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**GENERAL ASPECTS OF DIGITAL  
TRANSMISSION SYSTEMS**

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**CHARACTERISTICS OF A FLEXIBLE  
MULTIPLEXER IN A PLESIOCHRONOUS  
DIGITAL HIERARCHY ENVIRONMENT**

**ITU-T Recommendation G.797**

(Previously "CCITT Recommendation")

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## FOREWORD

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The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

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## NOTE

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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## SUMMARY

This Recommendation covers functional requirements for a Flexible Multiplexer (FM). The FM stands for an equipment or the relevant functions able to provide time division multiplexing and demultiplexing of signals supporting a variety of user services. In addition the flexible multiplexer provides enhanced management capabilities. It is based on 64 and  $n \times 64$  kbit/s services. The flexible multiplexer can be used in the access part of a digital transmission network (PDH in the case of this Recommendation).

This Recommendation mainly describes the provision of analogue and digital leased line services. Some technical solutions for the transport of PSTN and ISDN signals are also indicated. The provision of on-demand services according to Recommendations G.964 and G.965 specifying the V5 interfaces are for further study.



# CHARACTERISTICS OF A FLEXIBLE MULTIPLEXER IN A PLESIOCHRONOUS DIGITAL HIERARCHY ENVIRONMENT

(revised 1996)

## Scope of the Recommendation

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  $n \times 64$  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).

## 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.

**1.1.1 flexible access system (FA):** 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.

**1.1.2 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.

**1.1.3 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.

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

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

**1.1.6 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 subclause contains the abbreviations which are not defined in the core text of the Recommendation.

ADPCM	Adaptive Differential Pulse Code Modulation
AIS	Alarm Indication Signal

CRC	Cyclic Redundancy Check
DC	Direct Current
DCE	Data Circuit-terminating Equipment
DTE	Data Terminal Equipment
ES	Errored Second
FAS	Frame Alignment Signal
fr0	Frame 0 of the CAS G.704 multiframe
ISO	International Standardization Organization
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
NFAS	Non Frame Alignment Signal
PCM	Pulse Code Modulation
ppm	part per million
Q	The NE interface to the TMN
SB-ADPCM	Sub-Band Adaptive Differential Pulse Code Modulation
SES	Severely Errored Second
TS	Time Slot
TS0	Time Slot 0 of a 2048 kbit/s G.704 frame
TS16	Time Slot 16 of a 2048 kbit/s G.704 frame
UI	Unit Interval

### 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 distribution of functions in Flexible Access system.

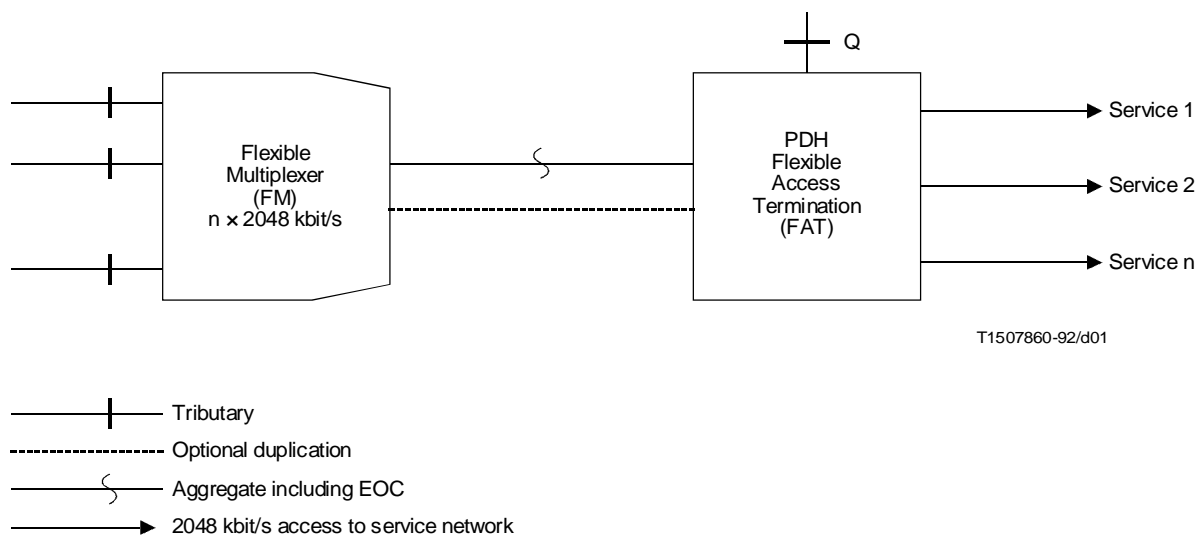


FIGURE 1/G.797

**Flexible access system – application of monoservice 2048 kbit/s frames**



In the network configuration given in Figure 1, the Flexible Access Termination (FAT) is serving as a high order multiplexer.

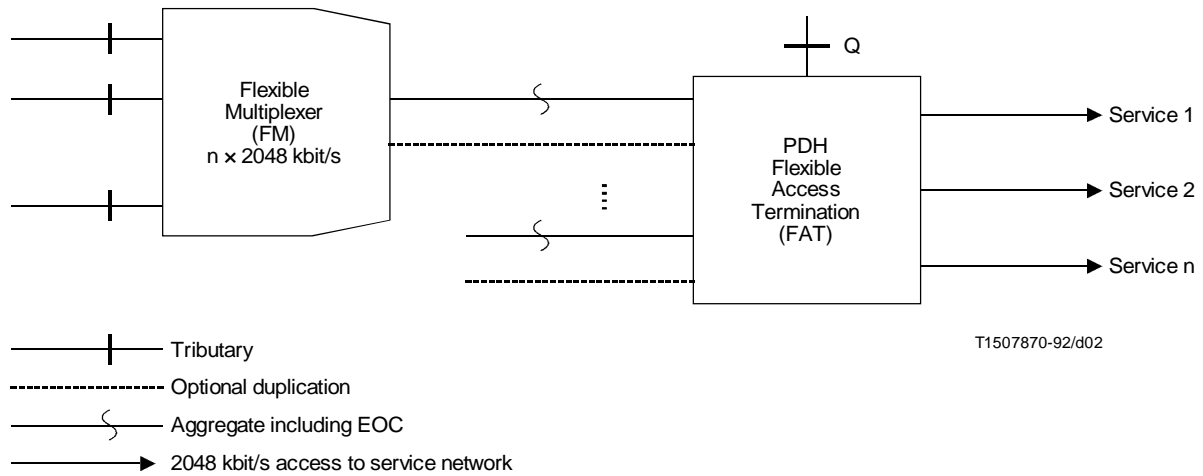


FIGURE 2/G.797

**Flexible access system – application of multiservice 2048 kbit/s G.704 frames**

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 realized in 2048 kbit/s G.704 framed signals, the restitution of individual signals with analogue 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**

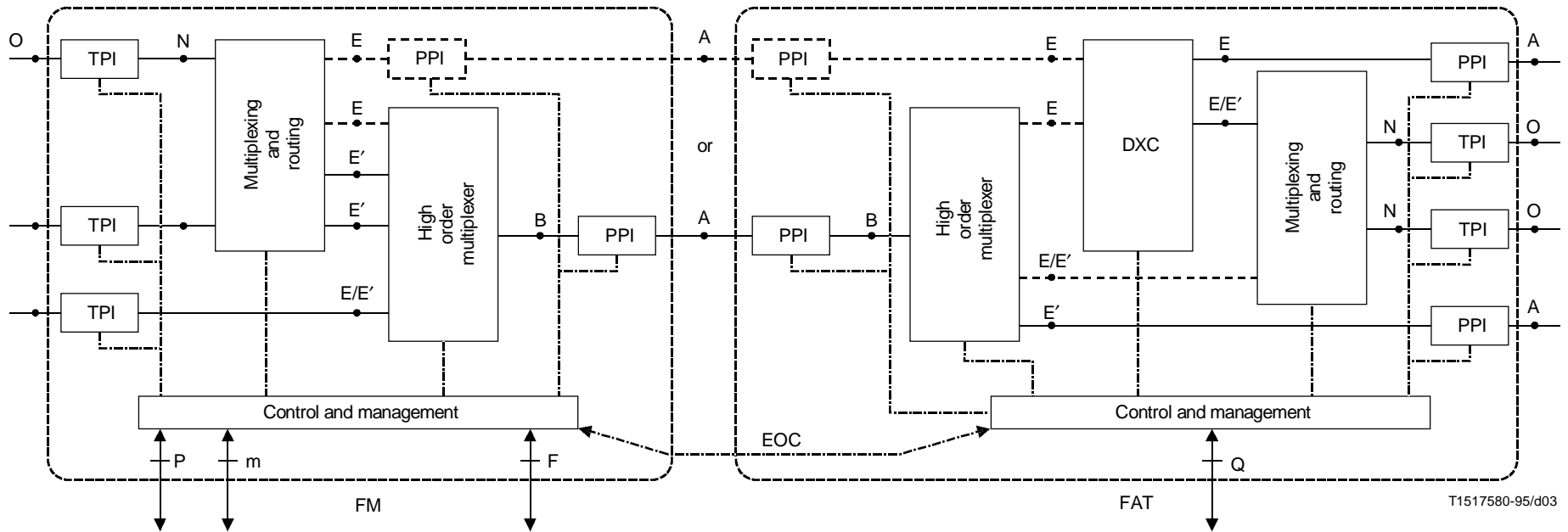
The services considered for the Flexible Multiplexer are derived from the Integrated Services Digital Network (ISDN), the Public Switched Telephone Network (PSTN), a Circuit Switched Data Network (CSDN), a Packet Switched Data Network (PSDN) and a Leased Line Network.

**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 x 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 x 2048 kbit/s, 1 x 8448 kbit/s, 1 x 34 368 kbit/s or 1 x 139 264 kbit/s.



NOTE – The Reference Points to Figure 3, except those related to the management interfaces, are defined in clause 3.

FIGURE 3/G.797  
**Functional representation of the flexible access system**

## **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  $\pm 1$  ppm to  $\pm 50$  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 synchronizing another equipment or to control the internal timing signal is an optional function.

On failure condition on the active synchronization signal, it shall be possible to programme a fall-back strategy up to three steps, see 11.1.3.

Complementary information is given in clause 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) in any 2048 kbit/s G.704 framed 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 analogue to digital conversion, rate adaptation, handling of signalling information and control signals.

### **2.3 Concentration function for switched services**

When implemented, this function should apply the principles provided in Recommendation G.965. The corresponding requirements are not described in this Recommendation and remain for further study.

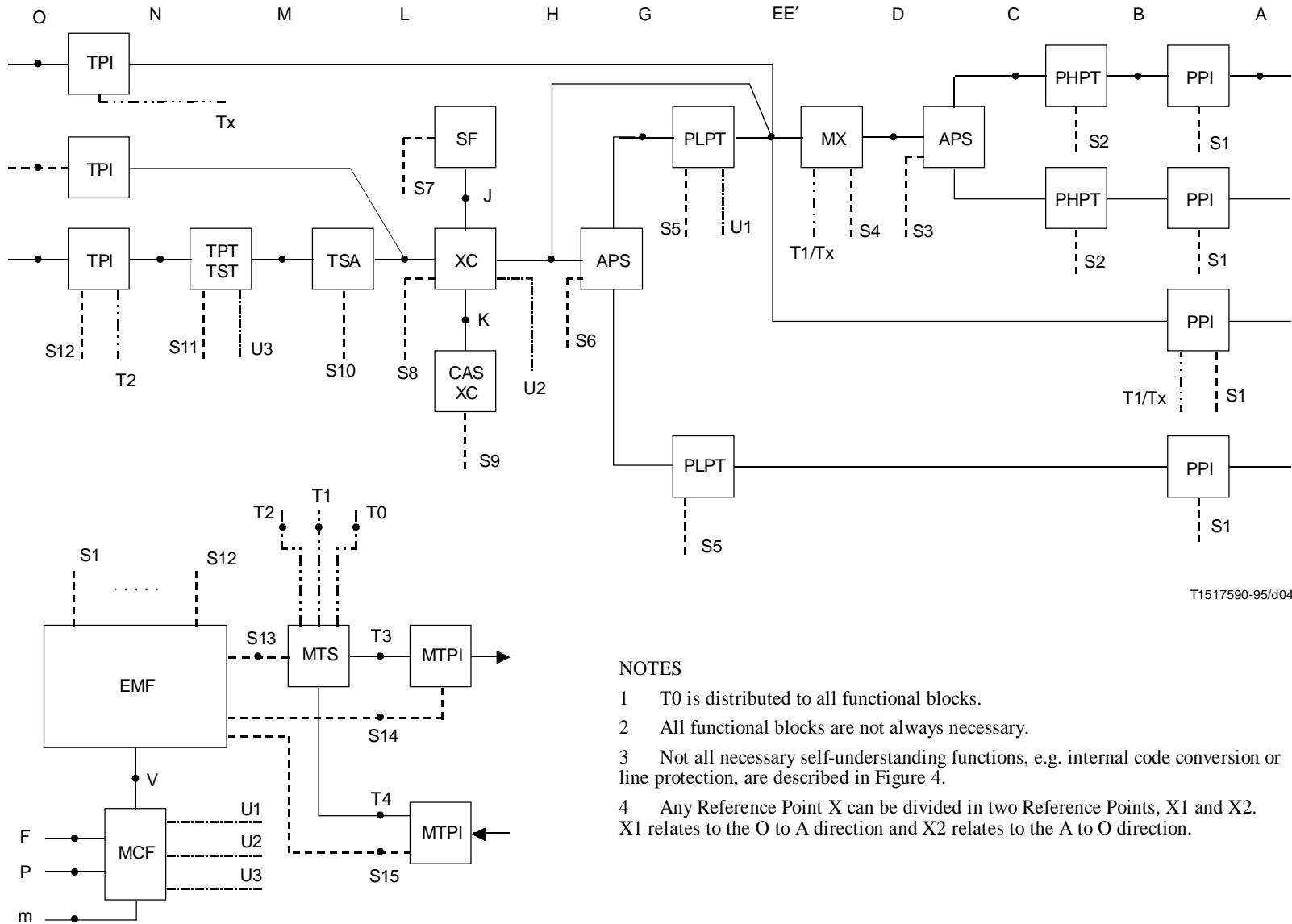
### **2.4 Management**

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



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FIGURE 4/G.797  
General functional block diagram

## 3.2 Definition of functional blocks

**3.2.1 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.

**3.2.2 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.

**3.2.3 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.

**3.2.4 Plesiochronous Higher Order Multiplexer (MX):** Digital multiplexing function according to Recommendations G.742, G.751.

**3.2.5 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.

**3.2.6 Cross Connect Function (XC):** The cross connect function allows the mapping of 64 or  $n \times 64$  kbit/s signals from tributary side to related 2048 kbit/s G.704 logical frame signal.

**3.2.7 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.

**3.2.8 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.

**3.2.9 Multiplexer Timing Physical Interface (MTPI):** The multiplexer timing physical interface terminates (or generates) electrically the external synchronization signal.

**3.2.10 Multiplexer Timing Source (MTS):** The multiplexer timing source provides all internal timing signals necessary for the flexible multiplexer.

**3.2.11 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.

**3.2.12 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 or via the m Reference Point.

**3.2.13 Special Function (SF):** The special functions could be point to multipoint mode of operation, PCM to ADPCM transcoding, conference bridging, broadcasting.

**3.2.14 Channel Associated Signalling (CAS) Cross Connect (CAS XC):** This realizes the cross connection of abcd bits of TS16, when used, in relation with correspondent 64 kbit/s TS.

**3.2.15 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  $n \times 64$  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 ITU-T Recommendation.
- V Information serving for external management.
- Si Management points.
- T0 Internal timing signal.
- T1 Synchronization signal derived from a 2048 kbit/s aggregate signal.
- T2 Synchronization signal derived from a 2048 kbit/s tributary signal.
- T3, T4 2048 kHz external synchronization signal.
- Tx 2048 kHz signal derived from a 2048 kbit/s tributary or aggregate signal not necessarily synchronous to the internal timing signal.
- U1, U3 4 kbit/s EOC.
- U2 64 kbit/s EOC.
- F A management interface connecting workstation to the OSF or the MF according to Recommendation M.3010.
- m A non-standard Reference Point between equipment function and the Q Adapter function according to Recommendation M.3010.
- P User management interface for local operation (not to be standardized).

## 4 Tributary interfaces

### 4.1 Analogue interfaces

#### 4.1.1 Voiceband 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 analogue 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 authorized 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 reconstitute 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 references to clauses/subclauses in Recommendations G.712 and Q.552 for the characteristics of input and output ports of analogue interfaces.

TABLE 1/G.797

#### Characteristics of input and output analogue interfaces

Characteristic	4-wire Rec. G.712	2-wire Rec. G.712	PSTN Rec. 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 distortion	7	7	3.1.1.5
Group delay (Note)	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 distortion	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
NOTE – 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 destined 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 reconstitute 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 destined 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 Wideband interface**

#### **4.1.2.1 Wideband (7 kHz)**

##### **4.1.2.1.1 Physical aspect at O Reference Point**

Access for analogue wideband 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 Analogue 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, clause 3/G.722, clause 5/G.722 and clause 6/G.722. Complementary decoding and converting system shall be provided to reconstitute analogue signal at O2 Reference Point. The decoding and converting system shall be according to 1.1/G.722, 1.5/G.722, clause 4/G.722, clause 5/G.722 and clause 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 II/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 destined 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 analogue wideband 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 clause 3/J.41 and one of the sub-clauses 4/J.41 (instantaneous companding) or of clause 5/J.41 (near instantaneous companding). Complementary decoding system shall be provided to reconstitute analogue signal at the M2 Reference Point.

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

##### 4.1.2.2.4 Performance

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

NOTE – Reference should be made to appropriate part of Recommendations J.42, J.43, J.44 and ITU-R 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  $6 \times 64$  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 ITU-R Recommendations 724 and 718 are required, encoded signals shall respectively use from  $5 \times 64$  kbit/s octets to  $30 \times 64$  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 destined 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 ITU-R 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 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 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 Recommendation 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,  $n \times 64$  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 an optional method to carry maintenance information according to Recommendation V.54;
- 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 Recommendations V.110 and/or V.120 and I.460.

NOTE – The attention is drawn on alternatives bit rate adaptation methods which may be required for a period of time to take into account actual implementations of digital leased line networks. These are not to be standardized in the present Recommendation as they are based upon network providers requirements. Reference should be made to Recommendations X.50, X.50 *bis*, X.51, X.51 *bis* and X.58.

#### 4.2.1.1.5 Control signals

The function of control signals, the dependence 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  $n \times 64$  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 destined to) the L Reference Point. The mapping function of the equipment shall guarantee octet sequence integrity for  $n \times 64$  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 or in-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 an 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 Recommendations X.27 (or V.11) for bit rate greater than 9.6 kbit/s or X.26 (or 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, care should be exercised to prevent V.10 or V.11 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 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  $n \times 64$  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 4.2.1.1.3).

For application ii) the transfer from end-to-end of C on I may be done by the use, in addition of the  $n \times TS$ , 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  $n \times 64$  kbit/s signal is not greater than 600 ms 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 options iii) and iv).

#### **4.2.1.2.6 Signal at L Reference Point**

Signals are present at the L Reference Point as 64 or  $n \times 64$  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  $n \times 64$  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 destined 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 out-band or in-band 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 continue 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 destined to) the L Reference Point.

#### 4.2.2.6 Test functions

The interface shall provide the following test facilities preferably by the means of the management of the equipment:

- 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 baseband line termination

An Integrated Baseband Line termination (ILT), see Figure 5, is part of a system comprising a remote DCE function and a metallic line. The whole system is acting as a subsystem for the flexible multiplexer.

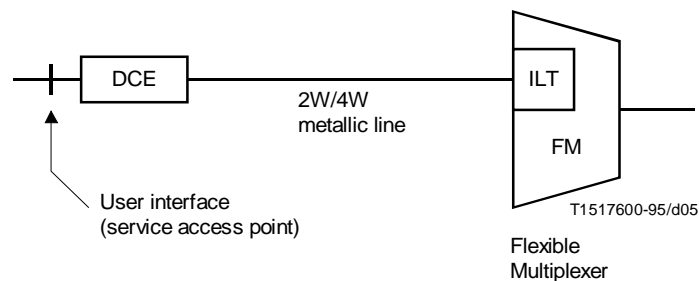


FIGURE 5/G.797

**Baseband DCE for remote access to the flexible multiplexer**

A number of transmission techniques may be used for this application including 2- or 4-wire systems for user payload ranging up to 2048 kbit/s. Appendix I describes a system derived from the ISDN basic access digital transmission system. The DCE functions for bit rates not greater than 64 kbit/s are specified in Recommendation V.38.

#### 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 clause 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 CRC-4 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 Recommendation G.735 and clause 5/G.704);
- selection of TS passed through the equipment.

Complementary information is given in clause 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 slip 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  $n \times 64$  kbit/s signals derived from (or destined 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 ISDN basic access, user-network interface

This function allows the provision of the user-network interface of the ISDN basic access 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 system 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 depends 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  $n \times 64$  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  $3 \times$  TS: one TS is associated to the B1 channel, a second TS is associated to the B2 channel, bit 1 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.

NOTE – Alternative methods for the transfer of signalling signals may be taken from Recommendations G.964 and G.965.

#### 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  $3 \times$  free TS for the transport of one basic access signal (or any set of  $5 \times$  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 equipment shall guarantee octet sequence integrity within the same frame for the  $n \times 64$  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 destined 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 Recommendation I.430.

## **5 Aggregate interfaces**

### **5.1 2048 kbit/s interface**

#### **5.1.1 Electrical characteristics at A Reference Point**

According to clause 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 CRC-4 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 Recommendation G.735 and clause 5/G.704);
- selection of TS passed through the equipment.

Complementary information is given in clause 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 clause 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 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  $n \times 64$  kbit/s data channel or an encoded sound programme/wideband D-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 G1) 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 clause 7/G.703.

### **5.2.2 Framing at B Reference Point**

The frame structure is according to clause 3/G.742 and clause 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 Synchronization interface at 2048 kHz**

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

## **7 Local control interface**

The equipment should provide local access to the management functions 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 cases 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 clause 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 Analogue tributary interfaces**

For analogue 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 analogue 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 clause 7/V.28, clause 11/V.10 and clause 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**

The detection of this condition shall comply with 4.1/G.775.

###### **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**

The detection of this condition shall comply with 4.2/G.775.

###### **9.1.1.4.2 Loss of signal at O2 Reference Point**

The detection of this condition is optional. If required the condition shall be detected in accordance to 9.1.1.4.1.

##### **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 $1 \times 10^{-3}$**

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 CRC-4 procedure. Details are given in clause 14.

#### **9.1.2.4.3 Reception of AIS**

An AIS defect condition is determined when the incoming signal has less than two 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. Refer to 5.2/G.732.

#### **9.1.2.4.6 Reception of AIS in TS16**

This condition shall be detected only when CAS or CCS is required. When CAS is used, it is detected as follows.

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

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

#### **9.1.2.4.7 Reception of CRC-4 errored block**

This condition shall be detected when the CRC-4 procedure is activated.

#### **9.1.2.4.8 CRC-4 errored block received at remote end**

This condition shall be detected when the CRC-4 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 Si 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 9.2.4. 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 clause 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 Recommendation 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 Recommendation 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.

NOTE – 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 at O1 Reference Point	Yes	At O2 reference point (Note 3)	At M1 Reference Point
Loss of octet timing (Note 2) at O1 Reference Point	Yes	Not applicable	Not applicable
Loss of signal at O2 Reference Point	Yes	Not applicable	Not applicable
AIS received (Note 2) at M1 Reference Point	Yes	Not applicable	At L1 Reference Point
NOTES 1 Consequent actions related to the generation of Defect information are specified in clause 14. These actions could be taken at the level of the equipment (e.g. bell, lamp) 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 clause 9.1.2.4, the equipment should take consequent actions as specified in Table 3.

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 N1 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 $1 \times 10^{-3}$ (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, 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
<p>NOTES</p> <p>1 Consequent actions related to the generation of defect information are specified in clause 14. These actions could be taken at the level of the equipment (e.g. bell, lamp) and at the level of the management of the equipment.</p> <p>2 Provision shall be made for disabling this action.</p> <p>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.</p> <p>4 The detection of this defect condition is optional.</p> <p>5 This consequent action is optional.</p>				

## 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 to 10.1.1.2.



### **10.1.1.2 Loss of signal at A2 Reference Point**

The detection of this condition shall comply with 4.2/G.775.

## **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 clause 4/G.742.

#### **10.1.2.1.3 Defect indication from a remote equipment**

This is detected on bit 11 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 (1536 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 13 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 (LOF)**

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

### **10.1.3.2 Error ratio $1 \times 10^{-3}$**

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 CRC-4 procedure. Details are given in clause 14.

### **10.1.3.3 Reception of AIS**

An AIS defect condition is determined when the incoming signal has less than two 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.

### **10.1.3.4 Defect indication from a remote equipment**

This is detected on bit 3 TS0 NFAS.

### **10.1.3.5 Loss of multiframe alignment**

This condition shall be detected only when CAS is required. Refer to 5.2/G.732.

### **10.1.3.6 Reception of AIS in TS16**

This condition shall be detected only when CAS or CCS is required. When CAS is used, it is detected as follows.

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

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

### **10.1.3.7 Reception of CRC-4 errored block**

This condition shall be detected when the CRC-4 procedure is activated.

### **10.1.3.8 CRC-4 errored block received at remote end**

This condition shall be detected when the CRC-4 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 Si 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 A1 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 clause 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 Si 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 clause 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 Si Reference Points.

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 clause 14 specifying the management aspects of Flexible Multiplexer.

## **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  $n \times 64$  kbit/s path or associated signalling a, b, c, d path or both paths from the L1 Reference Point to the E1/E'1 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 synchronization 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.

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 the 16 constituent 8448 kbit/s at D2 Reference Point
AIS received in 139 264 kbit/s signal		No	Yes, to the 16 constituent 8448 kbit/s at D2 Reference Point
Defect indication from remote end in 139 264 kbit/s signal		No	No
Loss of frame in 34 368 kbit/s signal		Yes bit 11 Group I	Yes, to the 4 constituent 8448 kbit/s at D2 Reference Point
AIS received in 34 368 kbit/s signal		No	Yes, to the 4 constituent 8448 kbit/s at D2 Reference Point
Defect indication from remote end in 34 368 kbit/s signal		No	No
Loss of frame in 8448 kbit/s signal		Yes bit 11 Group I	Yes, to the 4 constituent 2048 kbit/s at D2 Reference Point
AIS received in 8448 kbit/s signal		No	Yes, to the 4 constituent 2048 kbit/s at D2 Reference Point
Defect indication from remote end in 8448 kbit/s signal		No	No
<p>NOTE – Consequent actions related to the generation of defect information are specified in clause 14. These actions could be taken at the level of the equipment (e.g. bell, lamp) and at the level of the management of the equipment.</p>			

TABLE 5/G.797

**Defect or failure conditions at E2/E'2 Reference Points and consequent actions  
at H2 or E1/E'1 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 E1 Reference Point	AIS applied at H2 Reference Point	
			Data TS	TS16
Loss of frame alignment	Yes	Yes bit 3 TS0 NFAS	Yes	Yes
Error ratio $1 \times 10^{-3}$ (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, 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
<p>NOTES</p> <p>1 Consequent actions related to the generation of defect information are specified in clause 14. These actions could be taken at the level of the equipment (e.g. bell, lamp) and at the level of the management of the equipment.</p> <p>2 Provision shall be made for disabling this action.</p> <p>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.</p> <p>4 The detection of this defect condition is optional.</p> <p>5 This consequent action is optional.</p>				

## 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 A1 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 defined;
- AIS at the E1/E'1 or L2 Reference Point(s) in the 64 or  $n \times 64$  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 clause 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 E1 and N2 Reference Points	AIS applied
Failure of power supply	Yes	No	Yes, at A1 and O2 Reference Points (if practicable)
Failure of a connection		No	Yes, at E1 and L2 Reference Points (Note 3)
Loss of synchronization signal(s)		Yes (Note 2)	No
<p>NOTES</p> <p>1 Consequent actions related to the generation of defect information are specified in clause 14. These actions could be taken at the level of the equipment (e.g. bell, lamp) and at the level of the management of the equipment.</p> <p>2 In order to enable appropriate actions at the remote ends the indication of loss of synchronization 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 is suggested for this application.</p> <p>3 AIS is applied only to data TS and/or related signalling when the corresponding 64 kbit/s path and/or signalling path respectively have failed.</p>			

**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 on data 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 depends 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 depends on national requirements.

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

## **12 Performance monitoring**

The following short-term 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.2100, M.2110 and M.2120. More details are given in clause 14 specifying management aspects of flexible multiplexer.

The strategy to determine long-term performance evaluation is based on Recommendation G.826.

## **13 Performance of the equipment**

### **13.1 Jitter**

#### **13.1.1 139 264 kbit/s aggregate**

##### **13.1.1.1 Jitter at 139 264 kbit/s output**

When the timing source is jitter free, the peak-to-peak jitter at any 139 264 kbit/s output should not exceed 0.05 UI when it is measured in the range from  $f_1 = 100$  Hz to  $f_4 = 3500$  kHz.

##### **13.1.1.2 Jitter tolerance at 139 264 kbit/s input**

The tolerance to jitter of any 139 264 kbit/s input should be according to clause 3/G.823.

##### **13.1.1.3 Jitter transfer function**

Two situations need to be considered.

When the 139 264 kbit/s signal is obtained from 4 tributaries at 34 368 kbit/s, the jitter transfer function between the 34 368 kbit/s signal used for synchronization purposes and any 139 264 kbit/s output should not exceed the gain/frequency limits given in Figure 2/G.751. The input shall be modulated with sinusoidal jitter. The test sequence shall be binary pattern 1000.

When the 139 264 kbit/s signal is obtained from 16 tributaries at 8448 kbit/s, the jitter transfer function between the 8448 kbit/s signal used for synchronization purposes and any 139 264 kbit/s output should not exceed the gain/frequency limits given in Figure 3/G.751. The input shall be modulated with sinusoidal jitter. The test sequence shall be binary pattern 1000.

#### **13.1.2 34 368 kbit/s aggregate**

##### **13.1.2.1 Jitter at 34 368 kbit/s output**

When the timing source is jitter free, the peak-to-peak jitter at any 34 368 kbit/s output should not exceed 0.05 UI when it is measured in the range from  $f_1 = 100$  Hz to  $f_4 = 800$  kHz.

##### **13.1.2.2 Jitter tolerance at 34 368 kbit/s input**

The tolerance to jitter of any 34 368 kbit/s input should be according to clause 3/G.823.

### 13.1.2.3 Jitter transfer function

The jitter transfer function between the 8448 kbit/s signal used for synchronization purposes and any 34368 kbit/s output should not exceed the gain/frequency limits given in Figure 1/G.751. The input shall be modulated with sinusoidal jitter. The test sequence shall be binary pattern 1000.

### 13.1.3 8448 kbit/s aggregate

#### 13.1.3.1 Jitter at 8448 kbit/s output

When the timing source is jitter free, the peak-to-peak jitter at any 8448 kbit/s output should not exceed 0.05 UI when it is measured in the range from  $f_1 = 20$  Hz to  $f_4 = 400$  kHz.

#### 13.1.3.2 Jitter tolerance at 8448 kbit/s input

The tolerance to jitter of any 8448 kbit/s input should be according to clause 3/G.823.

#### 13.1.3.3 Jitter transfer function

The jitter transfer function between the 2048 kbit/s signal used for synchronization purposes and any 8448 kbit/s output should not exceed the gain/frequency limits given in Figure 1/G.742. The input shall be modulated with sinusoidal jitter. The test sequence shall be binary pattern 1000.

### 13.1.4 2048 kbit/s aggregate and tributary

#### 13.1.4.1 Jitter at 2048 kbit/s output

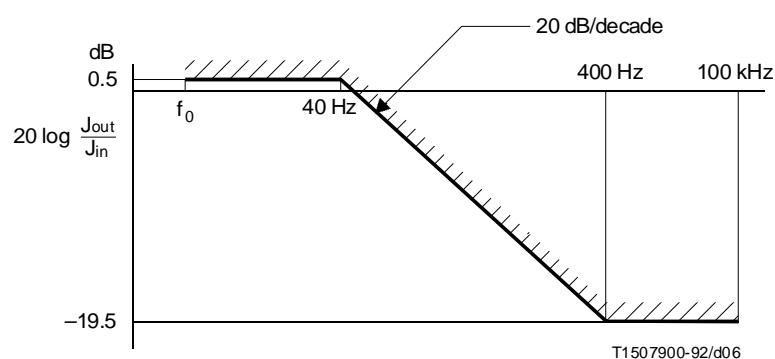
When the timing source is jitter free, the peak-to-peak jitter at any 2048 kbit/s output should not exceed 0.05 UI when it is measured in the range from  $f_1 = 20$  Hz to  $f_4 = 100$  kHz.

#### 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 clause 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 6. The input shall be modulated with sinusoidal jitter.



#### NOTES

- 1 The frequency  $f_0$  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 6/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 $n \times 64$ kbit/s signals

The transfer delay for 64 and  $n \times 64$  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  $\mu$ s between O and E/E' Reference Points (see Note in 13.2.3).

### 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 in 13.2.3).

### 13.2.3 Control signals

The transfer delay for any control signal present at the tributary side in a data interface through any flexible multiplex equipment should not exceed 7 ms between O and E/E' Reference Points (see Note).

NOTE – The additional transfer delay for digital signals passing through any higher order multiplexing function between the E/E' and the A Reference Points should be minimized.

## 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  $1 \times 10^{-11}$  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  $1 \times 10^{-11}$  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 independent external synchronization signals).

## 13.4 Service availability

This performance parameter is not to be standardized. It depends on the MTBF of FAS components and on the MTTR achieved in a given network. Recommendation E.862 provides means for evaluating the loss of traffic due to a failure situation and its impact on the grade of service.

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 is given in clause 14 specifying the management aspects of flexible multiplexer.

NOTE – Additionally, channel protection for leased circuit applications may be arranged externally to the flexible multiplexer by temporary use of switched connections. This function is not considered in this Recommendation.

### **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 A1 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 independence**

The flexible multiplex equipment should be insensitive to any binary pattern within the 64 or  $n \times 64$  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.

## **Appendix I**

### **Baseband line transmission system**

(This appendix does not form an integral part of this Recommendation)

#### **I.1 General**

This appendix contains a set of requirements to be considered as a complement to the present Recommendation and to Recommendation V.38. It describes functional characteristics of an implementation of Transmission Unit shown on Figure I.1/V.38 and to the ILT functional block shown in Figure 5.

Objectives are to operate on 2-wire metallic lines that meet minimum ISDN requirements and to use existing components designed for ISDN basic access line transmission system, reception and maintenance processing.

Alternative systems may be implemented. The description of these systems requires further study.

#### **I.2 Physical model of the line transmission system**

See Figure I.1.

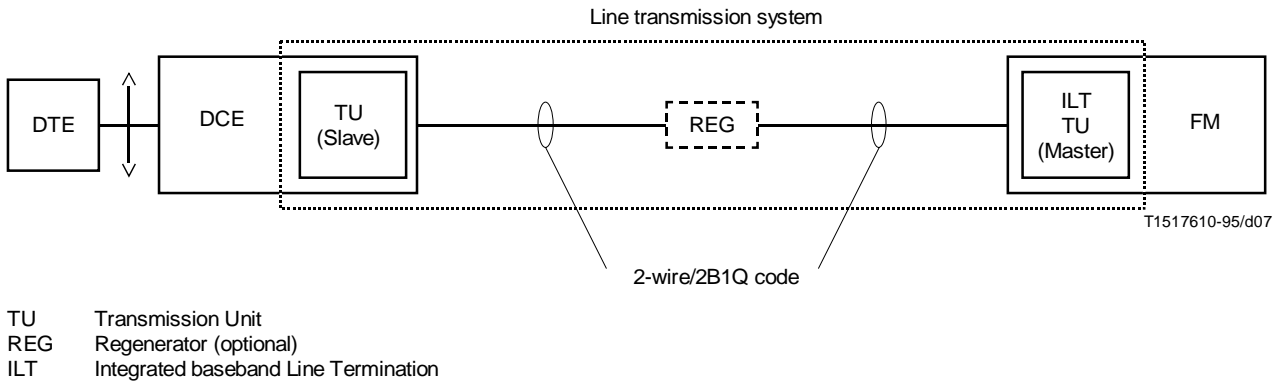


FIGURE I.1/G.797  
**Physical model of the line transmission system**

### I.3 Functional description of the DCE

DCE characteristics (DTE/DCE interface, bit rate adaptation, end-to-end control or signalling, testing and multiplexing facilities) are specified in Recommendation V.38. See Figure I.2.

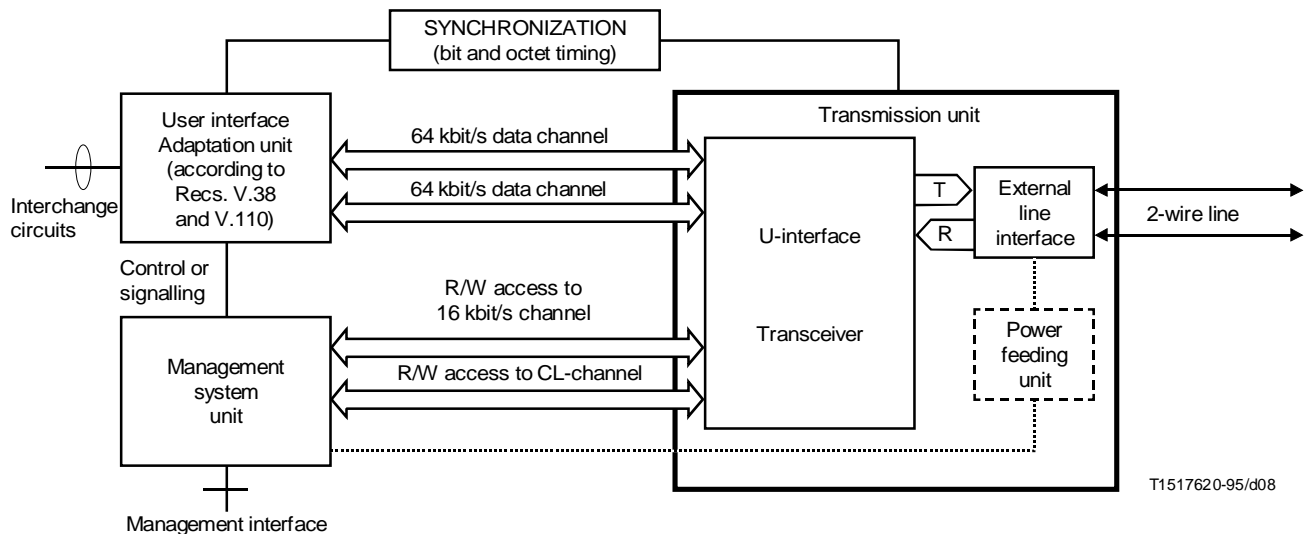


FIGURE I.2/G.797  
**Functional block diagram of the DCE**

### I.4 Functions of TU functional block

Transmission Unit incorporated within the DCE (see Figure I.1) interwork with a remote Transmission Unit at the other end of the local loop that is part of the baseband line termination integrated within the flexible multiplexer (see Figure I.1).

Operation of both units is not symmetrical. One is configured to operate in the Master mode and the other configured to operate in the Slave mode. TU in the flexible multiplexer should always work in Master mode.

TU working in Slave mode provides the different NT1 functions. TU working in Master mode provides LT functions. NT1 and LT functions are referring to Recommendation G.961. See Figure I.3.

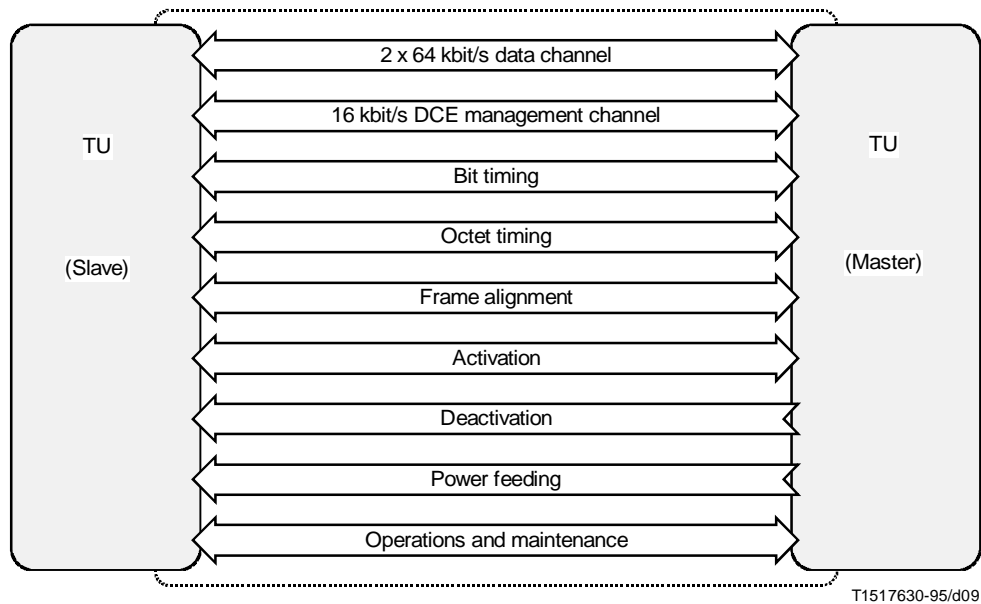


FIGURE I.3/G.797  
**Functions of TU functional blocks**

#### I.4.1 Data channels

This function provides two bidirectional and independent 64 kbit/s data channels. These correspond to the two B-channels in ISDN basic access signals. A concatenation function may optionally provide instead a single 128 kbit/s data channel.

#### I.4.2 DCE Management channel

This function provides a 16 kbit/s bidirectional channel for the management of the DCE Main functions. This corresponds to the D-channel in ISDN basic access signals. Alternatively, this may be used as a complementary resource for data transmission. A concatenation function may optionally provide in conjunction with the two 64 kbit/s data channels a single 144 kbit/s data channel.

When the 16 kbit/s channel is not allocated to the transmission of management information, the use of the eoc (defined in I.5.7.1) should be used for the management of the DCE.

#### I.4.3 Bit timing

This function provides bit timing to enable the TU to recover information from the aggregate stream. Bit timing for direction Slave TU to Master TU shall be derived from clock received by Slave TU from the Master TU.

#### **I.4.4 Octet timing**

This function provides 8 kHz octet timing for the 64 kbit/s data channels. It shall be derived from the frame alignment.

#### **I.4.5 Frame alignment**

This function enables TU to recover time division multiplexed channels.

#### **I.4.6 Activation**

This function restores the line transmission system between two TU functional blocks to its normal operational status. At the end of activation procedure, transparency of data and 16 kbit/s management or data channel is achieved; it is not necessary for DTE to be connected during this procedure. It is suggested that only the Master TU initiates the activation procedure.

The activation procedure may be initiated automatically following the detection of a loop connected to the Master TU or be under the control of the management system of the flexible multiplexer.

In normal operation, the line transmission system is always activated.

#### **I.4.7 Deactivation**

This procedure is only permitted to Master TU. This procedure is initiated by Master TU before initiating testing loops in Slave TU (and regenerator if required).

#### **I.4.8 Power feeding**

The power feeding of the TU is handled locally by the DCE. In case of power failure, a battery is provided to permit a restricted function and to indicate fault conditions to the distant unit.

The regenerator (if required) may be either locally power fed or remotely powered from the flexible multiplexer.

Optionally remote power feeding of the regenerator and of the TU function in the DCE may be provided by the flexible multiplexer. Remote power feeding of the other DCE functions (user interface adaptation, management system) is not required.

#### **I.4.9 Maintenance**

The functions needed for operations and maintenance of the transmission system – including the TU and one regenerator (if required) – and for activation/deactivation procedures are combined in one transport resource available in the line signals along with the 64 kbit/s data and 16 kbit/s management or data channels. This transport resource is named the CL-channel.

The following functions are provided by the CL-channel:

- maintenance command (loopback control in the TU functional block or in the regenerator);
- maintenance information;
- indication of fault conditions;
- information regarding power feeding in the slave TU.

### **I.5 Requirements for a line transmission system using 2B1Q line code**

#### **I.5.1 Line code**

The line code is 2B1Q (2 binary, 1 quaternary). This is a 4-level code and it is used without redundancy. This code is described in Appendix II/G.961.

The aggregate bit stream entering the TU functional block before transmission ( $2 \times 64$  kbit/s channel, 16 kbit/s management or data channel, CL-channel) is grouped into pairs of bits for conversion into quaternary symbols called quats. The 64 kbit/s data channels and the 16 kbit/s management or data channel are scrambled before coding.

M1 through M6 bits of the CL-channel are also paired, coded and scrambled the same way. The relationship of the bits in the 64 kbit/s data channels and 16 kbit/s management or data channel to quats are shown in Figure I.4.

For reason of convenience the 64 kbit/s data channels and the 16 kbit/s management or data channel are presented as B1, B2 and D-channels respectively in Figure I.4.

	time →								
data	B1 (64 kbit/s data channel)				B2 (64 kbit/s data channel)				D (16 kbit/s channel)
pair of bits	b11 b12	b13 b14	b15 b16	b17 b18	b21 b22	b23 b24	b25 b26	b27 b28	d1 d2
quat	q1	q2	q3	q4	q5	q6	q7	q8	q9
bits	8				8				2
quats	4				4				1

- B1 64 kbit/s data channel
- B2 64 kbit/s data channel
- D 16 kbit/s management or data channel
- b11 first bit of B1 octet as received by TU
- b18 last bit of B1 octet as received by TU
- b21 first bit of B2 as received by TU
- b28 last bit of B2 octet as received by TU
- d1 d2 consecutive 16 kbit/s management channel
- qi ith quat relative to start of a given 18 bit 2B+D data field

FIGURE I.4/G.797

**2B1Q bit encoding for 64 kbit/s data and 16 kbit/s management or data channels**

**I.5.2 Line modulation rate**

The gross bit rate is 160 kbit/s comprising:

- 144 kbit/s for the two × 64 kbit/s data channels and the 16 kbit/s management or data channel;
- 16 kbit/s for the line overhead (4 kbit/s for the CL-channel and 12 kbit/s for the frame alignment word).

The line symbol rate (modulation rate) is 80 kbauds.

**I.5.3 Clock tolerance**

Clock tolerance of the free running TU clock is ± 100 ppm.

The timing of the Master TU is derived from the multiplexer timing signal (see 1.6). Under normal condition the multiplexer timing signal is traceable to the G.811 network reference clock. Under failure condition the timing of the Master TU should generate a signal with an accuracy better than ± 5 ppm.

**I.5.4 Frame structure**

A frame shall be of 120 quaternary symbols transmitted within a nominally 1,5 ms interval. Each frame contains a frame word, data and/or management channel bits and CL-channel bits.

### **I.5.5 Frame and multiframe word**

The Frame Word (FW) is used to allocate bit positions to the data, management channel and CL-channels.

The code for the frame word in all frames except the first in a multiframe is:

$$FW = +3 +3 -3 -3 -3 +3 -3 +3 +3$$

The code for the first word of the first frame of a multiframe is the Inverted Frame Word (IFW):

$$IFW = -3 -3 +3 +3 +3 -3 +3 -3 -3$$

The frame and multiframe words are the same for both directions.

### **I.5.6 Frame offset between Slave TU and Master TU**

The Slave TU synchronizes transmitted frames with received frames from the Master TU. Transmitted frames are offset with respect to received frames by  $60 \pm 2$  quaternary symbols (i.e. about 0,75 ms).

### **I.5.7 CL-channel**

#### **I.5.7.1 Structure of the CL-channel**

The CL-channel consists of the last three symbols (6 bits) in each basic frame of the multiframe; forty-eight bits of a multiframe are used for the CL-channel.

The bit rate for the CL-channel is 4 kbit/s:

- 24 bits per multiframe (2 kbit/s) are allocated to an embedded operation channel (eoc) which supports operations communications needs between the TU;
- 12 bits per multiframe (1 kbit/s) are allocated to a Cyclic Redundancy Check (CRC) function;
- 12 bits per multiframe (1 kbit/s) are allocated to other functions as shown in Figure I.5.

#### **I.5.7.2 Functions of the CL-channel**

Functions of the CL-channel listed below are based on bit allocation for the multiframe defined in Figure I.5:

- error monitoring function (crc bits);
- far end block error (febe bit);
- activation (act);
- deactivation (dea);
- power status of slave TU ( $ps_1$ ,  $ps_2$ );
- slave TU Test mode indicator (ntm); its use is optional. It may be used by Slave TU to indicate that a maintenance action has been locally initiated by the customer;
- alarm Indicator bit (aib); its use is optional. It can be used by Master TU to indicate a failure of intermediate transmission system, i.e. when Master TU is part of a flexible multiplexer or that a maintenance action has been locally initiated by the customer;
- embedded operation Channel functions (eoc). Functions provided are essentially 144 kbit/s signal (2B+D) loopbacks, 64 kbit/s signals (B1 and B2) loopbacks in Slave TU (type 2 loopback) or in regenerator (loopback 1A) if required. Only Master TU is permitted to control loopbacks by this way.

64 eoc message codes have been reserved for standard applications or for internal network use. Other codes may be used for non-standard applications such as supporting DCE management functions. At least 120 codes are available for this purpose. Any use of such messages shall not interfere with 16 kbit/s management channel when provided.

		Framing	$12 \times (2B+D)$	CL-channel (bits M1 to M6)					
	quat positions	1-9	10-117	118s	118m	119s	119m	120s	120m
	bit positions	1-18	19-234	235	236	237	238	239	240
Multi-frame	Frame	Frame word		M1	M2	M3	M4	M5	M6
A	TU Master → TU Slave								
	1	IFW	$12 \times (2B+D)$	eoc <sub>a1</sub>	eoc <sub>a2</sub>	eoc <sub>a3</sub>	act	1	1
	2	FW	$12 \times (2B+D)$	eoc <sub>dm</sub>	eoc <sub>i1</sub>	eoc <sub>i2</sub>	dea	1	febe
	3	FW	$12 \times (2B+D)$	eoc <sub>i3</sub>	eoc <sub>i4</sub>	eoc <sub>i5</sub>	1	crc <sub>1</sub>	crc <sub>2</sub>
	4	FW	$12 \times (2B+D)$	eoc <sub>i6</sub>	eoc <sub>i7</sub>	eoc <sub>i8</sub>	1	crc <sub>3</sub>	crc <sub>4</sub>
	5	FW	$12 \times (2B+D)$	eoc <sub>a1</sub>	eoc <sub>a2</sub>	eoc <sub>a3</sub>	1	crc <sub>5</sub>	crc <sub>6</sub>
	6	FW	$12 \times (2B+D)$	eoc <sub>dm</sub>	eoc <sub>i1</sub>	eoc <sub>i2</sub>	1	crc <sub>7</sub>	crc <sub>8</sub>
	7	FW	$12 \times (2B+D)$	eoc <sub>i3</sub>	eoc <sub>i4</sub>	eoc <sub>i5</sub>	uoa	crc <sub>9</sub>	crc <sub>10</sub>
	8	FW	$12 \times (2B+D)$	eoc <sub>i6</sub>	eoc <sub>i7</sub>	eoc <sub>i8</sub>	aib	crc <sub>11</sub>	crc <sub>12</sub>
B, C...									
1	TU Slave → TU Master								
	1	IFW	$12 \times (2B+D)$	eoc <sub>a1</sub>	eoc <sub>a2</sub>	eoc <sub>a3</sub>	act	11	1
	2	FW	$12 \times (2B+D)$	eoc <sub>dm</sub>	eoc <sub>i1</sub>	eoc <sub>i2</sub>	ps <sub>1</sub>	11	febe
	3	FW	$12 \times (2B+D)$	eoc <sub>i3</sub>	eoc <sub>i4</sub>	eoc <sub>i5</sub>	ps <sub>2</sub>	crc <sub>1</sub>	crc <sub>2</sub>
	4	FW	$12 \times (2B+D)$	eoc <sub>i6</sub>	eoc <sub>i7</sub>	eoc <sub>i8</sub>	ntm	crc <sub>3</sub>	crc <sub>4</sub>
	5	FW	$12 \times (2B+D)$	eoc <sub>a1</sub>	eoc <sub>a2</sub>	eoc <sub>a3</sub>	cso	crc <sub>5</sub>	crc <sub>6</sub>
	6	FW	$12 \times (2B+D)$	eoc <sub>dm</sub>	eoc <sub>i1</sub>	eoc <sub>i2</sub>	1	crc <sub>7</sub>	crc <sub>8</sub>
	7	FW	$12 \times (2B+D)$	eoc <sub>i3</sub>	eoc <sub>i4</sub>	eoc <sub>i5</sub>	sai	crc <sub>9</sub>	crc <sub>10</sub>
	8	FW	$12 \times (2B+D)$	eoc <sub>i6</sub>	eoc <sub>i7</sub>	eoc <sub>i8</sub>	1*	crc <sub>11</sub>	crc <sub>12</sub>
2, 3...									

2B+D	data bits (data and management channels)
quat	any pair of bit forming a quaternary symbol
s	sign bit (first) in a quat
m	magnitude bit (second) in a quat
FW/IFW	frame word/inverted frame word, bits 1-18 in a frame
1	reserved for future definition
1*	reserved for network use (network indicator)
CL	CL-channel bits M1 to M6 (bits 235 - 240 in basic frame structure)
eoc	embedded operation channel
eoc <sub>ai</sub>	address bits
eoc <sub>dm</sub>	data/message indicator
eoc <sub>i</sub>	information (data or message)
crc <sub>n</sub>	Cyclic Redundancy Check procedure (applicable to 2B+D and M4)
n	most significant bit
n+1	following most significant bit, etc.
febe	far end block error (ZERO for errored multiframe)
ps <sub>1</sub> , ps <sub>2</sub>	power status bits (ZERO indicate power problem)
ntm	test mode bit (ZERO indicate the slave TU test mode)
cso	cold start only bit (optional, set to ZERO if not used)
sai	S/T interface activity indicator (optional, set to ONE if not used)
act	activation bit (set to ONE during activation to indicate readiness for layer 2 communication progress)
dea	deactivation bit (ZERO indicates the Master TU's intention to deactivate)
uoa	U Only Activation (optional, set to ONE to activate user interface)
aib	alarm indicator bit (ZERO indicates interruption)

FIGURE I.5/G.797

**2B1Q multiframe technique and bit assignment**



## **I.6 DCE Management channel**

### **I.6.1 Protocol and procedure**

Detailed protocol and procedure for the management of DCE are for further study.

### **I.6.2 Functions provided**

This channel may support end-to-end control or signalling and maintenance information and acknowledgements related to:

- alarm;
- performance;
- state of interchange circuits (105/109, C/I) when an in-band end-to-end control channel in the 64 kbit/s data channel is not provided;
- remote loop 2 command and acknowledgement;
- configuration of the DCE connected to the flexible multiplexer.

## **I.7 Management System Unit**

### **I.7.1 General**

The Management System Unit monitors the different testing facilities of the DCE as described in Recommendation V.38.

Management System Unit terminates the management channel and the CL-channel.

It receives and analyses information coming from the management interface, from the user interface, from the local TU functional block, from the remote TU functional block through the CL-channel and from the remote end DCE through the management channel assuming that the intervening network supports this function.

The Management System Unit handles the inter working of the DCE functions with the monitoring functions of the line transmission system.

### **I.7.2 Specific functions of the Management System Unit with TU working in Slave mode**

The Management System Unit:

- manages the procedure of activation for the line transmission system initiated by the master TU;
- generates loopback confirmation.

Optionally, when the Management System Unit of a Slave TU detects a loop command coming from the management interface or from the interchange circuits of the user interface or from the DCE management channel, it communicates this test mode status to the Master TU by setting the ntm bit to value ZERO.

### **I.7.3 Specific functions of Management System Unit with TU working in Master mode**

The Management System Unit:

- initiates and manages the procedure of activation/deactivation for the line transmission system;
- controls the procedures for setting of loopbacks in the line transmission system.

When the Management System Unit of the Master TU has detected a loop command coming from the management interface of the flexible multiplexer or from the remote end DCE management channel, it communicates this test mode status to the Slave TU by setting the aib bit to the value ZERO.