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GENERAL ASPECTS OF DIGITAL TRANSMISSION SYSTEMS

CHARACTERISTICS OF A FLEXIBLE MULTIPLEXER IN A PLESIOCHRONOUS DIGITAL HIERARCHY ENVIRONMENT

ITU-T Recommendation G.797

(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 G.797 was prepared by the ITU-T Study Group XV (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 Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.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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ABSTRACT

This Recommendation gives the characteristics of a flexible multiplex equipment able to handle a variety of services with transparency for service provider, allowing enhanced management capabilities and to be used in the local network. Concentration function for switched services is not precluded and further study is necessary to cover this application. Tributaries of this multiplexer present usual interfaces related to services to which they are connected. Internal mapping functions are based on Recommendation G.704 and on 64 and n × 64 kbit/s signals. The handling of sub-64 kbit/s signals is not precluded. The equipment is intended to be installed in a plesiochronous digital hierarchy (PDH) environment. Management of the equipment is in line with general principles of the telecommunications management network (TMN).

Recommendation G.797

CHARACTERISTICS OF A FLEXIBLE MULTIPLEXER IN A PLESIOCHRONOUS DIGITAL HIERARCHY ENVIRONMENT

(Helsinki, 1993)

1 General characteristics

1.1 Definitions

For the purposes of this Recommendation, the following definitions apply.

Refer also to 1.2 for additional functional description.

flexible access system (FAS): A flexible access system is a means of providing a wide range of telecommunication services to customers in a flexible manner. These services may be delivered at the customer premises or from a public network location.

On the network side, connections are established to the appropriate service networks.

The flexible access system is managed by the TMN.

flexible multiplexer (FM): A device that provides time division multiplexing and demultiplexing of signals supporting a variety of user services. In addition, the device provides enhanced management capabilities.

The flexible multiplexer is part of flexible access system.

flexible access termination (FAT): In a plesiochronous digital hierarchy, the flexible access termination is used in conjunction with the flexible multiplexer to constitute a flexible access system.

monoservice 2048 kbit/s G.704 frame: A digital signal with structure according to 2.3 and 5/G.704 comprising constituent 64 kbit/s or n × 64 kbit/s signals and any related signalling corresponding to only one particular service network.

multiservice 2048 kbit/s G.704 frame: A digital signal with structure according to 2.3/G.704 comprising constituent 64 kbit/s or n × 64 kbit/s signals and any related signalling corresponding to various service networks.

embedded operation channel (EOC): An embedded operation channel is a physical channel of the managed network used for management communication purposes, specifically to exchange information between network element (NE) functions and operations system (OS) or mediation device (MD) functions. It may be carried over different physical bearers.

1.2 Abbreviations

This paragraph contains the abbreviations which are not defined in the core text of the Recommendation.

TS	Time-slot
PCM	Pulse code modulation
ADPCM	Adaptive differential pulse code modulation
ppm	part per million
UI	Unit interval
Q	The NE interface to the TMN
DC	Direct current
ES	Errored second
SES	Severely errored second

TS16	Time-slot 16 of a 2048 kbit/s G.704 frame
SB-ADPCM	Sub-band-Adaptive differential pulse code modulation
DTE	Data terminal equipment
DCE	Data circuit equipment
AIS	Alarm indication signal
CRC	Cyclic redundancy check
TS0	Time-slot 0 of a 2048 kbit/s G.704 frame
FAS	Frame alignment signal
NFAS	Non frame alignment signal
fr0	Frame 0 of the CAS G.704 multiframe
MTBF	Mean time between failure
MTTR	Mean time to repair

1.3 Application of the equipment

1.3.1 Network configurations

The recommended network configurations are given in Figures 1 and 2. Figure 3 describes the repartition of functions in flexible access system.

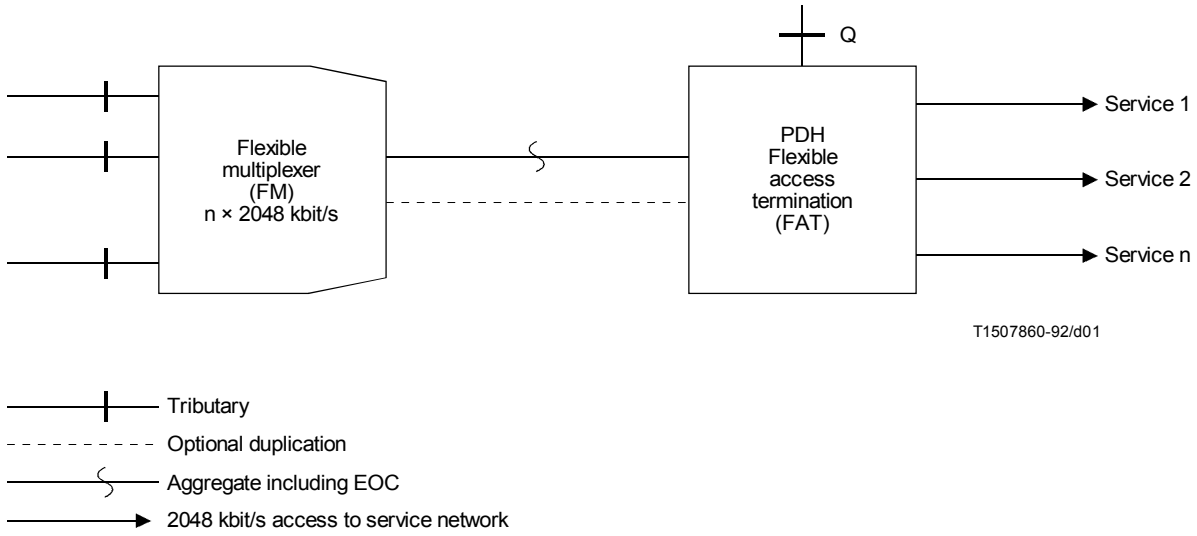


FIGURE 1/G.797

Flexible access system, application of monoservice 2048 kbit/s frames

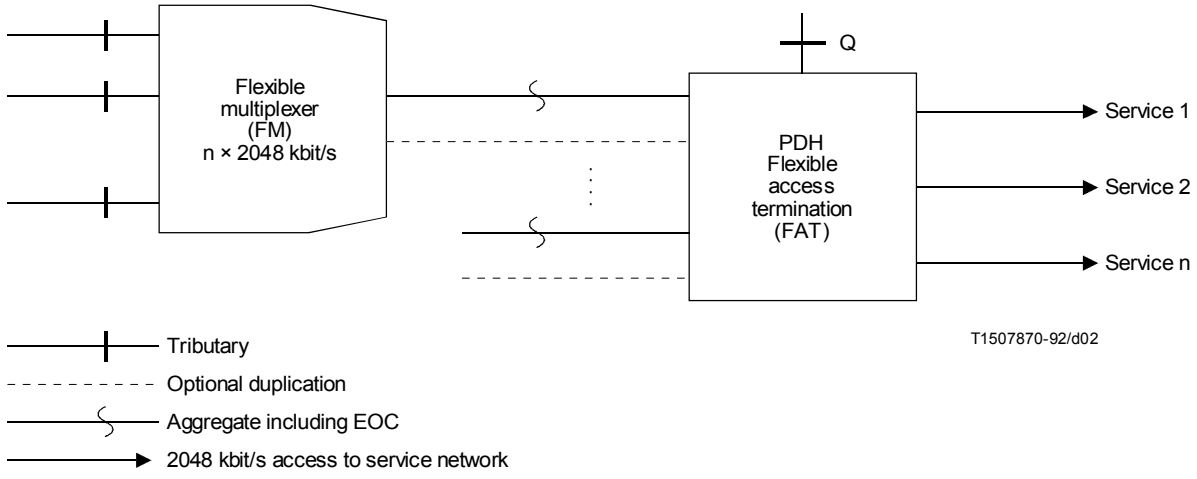
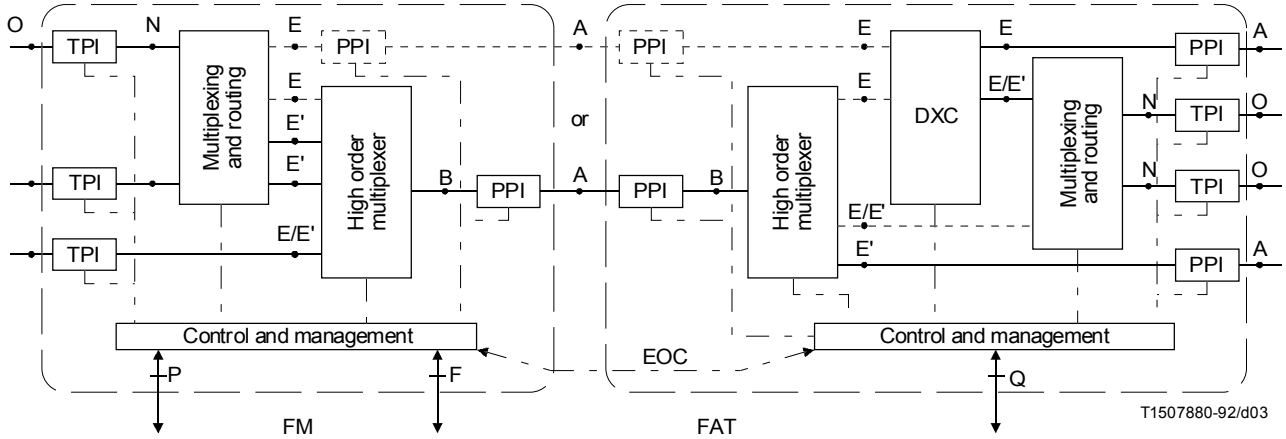


FIGURE 2/G.797

Flexible access system, application of monoservice 2048 kbit/s G.704 frames



NOTE – The reference points, except the Q-reference point, are defined in clause 3.

FIGURE 3/G.797

Functional representation of the flexible access system

In the network configuration given in Figure 1, the flexible access termination (FAT) is serving as a high order multiplexer.

In the network configuration given in Figure 2, the flexible access termination (FAT) is serving as an equipment derived from a digital cross connect equipment (DXC).

If access to particular service networks cannot be realised in 2048 kbit/s G.704 framed signals, the restitution of individual signals with analog type interfaces shall be covered by the flexible access termination. In that situation the flexible access termination includes functions similar to the flexible multiplexer.

The possible combination of elementary functions covering the presented requirements is described in Figure 3.

The flexible multiplexer is dependent on the FAT on control point of view.

1.3.2 Services

The services considered for the flexible multiplexer are derived from the integrated services digital network (ISDN), the public switched telephone network (PSTN), a circuit switched data network (CSDN), a packet switched data network (PSDN) and a leased line network.

1.4 Size

This parameter depends mainly on the network environment, it can change with time. Increasing an equipment should not disturb the existing traffic. Size to consider is ranging from 1 to 64 × 2048 kbit/s aggregates.

1.5 Modularity

The modularity of the equipment relating to both tributaries and aggregates should permit for the various sizes of the equipment to increase the total traffic treated by the multiplexer with minimum blocking effect on the expansion of that traffic. For the aggregate side the modularity should preferably be based on 1 × 2048 kbit/s.

1.6 Timing signal

It should be possible to derive the multiplexer timing signal from any of the following:

a) one of a number of external timing source(s) at 2048 kHz;

b) one of a number of 2048 kbit/s signal(s);

c) an internal oscillator with an accuracy of frequency of a range of ± 1 ppm to ± 50 ppm depending on application.

NOTES

1 In case b) a 2048 kbit/s signal could be a tributary signal.

2 The internal oscillator should not be used as a primary timing source when the flexible multiplexer is connected to the synchronous network.

3 The provision of the timing signal to an output of synchronization interface for the purpose of synchronising an other equipment or to control the internal timing signal is an option depending on national requirements.

On failure condition on the active synchronisation signal, it shall be possible to program a fall-back strategy up to three steps (see 9.4.1.3).

Complementary information is given in 14 corresponding to the management aspects of the equipment.

2 Functions

2.1 Mapping

The mapping function relates to the allocation of time-slot(s) of one 2048 kbit/s aggregate signal to any tributary signal. The mapping function is based on Recommendation G.704.

2.2 Signal processing

The signal processing covers functions such as analog to digital conversion, rate adaptation, handling of signalling information and control signals.

2.3 Concentration

For further study.

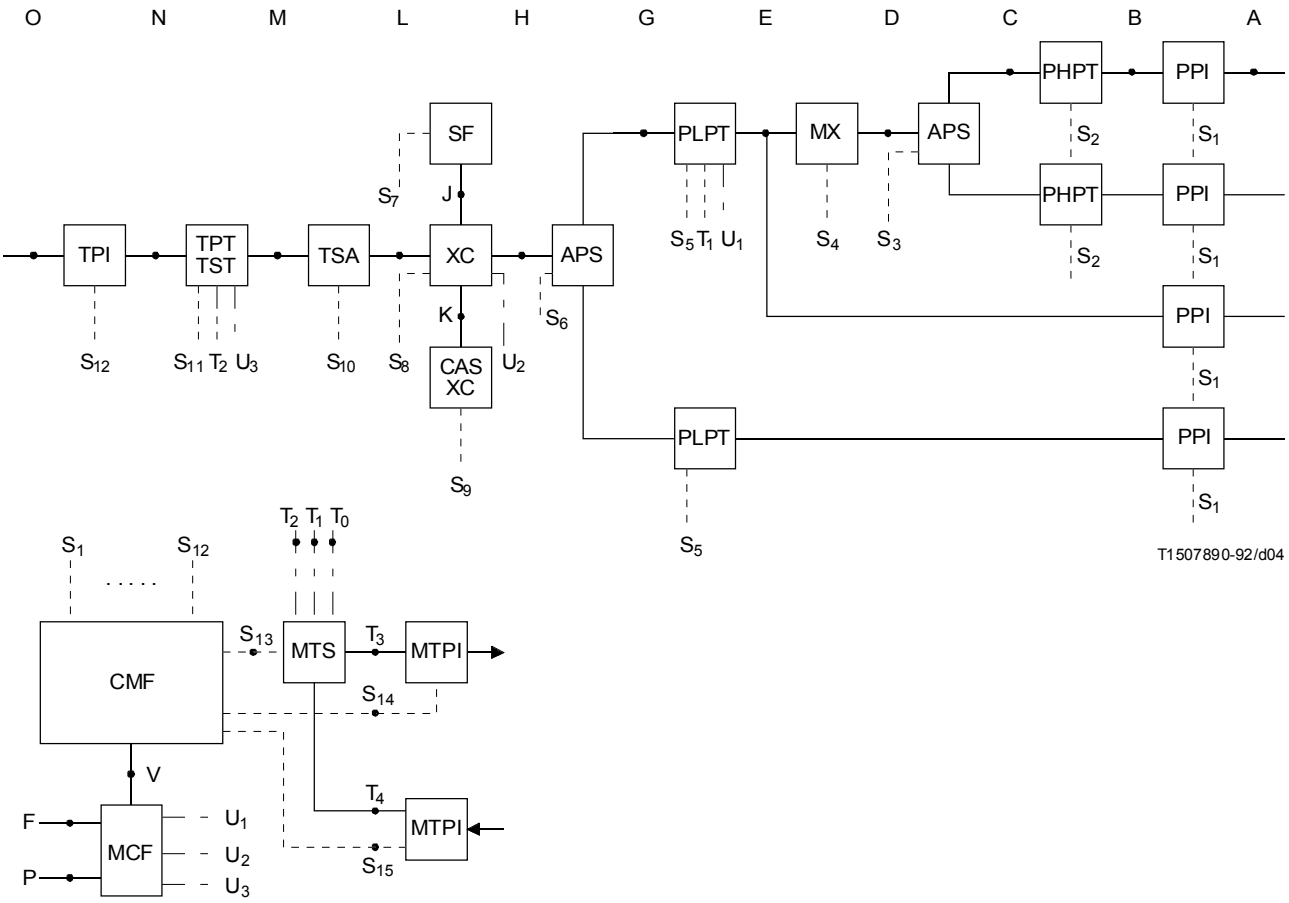
2.4 Management

The management includes control functions and provision of maintenance information. The management functions of the flexible multiplexer are presented in 14.

3 Functional representation of the equipment and definition of reference points

3.1 Functional representation

Figure 4 describes the functional representation of the flexible multiplexer and locates appropriate reference points.



NOTES

1 T_0 is distributed to all functional blocks.

2 All functional blocks are not always necessary.

3 Not all necessary self understanding functions, e.g. internal code conversion or line protection, are described in Figure 4.

4 Any reference point X can be divided in two reference points, X1 and X2. X1 and X2 relate respectively to the O to A and A to O directions.

FIGURE 4/G.797

General functional block diagram

3.2 Definition of functional blocks

plesiochronous physical interface (PPI): The plesiochronous physical interface concerns the aggregate interface, terminating the related transmission system. When appropriate, it also extracts clock signal from the received signal.

tributary physical interface (TPI): The tributary physical interface concerns a variety of service related interfaces terminating the corresponding circuits. When appropriate, it also extracts clock signal from the received signals and operates on any control/signalling signals.

plesiochronous higher order path termination (PHPT): The plesiochronous higher order path termination terminates high order logical signals of aggregate interface at 8448, 34 368, 139 264 kbit/s. Related functions concern frame generation and recovery and detection of defect or failure condition on higher order logical signal.

plesiochronous higher order multiplexer (MX): Digital multiplexing function according to Recommendations G.742 and G.751.

plesiochronous lower order path termination (PLPT): The plesiochronous lower order path termination terminates 2048 kbit/s logical signals at the aggregate side of the equipment. Related functions concern frame generation and recovery and detection of defect or failure condition on 2048 kbit/s logical signal.

cross connect function (XC): The cross connect function allows the mapping of 64 kbit/s or n × 64 kbit/s signals from tributary side to related 2048 G.704 logical frame signal.

tributary signal adaptation (TSA): The tributary signal adaptation modifies tributary signal when necessary to be able to handle it in a G.704 type frame format.

tributary path termination/tributary signal termination (TPT/TST): This function is similar to PLPT function when the tributary interface is related to an application of 2048 kbit/s G.704 frame. For other interfaces, it generates or terminates information and any signalling or control signal.

multiplexer timing physical interface (MTPI): The multiplexer timing physical interface terminates (or generates) electrically the external synchronization signal.

multiplexer timing source (MTS): The multiplexer timing source provides all internal timing signals necessary for the flexible multiplexer.

equipment management function (EMF): The equipment management function gives the possibility to the local user or to the TMN to perform all the management functions of the equipment. It is connected to every functional block of the flexible multiplexer.

message communication function (MCF): This functional block is able to terminate and generate the embedded operation channel(s) (EOC) which may be transported on a Sa-bit or on several Sa-bits of TS0 either on aggregate side or on tributary side of the flexible multiplexer. Alternatively, the EOC may be transported on a 64 kbit/s TS at the aggregate side. This functional block is able to interwork with the local user via the F or P interfaces.

special function (SF): The special functions could be point to multipoint mode of operation, PCM to ADPCM transcoding, conference bridging, broadcasting, etc.

channel associated signalling cross connect (CAS XC): This realizes the cross connection of abcd bits of TS16, when used, in relation with correspondent 64 kbit/s TS.

automatic protection switch (APS): This optional function is used when 1 + 1 protection switch is required for the digital path. The switchover function may be done under the control of CMF or automatically.

3.3 Definition of reference points

A	Line signal according to Recommendation G.703
B	High order logical signal
C, D	High order logical framed signal
E	Multiservice 2048 kbit/s logical signal
E'	Monoservice 2048 kbit/s logical signal
G, H	2048 kbit/s G.704 logical framed signal

J	Access to optional special functions
K	Access to optional CAS cross connection
L	G.704 formatted 64 or n × 64 kbit/s signal
M	Logical and/or electrical signal to be transmitted including any control or signalling
N	Logical and/or electrical signal to be transmitted including any control or signalling
O	Tributary line signal according to relevant CCITT Recommendation
V	Information serving for external management
S_i	Management points
T_0	Internal timing signal
T_1	Synchronization signal derived from a 2048 kbit/s aggregate signal
T_2	Synchronization signal derived from a 2048 kbit/s tributary signal
T_3, T_4	2048 kHz external synchronization signal
U_1, U_3	4 kbit/s EOC
U2	64 kbit/s EOC
F	User interface according to Recommendation M.3010
P	User interface for local operation (not to be standardized)

4 Tributary interfaces

4.1 Analog interfaces

4.1.1 Voice band interfaces

4.1.1.1 2-wire/4-wire (with optional in-band signalling or DC signalling)

4.1.1.1.1 Physical aspects at O reference point

Access for analog signals is a 2-wire or a 4-wire line with a nominal impedance according to 5.1/G.712. For the optional DC signalling access, the physical characteristics are according to national requirements.

4.1.1.1.2 Configurable parameters

The equipment shall be designed to allow configuration of following parameters either by adjustment of hardware or preferably by the mean of the management of the equipment:

- 2-wire or 4-wire configuration;
- in-band or out-of-band signalling (DC signalling);
- selection of particular signalling protocol. The set of authorised protocols is a national requirement;
- level adaptation of signals at M1 and O2 reference points;
- selection of particular signalling status at O2 reference point in case of defect or failure condition affecting the voice channel when DC signalling is used.

4.1.1.1.3 Coding law

The analogue signal at the O1 reference point shall be encoded in accordance to A-law according to Recommendation G.711. Complementary decoding system shall be provided to restitute analogue signal at O2 reference point.

4.1.1.1.4 Performance

The overall end-to-end performance of the voice channel shall be in accordance with Recommendation G.712.

Considering individual interface, the transmit and receive parts of voice channel shall comply with Recommendation G.712.

Table 1 gives characteristics of input and output ports of analogue interfaces in accordance with Recommendation G.712.

TABLE 1/G.797

Characteristics of input and output analogue interfaces

Characteristic (Note 1)	4-wire G.712	2-wire G.712	PSTN Q.552
Relative levels at input and output	2.1	2.2	2.2.4
Short-term and long-term stability	4	4	3.1.1.3
Nominal impedance and Return loss	5	5	2.2.1
Impedance unbalance about earth	6	6	2.2.2
Attenuation/frequency distorsion	7	7	3.1.1.5
Group delay (Note 2)	8	8	3.1.2
Idle channel noise	9	9	3.3.2
Discrimination against out-of-band input signals	10.1, 10.3	10.1, 10.2	3.1.6
Spurious out-of-band signals at the channel output	11.1	11.1	3.1.7
Spurious in-band signals at the channel output port	11.2	11.2	
Total distorsion	12	12	3.3.3
Variation of gain with input level	13	13	3.1.1.4
Crosstalk	14	14	3.1.4
Interference from signalling	15.1, 15.3	15.2, 15.4	
Echo and stability		16	3.1.8

NOTES

1 Characteristics and references in this table are related to (sub)clauses of Recommendations G.712 and Q.552.

2 For further study.

4.1.1.1.5 Signalling aspects

The characteristics of signals and the performance of circuits related to DC signalling interface are national requirements.

4.1.1.1.6 Signals at L reference point

At the L1 reference point, encoded-octets derived from analogue signals shall use one 64 kbit/s octet of the associated G.704 type formatted signal. a, b, c, d signalling bits, when used, shall be present in the associated 500 bit/s channels corresponding to TS16 as specified in Recommendation G.704. Any unused a, b, c or d bit should be set respectively to 1, 1, 0 or 1.

4.1.1.1.7 Mapping characteristics at H reference point

The mapping characteristics of the equipment shall allow the selection of any free TS, and corresponding TS16 when necessary, of the signal at the H reference point for the transmission of signals derived from (or destinated to) the L reference point.

4.1.1.1.8 Test functions

Provision should be made to enable loopback either

- electrical, at the O (O2 connected to O1) or N (N2 connected to N1) reference points. The loopback at O reference point may be manual and includes both voice and signalling; or
- logical, at the L (L2 connected to L1) or M (M2 connected to M1) reference points. This loopback shall be controlled by the management of the equipment and includes both voice and signalling. When activated, no analogue signal shall be present at the O2 reference point and signalling shall be derived from idle pattern on abcd bits; or
- both.

The equipment shall provide under management control the connection of the external 2-wire or 4-wire circuit, and any additional signalling wires, at O reference point to a metallic test bus.

4.1.1.2 2-wire for PSTN

4.1.1.2.1 Physical aspects at O reference point

According to national requirements.

4.1.1.2.2 Configurable parameters

The equipment shall be designed to allow configuration of following parameters either by adjustment of hardware or preferably by the mean of the management of the equipment:

- level adaptation of signals at M1 and O2 reference points;
- selection of particular signalling status at O2 reference point in case of defect or failure condition affecting the voice channel.

4.1.1.2.3 Coding rules

The analogue signal at the O1 reference point shall be encoded in accordance to A-law according to Recommendation G.711. Complementary decoding system shall be provided to restitute analogue signal at O2 reference point.

The coding/decoding process for signalling including ringing and optional metering is according to national requirements.

4.1.1.2.4 Performance

Overall performance for the channel is according to interface Z of Recommendation Q.552. References to specific characteristics of input and output analogue ports are given in Table 1.

4.1.1.2.5 Signalling aspects

According to national requirements.

4.1.1.2.6 Signals at L reference point

At the L1 reference point, encoded-octets derived from analogue signals shall use one 64 kbit/s octet of the associated G.704 type formatted signal. a, b, c, d signalling bits shall be present in the associated 500 bit/s channels corresponding to TS16 as specified in Recommendation G.704. Any unused a, b, c or d bit should be set respectively to 1, 1, 0 or 1.

4.1.1.2.7 Mapping characteristics at H reference point

The mapping characteristics of the equipment shall allow the selection of any free TS, and corresponding TS16 when necessary, of the signal at the H reference point for the transmission of signals derived from (or destinated to) the L reference point.

4.1.1.2.8 Test functions

The equipment shall provide under management control the connection of the external 2-wire circuit, and any additional signalling wires, at O reference point to a metallic test bus.

4.1.1.3 2-wire/4-wire with low bit rate coding (option)

For further study.

4.1.2 Wide band interface

4.1.2.1 Wide band (7 kHz)

4.1.2.1.1 Physical aspects at O reference point

Access for analog wide band signals is a 4-wire interface with a nominal impedance of 600 ohms according to 2.1/G.722.

4.1.2.1.2 Configurable parameters

The equipment shall be designed to allow configuration of following parameters either by adjustment of hardware or preferably by the mean of the management of the equipment:

- level adaptation of signals at M1 and O2 reference points;
- impedance adaptation at O1 and O2 reference points;
- selection of the functional mode for the interface (48, 56 or 64 kbit/s coding bit rate).

4.1.2.1.3 Analog to digital conversion and coding law

The analogue signal presented at the O1 reference point shall be converted and encoded in accordance to 1.1/G.722, 1.4/G.722, 3/G.722, 5/G.722 and 6/G.722. Complementary decoding and converting system shall be provided to restitute analogue signal at O2 reference point. The decoding and converting system shall be according to 1.1/G.722, 1.5/G.722, 4/G.722, 5/G.722 and 6/G.722.

4.1.2.1.4 Performance

The overall performance of the channel, from end to end, shall be in accordance with 2.2/G.722, 2.4/G.722 and 2.5/G.722. Attention is drawn on Appendix 2/G.722 providing digital test sequences of the digital processing parts of the SB-ADPCM algorithm.

4.1.2.1.5 Signalling aspects

End to end signalling may be provided when the selected functional mode for the interface corresponds to 48 or 56 kbit/s coding bit rate. The mapping of signalling information and digital encoded signal shall be according to Recommendations G.725 and H.221.

4.1.2.1.6 Signals at L reference point

At the L1 reference point, encoded-octets derived from analogue signals shall use one 64 kbit/s of the associated G.704 formatted signal.

4.1.2.1.7 Mapping characteristics at H reference point

The mapping characteristics of the equipment shall allow the selection of any free TS of the signal at the H reference point for the transmission of signals derived from (or destinated to) the L reference point.

4.1.2.1.8 Test functions

Provision shall be made to enable loopbacks, either

- electrical, at the O (O2 connected to O1) or N (N2 connected to N1) reference points. The loopback at the O reference point may be manual; or
- logical at the L reference point. Logical loopback shall be controlled by the management of the equipment:
  - a first loopback with signals from L2 reference point transmitted to L1 reference point is provided. When activated, no analogue signal shall be present at the O2 reference point;
  - a second set of loopbacks according to Figure 9/G.722 is provided. When activated, continuous binary 1s are applied to related signals at H1 reference point.

The equipment shall provide under management control the connection of the external 4-wire circuit, and any additional signalling wires, at O reference point to a metallic test bus.

4.1.2.2 Sound programme (15 kHz)

4.1.2.2.1 Physical aspects at O reference point

Access for analog wide band signals is a 4-wire interface with a nominal impedance of 600 ohms.

4.1.2.2.2 Configurable parameters

The equipment shall be designed to allow configuration of following parameters either by adjustment of hardware or preferably by the mean of the management of the equipment:

- level adaptation of signals at M1 and O2 reference points;
- impedance adaptation at O1 and O2 reference points.

4.1.2.2.3 Coding law

The analogue signal at the M1 reference point shall be encoded in accordance to 3/J.41 and one of the 4/J.41 (Instantaneous companding) or 5/J.41 (Near instantaneous companding). Complementary decoding system shall be provided to restitute analogue signal at the M2 reference point.

NOTE – Other coding methods may be required according to Recommendations J.42, J.43, J.44 and CCIR Recommendations 724 and 718.

4.1.2.2.4 Performance

The transmission performance per encoder/decoder pair shall be according to 2/J.41.

NOTE – Reference should be made to appropriate part of Recommendations J.42, J.43, J.44 and CCIR Recommendations 724 and 718 when another coding method is required.

4.1.2.2.5 Signalling aspects

For further study.

4.1.2.2.6 Signals at L reference point

At the L reference point, encoded signals shall use 6×64 kbit/s octets of the associated G.704 formatted signal. The 6 selected octets shall be within one single frame time scale.

NOTE – When other coding methods according to Recommendations J.42, J.43, J.44 and CCIR Recommendations 724 and 718 are required, encoded signals shall respectively use from 5×64 kbit/s octets to 30×64 kbit/s octets.

4.1.2.2.7 Mapping characteristics at H reference point

The mapping characteristics of the equipment shall allow the selection of any set of 6 free TS of the signal at the H reference point for the transmission of signals derived from (or destinated to) the L reference point and in particular those according to Recommendation G.735. The mapping function shall guarantee time slot integrity within each frame between L and H reference points.

NOTE – When signals are encoded in accordance with Recommendations J.42, J.43, J.44 and CCIR Recommendations 724 and 718, the equipment shall allow the selection of any set of free TS in appropriate number.

4.1.2.2.8 Test functions

Provision shall be made to enable loopbacks; either

- electrical at the O or N reference points. The loopback at the O reference point may be manual; or
- logical at the L reference point. Logical loopbacks shall be controlled by the management of the equipment:

  a) a first loopback with signals from L2 reference point transmitted to L1 reference point is provided. When activated, no analogue signal shall be present at the O2 reference point;

  b) a second loopback with signals from L1 reference point transmitted to L2 reference point is provided. When activated, continuous binary 1s are applied to related signals at H1 reference point.

The equipment shall provide under management control the connection of the external 4-wire circuit, and any additional signalling wires, at O reference point to a metallic test bus.

4.2 Digital interfaces

4.2.1 DTE/DCE interfaces

4.2.1.1 V.24

V.24/V.28 interface shall be provided when a DTE or a DCE is connected to the equipment with a bit rate not greater than 20 kbit/s.

V.24/V.11 (V.10) interface shall be provided when a DTE or a DCE is connected to the equipment with a bit rate greater than 20 kbit/s.

4.2.1.1.1 Physical aspects at O reference point for V.24/V.28 interface

The connector to be used is a 25-pole connector according to ISO 2110. The minimum set of the circuits defined in Recommendation V.24 and to be handled at the interface is the following:

- 102, 103, 104, 105, 106, 107, 108, 109, 114, 115, 140, 141, 142.

Electrical characteristics of circuits and signals are according to Recommendation V.28.

4.2.1.1.2 Physical aspects at O reference point for V.24/V.11 (V.10) interface

The connector to be used is a 37-pole connector according to ISO 4902. The minimum set of the circuits defined in Recommendation V.24 and to be handled at the interface is the following:

- 102 (and 102a, 102b if required), 103, 104, 105, 106, 107, 109, 114, 115, 140, 141, 142.

Electrical characteristics of circuits and signals related to data or timing circuits are according to Recommendation V.11.

Electrical characteristics of circuits and signals related to control circuits may be according to Recommendations V.11 or V.10.

NOTE – Alternatively, it should be possible to use a 25-pole connector according to the revised version of ISO 2110.

4.2.1.1.3 Configurable parameters

The equipment shall be designed to allow configuration of following parameters either by adjustment of hardware or preferably, by the mean of the management of the equipment:

- DCE or DTE mode;
- selection of circuits in operation at the O reference point, care should be exercised to prevent V.28 receivers which are no longer connected to generators from being falsely triggered by crosstalk on the interchange cable;
- selection of additional functions/circuits in the V.28 interface (113, 133, 125, 111, 112);
- selection of additional functions/circuits in the V.11 (V.10) interface (108, 113, 125, 111, 112);
- application of permanent ON or OFF condition on any circuit;
- synchronous or asynchronous mode of operation;

– selection of bit rate, the recommended bit rates are: 2.4, 4.8, 9.6, 19.2, 48, 56, 64, n × 64 kbit/s ($2 \leq n \leq 30$ or 31);

– selection of the bit rate adaptation method;

– selection of an address for the interface for point-to-multipoint configuration for maintenance purposes;

– selection of any control signals to be transmitted from end-to-end;

– selection of data pattern and control signals to be applied at the O reference point in case of defect or failure condition affecting the data channel.

4.2.1.1.4 Signal processing

The signal processing includes bit rate adaptation to 64 kbit/s for sub-64 kbit/s data signal, any asynchronous to synchronous conversion, control signals adaptation.

The bit rate adaptation should be according to Recommendation V.110 and/or V.120.

Other bit rate adaptations are left for further study.

4.2.1.1.5 Control signals

The function of control signals, the dependance of any control signal with other control or timing signal shall be according to Recommendation V.24.

4.2.1.1.6 Signal at L reference point

Processed signals are present at the L reference point as a 64 kbit/s or n × 64 kbit/s G.704 type formatted signal. abcd signalling bits, when used for exchange of control signals, shall be present in the associated 500 bit/s channels corresponding to TS16 as specified in Recommendation G.704.

Any unused a, b, c, d bits should be set to 1, 1, 0, 1 respectively.

4.2.1.1.7 Mapping characteristics at H reference point

The mapping characteristics of the equipment shall allow the selection of any free TS, and corresponding TS16 when necessary, of the signal at the H reference point for the transmission of signals derived from (or destinated to) the L reference point. The mapping function of the equipment shall guarantee octet sequence integrity for n × 64 kbit/s signals.

4.2.1.1.8 Test functions

The interface shall provide a local loopback 3 (e.g. at L reference point) according to Recommendation V.54. It shall be possible to control a local or a remote loopback 2 (e.g. at N reference point) according to Recommendation V.54 by the mean of the management of the equipment or by using end-to-end out-band signalling when the service network provides this function.

When any loopback is activated, signals at O2 reference point shall be provided according to Recommendation V.54.

When loopback 3 is activated, continuous binary 1s shall be applied both for related data and signalling bits at H1 reference point.

4.2.1.2 X.24 interface

This interface shall be provided when a DTE is connected to the equipment with a bit rate not greater than 1984 kbit/s. Four options in the application of the interface are available:

i) *Data transfer*

In this application, the X.24 interface is used without any protocol. Only the essential circuits G, T, R, S shall be in operation to permit the bidirectional data transfer.

ii) *Data and signalling transfer*

In this application, the X.24 interface is used without any protocol. It is assumed that the service network is able to carry end-to-end out-band signalling. The signalling information relates to signals on C and I circuits at the O reference point. The circuits G, T, R, S, C, I and optionally B shall be in operation.

iii) *X.21 leased circuit service*

In this application, the X.24 interface is used to provide access to the service defined in 5.2/X.21 and in Figure A.3/X.21, leased circuit service.

iv) *X.21 switched circuit*

In this application, the X.24 interface is used to provide a remote access via the flexible access system to a X.21 service network. It is understood that the flexible multiplexer shall not act as a circuit switching exchange.

4.2.1.2.1 Physical aspects at O reference point

The connector to be used is according to ISO 4903. The minimum set of the circuits defined in Recommendation X.24 and to be handled at the interface is the following:

– G (or Ga, Gb), T, R, C, I, S, B.

Electrical characteristics of circuits and signals are according to Recommendation X.27 (or Recommendation V.11) for bit rate greater than 9.6 kbit/s or X.26 (or Recommendation V.10) for bit rate not greater than 9.6 kbit/s.

Circuits required for options iii) and iv) are G (or Ga, Gb), T, R, S, C, I, B.

4.2.1.2.2 Configurable parameters

The equipment shall be designed to allow configuration of following parameters either by adjustment of hardware or preferably, by the mean of the management of the equipment:

– selection of circuits in operation at the O reference point;

– selection of additional functions/circuits in the interface (X, F);

– selection of one of the four basic applications of the interface;

– application of permanent ON or OFF condition on any control circuit;

– selection of particular condition to present at O2 reference point in case of test condition or defect or failure condition affecting the channel;

– selection of bit rate. Recommended bit rates are n × 64 kbit/s;

– when using CAS, the use of one or n signalling channels as indicated in 4.2.1.2.6.

4.2.1.2.3 Signal processing

The signal processing may be required if the application of the interface is related to bit rate below 64 kbit/s (refer to 4.2.1.1.4).

For application ii) the transfer from end-to-end of C on I may be done by the use, in addition of the n × TS, of the a-bit of associated TS16.

For applications iii) and iv) the interface shall be able to process the protocol required in the switched or leased circuit services of Recommendation X.21. For application iv), it is limited to the functions presented in 4.2.1.2.

4.2.1.2.4 Performance

The tolerance for the transition shift between data and control signals due to the transmission into the core network for application ii) should take into account the differential transfer delay within cross connect equipment. For a single cross connect equipment the transfer delay for a 64 or n × 64 kbit/s signal is not greater than 600 µs while it is not greater than 7 ms for the corresponding signalling as specified in Recommendation G.796.

4.2.1.2.5 Control signal

The function of control signal is end-to-end signalling in option ii) and according to Recommendation X.21 in option iii) and iv).

4.2.1.2.6 Signal at L reference point

Signals are present at the L reference point as 64 or n × 64 kbit/s G.704 type formatted signal. The a signalling bit, when used for exchange of control signal, shall be present in the associated 500 bit/s channel corresponding to TS16 as specified in Recommendation G.704 and b, c, d bits are set to 1, 0, 1 respectively. The use of only the first of the n associated a-bits for n × 64 kbit/s channels may be selected when configuring the equipment.

4.2.1.2.7 Mapping characteristics at H reference point

The mapping characteristics of the equipment shall allow the selection of any free TS, and corresponding TS16 when necessary, of the signal at the H reference point for the transmission of signals derived from (or destinated to) the L reference point.

4.2.1.2.8 Test functions

The interface shall provide a local loopback 3b (e.g. at L reference point) according to Recommendation X.150. Loopback 3b should be controlled by the management of the equipment. It shall be possible to control a local or remote loopback 2b (e.g. at the N reference point) according to Recommendation X.150 by the mean of the management of the equipment or by using end-to-end signalling in options ii), iii) and iv).

When any loopback is activated in option iii) and iv), the equipment shall provide signals at O2 reference point according to Recommendation X.21.

When loopback 3b is activated in option i) and ii), continuous binary 1s shall be applied to related data and any control signals at H1 reference point. In option ii), the loopback relates to both data and control signals.

When loopback 2b is activated, the signals presented at O2 reference point are

- transporting continuous binary 1s on R circuit in option i);
- transporting continuous binary 1s or 0s, as preselected, on R circuit and providing permanent ON or OFF condition, as preselected, on I circuit in option ii).

When activating the loopback 2b, the equipment continues to provide the timing signal(s) at the O2 reference point for all options.

4.2.2 G.703 64 kbit/s codirectional

4.2.2.1 Physical aspects at O reference point

The electrical characteristics of the interface at the O reference point shall be according to 1.2.1/G.703.

4.2.2.2 Configurable parameter

The equipment shall be designed to allow configuration of following parameter either by adjustment of hardware or preferably, by the mean of the management of the equipment:

- use of octet timing at O1 reference point.

4.2.2.3 Signal processing

The signal present at the O1 reference point is converted to the internal code used by the equipment. The internal code is converted according to 1.2.1.3/G.703 and presented at the O2 reference point.

Additional functions are

- 64 kHz timing signal recovery from signal at O1 reference point;
- 8 kHz timing signal recovery from signal at O1 reference point in case where octet timing is required;
- octet slips control at N1 reference point.

4.2.2.4 Signal at L reference point

Signals are present at the L reference point as 64 kbit/s G.704 formatted signal. When octet timing is used, bit 8 of the codirectional signal shall be bit 8 of the corresponding octet at the L reference point.

4.2.2.5 Mapping characteristics at H reference point

The mapping characteristics of the equipment shall allow the selection of any free TS of the signal at the H reference point for the transmission of signals derived from (or destinated to) the L reference point.

4.2.2.6 Test functions

The interface shall provide the following test facilities:

- Loopback at the O reference point. Signal from O2 reference point is transmitted to O1 reference point and line is terminated on its nominal impedance. This loopback may be manual.
- Logical loopbacks equivalent to loopbacks 3b (e.g. at L reference point) and 2b (e.g. at the N reference point) as defined in Recommendation X.150,
  - when loopback 3b is activated, continuous binary 1s shall be applied to corresponding TS at the H1 reference point;
  - when loopback 2b is activated, the content of signal at the O2 reference point shall be continuous binary 1s.

4.2.3 Integrated base band line termination

For further study.

4.2.4 Tributaries supported in a G.704 frame

4.2.4.1 2048 kbit/s signals

4.2.4.1.1 Electrical characteristics at O reference point

According to 6/G.703. The 75 ohms coaxial pair option or the 120 ohms symmetrical pair option should be provided as required by the Administration.

4.2.4.1.2 Configurable parameters

The equipment shall be designed to allow configuration of following parameters either by adjustment of hardware or preferably, by the mean of the management of the equipment:

- use of CRC4 procedure;
- use of a particular Sa-bit for a 4 kbit/s data link to support the EOC related to U2 reference point;
- use of TS16 for channel associated signalling;
- use of TS16 for common channel signalling;
- use of a particular TS as support of the EOC related to U2 reference point;
- use of particular Sa-bit for additional far end defect or failure information;
- use of particular TS allocation (e.g. according to G.735, 5/G.704);
- selection of TS passed through the equipment.

Complementary information is given in 14 specifying management aspects of the equipment.

4.2.4.1.3 Signal processing

Signal at O1 reference point shall be regenerated and the timing signal recovered. Signal generated at O2 reference point is according to A.1/G.703. No additional signal processing is required. A frame slips control at M1 reference point is performed by the TPT functional block.

4.2.4.1.4 Mapping characteristics at H reference point

The mapping characteristics of the equipment shall allow the selection of any free TS of the signal at the H reference point for the transmission of 64 or n × 64 kbit/s signals derived from (or destinated to the) L reference point. When common channel signalling is used at the tributary side, it shall be transferred to any free TS at the H reference point. When channel associated signalling is used at the tributary side, abcd bits shall be transferred to TS16 at H reference point in accordance to the related 64 kbit/s TS allocation. Continuous binary 1s shall be applied at L2 reference point for 64 kbit/s octets and any associated signalling bits which are not passing through the equipment.

4.2.4.1.5 Test functions

The interface shall provide the following test facilities:

- Loopback at the O reference point. Signal at O2 reference point is transmitted to O1 reference point and line is terminated on its nominal impedance. This loopback may be manual.
- Logical loopbacks equivalent to loopbacks 3b (e.g. at L reference point) and 2b (e.g. at N reference point) as defined in Recommendation X.150 for the whole 2048 kbit/s signal. These loopbacks should be controlled by the management of the equipment.

When loopback 3b is activated, continuous binary 1s shall be applied to corresponding TS and any associated signalling bits at the H1 reference point.

When loopback 2b is activated, the content of signal at the O2 reference point is AIS.

4.2.5 Basic ISDN user-network interface

This function allows the provision of the basic ISDN user-network interface for users which may be remotely located from the flexible multiplex equipment or for local users. In the first case, the provision of the S/T interface implies the use of an access digital transmission system while, for local users, the equipment provides the S/T interface at the tributary side.

4.2.5.1 Access digital transmission termination

That function terminates the access digital transmission system and is integrated into the flexible multiplexer.

4.2.5.1.1 Physical aspects at O reference point

Refer to Recommendation G.961. The selection of one of the options is depending on national requirements.

4.2.5.1.2 Configurable parameters

For further study.

4.2.5.1.3 Signal processing

Signal processing is required to transfer the 2B + D-channel signals as a number of 64 kbit/s signals. The equipment will not process any of the D-channel information, and pass it as a simple 64 or sub-64 kbit/s signal. Nevertheless the access digital transmission termination performs the necessary function related to the frame recovery and delivers the constituent channel signals.

4.2.5.1.4 Performance

Refer to Recommendations G.960 and G.961.

4.2.5.1.5 Control signals

For further study.

4.2.5.1.6 Signal at L reference point

Signals are present at the L reference point as 64 or n × 64 kbit/s G.704 type formatted signal. The recommended process for the presentation of signal at L reference point is the format complying to 3.5/Q.512. A single basic access signal occupies 3 × TS: one TS is associated to the B1-channel, a second TS is associated to the B2-channel, bit l and bit 2 of the third TS are associated to the D-channel, bit 3 and bit 4 of the third TS are associated to control signals of the basic access and bit 5 to bit 8 of the third TS are set to 1.

Alternatively, it could be possible to make use of TS16. a, b, c, d bits, when used for exchange of control signals shall be present in the associated 500 bit/s channels corresponding to TS16 as specified in Recommendation G.704. Any unused a, b, c, d bits should be set to 1, 1, 0, 1 respectively.

4.2.5.1.7 Mapping characteristics at H reference point

When considering the generation of a monoservice 2048 kbit/s G.704 frame, the mapping characteristics of the equipment shall comply with 3.5/Q.512.

When considering the generation of a multiservice 2048 kbit/s G.704 frame, the mapping characteristics of the equipment shall allow the selection of any set of 3 × free TS for the transport of one basic access signal (or any set of 5 × free TS in case of two basic access signals). The recommended format for the mapping function is derived from 3.5/Q.512.

NOTES

1 The mapping function of the he equipment shall guarantee octet sequence integrity within the same frame for the n × 64 kbit/s signal present at the L reference point.

2 While the specification of sub-64 kbit/s multiplexing function is for further study, this shall provide up to 4:1 sub-rate multiplexing for the D-channel signals via the J reference point when the alternative use of TS16 as described in 4.2.5.1.6 is required. The mapping characteristics of the equipment shall allow the selection of any free 1/4 TS of signals derived from (or destinated to) the L reference point.

4.2.5.1.8 Test functions

Refer to Recommendation I.603.

4.2.5.2 S/T interface

This function is provided for local users.

4.2.5.2.1 Physical aspects at O reference point

The details for the physical characteristics of S/T interface are given in Recommendation I.430.

4.2.5.2.2 Configurable parameters

Not applicable.

4.2.5.2.3 Signal processing

Signal processing is required for the transfer of the 2B + D-channel signals as a number of 64 kbit/s signal. For the S/T interface, the equipment will not process any of the D-channel information and pass it as a simple 64 or sub-64 kbit/s signal. Nevertheless, the S/T interface performs the necessary recovery of constituent channels.

4.2.5.2.4 Performance

Refer to Recommendation I.430.

4.2.5.2.5 Control signals

For further study.

4.2.5.2.6 Signal at L reference point

Refer to 4.2.5.1.6.

4.2.5.2.7 Mapping characteristics at H reference point

Refer to 4.2.5.1.7.

4.2.5.2.8 Test functions

Refer to I.430.

5 Aggregate interfaces

5.1 2048 kbit/s interface

5.1.1 Electrical characteristics at A reference point

According to 6/G.703.

5.1.2 Configurable parameters

The equipment shall be designed to allow configuration of following parameters either by adjustment of hardware or preferably, by the mean of the management of the equipment:

- use of CRC4 procedure;
- use of a particular Sa-bit for a 4 kbit/s data link to support the EOC related to U2 reference point;
- use of TS16 for channel associated signalling;
- use of TS16 for common channel signalling;
- use of a particular TS as support of the EOC related to U2 reference point;
- use of particular Sa-bit for additional far end defect or failure information;
- use of particular TS allocation (e.g. according to G.735 and 5/G.704);
- selection of TS passed through the equipment.

Complementary information is given in 14 specifying management aspects of the equipment.

5.1.3 Framing at E/E′ reference point

5.1.3.1 Monoservice 2048 kbit/s signal (E′ reference point)

Refer to 2.3/G.704 and 5/G.704 for basic frame structure and for characteristics of frame structure carrying channels at various bit rates in 2048 kbit/s. Bit 1 of the frame should be used in accordance with 2.2.3/G.704, i.e. for a CRC check bit procedure.

Refer to 2.2.3/G.735 for TS order of 384 kbit/s sound programme signals contained in a 2048 kbit/s frame.

Depending on the application, some 2048 kbit/s aggregate frames at E′ reference point could contain channel associated signalling (CAS) or common channel signalling (CCS).

5.1.3.2 Multiservice 2048 kbit/s signal (E reference point)

The frame structure is based on Recommendation G.704. Reference should be made to 2.3/G.704 for basic frame structure. Bit 1 of the frame should be used in accordance with 2.2.3/G.704, i.e. for a CRC check bit procedure.

Depending on the application, some 2048 kbit/s aggregate frames at E reference point could contain channel associated signalling or common channel signalling.

An encoded analogue channel or a 64 kbit/s data channel may use any free TS in a 2048 kbit/s frame (see Note).

A n × 64 kbit/s data channel or an encoded sound programme/wide band channel may use any set of n free TS in a 2048 kbit/s frame (see Note).

For ISDN basic access the mapping function of the equipment may provide either 3 free TS or 5 free TS for the transport of 2 ISDN basic access in a 2048 kbit/s frame as described in 4.2.5.1.7 and 4.2.5.2.7 (see Note).

NOTE – These various signals may coexist on a single 2048 kbit/s frame.

5.1.4 Test functions

The recommended process for the monitoring of digital paths uses service performance monitoring. Nevertheless, it could be required to provide logical loopbacks at the aggregate side (e.g. C2 connected to C1 or G2 connected to Gl) according to national requirements.

If provided, this loopback shall be under control of the management of the equipment. When activated, continuous binary 1s shall be applied either to corresponding TS and any associated signalling bits at the L2 reference point and in consequence at the U1 and U2 reference points.

Attention is drawn to the control of this loopback which shall not be derived from the U1 or U2 reference point as the recommended loopback is not transparent and breaks the communication channel between the MCF and the OS.

5.2 8448 kbit/s interface

5.2.1 Electrical characteristics at A reference point

According to 7/G.703.

5.2.2 Framing at B reference point

The frame structure is according to 3/G.742 and 5/G.742.

5.2.3 Test functions

The recommended process for the monitoring of digital paths uses service performance monitoring. Nevertheless, it could be required to provide logical loopbacks at the aggregate side (e.g. C2 connected to C1 or B2 connected to B1) according to national requirements.

If provided, this loopback shall be under the control of the management of the equipment. When activated, continuous binary 1s shall be applied to the constituent low order digital signal at E2 reference point.

Attention is drawn to the control of this loopback which shall not be derived from the U1 or U2 reference point as the recommended loopback is not transparent and breaks the communication channel between the MCF and the OS.

5.3 34 368 kbit/s interface

5.3.1 Electrical characteristics at A reference point

According to 8/G.703.

5.3.2 Framing at B reference point

The frame structure is according to 1.4.2/G.751 and 1.4.4/G.751.

5.3.3 Test functions

Refer to 5.2.3.

5.4 139 264 kbit/s interface

5.4.1 Electrical characteristics at A reference point

According to 9/G.703.

5.4.2 Framing at B reference point

The frame structure is according to 1.5.2/G.751 and 1.5.4/G.751.

5.4.3 Test functions

Refer to 5.2.3.

6 Synchronisation interface at 2048 kHz

The physical/electrical characteristics of the synchronization interface at 2048 kHz shall be according to 10/G.703.

7 Local operator interfaces

The equipment should provide access to the management functions to the local operator via at least the two following interfaces:

- the F-interface according to Recommendation M.3010 allowing access to the operations system;
- the P-interface giving access to essential control and maintenance functions in case where the F-interface is not provided or no more available. This interface is not subject of any standardization and should be according to national requirements.

Complementary information is given in 14 corresponding to the management aspects of the equipment.

8 Power interfaces

It should be possible to power the equipment either from the DC current used in the telecommunication centre or from the mains when the flexible multiplexer is remotely located. In that case a stand-by battery should be provided.

9 Defect or failure conditions and consequent actions for the tributary interfaces

9.1 Defect or failure conditions

9.1.1 O reference point

9.1.1.1 Analog tributary interfaces

For analog tributary interfaces according to 4.1.1.1, 4.1.1.3 and 4.1.2, there is no requirement for the detection of any defect or failure condition.

For analog tributary interface according to 4.1.1.2, the defect or failure conditions to be detected by the equipment are according to national requirements.

9.1.1.2 Data interfaces

The equipment should be able to detect the loss of power condition for the DTE (or for the DCE when the tributary interface is configured as a DTE) and the loss of connection between the DTE and the DCE. This includes (where applicable) interchange circuits 105, 107 and 108. These circuits shall assume an OFF condition (type 1 in accordance with the classification given in 7/V.28, 11/V.10 and 9/V.11*)*.

9.1.1.3 G.703 64 kbit/s codirectional

The equipment shall detect the following conditions.

9.1.1.3.1 Loss of signal at O1 reference point

A loss of signal (LOS) defect condition at the O1 reference point is determined by the absence of signal transitions of either positive or negative polarity over a period of 255 contiguous pulse positions, starting with the last receipt of a pulse.

A LOS condition is deemed to be terminated on the detection of an average pulse density of at least 12.5% over a period of 255 contiguous pulse positions starting with a receipt of a pulse.

9.1.1.3.2 Loss of signal at O2 reference point

The detection of this condition is optional. If required, the condition shall be detected in accordance to 9.1.1.3.1.

9.1.1.3.3 Loss of octet timing at O1 reference point

The detection of this condition is optional.

9.1.1.4 G.703 2048 kbit/s

The equipment shall detect the following conditions.

9.1.1.4.1 Loss of signal at O1 reference point

Refer to 9.1.1.3.1.

9.1.1.4.2 Loss of signal at O2 reference point

Refer to 9.1.1.3.2.

9.1.1.5 ISDN basic access

The defect or failure conditions to be detected by the equipment are according to national requirements.

9.1.2 N1 (or M1) reference point

9.1.2.1 Analogue tributary interfaces

There is no requirement for the detection of any defect or failure condition.

9.1.2.2 Data interfaces

Depending on particular implementation some defect or failure conditions may be detected but these are not subject to standardization.

9.1.2.3 G.703 64 kbit/s codirectional

The equipment shall detect the following condition:

– Reception of AIS. The detection of this condition is an option selectable when configuring the related interface.

9.1.2.4 G.704 2048 kbit/s

The equipment shall detect the following conditions.

9.1.2.4.1 Loss of frame alignment (LOF)

Refer to 4.1.1/G.706 and 4.1.2/G.706.

9.1.2.4.2 Error ratio 1×10^{-3}

The detection of this defect shall comply with 4.1.5/G.736.

The detection of this defect is optional. When required, it could be determined by counting either the number of errored frame alignment signals or the number of errored bits in frame alignment signals or by using the CRC4 procedure. Details are given in 14.

9.1.2.4.3 Reception of AIS

An AIS defect condition is determined when the incoming signal has two or less ZEROs in each of two consecutive diframe periods (512 bits per diframe).

The defect is cleared if each of two consecutive diframe periods contains three or more ZEROs or FAS has been found.

9.1.2.4.4 Defect indication from a remote equipment

This is detected on bit 3 TS0 NFAS.

9.1.2.4.5 Loss of multiframe alignment

This condition shall be detected only when CAS is required.

9.1.2.4.6 Reception of AIS in TS16

An AIS condition is determined when the incoming signal in TS16 has three or less ZEROs in each of two consecutive CAS multiframe periods.

The defect is cleared if each of two consecutive CAS multiframe periods contains four or more ZEROs or if the multiframe alignment has been found.

9.1.2.4.7 Reception of CRC4 errored block

This condition shall be detected when the CRC4 procedure is activated.

9.1.2.4.8 CRC4 errored block received at remote end

This condition shall be detected when the CRC4 procedure is activated.

9.1.2.4.9 Frame slip

9.1.2.5 Basic ISDN user-network interface

For further study.

9.2 Consequent actions

The consequent actions may be taken at N1 or M1 or L1 or N2 or O2 and appropriate S_i reference points.

Further to the detection of a defect or a failure condition, appropriate consequent actions should be taken as specified in 9.2.1 to 9.2.5. The consequent actions should be taken as soon as possible:

- the consequent actions at N1 or M1 (or L1) reference points should be taken within 2 ms of the detection of the relevant defect or failure condition respectively at the O1 or N1 reference points;
- the maximum period between the detection of a defect or failure condition at the O1 reference point and the transmission of any defect indication or application of any defect condition at the O2 reference point should be of the order of 100 ms;
- the maximum period between the detection of a defect or failure condition at the N1 reference point and the transmission of any defect indication at the N2 reference point should be of the order of 100 ms;
- the maximum period between the detection of a defect or failure condition at the O or N1 reference points and the generation of management information is defined in 14.

9.2.1 Analogue tributary interface

For analogue PSTN/2W interface according to 4.1.1.2, the consequent actions at N1 (or M1 or O2) reference points are according to national requirements.

9.2.2 Data interfaces

9.2.2.1 V.24

Consequent actions to detection of DTE (or DCE) loss of power or loss of DTE/DCE connection are application of all ONEs on data signal and OFF condition on control signals at M1 reference point.

9.2.2.2 X.24

Consequent actions to detection of DTE (or DCE) loss of power or loss of DTE/DCE connection are application of all ONEs on data signal [options i) and ii)] and OFF condition on control signals [option ii)] at M1 reference point. Consequent actions for options iii) and iv) are according to Recommendation X.21.

Options i) to iv) are those defined in 4.2.1.2.

9.2.3 G.703 64 kbit/s codirectional

Consequent actions should be taken as specified in Table 2.

TABLE 2/G.797

Defect or failure conditions and consequent actions for G.703 64 kbit/s interface

Defect or failure condition	Consequent actions		
	Defect information generated (Note 1)	Removal of octet timing	Application of AIS
Loss of signal O1 reference point	Yes	At O2 reference point (Note 3)	At M1 reference point
Loss of Octet Timing (Note 2) O1 reference point	Yes	N.A.	N.A.
Loss of signal O2 reference point	Yes	N.A.	N.A.
AIS received (Note 2) M1 reference point	Yes	N.A.	At L1 reference point

N.A. Not applicable.

NOTES

1 Consequent actions related to the generation of Defect information are specified in 14.
These actions could be taken at the level of the equipment (e.g. bell, lamp, etc.) and at the level of the management of the equipment.

2 The detection of this condition is optional.

3 This consequent action is optional.

9.2.4 G.704 2048 kbit/s

9.2.4.1 For LOS condition

Further to the detection of a LOS condition at the O1 reference point, the equipment shall apply an AIS at the N1 reference point.

9.2.4.2 For defect or failure conditions related to N1 reference point

Further to the detection of any defect or failure condition as defined in 9.1.2.4, the equipment should take consequent actions as specified in Table 3.

10 Defect or failure conditions and consequent actions for the aggregate

10.1 Defect or failure conditions

10.1.1 A reference point

The equipment shall detect the following condition.

10.1.1.1 Loss of signal at A1 reference point

The detection of this condition is optional. If required, the condition shall be detected in accordance with 10.1.1.2.

TABLE 3/G.797

Defect or failure conditions at N1 reference point and consequent actions at L1 or N2 reference points

Defect or failure condition at the Nl reference point	Consequent actions			
	Defect information generated (Note 1)	Defect indication to remote end at N2 reference point	AIS applied at L1 reference point	
			Data TS	TS16 bits
Loss of frame alignment	Yes	Yes, bit 3 TS0 NFAS	Yes	Yes
Error ratio 1×10^{-3} (Note 4)		Yes, bit 3 TS0 NFAS	Yes (Note 2)	Yes (Note 2)
Defect indication received from remote end in TS0		No	No	No
AIS received		Yes (Notes 3 and 5)	Yes	Yes
Loss of multiframe alignment		Yes, bit 6 TS16 fr0	No	Yes
Defect indication received from remote end bit 6 TS16 fr0		No	No	No
AIS received in TS16		Yes, bit 6 TS16 fr0	No	Yes

NOTES

1 Consequent actions related to the generation of defect information are specified in 14.

These actions could be taken at the level of the equipment (e.g. bell, lamp, etc.) and at the level of the management of the equipment.

2 Provision shall be made for disabling this action.

3 In order to enable appropriate actions at the remote end, the indication of reception of AIS may be transmitted in addition of any other defect indication to the remote end. The use of the 4 kbit/s data link on Sa4 in TS0 NFAS or the use of a free Sa bit of TS0 NFAS is suggested for this application.

4 The detection of this defect condition is optional.

5 This consequent action is optional.

10.1.1.2 Loss of signal at A2 reference point

A loss of signal (LOS) defect condition at the A2 reference point at 8448 kbit/s, 34 368 kbit/s or 139 264 kbit/s is determined by the absence of signal transitions of either positive or negative polarity over a period of 255 contiguous pulse positions, starting with the last receipt of a pulse.

A LOS condition is deemed to be terminated on the detection of an average pulse density of at least 12.5% over a period of 255 contiguous pulse positions starting with a receipt of a pulse.

10.1.2 B2 reference point

10.1.2.1 8448 kbit/s interface

The equipment shall detect the following conditions.

10.1.2.1.1 Reception of AIS

An AIS defect condition at the B2 reference point is determined when the incoming signal has four or less ZEROs in each of two consecutive frame periods (848 bits per frame).

The defect is cleared if each of two consecutive frame periods contains five or more ZEROs or FAS has been found.

10.1.2.1.2 Loss of frame alignment (LOF)

Refer to 4/G.742.

10.1.2.1.3 Defect indication from a remote equipment

This is detected on bit l1 in group I of 8448 kbit/s G.742 frame.

10.1.2.2 34 368 kbit/s interface

The equipment shall detect the following conditions.

10.1.2.2.1 Reception of AIS

An AIS defect condition at the B2 reference point is determined when the incoming signal has four or less ZEROs in each of two consecutive frame periods (l536 bits per frame).

The defect is cleared if each of two consecutive frame periods contains five or more ZEROs or FAS has been found.

10.1.2.2.2 Loss of frame alignment (LOF)

Refer to 1.4.3/G.751.

10.1.2.2.3 Defect indication from a remote equipment

This is detected on bit 11 in group I of 34 368 kbit/s G.751 frame.

10.1.2.3 139 264 kbit/s interface

The equipment shall detect the following conditions.

10.1.2.3.1 Reception of AIS

An AIS defect condition at the B2 reference point is determined when the incoming signal has five or less ZEROs in each of two consecutive frame periods (2928 bits per frame).

The defect is cleared if each of two consecutive frame periods contains six or more ZEROs or FAS has been found.

10.1.2.3.2 Loss of frame alignment (LOF)

Refer to 1.5.3/G.751.

10.1.2.3.3 Defect indication from a remote equipment

This is detected on bit l3 in group I of 139 264 kbit/s G.751 frame.

10.1.3 E2/E′2 reference point (G.704 2048 kbit/s)

The equipment shall detect the following conditions.

10.1.3.1 Loss of frame alignment

Refer to 4.1.1/G.706 and 4.1.2/G.706.

10.1.3.2 Error ratio 1×10^{-3}

The detection of this defect shall comply with 4.1.5/G.736.

The detection of this defect is optional. When required, it could be determined by counting either the number of errored frame alignment signals or the number of errored bits in frame alignment signals or by using the CRC4 procedure. Details are given in 14.

10.1.3.3 Reception of AIS

Refer to 9.1.2.4.3.

10.1.3.4 Defect indication from a remote equipment

Refer to 9.1.2.4.4.

10.1.3.5 Loss of multiframe alignment

This condition shall be detected only when CAS is required.

10.1.3.6 Reception of AIS in TS16

This condition shall be detected only when CAS or CCS is required.

Refer to 9.1.2.4.6.

10.1.3.7 Reception of CRC4 errored block

This condition shall be detected when the CRC4 procedure is activated.

10.1.3.8 CRC4 errored block received at remote end

This condition shall be detected when the CRC4 procedure is activated.

10.1.3.9 Frame slip

10.2 Consequent actions for defect or failure conditions related to the A reference point

The consequent actions may be taken at B2 and appropriate S_i reference points. The consequent actions should be taken as soon as possible.

Further to the detection of LOS condition at the A2 reference point, an AIS condition shall be applied at the B2 reference point within 2 ms of the detection of LOS condition for the 2048 kbit/s aggregate interface and within 1 ms of the detection of LOS condition for the 8448 kbit/s, 34 368 kbit/s and 139 264 kbit/s aggregate interfaces.

The maximum period between the detection of LOS condition at the A2 (and Al when required) reference point(s) and the generation of defect or failure information is dependent on the maintenance strategy for the equipment. It is covered in 14 specifying the management aspects of flexible multiplexer.

10.3 Consequent actions for defect or failure conditions related to the B2 reference point

Further to the detection of a defect or a failure condition, appropriate consequent actions shall be taken as specified in Table 4.

The consequent actions may be taken at D2 (or C2) or B1 and appropriate S_i reference points. The consequent actions should be taken as soon as possible:

- AIS at the D2 (or C2) reference point should be applied within 1 ms of reception of AIS condition or loss of frame alignment condition at the B2 reference point;
- the maximum period between the detection of loss of frame alignment condition at the B2 reference point and the transmission of a defect indication in signal at the B1 reference point should be of the order of 100 ms;
- the maximum period between the detection of a defect or a failure condition and the generation of defect or failure information is dependent on the maintenance strategy for the equipment. It is covered in 14 specifying the management aspects of flexible multiplexer.

10.4 Consequent actions for defect or failure conditions related to the E2/E2′ reference point

The consequent actions may be taken at H2 (or G2, or L2) or E1/E′1 and appropriate S_i reference points.

TABLE 4/G.797

Defect and failure conditions at the B2 reference point and consequent actions at the D2 or B1 reference points

Defect or failure condition at B2 reference point	Consequent actions		
	Defect information generated (Note)	Defect indication to remote end at B1 reference point	AIS applied
Loss of frame in 139 264 kbit/s signal	Yes	Yes bit 13, group I	Yes to 16 × constituent 8448 kbit/s at D2 reference point
AIS received in 139 264 kbit/s signal		No	Yes to 16 × constituent 8448 kbit/s at D2 reference point
Defect indication from remote end 139 264 kbit/s signal		No	No
Loss of frame in 34 368 kbit/s signal		Yes bit 11, group I	Yes to 4 × constituent 8448 kbit/s at D2 reference point
AIS received in 34 368 kbit/s signal		No	Yes to 4 × constituent 8448 kbit/s at D2 reference point
Defect indication from remote end 34 368 kbit/s signal		No	No
Loss of frame in 8448 kbit/s signal		Yes bit 11, group I	Yes to 4 × constituent 2048 kbit/s at D2 reference point
AIS received in 8448 kbit/s signal		No	Yes to 4 × constituent 2048 kbit/s at D2 reference point
Defect indication from remote end 8448 kbit/s signal		No	No
NOTE – Consequent actions related to the generation of defect information are specified in 14. These actions could be taken at the level of the equipment (e.g. bell, lamp, etc.) and at the level of the management of the equipment.			

Further to the detection of any defect or failure condition, appropriate consequent actions shall be taken as specified in Table 5. The consequent actions should be taken as soon as possible:

- AIS at H2 reference point should be applied within 2 ms of the detection of the relevant defect or failure condition;
- the maximum period between the detection of a defect or a failure condition and the transmission of a defect indication at the E1/E′1 reference point shall be of the order of 100 ms;
- the maximum period between the detection of a defect or a failure condition and the generation of defect or failure information is dependent on the maintenance strategy for the equipment. It is covered in 14 specifying the management aspects of flexible multiplexer.

TABLE 5/G.797

Defect or failure conditions at E2/E′2 reference points and consequent actions at H2 or El/E′l reference points

Defect or failure condition at the E2/E'2 reference point	Consequent actions			
	Defect information generated (Note 1)	Defect indication to remote end at El reference point	AIS applied at H2 reference point	
			Data TS	TS16 bits
Loss of frame alignment	Yes	Yes, bit 3 TS0 NFAS	Yes	Yes
Error ratio 1×10^{-3} (Note 4)		Yes, bit 3 TS0 NFAS	Yes (Note 2)	Yes (Note 2)
Defect indication received from remote end in TS0		No	No	No
AIS received		Yes (Notes 3 and 5)	Yes	Yes
Loss of multiframe alignment		Yes, bit 6 TS16 fr0	No	Yes
Defect indication received from remote end bit 6 TS16 fr0		No	No	No
AIS received in TS16		Yes, bit 6 TS16 fr0	No	Yes

NOTES

1 Consequent actions related to the generation of defect information are specified in 14.

These actions could be taken at the level of the equipment (e.g. bell, lamp, etc.) and at the level of the management of the equipment.

2 Provision shall be made for disabling this action.

3 In order to enable appropriate actions at the remote end, the indication of reception of AIS may be transmitted in addition of any other defect indication to the remote end. The use of the 4 kbit/s data link on Sa4 in TS0 NFAS or the use of a free Sa bit of TS0 NFAS is suggested for this application.

4 The detection of this defect condition is optional.

5 This consequent action is optional.

11 Defect or failure conditions and consequent actions for the core of the equipment

11.1 Defect or failure conditions

The equipment shall detect the following conditions.

11.1.1 Failure of power supply

11.1.2 Failure of a connection

A connection inside the equipment shall be deemed to have failed when either the 64 or n × 64 kbit/s path or associated signalling a, b, c, d path or both paths from the L1 reference point to the E1/E1′ reference point or from the E2/E'2 reference point to the L2 reference point is (are) not available for a period greater than 1 second. The detection of this failure condition should be detected per direction.

11.1.3 Loss of synchronisation signal(s)

The equipment is timed by its own internal oscillator in case where this is not the normal mode of operation.

In the case of loss of active synchronization reference, the equipment shall switch over to other reference according the programmed fall-back strategy.

11.2 Consequent actions at the O2 or A1 or E1/E′1 or L2 or N2 reference points

11.2.1 2048 kbit/s, 8448 kbit/s, 34 368 kbit/s or 139 264 kbit/s interfaces

Further to the detection of a defect or a failure condition, appropriate consequent actions shall be taken as specified in Table 6. The consequent actions should be taken as soon as possible:

- AIS at the O2 reference point of a 2048 kbit/s tributary interface or Al reference points of a 2048 kbit/s, 8448 kbit/s, 34 368 kbit/s or 139 264 kbit/s aggregate interface should be applied, if practicable within a period to be determined;
- AIS at the E1/E′1 or L2 reference point(s) in the 64 or n × 64 kbit/s channels and in any related signalling channel should be applied within 2 ms of the detection of the failure of a connection depending on the affected direction;
- the maximum period between the detection of the loss of synchronization signal(s) defect condition and the transmission of any defect indication at the E1/E′1 and N1 (in case of a 2048 kbit/s tributary interface) reference points is for further study;
- the maximum period between the detection of a defect or a defect or failure condition and the generation of failure information is dependent on the maintenance strategy for the equipment. It is covered in 14 specifying the management aspects of flexible multiplexer.

TABLE 6/G.797

Defect or failure conditions and consequent actions for the core of the equipment

Defect or failure condition	Consequent actions		
	Defect information generated (Note 1)	Defect indication to remote end at El and N2 reference point	AIS applied
Failure of power supply	Yes	No	Yes, Al and O2 reference points (if practicable)
Failure of a connection		No	Yes, El and L2 reference points (Note 3)
Loss of synchronization signal(s)		Yes (Note 2)	No

NOTES

1 Consequent actions related to the generation of defect information are specified in 14.

These actions could be taken at the level of the equipment (e.g. bell, lamp, etc.) and at the level of the management of the equipment.

2 In order to enable appropriate actions at the remote ends the indication of loss of synchronisation signal(s) may be transmitted. The use of the 4 kbit/s data link on Sa4 in TS0 NFAS or the use of a free Sa-bit of TS0 NFAS or the use of a free Sa-bit of TS0 NFAS is suggested for this application.

3 AIS is applied only to data TS and/or related signalling when the corresponding 64 lbit/s path and/or signalling path respectively have failed.

11.2.2 Other tributary interfaces

Further to the detection of a failure of power supply:

- when practicable, an all ONEs signal should be applied and control signals should present an OFF condition at the O2 reference point for the DTE/DCE interfaces;
- if practicable, an all ONEs signal should be applied and according to national requirements the octet timing could be removed at the O2 reference point for the G.703 64 kbit/s interface;
- the analogue interfaces should present a 0 volt signal at the O2 reference point. The reaction on signalling is depending on national requirements.

Further to the detection of a failure of a connection in the A to O direction and if the data path is concerned:

- an all ONEs signal should be applied at the O2 reference point for the DTE/DCE interfaces within 2 ms of the detection of the condition;
- an all ONEs signal should be applied and according to national requirements the octet timing could be removed at the O2 reference point for the G.703 64 kbit/s interface within 2 ms of the detection of the condition;
- the analogue interfaces should present a 0 volt signal at the O2 reference point within 2 ms of the detection of the condition.

Further to the detection of a failure of a connection in the A to O direction and if the signalling or control path is concerned:

- an OFF condition should be applied on the control signals at the O2 reference point for the DTE/DCE interfaces within 2 ms of the detection of the condition;
- for analogue interfaces, the reaction on signalling at the O2 reference point is depending on national requirements.

The consequent actions to these defect or failure conditions for the basic ISDN user-network interface is for further study.

12 Performance monitoring

The following performance indications can be derived from error event and other defect or failure conditions:

- unavailable time;
- degraded performance;
- unacceptable performance.

The strategy to determine these quality performance parameters are described in Recommendations M.20, M.550 and M.557. More details are givenin 14 specifying management aspects of flexible multiplexer.

13 Performance of the equipment

13.1 Jitter

13.1.1 139 264 kbit/s aggregate

For further study.

13.1.2 34 368 kbit/s aggregate

For further study.

13.1.3 8448 kbit/s aggregate

For further study.

13.1.4 2048 kbit/s aggregate and tributary

13.1.4.1 Jitter at 2048 kbit/s output

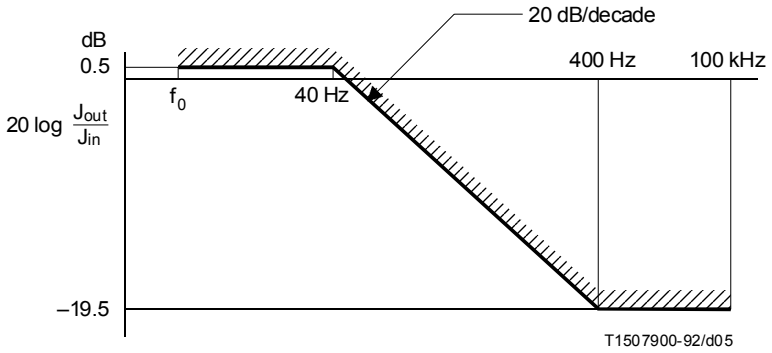
When the timing source is jitter free, the peak-to-peak jitter at any 2048 kbit/s output should not exceed 0.05 UI when it is measured in the range from f_1 = 20 Hz to f_4 = 100 kHz.

13.1.4.2 Jitter tolerance at 2048 kbit/s input

The tolerance to jitter of any 2048 kbit/s input should be according to 3/G.823.

13.1.4.3 Jitter transfer function

The jitter transfer function between the input used for synchronization purposes and any 2048 kbit/s output should not exceed the gain/frequency limits given in Figure 5. The input shall be modulated with sinusoidal jitter.



NOTES

1 The frequence f_0 should be below 20 Hz and as low as possible (for example 10 Hz), taking into account the limitations of measuring equipment.

2 To achieve accurate measurements, the use of a selective method is recommended with a bandwidth sufficiently small referred to relevant measurement frequency, but not over 40 Hz.

FIGURE 5/G.797

Jitter transfer

13.1.5 G.703 64 kbit/s tributary

The tolerance to jitter at the codirectional input shall be according to 3.1.1/G.823.

When the timing signal is jitter free, the jitter at the codirectional output shall be according to 6.2.1/G.736.

The jitter transfer function between any 2048 kbit/s input signal used for the synchronization of the equipment (or 2048 kHz external synchronization signal) and the codirectional output shall be according to 6.3.3/G.736.

13.2 Transfer delay

This performance parameter is applicable to digital tributary signals.

13.2.1 64 and n × 64 kbit/s signals

The transfer delay for 64 and n × 64 kbit/s signals present at the tributary side in a V, X, G.703 64 kbit/s or G.704 2048 kbit/s interface through any flexible multiplex equipment should be as small as possible taking into account the size of the corresponding buffers. The delay should not exceed 650 µs between O and E/E′ reference points (see Note).

13.2.2 CAS in TS16

The transfer delay for any 500 bit/s CAS signal present at the tributary side in a G.704 2048 kbit/s interface through any flexible multiplex equipment should not exceed 7 ms between O and E/E′ reference points (see Note).

13.2.3 Control signals

For further study.

NOTE – The additional tolerance for transfer delay for digital signals passing through any higher order multiplexing function between the E/E′ and the A reference points is for further study.

13.3 Slips

Three situations need to be considered:

i) the timing signal and the relevant input signal are timed from the same G.811 1×10^{-11} clock: no slips should occur assuming adequate wander buffers are provided;

ii) the timing signal and the relevant input signal are timed from separate G.811 1×10^{-11} clock: in this plesiochronous mode of operation, the rate of controlled slips should be in accordance with 2.3/G.823;

iii) the timing signal and the relevant input signal are independently timed as a result of loss of all synchronization signals: depending on the way the flexible multiplexer is synchronized it is possible to select one of the two following options derived from Recommendation G.796:

- for the first 24 hours, no more than 10 controlled slips per hour (flexible multiplexer with only one external synchronization signal);
- for the first 24 hours, no more than 300 controlled slips per hour (flexible multiplexer with several independant external synchronization signals).

13.4 Service availability

This performance parameter requires further study. It depends on the MTBF of FAS components and on the MTTR achieved in a given network.

In order to fulfil a particular value for the service availability it may be necessary to make use of automatic protection switch function as shown in Figure 4. This function can be considered at the high order aggregate path (i.e. at the C reference point) level or at the 2048 kbit/s aggregate path (i.e. at the G reference point) level. That does not preclude the use of external automatic line protection switch which is not covered by this Recommendation. It is understood that APS function should not be recursive.

When an APS function is required it shall be possible to select by the mean of the management of the equipment the criteria for the activation of the switching function from the main digital path to the stand-by one. The criteria may involve

- a number of defect conditions applicable at the B or E reference point respectively;
- a persistence time for any of the selected defect conditions;
- performance monitoring.

Monitoring the duplicated paths is necessary.

Priority level in the defect conditions should be provided in order to manage the selection of the active path.

The switching function should be realized without loss of information (i.e. within a bit interval).

More information are given in 14 specifying the management aspects of flexible multiplexer.

13.5 Error performance

The design objective long term error performance for a single pass through the equipment of a 64 kbit/s connection from/to reference points Al and O2 (respectively O1 and A2) should be

- no SES;
- no ES.

One month is given as an indicative time for the long term in Recommendation G.821.

13.6 Bit sequence independance

The flexible multiplex equipment should be insensitive to any binary pattern within the 64 or n × 64 kbit/s paths or any 500 bit/s signalling path through the equipment.

14 Management

For further study. Guidance could be taken from Recommendation G.784.

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