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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital transmission systems – Terminal equipments – Principal characteristics of multiplexing equipment for the synchronous digital hierarchy

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Characteristics of a flexible multiplexer in a synchronous digital hierarchy environment

ITU-T Recommendation G.785

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION G.785

CHARACTERISTICS OF A FLEXIBLE MULTIPLEXER IN A SYNCHRONOUS DIGITAL HIERARCHY ENVIRONMENT

Summary

This Recommendation covers functional requirements for a flexible multiplexer intended to be installed in a synchronous digital hierarchy environment. The flexible multiplexer provides time-division multiplexing and demultiplexing functions of signals supporting a variety of user services. This Recommendation should be used in conjunction with Recommendations G.783 and G.797 as only additional requirements are presented to describe the functions of the equipment.

Source

ITU-T Recommendation G.785 was prepared by ITU-T Study Group 15 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 8th of November 1996.

FOREWORD

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The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

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NOTE

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As of the date of approval of this Recommendation, the ITU had/had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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Introduction

This Recommendation gives the characteristics of a flexible multiplex equipment intended to be installed in a synchronous digital hierarchy environment. This Recommendation provides additional requirements to those presented in Recommendations G.797 and G.783 and necessary to describe the functions of the equipment. The flexible multiplex equipment is able to handle a variety of services with transparency for service provider, allowing enhanced management capabilities and to be used in the access network. The management of the equipment is in line with general principles of the Telecommunications Management Network (TMN).

Recommendation G.785

CHARACTERISTICS OF A FLEXIBLE MULTIPLEXER IN A SYNCHRONOUS DIGITAL HIERARCHY ENVIRONMENT

(Geneva, 1996)

1 General characteristics

1.1 Definitions

This Recommendation defines the following terms.

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): 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 × 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 × 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.

AIS Alarm Indication Signal

CRC Cyclic Redundancy Check

DC Direct Current

DCC Data Communication Channel

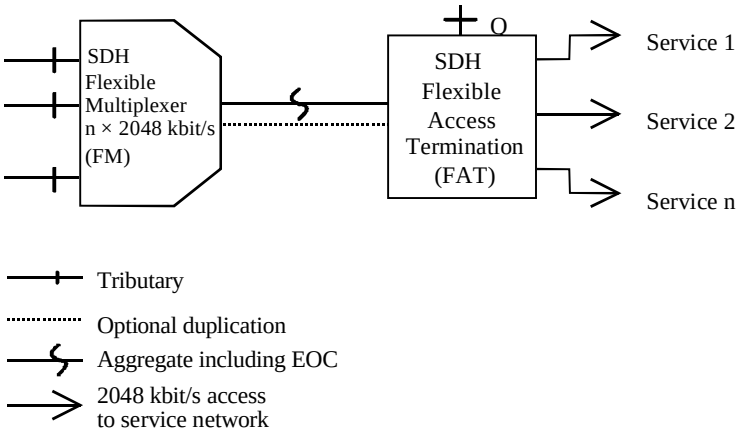
DCE Data Circuit-terminating Equipment

EOC	Embedded Operation Channel
ES	Errored Second
FA	Flexible Access system
FAT	Flexible Access Termination
FM	Flexible Multiplexer
HOA	Higher Order Assembler
ISO	International Organization for Standardization
MD	Mediation Device
MF	Mediation Function
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
NE	Network Element
OS	Operations System
ppm	part per million
Q	The NE interface to the TMN
QAF	Q Adaptation Function
Sa	A spare bit in time slot 0 of the 2048 kbit/s G.704 frame
SDH	Synchronous Digital Hierarchy
SES	Severely Errored Second
STM-1	Synchronous Transport Module-1
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
TTF	Transport Terminal Function
UI	Unit Interval
VC-12	Virtual Container-12

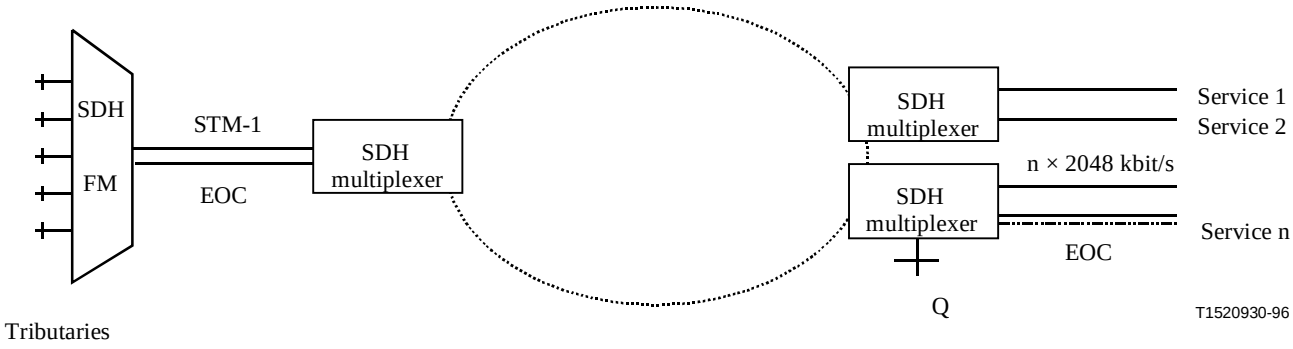
1.3 Application of the equipment

1.3.1 Network configurations

The recommended network configurations are given in Figures 1 and 2. Figures 3, 4 and 5 give the possible distribution of functions in a flexible access system.



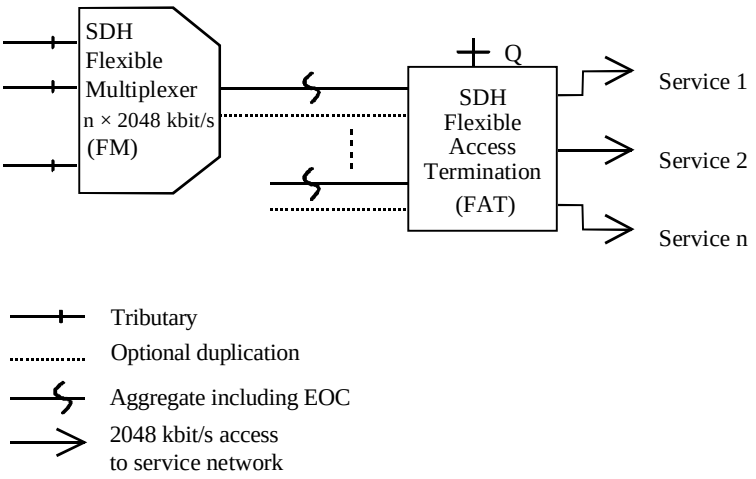
a) Functional view



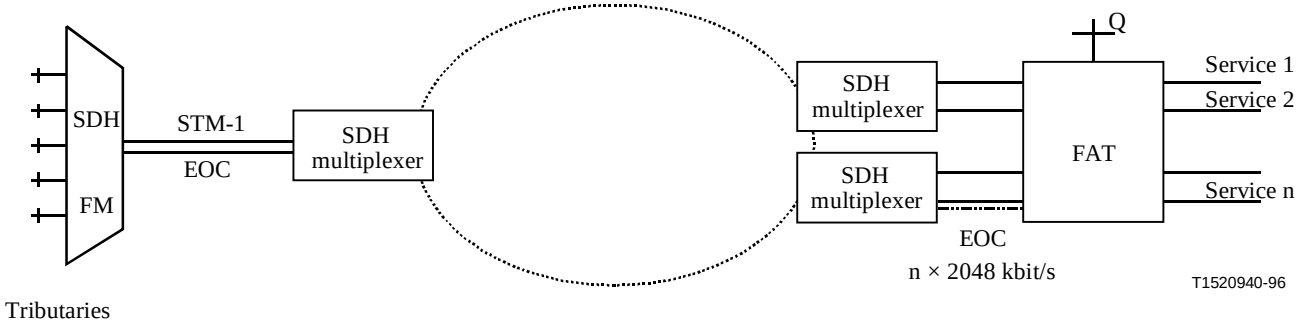
b) Access structure

Figure 1/G.785 – 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 the SDH multiplexer of type I.2 described in Recommendation G.782.



a) Functional view



b) Access structure

Figure 2/G.785 – 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) includes digital cross connect equipment (DXC) functions. The characteristics of cross connect equipment may be found in Recommendation G.796.

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 or with any other specific interface shall be covered by the flexible access termination. In that situation the flexible access termination includes functions similar to the flexible multiplexer as described in Recommendation G.797.

The possible combinations of elementary functions covering the presented requirements are described in the Figures 3, 4 and 5.

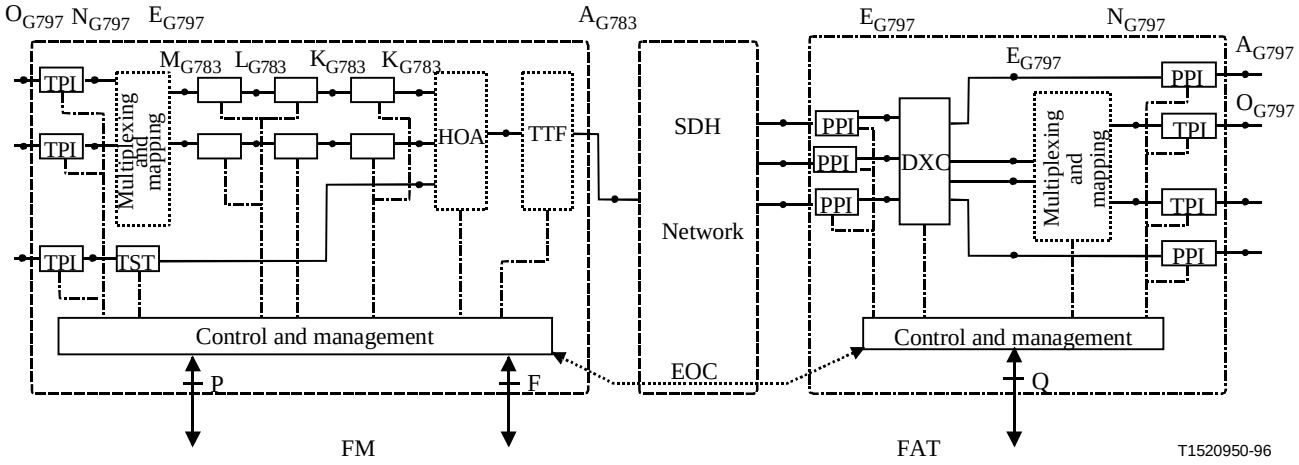


Figure 3/G.785 – FM with mulitservice 2048 kbit/s SDH transport/FAT

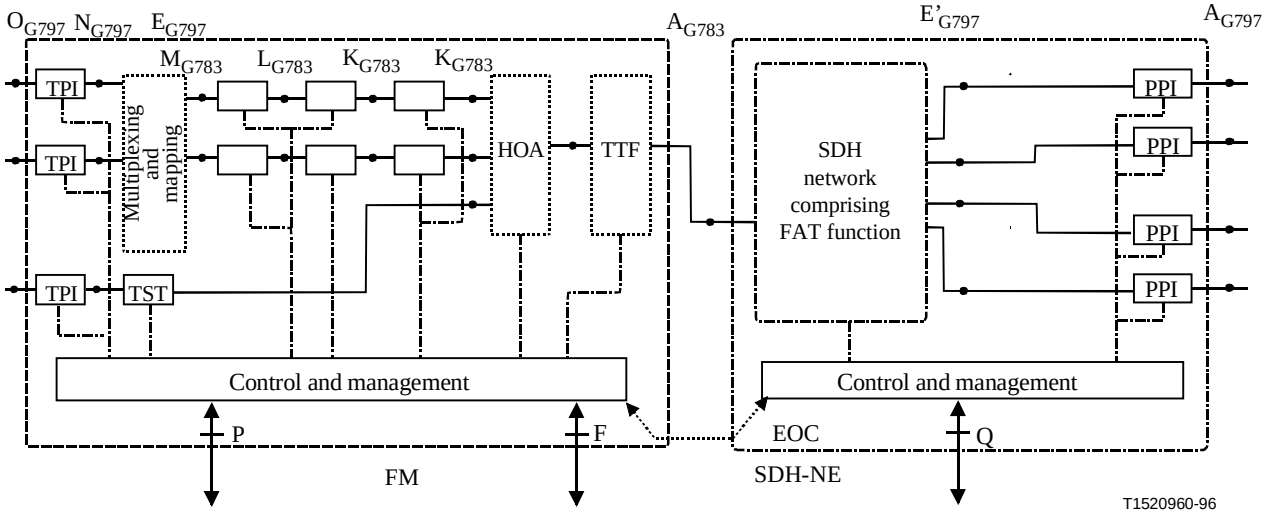


Figure 4/G.785 – FM with mulitservice 2048 kbit/s SDH transport including the FAT function

NOTE 1 – Figure 4 describes splitting of Flexible Access system (FA) functions where it is assumed that SDH components are able to arrange or re-arrange 64 and n × 64 kbit/s and any corresponding signalling within 2048 kbit/s G.704 framed signals. SDH equipment also provides necessary QAF to relay management information from the EOC to the Q interface.

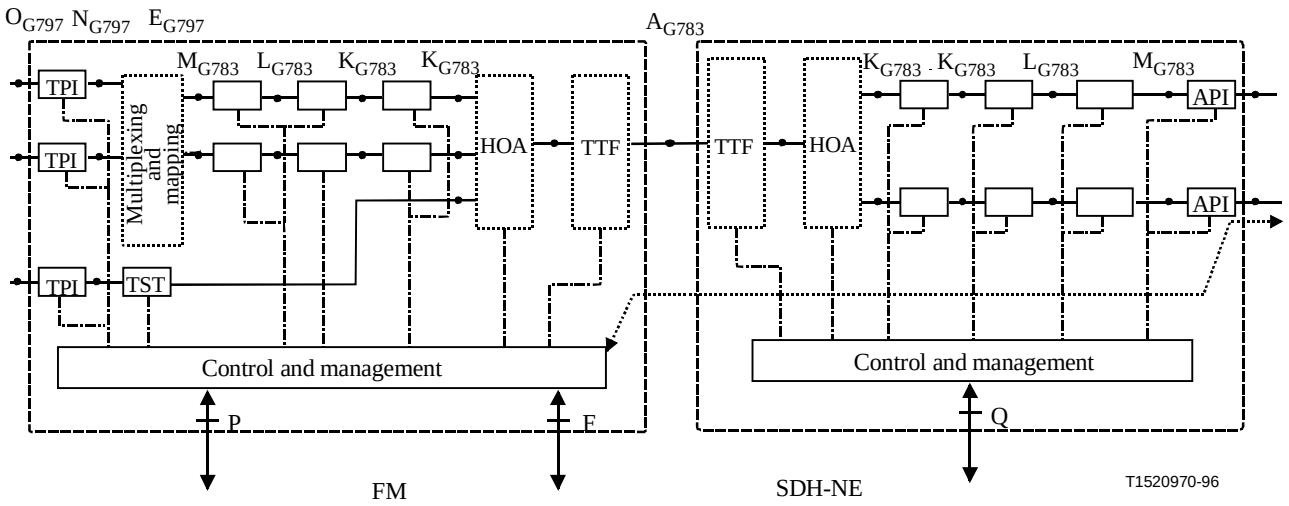


Figure 5/G.785 – FM with monoservice 2048 kbit/s SDH transport/no FAT

NOTE 2 – The reference points to Figures 3, 4 and 5 except those related to the management interfaces, are defined in clause 3.

The flexible multiplexer is dependent on the FAT on control point of view. Alternatively, the EOC providing access to the management functions for the flexible multiplexer may be terminated in a SDH-NE or forwarded to a service network.

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.

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 VC-12 or STM-1.

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 STM-1 signal;

c) an internal oscillator with an accuracy of frequency of ±4.6 ppm according to Recommendation G.813 on timing characteristics of SDH Equipment slave Clocks (SECs).

NOTE 1 – The internal oscillator should not be used as a primary timing source when the flexible multiplexer is connected to the synchronous network.

NOTE 2 – The provision of the timing signal to an output of synchronization interface for the purpose of synchronizing other 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, preferably from case a) to case b) and then to case c) as the last possibility.

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

2 Functions

2.1 Mapping

The mapping function comprises a two-step process. The first relates to the allocation of time slot(s) in any 2048 kbit/s G.704 framed aggregate signal to any tributary signal. This mapping function is based on Recommendation G.704. The second relates to the association of the 2048 kbit/s G.704 framed signals to a given VC-12. This two-step process is completed by multiplexing the VC-12 into a STM-1. This is based on Recommendation G.707.

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 for further study.

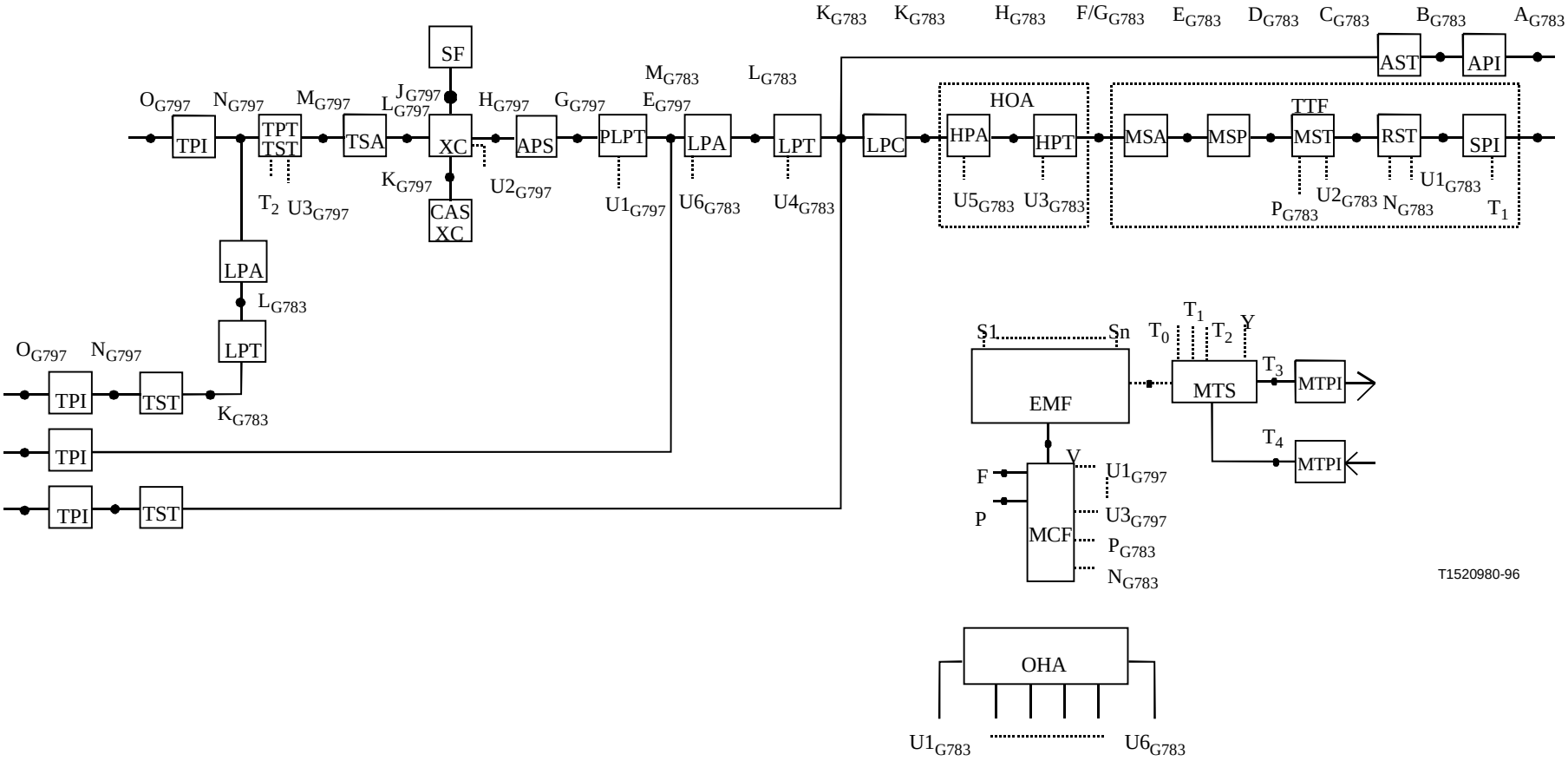
2.4 Management

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 6 describes the functional representation of a flexible multiplexer in a SDH environment and locates appropriate reference points.



NOTE 1 – T_0 is distributed to all functional blocks.
NOTE 2 – All functional blocks are not always necessary.
NOTE 3 – All functional blocks exchange management information with the EMF functional block via a S_i Reference Point.
NOTE 4 – Not all necessary self-understanding functions, e.g. internal code conversion or line protection, are described in Figure 6.
NOTE 5 – Any reference point X can be divided into two reference points, X1 and X2. X1 relates to the O_{G797} to A_{G783} direction and X2 relates to the A_{G783} to O_{G797} direction.

Figure 6/G.785 – General functional block diagram

3.2 Definition of functional blocks

3.2.1 Common blocks

3.2.1.1 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.

For SDH functions, the EMF function converts performance and alarm-related data into object-oriented messages for transmission over the DCC(s) and/or a Q interface. It also converts object-oriented messages related to other management functions for passing across the Sn reference points.

3.2.1.2 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.

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

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

3.2.2 Functional blocks defined in Recommendation G.797

3.2.2.1 plesiochronous physical interface (PPI) (see Figures 3, 4 and 5): The plesiochronous physical interface concerns the aggregate interface, terminating the related transmission system. When appropriate, it also extracts clock signal from the received signal.

3.2.2.2 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.

3.2.2.3 aggregate physical interface (API): The aggregate physical interface concerns a variety of G.703 interfaces terminating the corresponding digital transmission section. It also extracts clock signal from the received signals.

3.2.2.4 aggregate signal termination (AST): This function generates or terminates information signal.

3.2.2.5 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.

3.2.2.6 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.

3.2.2.7 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.

3.2.2.8 tributary path termination/tributary signal termination TPT/TST: This function is similar to a 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.

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

3.2.2.10 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.

3.2.2.11 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.

3.2.3 Functional blocks defined in Recommendation G.782

NOTE – The following definitions are taken from Recommendation G.782. They are relevant in the context of SDH-related Recommendations. For a more complete definition of the functional blocks, see Recommendation G.783.

3.2.3.1 higher order path adaptation (HPA): The HPA function adapts a lower order VC (VC-12 in the context of this Recommendation) to a higher order VC (VC-4 in the context of this Recommendation) by processing the TU pointer, which indicates the phase of the first byte of VC-1/2/3 POH relative to the first byte of VC-3/4 POH, and assembling/disassembling the complete VC-3/4.

3.2.3.2 higher order path termination (HPT): The HPT function terminates a higher order path by generating and adding the appropriate VC POH to the relevant container or assembly of TUGs at the path source and removing the VC POH and reading it at the path sink.

3.2.3.3 lower order path adaptation (LPA): The LPA function adapts a PDH signal to an SDH network by mapping/de-mapping the signal into/out of a synchronous container. If the signal is asynchronous, the mapping process will include bit level justification.

3.2.3.4 LPC: The LPC function provides for flexible interconnection of lower order VCs.

3.2.3.5 lower order path termination (LPT): The LPT function terminates a lower order path by generating and adding the appropriate VC POH to the relevant container at the path source, removing the VC POH and reading it at the path sink.

3.2.3.6 multiplex section adaptation (MSA): The MSA function processes the AU-3/4 pointer to indicate the phase of the first byte of VC-3/4 POH relative to the first byte of STM-N SOH and assembles/disassembles the complete STM-N frame.

3.2.3.7 multiplex section protection (MSP): The MSP function provides capability for switching a signal between and including two MST functions, from a working to a protection section.

3.2.3.8 multiplex section termination (MST): The MST function generates the MSOH in the process of forming an SDH frame signal and terminates the MSOH in the reverse direction.

3.2.3.9 overhead access (OHA): The OHA function provides integrated access to transmission overhead functions such as order wire.

3.2.3.10 regenerator section termination (RST): The RST function generates the RSOH in the process of forming an SDH frame signal and terminates the RSOH in the reverse direction.

3.2.3.11 SDH physical interface (SPI): The SPI function converts an internal logic level STM-N signal into an STM-N interface signal and vice versa.

3.3 Definition of reference points

3.3.1 Common reference points

F A management interface connecting workstation to the OSF or the MF according to Recommendation M.3010.

P User management interface for local operation (not to be standardized).

S_i Management points.

T_0 Internal timing signal.

T_1 Synchronization signal derived from a STM-N aggregate signal.

T_2 Synchronization signal derived from a tributary signal.

T_3,T_4 2048 kHz external synchronization signal.

V Information serving for external management.

3.3.2 Reference points defined in Recommendation G.797

E_{G797} Multiservice 2048 kbit/s logical signal.

E'_{G797} Monoservice 2048 kbit/s logical signal.

G_{G797},H_{G797} 2048 kbit/s G.704 logical framed signal.

J_{G797} Access to optional special functions.

K_{G797} Access to optional CAS cross connection.

L_{G797} G.704 formatted 64 or n × 64 kbit/s signal.

M_{G797} Logical and/or electrical signal to be transmitted including any control or signalling.

N_{G797} Logical and/or electrical signal to be transmitted including any control or signalling.

O_{G797} Tributary line signal according to the relevant ITU-T Recommendation.

$U1_{G797}$,$U3_{G797}$ 4 kbit/s EOC.

$U2_{G797}$ 64 kbit/s EOC.

3.3.3 Reference points defined in Recommendation G.783

A_{G783} See Recommendation G.783.

B_{G783} See Recommendation G.783.

C_{G783} See Recommendation G.783.

D_{G783} See Recommendation G.783.

E_{G783} See Recommendation G.783.

F_{G783} See Recommendation G.783.

G_{G783} See Recommendation G.783.

H_{G783} See Recommendation G.783.

K_{G783} See Recommendation G.783.

L_{G783} See Recommendation G.783.

M_{G783} See Recommendation G.783.

N_{G783} See Recommendation G.783.

P_{G783} See Recommendation G.783.

$U1_{G783}$ See Recommendation G.783.

$U2_{G783}$ See Recommendation G.783.

$U3_{G783}$ See Recommendation G.783.

$U4_{G783}$ See Recommendation G.783.

$U5_{G783}$ See Recommendation G.783.

Y_{G783} See Recommendation G.783.

4 Tributary interfaces

All tributary interfaces described in Recommendation G.797 may be supported.

In addition a flexible multiplexer in a SDH environment may also provide a function for the transfer of a VC-12 signal by the means of an integrated baseband line tributary interface. The characteristics of the corresponding tributary interface are given in the V-Series Recommendations specifying digital DCE functions.

5 Aggregate interfaces

5.1 SDH STM-1 interface

The STM-1 interface is provided for the transport of up to 63 × VC-12. Only essential functional blocks concerned by this application have been retained from Recommendation G.783. These are the LPA, LPT, LPC, HPA, HPT, MSA, MSP, MST, RST, OHA and SPI functional blocks (See Figure 6).

5.2 VC-12 integrated baseband line interface

The VC-12 integrated baseband line interface is provided for the transport of a single VC-12 on a line transmission system. This is defined in the V-Series Recommendations.

6 Synchronization interface at 2048 kHz

The physical/electrical characteristics of the synchronization interface at 2048 kHz shall be according to clause 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 d.c. 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

Defect or failure conditions and consequent actions related to tributary interfaces described in Recommendation G.797 should be referred for this Recommendation. Additional defect or failure conditions and consequent actions for the VC-12 integrated baseband line tributary interface are given in 9.1 and 9.2.

9.1 Defect or failure conditions for a VC-12 integrated baseband line tributary interface

The corresponding requirements are described in the V-Series Recommendations.

9.2 Consequent actions for a VC-12 integrated baseband line tributary interface

The corresponding requirements are described in the V-Series Recommendations.

10 Defect or failure conditions and consequent actions for the aggregate interfaces

10.1 Defect or failure conditions

10.1.1 STM-1 interface

For the defect or failure conditions concerning the SDH functional blocks, references should be made as following:

LPA (see Note).

LPT (see Note).

LPC not applicable.

HPA (see Note).

HPT (see Note).

MSA (see Note).

MSP (see Note).

MST (see Note).

RST (see Note).

SPI (see Note).

NOTE – Defect or failure conditions to be detected should be taken from Recommendation G.783.

10.1.2 VC-12 Integrated baseband line interface

The corresponding requirements are described in the V-Series Recommendations.

10.2 Consequent actions

10.2.1 STM-1 interface

For the consequent actions concerning the SDH functional blocks, references should be made as following:

LPA (see Note).

LPT (see Note).

LPC not applicable.

HPA (see Note).

HPT (see Note).

MSA (see Note).

MSP (see Note).

MST (see Note).

RST (see Note).

SPI (see Note).

NOTE – Consequent actions to defect or failure conditions should be taken in accordance with Recommendation G.783.

10.2.2 VC-12 Integrated baseband line interface

The corresponding requirements are described in the V-Series Recommendations.

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

11.1 Defect or failure conditions

The equipment should detect the conditions defined in 11.1/G.797. In a SDH environment the following condition:

Loss of synchronization signals should also be detected according to Recommendation G.783.

11.2 Consequent actions

The equipment should apply the consequent actions defined in 11.2/G.797. In a SDH environment the consequent actions to the loss of synchronization signals should also be applied according to Recommendation G.783.

12 Performance monitoring

The equipment should monitor the error performance of 2048 kbit/s G.704 framed signals.

The following short-term performance indications can be derived from error events and other defect or failure conditions:

– unavailable time;

– degraded performance;

– unacceptable performance.

The strategy to determine these 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

When applicable, the requirements for jitter performance contained in Recommendations G.825, G.783 and G.958 shall be met for the SDH interface.

For the 2048 kbit/s tributary interface, reference is made to 13.1.4.1, 13.1.4.2 and 12.1.4.3 of Recommendation G.797.

For the 64 kbit/s tributary interface, reference is made to 13.1.5/G.797.

13.2 Transfer delay

This performance parameter is applicable to digital tributary signals. For the PDH part of the flexible multiplexer the transfer delay shall not exceed 650 µs for 64 and n × 64 kbit/s signals and 7 ms for associated signalling signal. These values refer to reference points O_{G797} and E_{G797}. For the SDH part of the flexible multiplexer the transfer delay for the 2048 kbit/s signals shall not exceed 125 µs. This value applies to the reference points M_{G783} and A_{G783}.

The performance parameter for the transfer delay through the VC-12 baseband tributary and aggregate interfaces is given in the V-Series Recommendations.

13.3 Slips

Three situations need to be considered:

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

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

iii) The timing signal and the relevant input signal are independently timed as a result of loss of all synchronization signals: depending on the way the flexible multiplexer is synchronized it is possible to select one of the two following options derived from Recommendation G.796:
   - for the first 24 hours, no more than 10 controlled slips per hour (flexible multiplexer with only one external synchronization signal);
   - for the first 24 hours, no more than 300 controlled slips per hour (flexible multiplexer with several independent external synchronization signals).

13.4 Service availability

This performance parameter concerns the availability of connection to a service network and 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 a service connection availability, it may be necessary to make use of Automatic Protection Switch (APS) function as shown in Figure 6 and described in Recommendation G.797.

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 $A1_{G783}$ and $O2_{G797}$ (respectively $O1_{G797}$ and $A2_{G783}$) 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 should be taken from Recommendation G.784.

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