INTERNATIONAL TELECOMMUNICATION UNION

CCITT

G.782

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

GENERAL ASPECTS OF DIGITAL
TRANSMISSION SYSTEMS;
TERMINAL EQUIPMENTS

TYPES AND GENERAL CHARACTERISTICS OF SYNCHRONOUS DIGITAL HIERARCHY (SDH) MULTIPLEXING EQUIPMENT

Recommendation G.782

Geneva, 1990

FOREWORD

The CCITT (the International Telegraph and Telephone Consultative Committee) is a permanent organ of the International Telecommunication Union (ITU). CCITT is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The Plenary Assembly of CCITT which meets every four years, establishes the topics for study and approves Recommendations prepared by its Study Groups. The approval of Recommendations by the members of CCITT between Plenary Assemblies is covered by the procedure laid down in CCITT Resolution No. 2 (Melbourne, 1988).

Recommendation G.782 was prepared by Study Group XV and was approved under the Resolution No. 2 procedure on the 14 of December 1990.

CCITT NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication Administration and a recognized private operating agency.

Recommendation G. 782

TYPES AND GENERAL CHARACTERISTICS OF SYNCHRONOUS DIGITAL HIERARCHY (SDH) MULTIPLEXING EQUIPMENT

The CCITT,

considering

(a) that Recommendations G.707, G.708 and G.709 form a coherent set of specifications for the synchronous digital hierarchy (SDH) and the network node interface (NNI);

(b) that Recommendation G.781 gives the structure of Recommendations on multiplexing equipment for the SDH;

(c) that Recommendation G.783 specifies the characteristics of SDH multiplexing equipment functional blocks;

(d) that Recommendation G.784 addresses management aspects of the SDH;

(e) that Recommendation G.957 specifies characteristics of optical interfaces for use within the SDH;

(f) that Recommendation G.958 specifies digital line systems based on the SDH for use on optical fibre cables;

(g) that Recommendation G.703 describes electrical interfaces for use within the SDH,

recommends

that SDH multiplexing equipment should have general characteristics as described in this Recommendation.

1 Introduction

1.1 *Scope*

Recommendation G.781 gives the structure of Recommendations on SDH multiplexers. This Recommendation gives an overview of the functions of SDH multiplexing equipment, examples of various multiplexing equipment types and general performance requirements.

The possibilities of add/drop features, mixed payloads and flexible tributary/channel associations in SDH multiplexers make it difficult to provide a Recommendation which is unambiguous while remaining generic enough not to constrain implementation. To overcome these difficulties, the "functional reference model" approach has been adopted. Therefore this series of Recommendations describes the equipment in terms of various functional blocks. This logical partitioning is used to simplify and generalize the description. It does not imply any physical partitioning or implementation.

Only external interface requirements will be specified. For payloads these will conform to either STM-N (according to Recommendations G.707, G.708 and G.709) or Recommendation G.703. The interface to the transmission management network (TMN) will conform to Recommendation G.773. The points between function blocks exist only as logical reference points and not as internal interfaces; there is therefore no interface description or interface specification associated with these points.

1.2 *Abbreviations*

AIS	Alarm indication signal
AU	Administrative unit
AUG	Administrative unit group
DCC	Data communications channel
FEBE	Far end block error
FERF	Far end receive failure
HPA	Higher order path adaptation
HPC	Higher order path connection
HPT	Higher order path termination
LPA	Lower order path adaptation
LPC	Lower order path connection
LPT	Lower order path termination
MCF	Message communications function
MSOH	Multiplex section overhead
MSP	Multiplex section protection
MST	Multiplex section termination
MTPI	Multiplexer timing physical interface
MTS	Multiplexer timing source
NNI	Network node interface
NOMC	Network operators maintenance channel
PDH	Plesiochronous digital hierarchy
PI	Physical interface
POH	Path overhead
RSOH	Regenerator section overhead
RST	Regenerator section termination
SA	Section adaptation
SDH	Synchronous digital hierarchy
SEMF	Synchronous equipment management function
SOH	Section overhead
SPI	SDH physical interface
STM	Synchronous transport module
TMN	Telecommunications management network
TU	Tributary unit
TUG	Tributary unit group
VC	Virtual container

1.3 *Definitions*

Note — The following definitions are relevant in the context of SDH-related Recommendations.

1.3.1 *Administrative unit (AU)*

See Recommendation G.708.

1.3.2 *Administrative unit group (AUG)*

See Recommendation G.708.

1.3.3 *Data communications channel (DCC)*

See Recommendation G.784.

1.3.4 **higher order path**

In an SDH network, the higher order (HO) path layers provide a server network for the lower order (LO) path layers. The comparative terms lower and higher refer only to the two participants in such a client/server relationship. VC-1/2 paths may be described as lower order in relation to VC-3 and VC-4 while the VC-3 path may be described as lower order in relation to VC-4.

1.3.5 **higher order path adaptation (HPA)**

The HPA function adapts a lower order VC (VC-1/2/3) to a higher order VC (VC-3/4) by processing the TU pointer which indicates the phase of the VC-1/2/3 POH relative to the VC-3/4 POH and assembling/disassembling the complete VC-3/4.

1.3.6 **higher order path connection (HPC)**

The HPC function provides for flexible assignment of higher order VCs (VC-3/4) within an STM-N signal.

1.3.7 **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 at the path source and removing the VC POH and reading it at the path sink.

1.3.8 *Lower order path*

See higher order path above.

1.3.9 **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.

1.3.10 **lower order path connection (LPC)**

The LPC function provides for flexible assignment of lower order VCs in a higher order VC.

1.3.11 **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.

1.3.12 *Message communications function (MCF)*

See Recommendation G.784.

1.3.13 **multiplex section overhead (MSOH)**

The MSOH comprises rows 5 to 9 of the SOH of the STM-N signal.

1.3.14 **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.

1.3.15 **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.

1.3.16 **multiplexer timing physical interface (MTPI)**

The MTPI function provides the interface between an external synchronization signal and the multiplexer timing source.

1.3.17 **multiplexer timing source (MTS)**

The MTS function provides timing reference to the relevant component parts of a multiplexing equipment and represents the SDH network element clock.

1.3.18 *Path overhead (POH)*

See Recommendation G.708.

1.3.19 **regenerator section overhead (RSOH)**

The RSOH comprises rows 1 to 3 of the SOH of the STM-N signal.

1.3.20 **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.

1.3.21 **section adaptation (SA)**

The SA function processes the AU-3/4 pointer to indicate the phase of the VC-3/4 POH relative to the STM-N SOH and assembles/disassembles the complete STM-N frame.

1.3.22 *Synchronous digital hierarchy (SDH)*

See Recommendation G.707.

1.3.23 **synchronous equipment management function (SEMF)**

The SEMF converts performance data and implementation specific hardware alarms 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.

1.3.24 *Section overhead (SOH)*

See Recommendation G.708.

1.3.25 **SDH physical interface (SPI)**

The SPI function converts an internal logic level STM-N signal into an STM-N line interface signal.

1.3.26 *Synchronous transport module (STM)*

See Recommendation G.708.

1.3.27 *Telecommunications management network (TMN)*

See Recommendation M.30.

1.3.28 *Tributary unit (TU)*

See Recommendation G.708.

1.3.29 *Tributary unit group (TUG)*

See Recommendation G.708.

1.3.30 *Virtual container (VC)*

See Recommendation G.708.

2 Overview of equipment functions

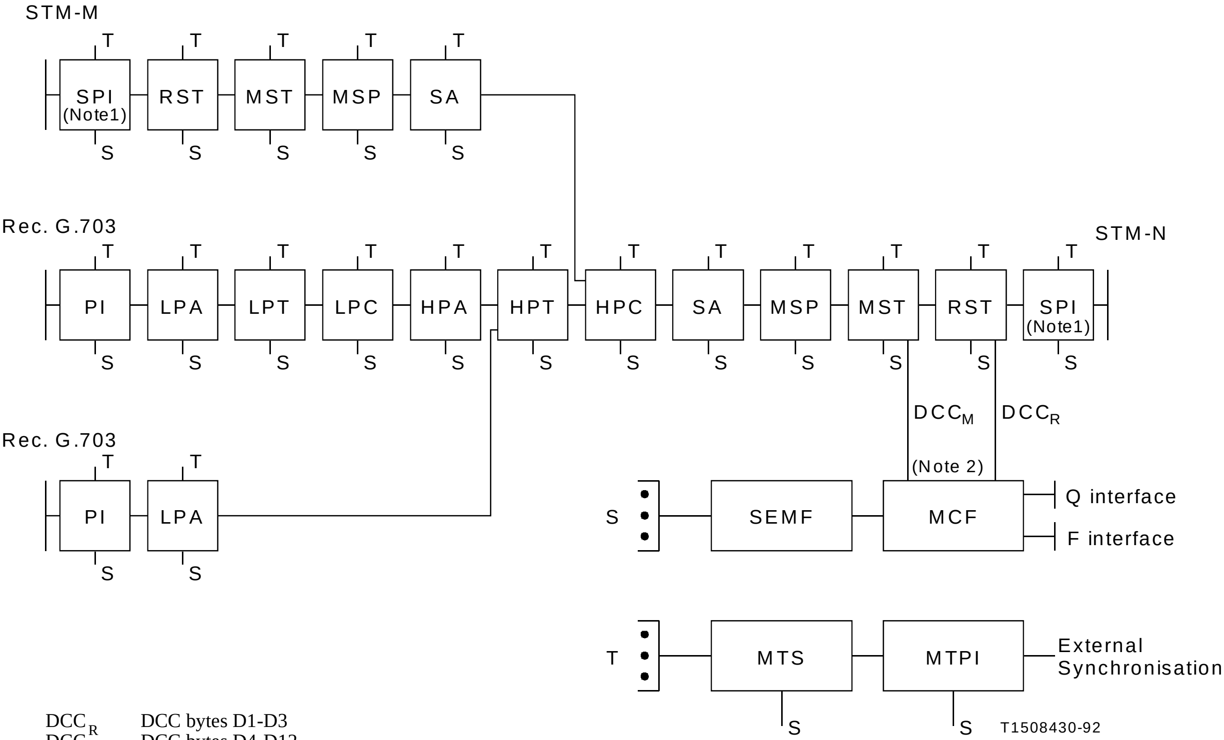
2.1 *Multiplexing method*

2.1.1 *Generalized logical blocks*

Figure 2-1/G.782 is a generalized Multiplexer Logical Block Diagram. It illustrates the steps that are required to assemble various payloads and multiplex them into an STM-N output. It does not represent a useful or practical network function. Examples of some configurations that may be deployed are given in § 3.

The only function blocks that are payload specific are the physical interface/path adaptation blocks used at the G.703 interfaces; all other functions are non-payload specific. Therefore all operations functions, except those associated with G.703 interfaces, are payload independent. New payload types can be added by providing a new interface function; all other parts of the system will be unaffected.

A brief description of the signal flow between a Recommendation G.703 interface and the STM-N output is provided in §§ 2.1.2 and 2.1.3. Description of functions performed by each of the logical blocks in Figure 2-1/G.782 is provided in Recommendations G.783 and G.784. Further descriptions of the synchronous equipment management function (SEMF) and message communications function (MCF) are given in § 2.2 and descriptions of the multiplexer timing source (MTS) and multiplexer timing physical interface (MTPI) are given in § 4.



DCC$_R$	DCC bytes D1-D3
DCC$_M$	DCC bytes D4-D12
HPA	Higher order path adaptation
HPC	Higher order path connection
HPT	Higher order path termination
LPA	Lower order path adaptation
LPC	Lower order path connection
LPT	Lower order path termination
MCF	Message communications function
MSP	Multiplex section protection
MST	Multiplex section termination
MTPI	Multiplexer timing physical interface
MTS	Multiplexer timing source
PI	Physical interface
RST	Regenerator section termination
S	Monitor points, alarms, controls
SA	Section adaptation
SEMF	Synchronous equipment management function
SPI	SDH physical interface
T	Timing

Note 1 – SPI options – in-station electrical
– in station optical
– inter-station optical.

Note 2 – DCC$_M$ may alternatively be passed via the OHA function as described in Recommendation G.783.

FIGURE 2-1/G.782

Generalized multiplexer logical block diagram

2.1.2 *Signal flow G.703 input to STM-N output: multiplexing*

Physical interface/ lower order path adaptation	Provides the appropriate G.703 interface and maps the payload into the container as specified in Recommendation G.709.
Lower order path termination	Adds the VC path overhead (VC-POH).
Lower order path connection	Allows flexible assignment of the VC-1/2 within the VC-3/4.
Higher order path adaptation	Processes the TU pointer to indicate the phase of the VC-1/2 POH relative to the VC-3/4 POH and assembles the complete VC-3/4.
Higher order path termination	Adds the VC-3/4 path overhead.
Higher order path connection	Allows flexible assignment of the VC-3/4 within the STM-N.

Section adaptation	Processes the AU-3/4 pointer to indicate the phase of the VC-3/4 POH relative to the STM-N SOH. Byte-multiplexes the AU Groups (AUGs) to construct the complete STM-N frame.
Multiplex section protection	Provides capability for branching the signal onto another line system for protection purposes.
Multiplex section termination	Generates and adds rows 5 to 9 of the SOH.
Regenerator section termination	Generates and adds rows 1 to 3 of the SOH; the STM-N signal is then scrambled except for row 1 of the SOH.
SDH physical interface	Converts the internal logic level STM-N signal into an STM-N interface signal. This may be an in-station electrical signal, an in-station optical signal or an inter-station optical signal.

2.1.3 *Signal flow STM-N input to G.703 output: demultiplexing*

SDH physical interface	Converts the interface signal into an internal logic level and recovers timing from the line signal.
Regenerator section termination	Identifies the STM-N frame word, descrambles the signal, and processes rows 1 to 3 of the SOH.

The remaining operations are the inverse of those performed when multiplexing except that the C-1/2 interface function must provide a buffer store and smoothing circuit to attenuate the clock jitter caused by the multiplex process, pointer moves and bit stuffing (if applicable).

2.2 *Operations, administration, maintenance and provisioning (OAM&P)*

2.2.1 *Overhead applications*

Recommendation G.708 specifies bandwidth allocated within the SDH frame structure for various control and maintenance functions. Two types of overhead are identified: Virtual Container Path Overhead (VC-POH) and Section Overhead (SOH).

2.2.1.1 *POH application*

Details of the functions provided by the POH are contained in Recommendations G.708 and G.709.

The VC-POH is generated and terminated at the point where the payload is assembled or disassembled. It is used for end to end monitoring of the payload and may transit several multiplex and line systems. Some of the VC-POH is completely payload independent, while other parts of the VC-POH are used in specific ways according to the type of payload. In all cases, the VC-POH is independent of user information. Thus it may be monitored at any point within an SDH network to confirm network operation.

2.2.1.2 *SOH application*

The section overhead (SOH) is subdivided into regenerator SOH (RSOH) comprising rows 1 to 3 and multiplex SOH (MSOH) comprising rows 5-9. The MSOH is accessible only at terminal equipments, whereas the RSOH is accessible at both terminal equipments and regenerators.

Details of the functions provided by RSOH and MSOH are given in Recommendation G.708. These functions include performance monitoring and section maintenance and operations functions.

In order to permit regenerators to read from and write to the RSOH without disrupting the primary performance monitoring, the RSOH is excluded from the B2 (BIP-24) calculation. Since B1 is recomputed at each regenerator, fault sectionalization is simplified.

The set of bytes E1, E2, F1 and D1 to D12 is referred to as the network operators maintenance channel (NOMC).

2.2.1.3 *Protection of the Network operators maintenance channel (NOMC)*

In a 1 + 1 protection system, the NOMC will be on both channels. In a 1:n protection system, the NOMC will be on only one channel, normally channel 1. If channel 1 fails, the NOMC will be switched to the protection channel, along with traffic.

It should be noted that failure of channel 1 will result in the loss of the NOMC under the following conditions:

i) the protection channel is carrying extra traffic and a FORCED switch is in operation;

ii) the protection channel is LOCKED OUT.

Loss of the NOMC under conditions i) and ii) above, and in the case of diversely routed protection spans, requires further study.

Bytes K1 and K2 shall be transmitted on the protection channel. In addition, they may also be transmitted on working channels. The receiver must be able to ignore bytes K1 and K2 on any of the working channels.

2.2.1.4 *Maintenance signals*

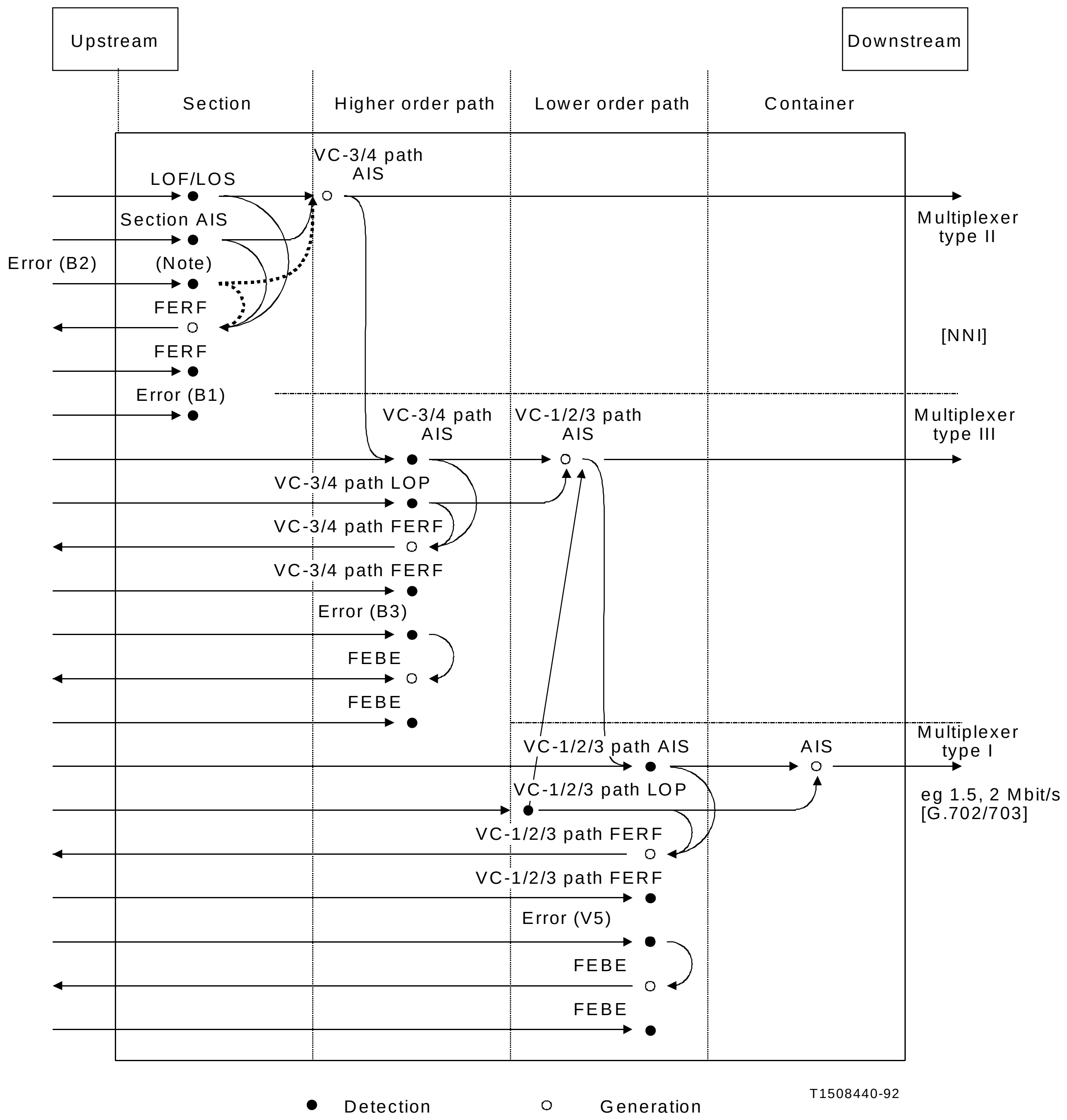
The maintenance signals defined in Recommendation G.709 § 2.3.1 at the section layer are section AIS and far end receive failure (FERF). At the path layer, Recommendation G.709 § 2.3.2 defines path AIS and path status information in the form of path FERF and far end block error (FEBE). These path maintenance signals apply at both higher order and lower order path level. Figure 2-2/G.782 illustrates the layer-to-layer and peer-to-peer maintenance interaction provided in the SDH overhead.

2.2.1.5 *Loss of signal at regenerators*

If a regenerator loses its input signal, a standby clock is activated and a signal containing valid RSOH and MS-AIS is transmitted downstream. This enables the NOMC functions carried by the RSOH to be activated if required.

2.2.2 *TMN access*

SDH multiplexers should provide interfaces for messages to or from the TMN via either the DCC or a Q interface or both. Messages arriving at the interface not addressed to the local multiplex should be relayed to the appropriate Q or DCC interface. The TMN can thus be provided with a direct logical link to any SDH equipment via a single Q interface and the interconnecting DCCs.



LOP Loss of pointer
FEBE Far end block error
LOS Loss of signal
LOF Loss of frame
FREF Far end receive failure

Note – The actions resulting from errors in B2 can be disabled: see description of MST function in Recommendation G.783.

FIGURE 2-2/G.782

SDH maintenance signal interaction

2.2.2.1 *Q -interface*

When access to the TMN is provided by a Q-interface, the interface will conform to Recommendation G.773. A choice has to be made between the B1, B2 and B3 protocol suites specified in that Recommendation.

2.2.2.2 *Data communications channel (DCC)*

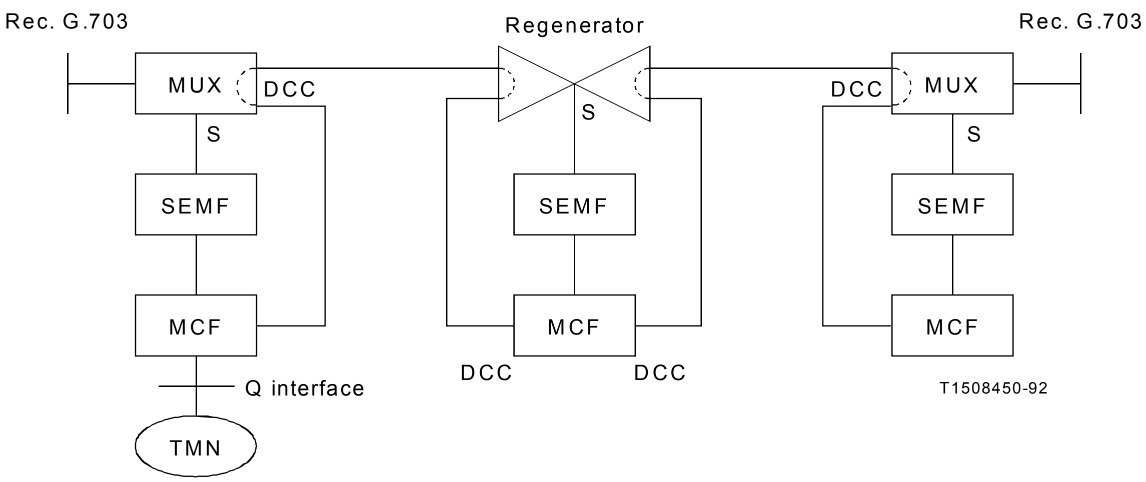
The use of the DCC is dependent on the network operator's maintenance strategy and the specific situation. It may not always be required as it is possible to carry out the required functions by other means.

There are two ways of using the DCC:

i) use of the D1 to D3 bytes located in the RSOH (DCC_R) and accessible at regenerators and other NEs;

ii) use of the D4 to D12 bytes located in the MSOH (DCC_M) and not accessible at regenerators. The specific use of the D4 to D12 bytes is for further study.

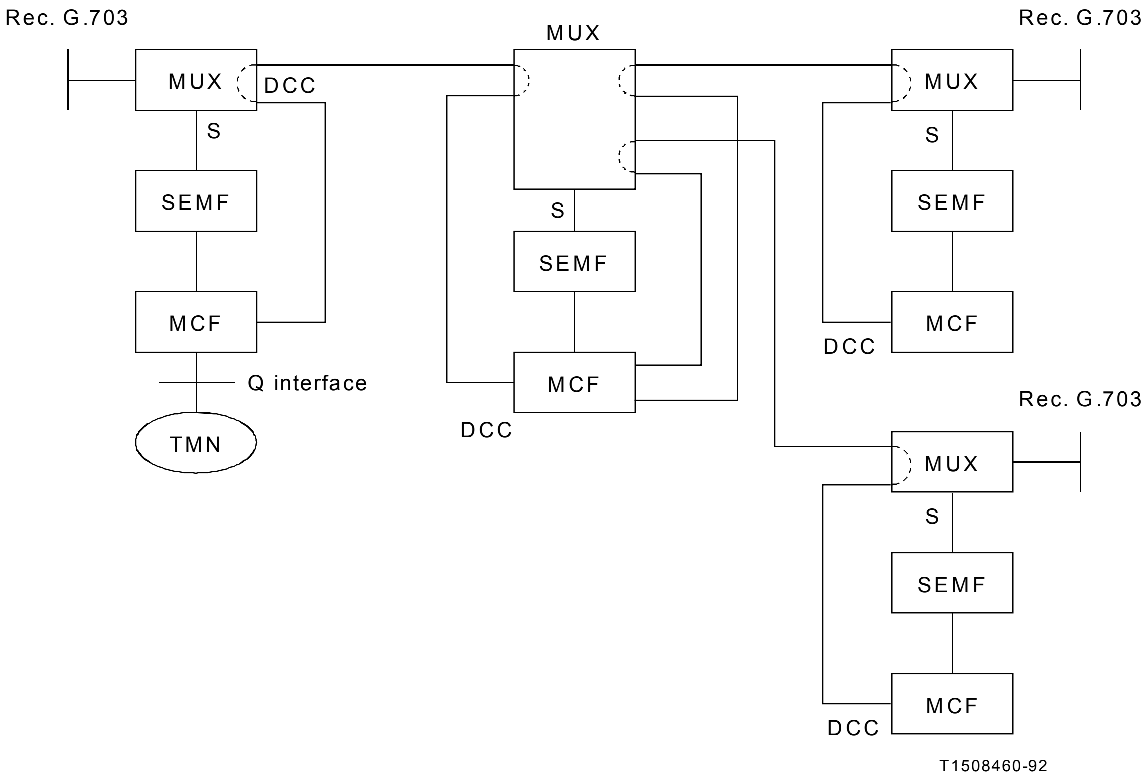
These channels are message based and provide communications between network elements. They can be used to support communications between sites and the TMN. Two examples are given in Figures 2-3/G.782 and 2-4/G.782.



Note – Legend as in Figure 2-1/G.782.

FIGURE 2-3/G.782

SDH linear system configuration



Note – Legend as in Figure 2-1/G.782.

FIGURE 2-4/G.782

SDH tree configuration

2.2.2.3 *Functionalities*

2.2.2.3.1 *Synchronous equipment management function (SEMF)*

This converts performance data and implementation specific hardware alarms into object-oriented messages for transmission on 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.

2.2.2.3.2 *Message communications function (MCF)*

This function receives and buffers messages from the DCC(s), Q-and F-interfaces and SEMF. Messages not addressed to the local site are relayed to one or more outgoing DCC(s) in accordance with local routing procedures and/or Q-interface(s). The function provides layer 1 (and layer 2 in some cases) translation between a DCC and a Q-interface or another DCC interface.

2.2.3 *Order-wire*

Use of the E1 and/or E2 bytes for providing an order-wire is optional. Byte E1 can be accessed at all regenerators and terminals to provide a local order-wire. Byte E2 can only be accessed at terminals and may be used to provide an order-wire between terminal sites.

2.2.4 *User channel*

Use of the F1 byte for providing a special user channel is optional. Byte F1 can be accessed at all regenerators and terminals.

2.3 *STM-N protection switching*

Protection switching of a signal provides a capability, using equipment redundancy and switching action, such that in the event of the failure of a “working” channel, the signal is available via a protection channel.

The use of protection switching is dependent on the network operator's maintenance strategy. It may not always be required. If required on SDH line systems, redundancy is provided for functions and physical medium between, and including, two MST functions, i.e. for the multiplex section. Thus, the Multiplex Section Protection (MSP) function included in multiplexing equipment provides protection for the STM-N signal against failures within a multiplex section.

The MSP function communicates with the corresponding far end MSP function to coordinate the switch action, via a bit-oriented protocol defined for the K bytes of the MSOH. It also communicates with the SEMF for automatic and manual switch control. Automatic protection switching is initiated based on the condition of the received signals. Manual protection switching provides both local and remote switching from commands received via the SEMF. The details of switch initiation, control and operation are described in Recommendation G.783.

2.3.1 *MSP architectures*

Two MSP architectures are defined: 1 + 1 (one plus one) and 1 : n (one for n).

2.3.1.1 *1 + 1 architecture*

In a 1 + 1 MSP architecture shown in Figure 2-5/G.782, the STM-N signal is transmitted simultaneously on both multiplex sections, designated working and protection sections; i.e. the STM-N signal is permanently connected (bridged) to the working and protection sections at the transmitting end. The MSP function at the receiving end monitors the condition of the STM-N signals received from both sections and connects (selects) the appropriate signal. Due to permanent bridging of the working channel, the 1 + 1 architecture does not allow an unprotected extra traffic channel to be provided.

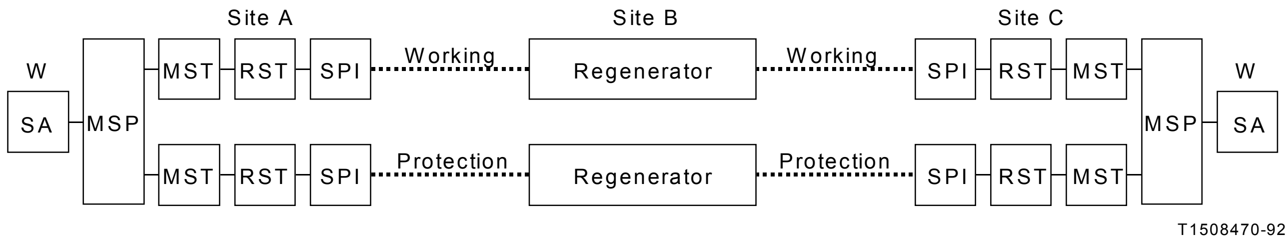


FIGURE 2-5/G.782

1+1 protection switch architecture

2.3.1.2 *1 : n architecture*

In a 1 : n MSP architecture shown in Figure 2-6/G.782, the protection section is shared by a number of working channels; the permitted values for n are 1 through 14. At both ends, any one of the n STM-N channels or an extra traffic channel (or possibly a test signal) is bridged to the protection section. The MSP functions monitor and evaluate the conditions of the received signals and perform bridging and selection of the appropriate STM-N signals from the protection section.

Note that 1 : 1 architecture is a subset of 1 : n (n = 1) and may have the capability to operate as 1 + 1 for interworking with a 1 + 1 architecture at the other end.

2.3.2 *Operation modes*

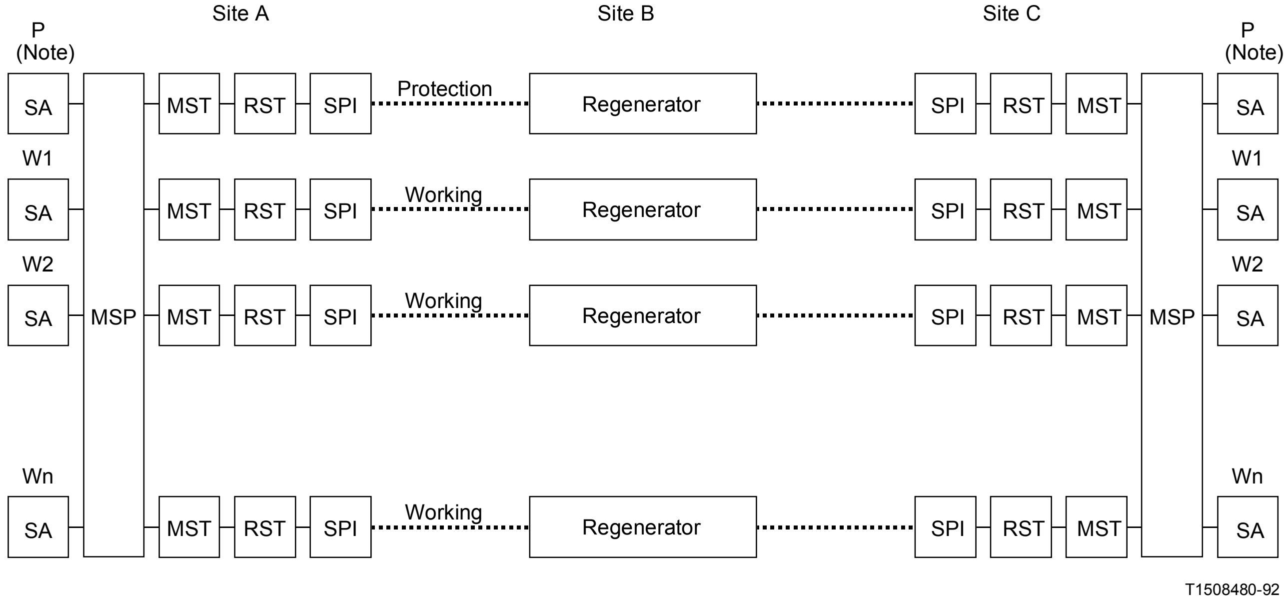
The MSP may operate either bi-directionally or uni-directionally and in either a revertive or non-revertive mode, depending on the network management.

In bi-directional operation, the channel is switched to the protection section in both directions, and switching of only one direction is not allowed. In uni-directional operation, the switching is complete when the channel in the failed direction is switched to protection.

In revertive mode of operation, the working channel is switched back to the working section, i.e. restored, when the working section has recovered from failure. In non-revertive mode of operation, the switch is maintained even after recovery from failure. For 1 : n architectures, only revertive mode is allowed.

2.4 *Integrated interfaces*

Section 3 describes multiplexer configurations for multiplexer functions that may be integrated with the line terminating function. It is envisaged that such direct SDH interfaces will also be provided on other network elements such as digital cross-connects or digital switches. These interfaces may be either intra-station or inter-station.



Note – Needed only for extra traffic.

FIGURE 2-6/G.782

1:n protection switch architecture

3 Multiplexing equipment types

This section provides some examples of equipment configurations and network applications for SDH equipment, based on the generalized multiplexer logical block diagram (Figure 2-1/G.782). The description of these examples is generic and no particular physical partitioning of functions is implied. The examples are not a complete set; other configurations may be useful in other network applications.

3.1 *Type I* (Figure 3-1/G.782)

This provides a simple G.703 to STM-N multiplex function. For example, 63 × 2048 kbit/s signals could be multiplexed to form an STM-1 output or, 12 × 44 736 kbit/s signals could be multiplexed to form an STM-4. The location of each of the tributary signals in the aggregate signal is fixed and dependent on the multiplex structure chosen.

3.2 *Type Ia* (Figure 3-2/G.782)

The ability to provide flexible assignment of an input to any position in the STM-N frame can be provided by including a VC-1/2 and/or VC-3/4 path connection function.

3.3 *Type II* (Figure 3-3/G.782)

This provides the ability to combine a number of STM-N signals into a single STM-M signal. For example, four STM-1 signals (from multiplexers or line systems) could be multiplexed to provide a single STM-4 signal. The location of each of the VC-3/4s of the STM-N signals is fixed in the aggregate STM-M signal.

3.4 *Type IIa* (Figure 3-4/G.782)

The ability to assign flexibly a VC-3/4 on one STM-N to any position in the STM-M frame can be provided by including a VC-3/4 path connection function.

3.5 *Types IIIa and IIIb*

These provide the ability to access any of the constituent signals within an STM-N signal without demultiplexing and terminating the complete signal. The interface provided for the accessed signal could be either according to G.703 or an STM-M (M<N). These are described in more detail below.

3.5.1 *Type IIIa* (Figure 3-5/G.782)

Figure 3-5/G.782 illustrates the case of a Type IIIa multiplexer where access to the constituent signal is via a G.703 interface.

The higher order path connection function allows the VC-3/4 signals within the STM-N signal to be either terminated locally or re-multiplexed for transmission. It also allows the VC-3/4 signals generated locally to be assigned to any vacant position in the STM-N output. The lower order path connection function allows the VC-1/2 signals (from the C-3/4 terminated by the VC-3/4 POH function) to be terminated locally or directly re-multiplexed back into an outgoing C-3/4. The lower order path connection function also allows the locally generated VC-1/2 signals to be routed to any (vacant) position on any outgoing C-3/4.

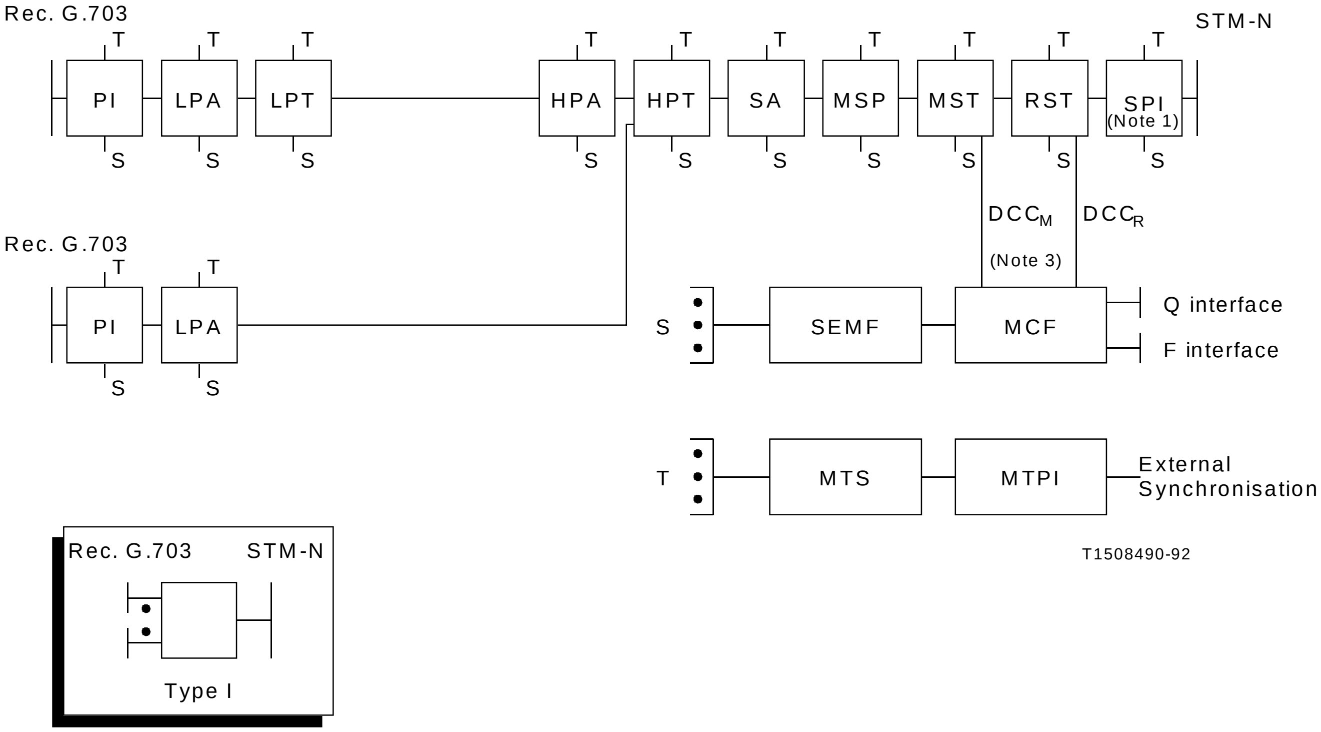
3.5.2 *Type IIIb* (Figure 3-6/G.782)

Figure 3-6/G.782 illustrates the case of a Type IIIb multiplexer where access to the constituent signal is via an STM-M interface.

This type has some additional functions to those required for Type IIIa, namely those for demultiplexing the STM-N signal into VC-1/2 signals.

3.6 *Type IV* (Figure 3-7/G.782)

This provides the translation function to allow C-3 payloads in a VC-3 to transit a network that uses SDH equipment which cannot support AU-3. Information on interworking is given in Recommendation G.708.



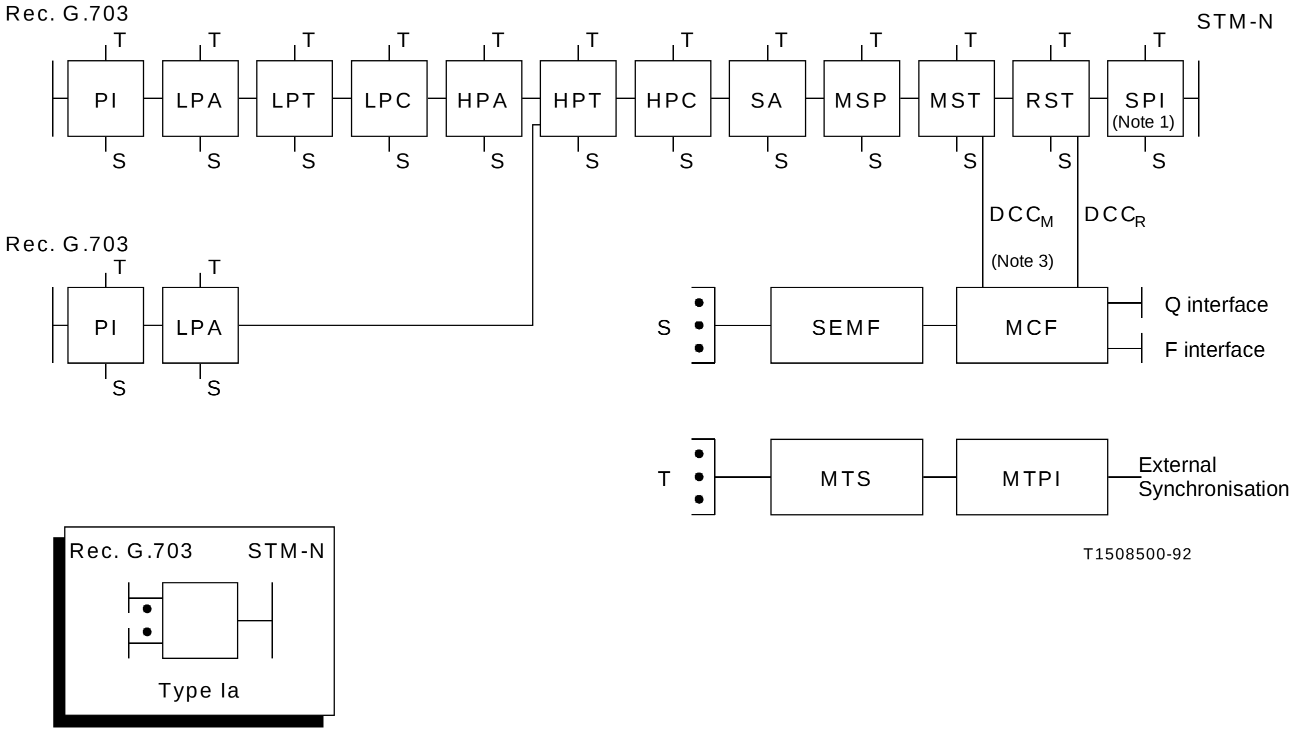
Note 1 – SPI options – In-station electrical
– In-station optical
– Inter-station optical.

Note 2 – Legend: see Figure 2-1/G.782.

Note 3 – DCC$_M$ may alternatively be passed via the OHA function.

FIGURE 3-1/G.782

Multiplexer type I



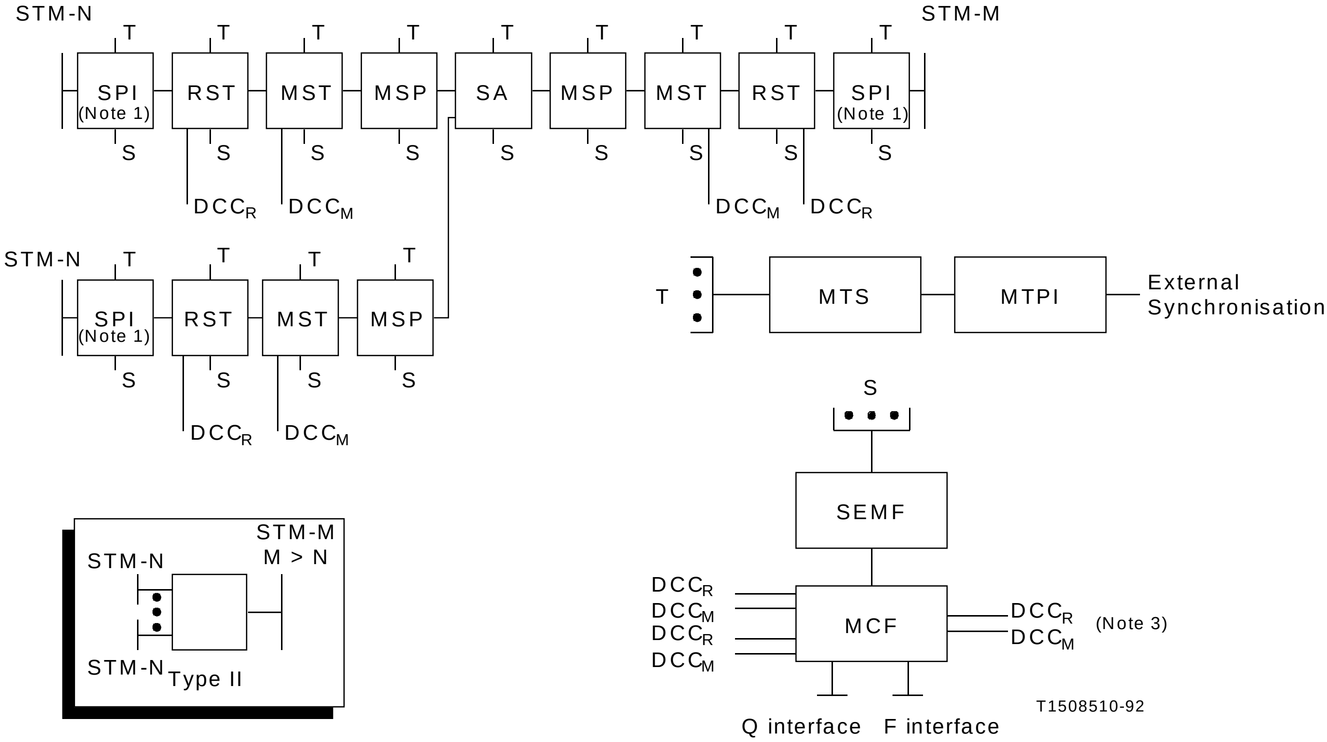
Note 1 – SPI options – In-station electrical
– In-station optical
– Inter-station optical.

Note 2 – Legend: see Figure 2-1/G.782.

Note 3 – DCC_M may alternatively be passed via the OHA function.

FIGURE 3-2/G.782

Multiplexer type Ia



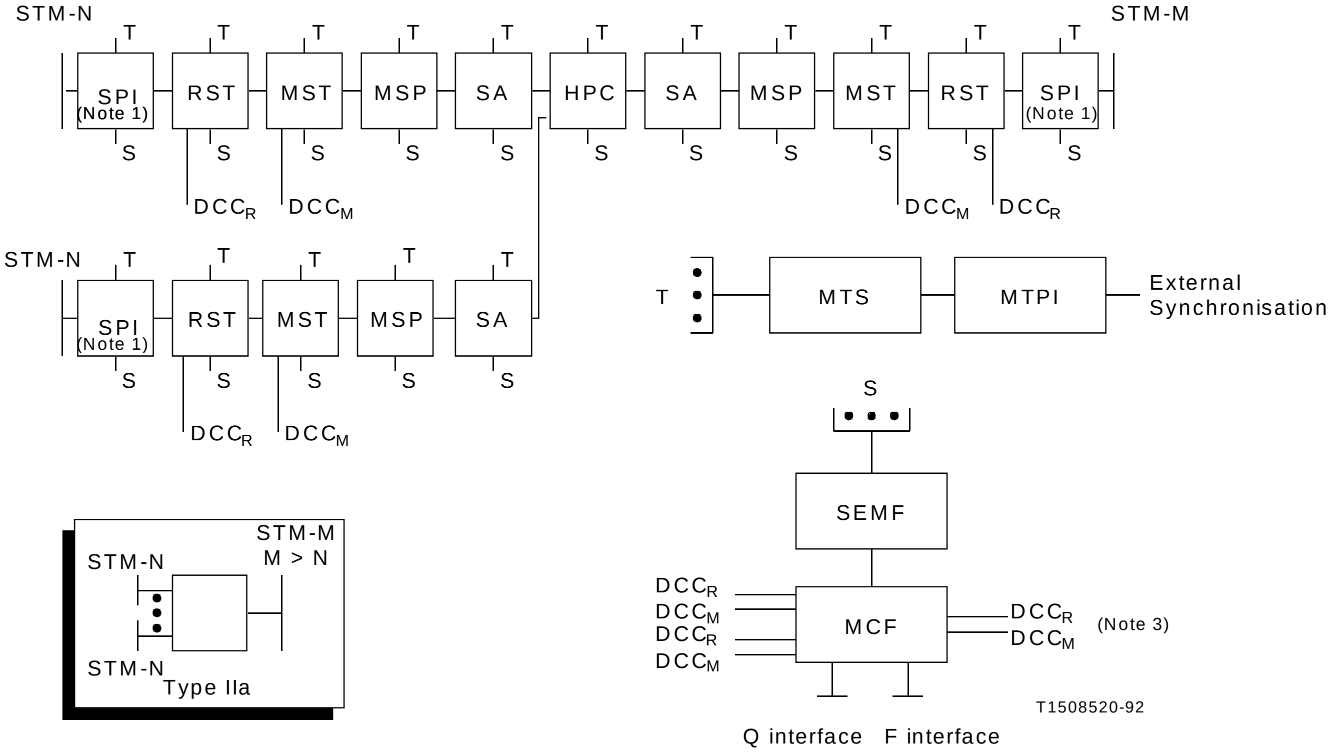
Note 1 – SPI options– In-station electrical
– In-station optical
– Inter-station optical.

Note 2 – Legend: see Figure 2-1/G.782.

Note 3 – DCC_M may alternatively be passed via the OHA function.

FIGURE 3-3/G.782

Multiplexer type II



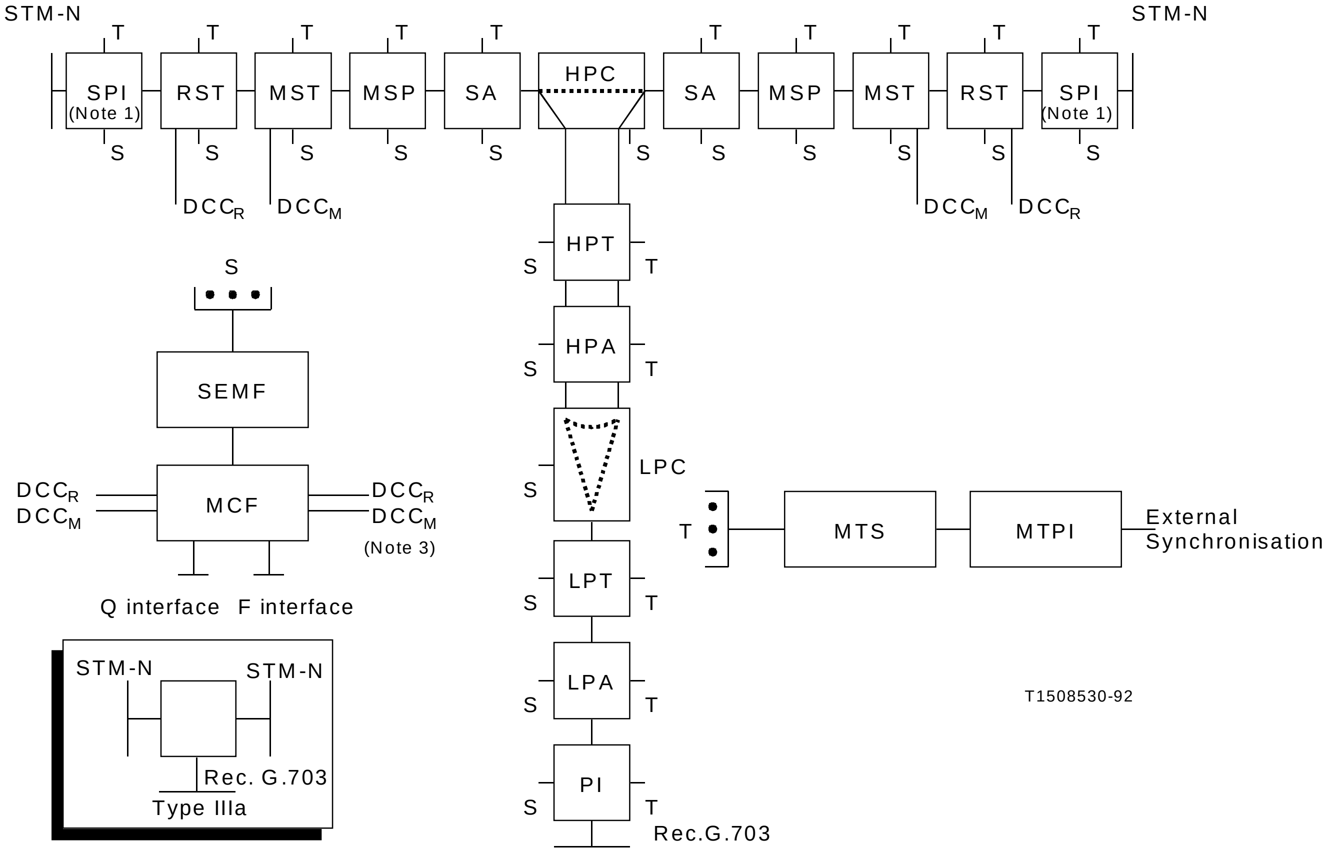
Note 1 – SPI options
- In-station electrical
- In-station optical
- Inter-station optical.

Note 2 – Legend: see Figure 2-1/G.782.

Note 3 – DCC_M may alternatively be passed via the OHA function.

FIGURE 3-4/G.782

Multiplexer type IIa



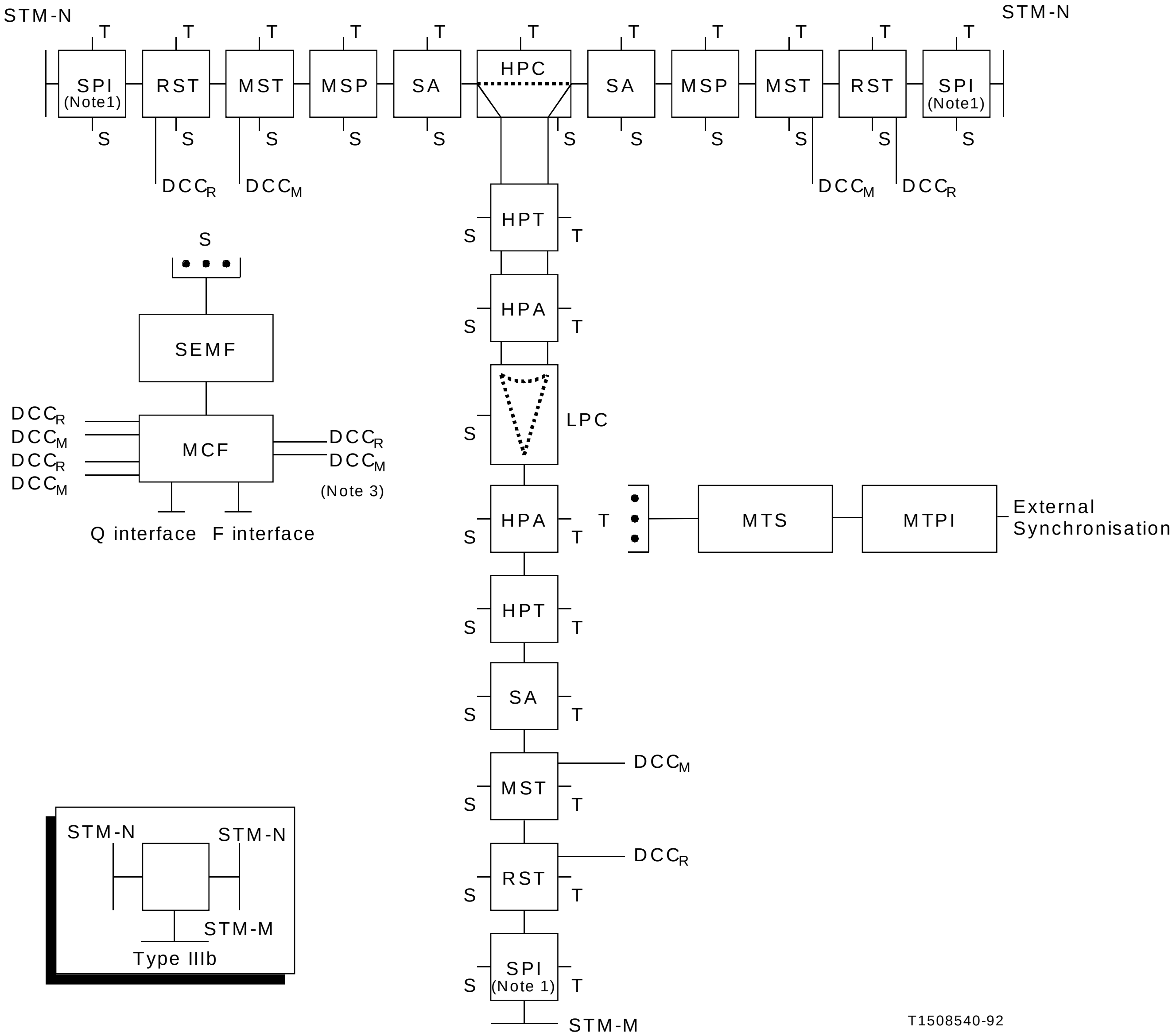
Note 1 – SPI options– In-station electrical
– In-station optical
– Inter-station optical.

Note 2 – Legend: see Figure 2-1/G.782.

Note 3 – DCC_M may alternatively be passed via the OHA function.

FIGURE 3-5/G.782

Multiplexer type IIIa



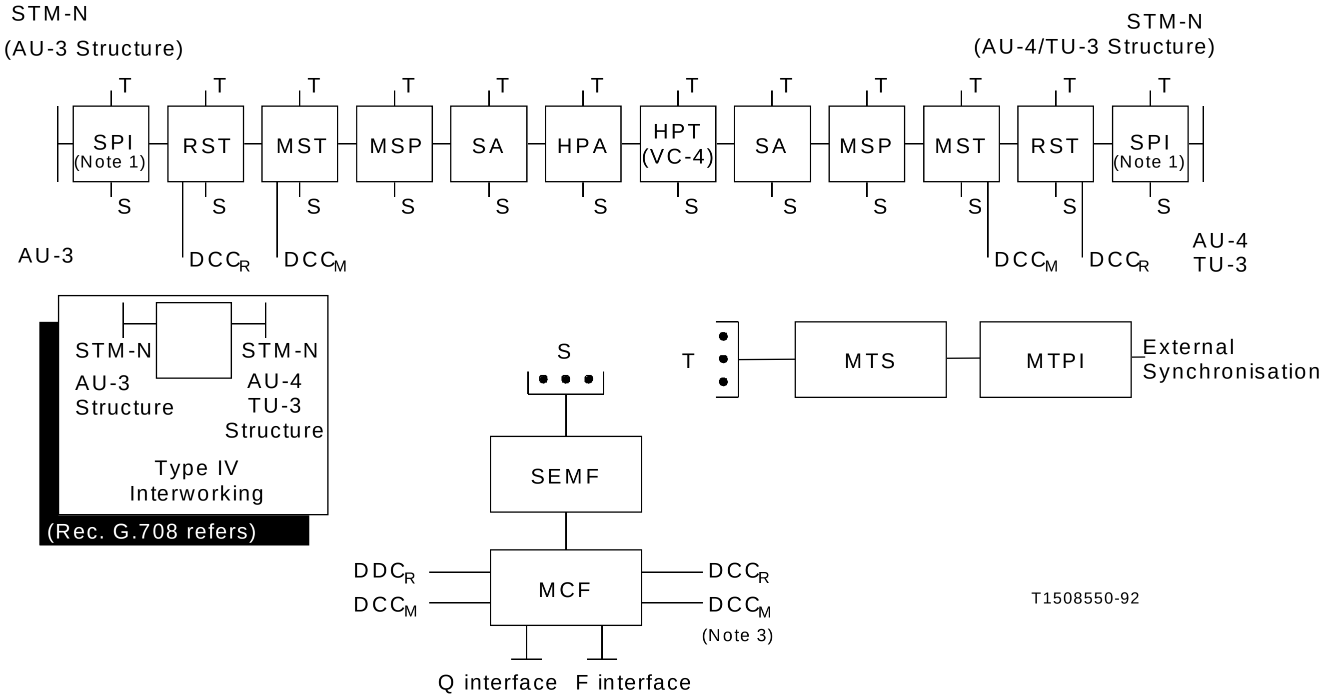
Note 1 – SPI options – In-station electrical
– In-station optical
– Inter-station optical.

Note 2 – Legend: see Figure 2-1/G.782.

Note 3 – DCC_M may alternatively be passed via the OHA function.

FIGURE 3-6/G.782

Multiplexer type IIIb



Note 1 – SPI options – In-station electrical
– In-station optical
– Inter-station optical.

Note 2 – Legend: see Figure 2-1/G.782.
Note 3 – DCC_M may alternatively be passed via the OHA function.

FIGURE 3-7/G.782

Multiplexer type IV

4 General performance requirements

4.1 *Timing and synchronization overview*

4.1.1 *General*

The SDH has been designed to operate as a synchronized network, accommodating G.811 plesiochronous operation and network wander by a scheme of pointer adjustments. SDH network jitter/wander performance is determined by SDH internal and external clock performance, network output wander at synchronization interfaces, and SDH line system jitter/wander. Pointer adjustment statistics, and related G.703 tributary output jitter/wander, are determined by SDH network jitter/wander performance and the design of the SDH demultiplexer at the boundary of an SDH network. This section provides general principles and applications guidelines for synchronization of SDH multiplexing equipment. Detailed timing and synchronization specifications are given in Recommendation G.783.

Figure 2-1/G.782 includes the following functional blocks related to timing and synchronization:

MTPI — provides the appropriate interface for G.703 based synchronization inputs/outputs;

MTS — provides the internal timing signals to the multiplexer equipment based on either an external input or internal oscillator.

4.1.2 *Guidelines for synchronization*

4.1.2.1 *SDH network application*

An SDH network application is one in which at least one of the tributary signals is an SDH signal, thus requiring pointer processing in the TU and/or AU paths. Two examples of SDH network applications are given below:

— SDH network comprising externally synchronized SDH network elements containing internal clocks. The specification of the quality of these clocks is in the province of SG XVIII;

— SDH network including network elements for which the transmit clock for a particular signal is derived directly from the corresponding receive clock (loop timing). Loop timing is typically used in small terminal stations, particularly in star networks, where an external synchronization reference interface is not available; e.g. access networks and equipment in customer premises.

All SDH network elements whose synchronization is traceable to a primary reference clock(s), shall be integrated into existing synchronization hierarchies. Primary reference and slave clocks are specified in Recommendations G.811 and G.812, respectively.

Note — Specification of network output wander requirements at synchronization interfaces is in the province of SG XVIII.

4.1.2.2 *SDH point-to-point application*

An SDH point-to-point application is one in which all tributary signals are asynchronous or plesiochronous according to Recommendation G.703, with no pointer processing in either the TU or AU paths. Synchronization is not required in this application but must be provided as soon as networking is extended beyond simple point-to-point.

4.1.2.3 *External synchronization interfaces*

Timing reference in a network element can be derived from three types of inputs:

i) G.703 external synchronization interface (for 2048 kHz, Recommendation G.703 applies; the case of 1544 kHz is for further study);

ii) G.703 tributary interface (carrying reference synchronization);

iii) STM-N interface.

Depending on the type of network element, one or more timing reference inputs may be available. SDH equipment should have the ability to switch automatically to another timing reference if the selected timing reference is lost. Timing reference is considered to be lost under the following conditions:

— loss of signal on the selected timing reference interfaces;

— AIS on the selected timing reference interface.

If the selected timing reference is an STM-N signal, switching to another timing reference should only take place after it has been established that any available protection switching of the STM-N and its terminating circuitry has failed to recover the STM-N.

4.1.2.4 *Loss of timing reference*

Loss of all incoming timing reference is a major fault calling for immediate maintenance action. In cases where some traffic remains, a sufficient timing accuracy can be maintained over a limited time period by using a clock in holdover mode. The action taken by the synchronous multiplexer under such conditions will depend on the network synchronization strategy. The effect of this on national and international paths is in the province of SG XVIII.

In some cases, where loss of reference timing signal due to a loss of the incoming signal results in loss of data from the network element, the only requirement for signalling loss of timing reference is to transmit AIS, for which entry into free-running mode is necessary. This is applicable, for example, to regenerators.

4.1.3 *Specification of jitter and wander*

SDH jitter and wander is specified at both STM-N and G.703 interfaces in order to control overall network jitter/wander accumulation. In order to assure control of this accumulation, the jitter and wander characteristics of all SDH based equipment are specified. The jitter and wander characteristics of SDH based multiplex equipment are given in G.783 and those of SDH based line systems are given in G.958.

4.2 *Equipment error performance*

The general error performance design objective is that no errors shall be introduced by the multiplexing equipment when operating within specified limits, under the most adverse environmental conditions given in § 4.4 below.

The specific requirement is that, when operating within specified limits under the environmental conditions given in § 4.4 below, the equipment should be capable of providing a level of performance which is consistent with the support of paths meeting the “high grade” performance classification identified in Recommendation G.821.

4.3 *Availability and reliability*

For further study.

4.4 *Environmental conditions*

For further study.

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