus modulation rate

Groups	padding TS numbers											
	sub-frame 1			sub-frame 2			sub-frame 3			sub-frame 4		
1	A09	A13	A17	B09	B13	B17	A09	A13	A17	B09	B13	B17
2	A10	A14	A18	B10	B14	B18	A10	A14	A18	B10	B14	B18
3	A11	A15	A19	B11	B15	B19	A11	A15	A19	B11	B15	B19
4	A12	A16	A20	B12	B16	B20	A12	A16	A20	B12	B16	B20
300 bit/s	--1--|											
50 bit/s	-------------------------6-------------------------|											
1,2 kbit/s	1 = All padding bits from group A and B											
modulation rate	number of channels per group homogeneously mapped											

Table C.3: Example of padding bits allocation versus modulation rate

Groups	padding TS numbers							
	sub-frame 1		sub-frame 2		sub-frame 3		sub-frame 4	
1	A09	A15	B09	B15	A09	A15	B09	B15
2	A10	A16	B10	B16	A10	A16	B10	B16
3	A11	A17	B11	B17	A11	A17	B11	B17
4	A12	A18	B12	B18	A12	A18	B12	B18
5	A13	A19	B13	B19	A13	A19	B13	B19
6	A14	A20	B14	B20	A14	A20	B14	B20
200 bit/s	------1-----|							
100 bit/s	------------2-----------|							
50 bit/s	-------------------------4-------------------------|							
1,2 kbit/s	1 = All padding bits from group A and B							
modulation rate	number of channels per group homogeneously mapped							

Examples for group 3: channel A11 (50 bit/s);
channel A17 (100 bit/s);
channel B11 (50 bit/s).

Table C.4: Example of padding bits allocation versus modulation rate

Groups	padding TS numbers						
1	P01	P07				P05	P37
2	P02	P08			P02	P06	P38
3	P03	P37			P03	P07	P39
4	P04	P38			P04	P08	P40
5	P05	P39					
6	P06	P40					
200 bit/s (*)	---1---			300 bit/s (*)	---1---		
100 bit/s(*)	--------2-------			100 bit/s (*)	------------3------------		
1,2 kbit/s(*)	1 = All padding bits P1 to P8 and P37 to P40						
	number of channels per group homogeneously mapped						

(*): modulation rate

C.2.2 Version 2

For the envelope TS the density of status information in the frame is one status bit in three data octets. Table C.5 represents this situation.

Concerning the padding TS, P03, P04, P06, P08, P09 and P10 bits are used as 1,2 kbit/s maintenance channel.

Table C.5: channel allocation, version 2

	9;6 kbit/s channels	19,2 kbit/s channels
channel 1	Sa1, A1, A3, A5	Sa1, A1, A2, A3, Sa4, A4, A5, A6
channel 2	Sb1, B1, B3, B5	Sb1, B1, B2, B3, Sb4, B4, B5, B6
channel 3	Sc1, C1, C3, C5	Sc1, C1, C2, C3, Sc4, B4, B5, B6
channel 4	Sa4, A2, A4, A6	
channel 5	Sb4, B2, B4, B6	
channel 6	Sc4, C2, C4, C6	

C.3 Strategy for frame alignment

C.3.1 Frame alignment recovery

The multiplexed signal is declared aligned at the occurrence of three consecutive frame alignment signals in one position of the frame.

C.3.2 Loss of frame alignment

Loss of frame alignment is declared when:

- three consecutive frame alignment signals are errored; or

- the frame alignment signal is recognised in more than one position for more than 16 consecutive frames.

This condition is transmitted to the far end on A-bit, with A = "0" in case of defect occurrence, when P01 (version 1) or P02 (version 2) have been programmed to carry this information.

C.4 Other framing aspects

Additional envelope sub-multiplexing function may be provided in order to increase transmission efficiency. This is complementary to the multiplexing arrangement described in Clause C.1 and is considered as an optional end-to-end function. When provided, the status bit is common to all sub-channels. Table C.6 gives four possible sub-channel mappings where the sub-channel modulation rates are referred to the corresponding envelope transmission capacity.

Table C.6: Envelope sub-channel mapping

sub-channel mapping	**envelope**										**sub-channel modulation rate**	**sub-channel**
	S	A	1	2	3	4	5	6	7	8		
I			X				X				1/4	A
				X				X			1/4	B
					X				X		1/4	C
						X				X	1/4	D
II			X		X		X		X		1/2	A
				X		X		X		X	1/2	B
III			X		X		X		X		1/2	A
				X				X			1/4	B
						X				X	1/4	C
IV			X		X		X		X		1/2	A
				X				X			1/4	B
						X					1/8	C
										X	1/8	D

Annex D: Mapping of signals based on CCITT Recommendation X.58

This Annex describes a multiplexing method for sub-64 kbit/s signals derived from CCITT Recommendation X.58 [12].

NOTE: Other existing implementations of CCITT Recommendation X.58 [12] may diverge from the description given in this Annex.

D.1 Frame structure

The frame structure for sub-64 kbit/s is organised in conjunction with the 2 048 kbit/s CCITT Recommendation G.704 [13] frame. Any of the TS from TS1 to TS31 may be configured to carry data or voice signals. Depending of the TS configuration the corresponding 64 kbit/s frame structure is described here-in-after for both data mode and voice mode. Depending on the application, a maintenance channel may be provided. When required, TS11 is used to convey its embedded maintenance messages. The description of the related protocol is given in Clause D.5.

D.1.1 Data mode

This is a 80-octet frame. The frame contains 640 bits and has a 10 ms duration. The frame structure is given in figure D.1.

10 octets

X1	A1	B1	C1	A2	B2	C2	A3	B3	C3	
D1	A4	B4	C4	A5	B5	C5	A6	B6	C6	
A7	B7	C7	D2	A8	B8	C8	A9	B9	C9	
A10	B10	C10	D3	A11	B11	C11	A12	B12	C12	8
A13	B13	X2	C13	A14	B14	C14	A15	B15	C15	lines
D4	A16	B16	C16	A17	B17	C17	A18	B18	C18	
A19	B19	C19	D5	A20	B20	C20	A21	B21	C21	
A22	B22	C22	D6	A23	B23	C23	A24	B24	C24	

Figure D.1: Frame structure for a TS in data mode

The frame alignment signal is composed of the two X1 and X2 octets. Hexadecimal value of X1 octet is 27_{HEX}, hexadecimal value of X2 octet is 05_{HEX} These two synchronisation octets are sent with the least significant bit first.

An, Bn, Cn, Dn, represent octets which are allocated to the data traffic.

D.1.2 Voice mode

This is a 80-octet frame. The frame contains 640 bits and has a 10 ms duration. The frame structure is given in figure D.2.

Octets are identified with reference to four numbering groups Pn, Qn, Rn and Sn for the purpose of their allocation to any voice channel.

There are no octet specifically allocated for the transmission of frame alignment signal. Nevertheless it is suggested to send the synchronisation octets within a TS in voice mode application whenever it is possible. For this purpose, there is a change in the octet numbering as shown in figure D.2 on positions 40 and 42 (assuming that the octet are numbered from 0 to 79 within the frame). This allows for extra multiplexing combinations in the TS while maintaining two synchronisation octets.

4 octets

P1	Q1	R1	S1
P2	Q2	R2	S2
P3	Q3	R3	S3
P4	Q4	R4	S4
P5	Q5	R5	S5
P6	Q6	R6	S6
P7	Q7	R7	S7
P8	Q8	R8	S8
P9	Q9	R9	S9
P10	Q10	R10	S10
R11	Q11	P11	S11
P12	Q12	R12	S12
P13	Q13	R13	S13
P14	Q14	R14	S14
P15	Q15	R15	S15
P16	Q16	R16	S16
P17	Q17	R17	S17
P18	Q18	R18	S18
P19	Q19	R19	S19
P20	Q20	R20	S20

20 lines

Figure D.2: Frame structure for a TS in voice mode

D.2 Octet allocation

D.2.1 Data mode

Octets are allocated in order to provide transport of sub-64 kbit/s data channels. The following range of sub-64 kbit/s bit rates is supported:

2,4 kbit/s	7,2 kbit/s	48 kbit/s	16 kbit/s
4,8 kbit/s	14,4 kbit/s	56 kbit/s	24 kbit/s
9,6 kbit/s			32 kbit/s
19,2 kbit/s			

NOTE: The frame is optimised for the bit rates of the first column, since it is expected that these bit rates are more likely used.

The frame structure in data mode provides a granularity of 800 bit/s per octet allocated to a given data channel.

Details of octet allocation versus the user bit rate are given below:

- 2,4 kbit/s, any of the following octet associations may be selected:

  $A_i\ A_{i+8}\ A_{i+16}$ i ranging from 1 to 8;
  $B_i\ B_{i+8}\ B_{i+16}$ i ranging from 1 to 8;
  $C_i\ C_{i+8}\ C_{i+16}$ i ranging from 1 to 8;
  D1 D3 D5;
  D2 D4 D6;

- 4,8 kbit/s, any of the following octet associations may be selected:

  $A_i\ A_{i+4}\ A_{i+8}\ A_{i+12}\ A_{i+16}\ A_{i+20}$ i ranging from 1 to 4;
  $B_i\ B_{i+4}\ B_{i+8}\ B_{i+12}\ B_{i+16}\ B_{i+20}$ i ranging from 1 to 4;
  $C_i\ C_{i+4}\ C_{i+8}\ C_{i+12}\ C_{i+16}\ C_{i+20}$ i ranging from 1 to 4;
  D1 D2 D3 D4 D5 D6;

- 9,6 kbit/s, any of the following octet associations may be selected:

  A i A i+2 A i+4 A i+6 A i+8 A i+10 A i+12 A i+14 A i+16 A i+18 A i+20 A i+22
  i = 1 or 2
  B i B i+2 B i+4 B i+6 B i+8 B i+10 B i+12 B i+14 B i+16 B i+18 B i+20 B i+22
  i = 1 or 2
  C i C i+2 C i+4 C i+6 C i+8 C i+10 C i+12 C i+14 C i+16 C i+18 C i+20 C i+22
  i = 1 or 2

- 19,2 kbit/s, any of the following octet associations may be selected:

  A1 to A24;
  B1 to B24;
  C1 to C24;

- 14,4 kbit/s:

  a 14,4 kbit/s channel is situated within a 19,2 kbit/s channel where the first 4,8 kbit/s constituent channel (containing A1 or B1 or C1) is not used;

- 7,2 kbit/s:

  a 7,2 kbit/s channel is situated within a 14,4 kbit/s channel. The allocated octets from the 14,4 kbit/s are all odd octets or all even octets;

- 16 kbit/s:

  a 16 kbit/s channel is situated within a 19,2 kbit/s channel. For this purpose the first 2,4 kbit/s constituent channel (containing A1 or B1 or C1) and one octet (A13 or B13 or C13) are not used;

- 24 kbit/s:

  a 24 kbit/s channel is made of the aggregation of one 19,2 kbit/s and one 4,8 kbit/s channel;

- 32 kbit/s:

  a 32 kbit/s channel is made from the aggregation of two 19,2 kbit/s channels each of them having their first constituent 2,4 kbit/s channel (containing octet A1 or B1 or C1) and one octet (A13 or B13 or C13) excluded;

- 48 kbit/s:

  a 48 kbit/s channel is made of the aggregation of two 19,2 kbit/s and one 9,6 kbit/s channels;

- 56 kbit/s:

  a 56 kbit/s channel is made from the aggregation of the three 19,2 kbit/s channels where octets A6 and A18 are excluded.

D.2.2 Voice mode

Octets are allocated to provide transport of sub-64 kbit/s voice channels. the following range of bit rate is supported:

- 48 kbit/s;
- 32 kbit/s;
- 24 kbit/s; and
- 16 kbit/s.

Any octet from the TS frame used in voice mode provides a 800 bit/s contribution to the 64 kbit/s TS bit rate. Any of the Pn, Qn, Rn or Sn octet groups has a contribution of 16 kbit/s to the 64 kbit/s TS bit rate.

Details of octet allocation versus the voice bit rate are given below.

- 48 kbit/s

  a 48 kbit/s voice channel is made of the aggregation of all the Qn Rn Sn octet suites;

- 32 kbit/s

  a 32 kbit/s is made of the aggregation of either the Pn Rn octet suites or the Qn Sn octet suites;

- 24 kbit/s

  a 24 kbit/s voice channel is made from a 48 kbit/s channel by using either all its odd octets or all its even octets;

- 16 kbit/s

  a 16 kbit/s channel is made of one of the Pn, Qn, Rn or Sn octet groups.

D.3 Strategy for frame alignment

D.3.1 Data mode

The corresponding information is not provided.

D.3.2 Voice mode

The corresponding information is not provided.

D.3.3 other alignment aspects

When more than one of the TS of the 2 048 kbit/s CCITT Recommendation G.704 [13] frame are used for the transport of signals according to subclause D.1.1 or to subclause D.1.2, there should be a co-ordination in the generation of these 64 kbit/s signals. The signals are ordered so that it may be possible to synchronise all TS signals on a particular one. The reference TS for this global synchronisation purpose should be TS11 as it contains the maintenance channel when available (see Clause D.1). Figure D.3 describes the relationship between TS signals for the frame generation ordering. This is related to a 80-octet frame within the TS11.

frame No.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Sync octet	TS 11	TS 12	TS 13		TS 14	TS 15	TS 16		TS 17	TS 18	TS 19		TS 20	TS 21	TS 22		TS 23	TS 24	TS 25	

frame No.	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Sync octet	TS 26	TS 27	TS 28		TS 29	TS 30	TS 31		TS 1	TS 2	TS 3		TS 4	TS 5	TS 6		TS 7	TS 8	TS 9	

frame No.	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
Sync octet	TS 10		TS 11	TS 12	TS 13		TS 14	TS 15	TS 16		TS 17	TS 18	TS 19		TS 20	TS 21	TS 22		TS 23	TS 24

frame No.	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
Sync octet	TS 25		TS 26	TS 27	TS 28		TS 29 1	TS 30 2	TS 31 3		TS 4	TS 5	TS 6		TS 7	TS 8	TS 9		TS 10	

Figure D.3: 2 048 kbit/s multiframe structure

D.4 Other framing aspects

D.4.1 Associated channel

For the transfer of information related to a particular sub-64 kbit/s data channel it is possible to allocate an associated channel which will be tied to the data channel. A composite channel is then formed by aggregation of the data channel and its associated channel. The bit rate of the associated channel is a multiple of 800 bit/s, 800 bit/s being the typical bit rate. The two following subclauses describe examples of application for the associated channel.

D.4.2 Status information transfer

In this application the associated channel contains synchronisation information, a pointer and status bits. Figure D.4 gives the general format for the associated channel octets.

bit number	7	6	5	4	3	2	1	0
	MSB							LSB

Figure D.4: Octet format for status information transfer

The detailed bit allocation is the following:

bit 0: synchronisation bit; taken from a 511 pseudo random sequence. This sequence is according to ITU-T Recommendation O.153 [18].

bits 5 to 1: this characterises the pointer value. This gives the octet number from the corresponding data channel for which the status information changes. Pointer value "0" indicates that there is no change in the status information. Pointer value "1" indicates that the present status information will change at the occurrence of the next octet of the corresponding data channel.

bits 7 and 6: These bits give the value of a predefined status signal.

D.4.3 Channel performance monitoring

In this application the associated channel contains a CRC procedure over the corresponding data channel. Data is divided in blocks, a block being a number of multiframes. The recommended number of multiframes to consider, M, is given in the following table D.1 and is depending of the data channel bit rate. The values for M parameter are providing block lengths as close as possible of 1 kbits.

Table D.1: Number of multiframes versus data channel bit rate

bit rates (kbit/s)	**M**
2,4	42
4,8	21
7,2	14
9,6	10
14,4	7
16	6
19,2	5
24	4
32	3
48	3
56	3
64	3

The associated channel contains a synchronisation octet, two CRC octets and an idle octets as indicated in figure D.5. Figure D.6 gives the structure for the synchronisation octet.

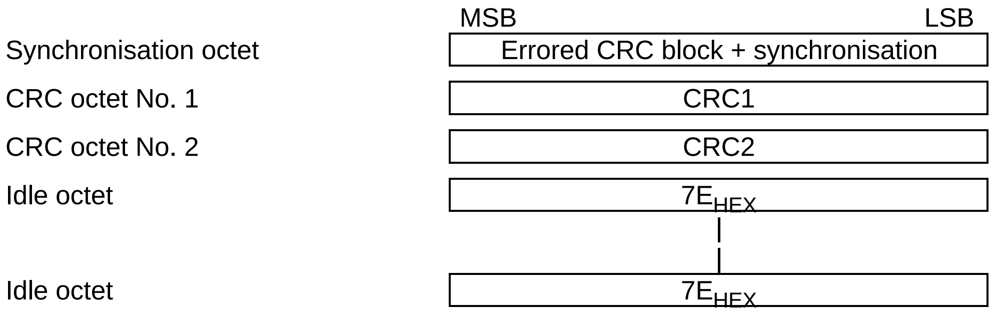
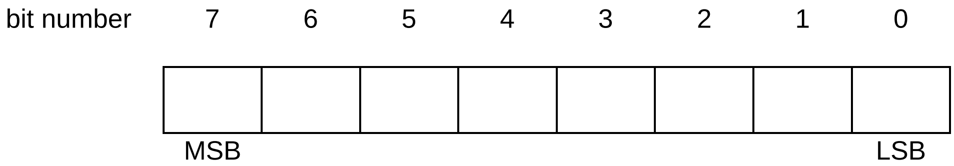


Figure D.5: Octet format for channel performance monitoring



- bits 5 to 0: synchronisation bits, 511 pseudo random sequence according to ITU-T Recommendation O.153 [18];
- bits 7, 6: Received CRC block (10 = errored CRC block received, 00 = no CRC error).

Figure D.6: Synchronisation octet format

The CRC polynomial generator is $x^{-16} + x^{-12} + x^{-5} + 1$. The idle octet content is the hexadecimal value of $7E_{HEX}$. The synchronisation octet contains the synchronisation bits and the result of the CRC calculation for the received signal sent to the remote end. The format of the synchronisation octet is given in figure D.6.

The CRC octets 1 and 2 contain the result of the CRC calculation over all data bits of the corresponding data channel since the last associated channel frame. The bits of the associated channel are excluded from the CRC calculation. At the beginning of a data block, the CRC coding algorithm should be initialised with 16 x bits equal to "0".

D.4.4 Associated channel allocation

For a given number of sub-64 kbit/s data channels the allocation of the associated channel is defined. This allocation is given in table D.2. Table D.2 applies to the case where the bit rate of the associated channel is 800 bit/s. This associated channel and its corresponding data channel constitute a composite channel.

Table D.2: Associated channel allocation rule

data channel bit rate (kbit/s)	allocated octets in the multiframe	associated channel allocation
19,2	A	D1
19,2	B	D2
19,2	C	D3
9,6; 4,8; 2,4	A1	D1
9,6; 4,8; 2,4	A2	D4
9,6; 4,8; 2,4	B1	D2
9,6; 4,8; 2,4	B2	D5
9,6; 4,8; 2,4	C1	D3
9,6; 4,8; 2,4	C2	D6

D.5 Maintenance channel

When a maintenance channel is necessary, it is implemented in TS11. This is a 19,2 kbit/s channel.

D.5.1 Allocation

The 19,2 kbit/s maintenance channel is supported by the Cn octet group.

D.5.2 Structure for the link layer

The maintenance channel is based on the link layer procedure according to ITU-T Recommendation X.25 [6], § 2. Basic LAPB (modulo 8) Asynchronous Balanced Mode applies.

RR and RNR command frames and SABM and DISC unnumbered command frames are used. The supervisory responses frames are RR and RNR, and the unnumbered response frames are DM and UA.

An additional XID procedure is defined to determine either a DTE address (03_{HEX}) or a DCE address (01_{HEX}). The procedure starts with the generation of a random 8-bit number between 0 and 255. If the number is below 128, a DTE mode initialisation is performed. Otherwise a DCE mode initialisation is performed. A new random number is generated and transmitted every 5 seconds in a XID frame until an XID frame is received. The random number contained in the received XID frame is compared with the generated random number. If the received number appears to be greater a link set-up procedure can be initiated. If it appears to be less then the address 03_{HEX} (respectively 01_{HEX}) is change into 01_{HEX} (respectively 03_{HEX}) and a link set-up procedure can be initiated. If the numbers are equal, a new random number is generated and transmission of XID frames continues.

The format for the XID frame and the hexadecimal value of the octets are given in table D.3.

Table D.3: Format for XID frame

address	01_{HEX} or 03_{HEX}
control field	AF_{HEX}
XID format ID	82_{HEX}
XID group ID	41_{HEX}
group length (high byte)	00_{HEX}
group length (low byte)	03_{HEX}
XID parameter ID	01_{HEX}
parameter length	01_{HEX}
XID parameter	random number
CRC (high byte)	
CRC (high byte)	

D.5.3 Network layer procedure

The information field from the data link layer contains an address field as a header. Two alternative addressing methods can be used. Each frame indicates in this address header which addressing method is used. The two alternative methods are described below.

Explicit addressing

When explicit addressing is used, the most significant bit of first octet is "0".

The address header starts with two octets a length indicator and a pointer, followed by the addresses of all the network units that the message will pass through or is destined to. The first address is the message originator's address and the last one is the destination's address. The number of addresses to consider is given by the length octet. The pointer octet points to that particular address corresponding to the next network unit in the list to receive the message. This is incremented when passing through the next network unit.

As an example, the next table D.4 give an address header sequence corresponding to a generator 10_{HEX} sending a message to a destination 07_{HEX} by routeing it over three network units having addresses 25_{HEX}, 03_{HEX} and 37_{HEX}. The most significant bit of the first octet is "0".

Table D.4: Example of explicit address header

05 length	01 pointer	10 25 03 37 07 addresses

Logical addressing

When logical addressing is used, the most significant bit of first octet is 1. The address header is composed of two octets. they contain a single 15-bit address. This corresponds to the address of the destination of the message. Any network unit has the knowledge of the routeing of the message in the network by checking this address.

All octets are sent with the least significant bit first. Table D.5 gives the description of the address header.

Table D.5: Logical address header

first octet								Second octet							
B7	B6	B5	B4	B3	B2	B1	B0	B7	B6	B5	B4	B3	B2	B1	B0
1	(15-bit address)														

Annex E: CCITT Recommendation X.50, division 3/V.110 interworking

This Annex described a proposal for interworking procedure which may be applied at the interconnection point of one network having the sub-64 kbit/s channels managed according to Annex B (i.e. according to CCITT Recommendation X.50 [8], division 3 and CCITT Recommendation X.50 bis [9]) and one network applying the principles presented in Clause 6 (i.e. according to ITU-T Recommendations V.110 [4] and I.460 [17]).

E.1 Functional description and reference points

E.1.1 Functional description

This Annex is based on the functional description given in figure E.1.

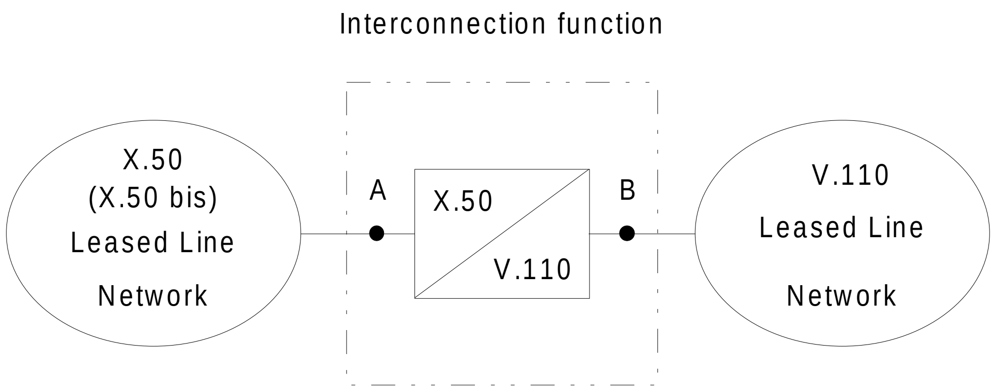


Figure E.1: Functional description for CCITT Recommendation X.50 [8] (div. 3)/ITU-T Recommendation V.110 [4] interworking

The interworking procedure is to be applied in the interconnection function between reference points A and B.

E.1.2 Definition of reference points

A: This reference point corresponds to part of 64 kbit/s related to a sub-64 kbit/s signal multiplexed according to Annex B.

B: This reference point corresponds to a sub-64 kbit/s signal presented on one of the 8 kbit/s, 16 kbit/s, 32 kbit/s or 64 kbit/s intermediate bit rates structured according to Clause 6.

The interworking procedure described here-in-after is intended to be applied to any of the sub-64 kbit/s channel multiplexed within the 64 kbit/s according to one of the CCITT Recommendations X.50 [8] or X.50 bis [9] at reference point A.

E.2 Mapping of signals having bit rate not greater than 19,2 kbit/s

E.2.1 From A to B reference points

In normal condition the signal at the B reference point is generated according to the following rules:

- the frame alignment signal is generated is independently of signal at the A reference point;

- data at 2,4 kbit/s, 4,8 kbit/s, 9,6 kbit/s, 14,4 kbit/s, and 19,2 kbit/s from A reference point are directly mapped in the intermediate bit rate frame at the B reference point according to tables 6.c, 6.e, 6.e, 6.d, 6.e respectively;

- the status bit S at the A reference point is copied on bits S4 and S9 at the B reference point;

- S1 = S3 = S6 = S8 = ON at B reference point;

- X = OFF at B reference point;

- E1, E2, E3 are coded under control of the TMN according to the bit rate of the leased circuit, this is complying to table 3;

- E4 = E5 = E6 = E7 = OFF at B reference point.

E.2.2 From B to A reference points at B reference point

In normal operation the signal at the A reference point is generated according to the following rules:

- the frame alignment signal is generated independently of the signal at the B reference point;

- data at 2,4 kbit/s, 4,8 kbit/s, 9,6 kbit/s, 14,4 kbit/s, 19,2 kbit/s from B reference point are directly mapped in a corresponding constituent channel having the same bit rate at the A reference point according to the mapping rules described in subclauses B.2.1, B.2.2 and B.2.3;

- the status bit S at A reference point reproduces the value of the corresponding S4 and S9 bits of the ITU-T Recommendation V.110 [4] frame at the B reference point.

E.3 Mapping of signals having a 48 kbit/s bit rate

E.3.1 From A to B reference points

In normal condition the signal at the B reference point is generated according to the following rules:

- the frame alignment signal is generated is independently of signal at the A reference point;

- data at 48 kbit/s from A reference point are directly mapped in the 64 kbit/s frame at the B reference point according to table 7;

- the status bit S at the A reference point is copied on bits S4 at the B reference point;

- S1 = S3 = ON at B reference point;

- X = OFF at B reference point.

E.3.2 From B to A reference points

In normal operation the signal at the A reference point is generated according to the following rules:

- the frame alignment signal is generated independently of the signal at the B reference point;

- data at 48 kbit/s from B reference point are directly mapped in the corresponding constituent 48 kbit/s channel at the A reference point according to the mapping rules described in subclause B.2.4;

- the status bit S at A reference point reproduces the value of the corresponding S4 bit of the ITU-T Recommendation V.110 [4] frame at the B reference point.

History

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