RECOMMENDATION ITU-R F.750-4*

ARCHITECTURES AND FUNCTIONAL ASPECTS OF RADIO-RELAY SYSTEMS FOR SYNCHRONOUS DIGITAL HIERARCHY (SDH)-BASED NETWORKS

(Questions ITU-R 160/9 and ITU-R 211/9)

(1992-1994-1995-1997-2000)

The ITU Radiocommunication Assembly,

considering

a) that ITU-T Recommendation G.707 specifies the bit rates, the multiplexing structure and the detailed mappings associated with the synchronous digital hierarchy (SDH);

b) that ITU-T Recommendation G.783 specifies the general characteristics and functions of synchronous multiplexing equipment and ITU-T Recommendation G.784 specifies the management of SDH equipment and networks;

c) that ITU-T Recommendations G.703 and G.957 specify the physical parameters of the electrical and optical interfaces of SDH equipment;

d) that ITU-T Recommendations G.803 and G.831 specify the architectures and management capabilities of transport networks based on the SDH;

e) that among the family of SDH equipment there will be synchronous digital radio-relay systems (SDH-DRRs);

f) that there is a need to ensure a complete operational integration of the SDH-DRRs in a synchronous network;

g) that Recommendation ITU-R F.751 specifies transmission characteristics and performance requirements of SDH digital radio-relay systems,

recommends

1 that digital radio-relay systems for the synchronous digital hierarchy should comply with the requirements described in Annex 1.

ANNEX 1

Contents

* This Recommendation should be brought to the attention of Radiocommunication Study Group 4 (Working Party 4B) and Telecommunication Standardization Study Groups 13 and 15.

1 Introduction

1.1 Scope

This Annex defines the architectures and functional aspects of the SDH-DRRS aiming at their complete operational integration in a SDH-based network.

The architectures are defined in terms of functional blocks without any constraint on physical implementation.

1.2 Abbreviations

ADM	Add/drop multiplexer
ATM	Asynchronous transfer mode
ATPC	Automatic transmitter power control
AU	Administrative unit
AUG	Administrative unit group
BIP	Bit interleaved parity
C	Container
DCC	Data communication channel
DRRS	Digital radio-relay system
DXC	Digital cross-connect
ECC	Embedded communication channel
FEC	Forward error correction
EW	Early warning
FOTS	Fibre optics transmission system
HO	Higher order path
HOVC	Higher order virtual container
HPA	Higher order path adaptation
HPC	Higher order path connection
HPT	Higher order path termination
IOS	Intra-office section
IOST	Intra-office section termination
ISI	Intra-station interface
LOF	Loss of frame
LOP	Loss of pointer
LOS	Loss of signal
LOVC	Lower order virtual container

LPA	Lower order path adaptation
LPC	Lower order path connection
LPT	Lower order path termination
MAF	Management application function
MCF	Message communications function
MS	Multiplex section
MSA	Multiplex section adaptation
MSOH	Multiplex section overhead
MSP	Multiplex section protection
MST	Multiplex section termination
MUX	Multiplexer
NE	Network element
NEF	Network element function
NNI	Network node interface
OAM	Operation, administration and maintenance
OH	Overhead
OHA	Overhead access
OLI	Optical line interface
OLT	Optical line termination
OR	Optical repeater
OSF/MF	Operation system function/Mediation function
PDH	Plesiochronous digital hierarchy
POH	Path overhead
PPI	Plesiochronous physical interface
RCSOH	Radio complementary section overhead
RF	Radio frequency
RFCOH	Radio frame complementary overhead
ROHA	Radio overhead access
RPI	Radio physical interface (generic)
RPPI	Radio plesiochronous physical interface
RPS	Radio protection switching
RR-EI	Radio-relay equipment interface
RR-MSA	Multiplex section adaptation for STM-0 radio-relay
RR-MST	Multiplex section termination for STM-0 radio-relay
RRR	Radio-relay regenerator
RR-RP	Radio-relay reference point for STM-0 radio-relay
RR-RSPI	Radio STM-0 synchronous physical interface

RR-RST	Regenerator section termination for STM-0 radio-relay
RR-SPI	Synchronous physical interface for STM-0 radio-relay
RRT	Radio-relay terminal
RS	Regenerator section
RSOH	Regenerator section overhead
RSPI	Radio synchronous physical interface
RST	Regenerator section termination
SDH	Synchronous digital hierarchy
SEMF	Synchronous equipment management function
SETPI	Synchronous equipment timing interface
SETS	Synchronous equipment timing source
SMN	Synchronous management network
SMS	SDH management sub-network
SOH	Section overhead
SPI	SDH physical interface
STM-*N*	Synchronous transport module of order *N*
STM-0	Synchronous transport module of order 0 equivalent to a transport of one AU-3 as defined by ITU-T Recommendation G.861 and frame structure at 51.84 Mbit/s defined by ITU-T Recommendation G.707. Defined also as RR-STM in previous versions of this Recommendation ITU-R F.750.
TMN	Telecommunications management network
T, T′	Baseband access points
TU	Tributary unit
TUG	Tributary unit group
VC	Virtual container

1.3 Definitions

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

Add/drop multiplexer (ADM)

They provide the ability to access any of the constituent signals within a STM-*N* signal without demultiplexing and terminating the complete signal. The interface provided for the accessed signal could be either according to ITU-T Recommendation G.703 or an STM-*m* ($m < n$).

Asynchronous transfer mode (ATM)

See ITU-T Recommendations I.150, I.311, I.321 and I.327.

Administrative unit (AU)

An AU is the information structure which provides adaptation between the higher order path layer and the multiplex section layer (see ITU-T Recommendation G.707 for details).

Administrative unit group (AUG)

An AUG consists of a homogeneous, byte interleaved assembly of AU-3s or AU-4s.

Atomic function

A function which if divided into simpler functions would cease to be uniquely defined for digital transmission hierarchies. It is therefore indivisible from a network point of view. The atomic functions for SDH equipments are defined in each network layer by ITU-T Recommendation G.783.

Bit interleaved parity (BIP)

BIP-X is a code defined as a method of error monitoring (see ITU-T Recommendation G.707 for details).

Container (C)

A container is the information structure which forms the network synchronous information payload for a VC (see ITU-T Recommendation G.707 for details).

Data communication channel (DCC)

See ITU-T Recommendation G.783.

Digital cross-connect (DXC)

See ITU-T Recommendation G.783.

Embedded communication channel (ECC)

See ITU-T Recommendation G.783.

Higher order path (HO)

In a SDH network, the higher order path layers provide a server network from the lower order path layers (see ITU-T Recommendation G.783).

Higher order virtual container (HOVC): VC-*n* (n = 3, 4)

This element comprises either a single C-*n* (n = 3, 4) or an assembly of TUGs (TUG-2s or TUG-3s), together with the VC POH appropriate to that level.

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 (see ITU-T Recommendation G.783).

Higher order path connection (HPC)

The HPC function provides for flexible assignment of higher order VCs (VC-3/4) within an STM-*N* signal (see ITU-T Recommendation G.783).

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 (see ITU-T Recommendation G.783).

Hitless switch

A switch event between a working and a protection channel which does not add any errors to those already produced by the propagation medium during the switching procedure.

Inter-office section

See ITU-T Recommendation G.958.

Intra-office section (IOS)

See ITU-T Recommendations G.957 and G.958 and § 3.1.

Intra-office section termination (IOST)

See ITU-T Recommendation G.958 and § 3.1.

Intra-station interface (ISI)

Interface with reduced SOH functionality. See ITU-T Recommendation G.707.

Lower order virtual container (LOVC): VC-*n* (*n* = 1, 2)

This element comprises a single C-*n* (*n* = 1, 2) plus the lower order VC POH appropriate to that level.

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.

Lower order path connection (LPC)

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

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 and removing the VC POH and reading it at the path sink.

Management application function (MAF)

This is the origination and termination of TMN messages. See ITU-T Recommendation G.784.

Message communications function (MCF)

See ITU-T Recommendation G.783.

Multiplex section adaptation (MSA)

The MSA function processes the AU-3/4 pointer to indicate the phase of the VC-3/4 POH relative to the STM-*N* SOH and byte multiplexes the AU groups to construct the complete STM-*N* frame (see ITU-T Recommendation G.783).

Multiplex section overhead (MSOH)

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

Multiplex section protection (MSP)

The MSP function provides the capability of branching the signal onto another line system for protection purposes (see ITU-T Recommendation G.783).

Multiplex section termination (MST)

The MST function generates and adds rows 5 to 9 of the SOH (see ITU-T Recommendation G.783).

Network element (NE)

This is an element of the SMS. See ITU-T Recommendation G.784.

Network element function (NEF)

See ITU-T Recommendation G.784.

Network node interface (NNI)

See ITU-T Recommendation G.707 and § 2.3.

Operation, administration and maintenance (OAM)

See ITU-T Recommendation G.784.

Overhead access (OHA)

The OHA function gives external interfaces to standardized SOH signals (see ITU-T Recommendation G.783).

Optical line interface (OLI)

See ITU-T Recommendation G.957.

Optical line termination (OLT)

See ITU-T Recommendation G.958.

Operation system function/mediation function (OSF/MF)

See ITU-T Recommendation G.784.

Path overhead (POH)

The VC POH provides for integrity of communication between the points of assembly of a VC and its point of disassembly.

Plesiochronous digital hierarchy (PDH)

See ITU-T Recommendations G.702 and G.703.

Radio complementary section overhead (RCSOH)

The transmission, in STM-0 DRRS, as a well identified case of RFCOH, of a capacity equivalent to the six missed columns of a full STM-1 SOH format (see § 6.6 and 6.7 and Recommendation ITU-R F.751).

Radio frame complementary overhead (RFCOH)

The transmission capacity contained in the radio frame (see § 4.4 and 6.7 and Recommendation ITU-R F.751).

Radio overhead access (ROHA)

The ROHA function gives external interfaces to radio specific SOH or RFCOH signals and gives suitable handling for the radio specific internal communication channels (see § 3.3.3 and 7.2.3).

Radio physical interface (RPI)

Generic terminology for the typical radio-relay functions, including modulator, demodulator, transmitter, receiver, possible radio-framer, etc. (see § 6.4).

Radio plesiochronous physical interface (RPPI)

A common description for the typical plesiochronous radio-relay functions, including modulator, demodulator, transmitter, receiver, possible radio-framer, etc. (see § 6.4).

Radio protection switching (RPS)

See § 3.3.2.

Radio-relay equipment interface (RR-EI) for STM-0 radio-relay

See Appendix 1.

Multiplex section adaptation for STM-0 radio-relay (RR-MSA)

See § 6.4.

Multiplex section termination for STM-0 radio-relay (RR-MST)

See § 6.

Radio-relay physical interface (RR-SPI) for STM-0 radio-relay

See § 6.5.

Radio-relay regenerator (RRR)

See § 3.1 and 3.4.

Radio-relay reference point for STM-0 radio-relay (RR-RP)

See § 6.2.

Radio-relay terminal (RRT)

See § 3.1 and 3.4.

Regenerator section (RS)

A regenerator section is part of a line system between two regenerator section terminations.

Regenerator section overhead (RSOH)

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

Radio synchronous physical interface (RSPI)

A common description for the typical synchronous radio-relay functions, including modulator, demodulator, transmitter, receiver, possible radio-framer, etc. (see § 6.4).

Radio STM-0 synchronous physical interface (RR-RSPI)

A common description for the typical STM-0 synchronous radio-relay functions, including modulator, demodulator, transmitter, receiver, possible radio-framer, etc. (see § 6).

Regenerator section termination (RST)

The RST function generates and adds rows 1 to 3 of the SOH; the STM-*N* signal is then scrambled except for row 1 of the SOH (see ITU-T Recommendation G.783).

Regenerator section termination for STM-0 radio-relay (RR-RST)

See § 6.4.

Synchronous equipment timing physical interface (SETPI)

The SETPI function provides the interface between an external synchronization signal and the multiplex timing source (see ITU-T Recommendations G.783 and G.813).

Synchronous equipment timing source (SETS)

The SETS function provides timing reference to the relevant component parts of multiplexing equipment and represents the SDH network element clock (see ITU-T Recommendation G.783).

Section overhead (SOH)

SOH information is added to the information payload to create an STM-*N*. It includes block framing information and information for maintenance, performance monitoring and other operational functions.

SDH physical interface (SPI)

The SPI function converts an internal logic level STM-*N* signal into an STM-*N* line interface signal (see ITU-T Recommendation G.783).

Synchronous equipment management function (SEMF)

The SEMF converts performance data and implementation specific hardware alarms into object-oriented messages for transmission over DCCs and/or a Q interface (see ITU-T Recommendation G.783).

Synchronous digital hierarchy management network (SMN)

This is a subset of the TMN. See ITU-T Recommendation G.784.

Synchronous digital hierarchy management subnetwork (SMS)

This is a subset of the SMN. See ITU-T Recommendation G.784.

Synchronous transport module of order N (STM-N)

A STM-*N* is the information structure used to support section layer connections in SDH. See ITU-T Recommendation G.707 for STM modules of order 1, 4, 16 and 64.

Synchronous transport module of order 0 (STM-0)

A STM-0 is the information structure used to support section layer connections in SDH equivalent to an AU-3 only. See ITU-T Recommendation G.861. It was also defined as RR-STM in previous versions of this Recommendation ITU R F.750.

Telecommunications management network (TMN)

The purpose of a TMN is to support administrations in the management of their telecommunications network. See ITU-T Recommendation M.30 for details.

Tributary unit (TU)

A TU is an information structure which provides adaptation between the lower-order path layer and higher-order path layer. See ITU-T Recommendation G.707 for details.

Tributary unit group (TUG)

One or more TUs, occupying fixed, defined positions in a higher-order VC payload is termed as a tributary unit group.

T, T'

Access points of telecommunications equipment as defined in Recommendation ITU-R F.596.

Virtual container (VC)

A VC is the information structure used to support path layer connections in the SDH. See ITU-T Recommendation G.707 for details.

2 Features and layering of the SDH-based networks

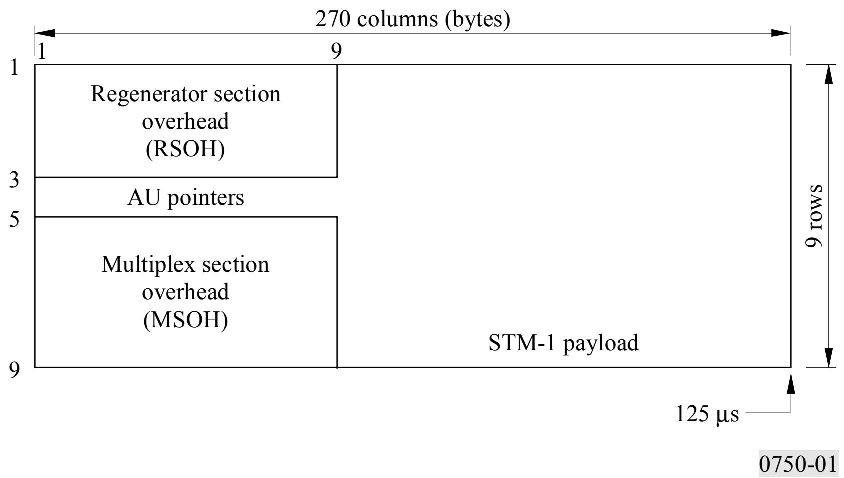
2.1 SDH description

The synchronous digital hierarchy (SDH) is described in ITU-T Recommendation G.707 (Network node interface for the synchronous digital hierarchy (SDH)). This Recommendation embraces a new multiplexing method and frame structure which result in a basic rate of 155 520 kbit/s, known as STM-1. The next higher level bit rates are 622 080 kbit/s or STM-4, 2 488 320 kbit/s or STM-16 and 9 953 280 kbit/s or STM-64.

The frame structure of the STM-1 provides a payload area and a section overhead (SOH) as shown in Fig. 1. The multiplexing method is such that a variety of signals may be combined to form the payload by building up tributaries into packages within the STM frame. The section overhead is divided into a number of bytes of RSOH and MSOH for transmission media management and network operator functions.

FIGURE 1

STM-1 frame structure



Details of the SOH are given in § 4. The higher order signals (STM-*N*) are formed by byte interleaving lower order STM-1 signals (see ITU-T Recommendation G.707).

2.2 SDH layering

2.2.1 Layering

One of the basic principles which is described in ITU-T Recommendation G.803 is the concept of layering of transport networks.

Figure 2 describes the layer model of the transport network. Features of the layered model are as follows:

– a circuit layer network, a path layer network and a transmission media layer network;

– the relationship between any adjacent two layers is a server/client relationship;

– each layer has its own OAM capability;

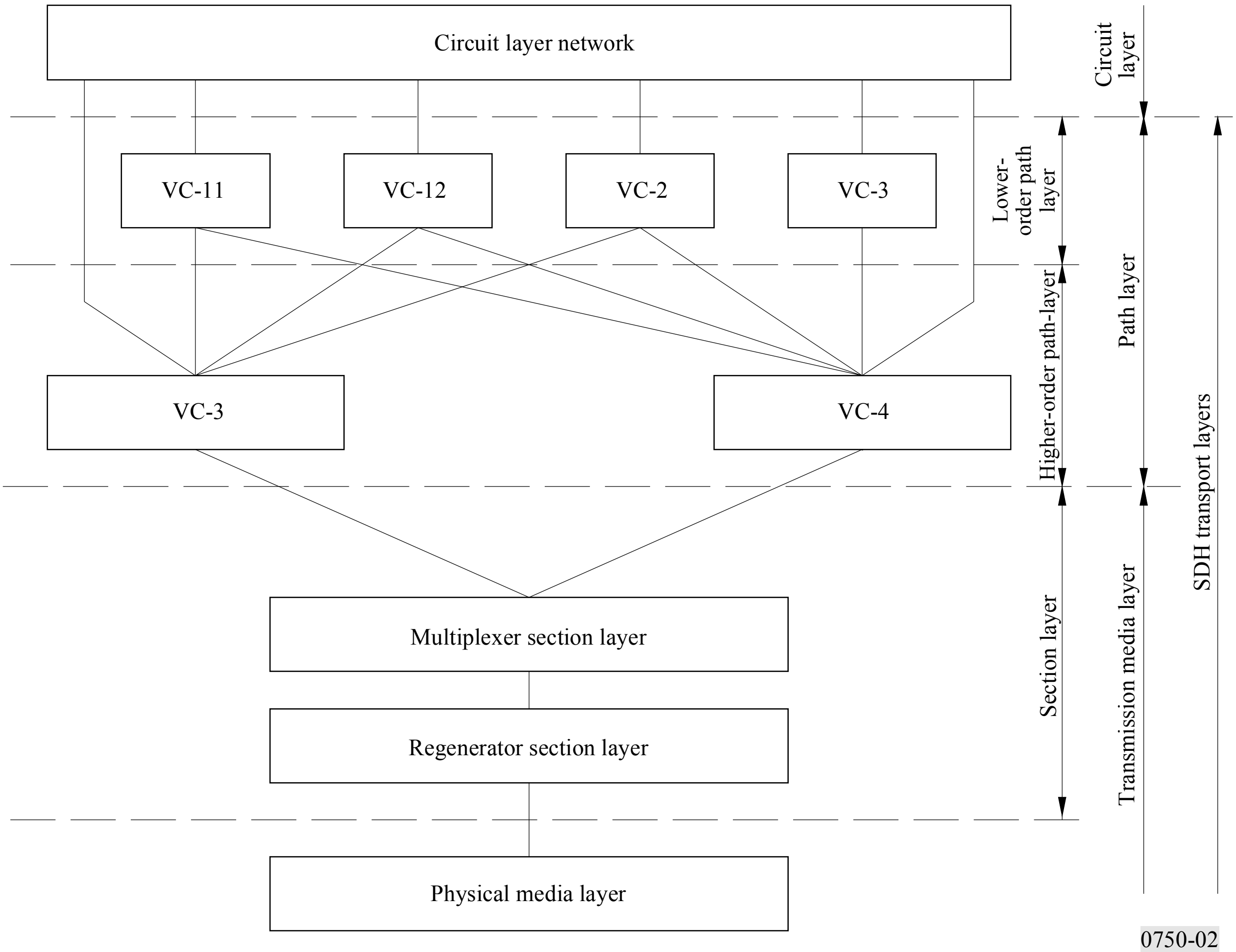
– a circuit layer network provides telecommunications services to users. The circuit layer network is independent of the path layer network;

– a path layer network is commonly used by the circuit layer networks for different services. The path layer network is independent of the transmission media layer network;

– a transmission media layer network is dependent on the transmission medium such as optical fibre and radio. The transmission media layer is divided into a section layer and a physical media layer. A section layer can be further divided into a multiplex section layer and a regenerator section layer.

FIGURE 2

SDH-based transport network layered model



2.2.2 Layering and the SDH frame structure

The SDH frame structure implies an organization of the network in logical layers, namely path and section layers.

The path layer consists of:

– the lower-order VC layer (LOVC) based on the tributary unit;

– the higher-order VC layer (HOVC) based on the administrative unit.

The section layer consists of:

– the multiplex section layer (MS), and

– the regenerator section layer (RS).

The RS is media dependent, the MS may be media dependent with a restricted point-to-point topology, while the LOVC and HOVC are designed to be media independent with a wide, complex meshed topology.

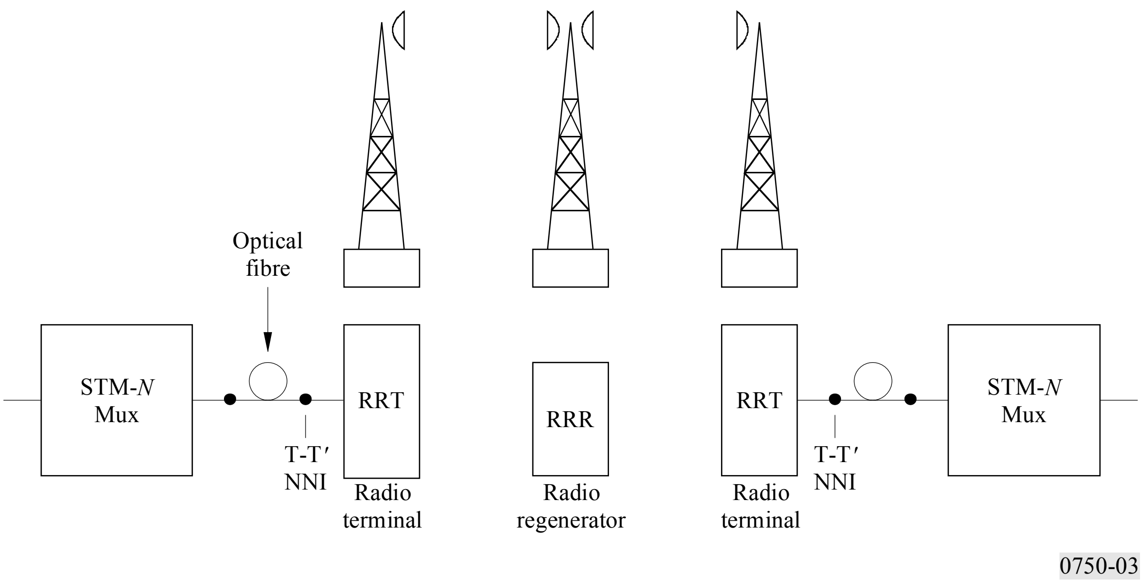
2.3 Network node interfaces (NNI)

The connection between radio systems and other SDH network elements shall be at standardized interface points. The recommended connection is to make T, T′ points (as defined in Recommendation ITU-R F.596) coincide with the network node interface (NNI) points identified in ITU-T Recommendation G.707.

An example of the positions of the T, T′ points and the NNIs is shown in Fig. 3, where optical connections are used; electrical interfaces, as foreseen in ITU-T Recommendation G.703, may be used too.

FIGURE 3

SDH radio system NNI interface points



2.4 Functional blocks of SDH equipment

The use of functional blocks has been firstly adopted by ITU-T Recommendation G.783 (1994 version) to simplify the specification of SDH equipment. Decomposition of SDH DRRS into functional blocks complying with these Recommendations is discussed in § 3.3 and 6.4.

A subsequent revision of ITU-T Recommendation G.783 (1997 version) further reduced the functional block more complex description into sets of simpler atomic functions.

This Recommendation ITU-R F.750 still utilizes the functional block methodology for describing specific radio-relay functions; the definition of equivalent atomic functions is for further study.

3 Application of radio-relay systems to SDH-based networks

3.1 General considerations

The scope of this section is to underline the possible applications and topologies foreseen for SDH-DRRS.

The inter-operability of equipment from different media and sources is maintained as long as the functional requirements of SDH are properly adhered to.

The following main applications for SDH-DRRS are foreseen:

– use of radio-relays to close an optical fibre ring (see an example in Fig. 4);

– connection in tandem with fibre optic systems (see an example in Fig. 5);

– multimedia protection (see an example in Fig. 6);

– point-to-multipoint systems with integral multiplex functions.

Media independent multiplex sections are possible only if all different media use the MSOH for the same overhead functions (with no media-dependent functions).

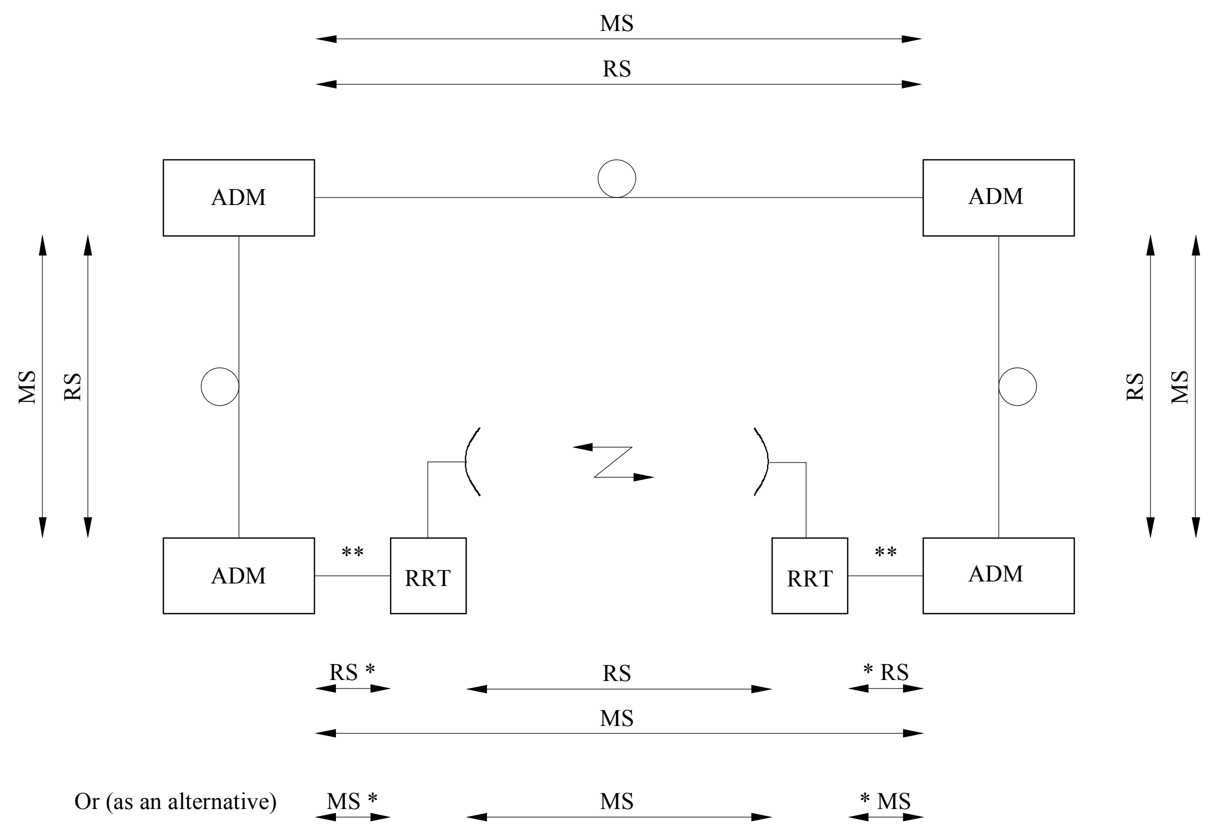
When using multi-line protection switching ($n + m$), the protected radio section may, in some cases, be coincident with a multiplex section (see § 3.3, 3.4 and Appendix 3).

It should be noted that if SDH radio-relay systems include facilities for radio-protection switching then they may need to access and recalculate the embedded block error monitoring present with the SOH in the B1 and B2 bytes. In this case, if the B2 bytes are recalculated, the radio-switching section should be regarded as a multiplex section.

The sections before a radio multiplex section can be either an intra-office section (IOS) or an inter-office connection.

FIGURE 4

Use of radio-relay to close a ring



* With possible reduced functionality of an intra-station section (see ITU-T Recommendation G.958) or with the functionality of an intra-station interface (see ITU-T Recommendation G.707).

** Optical, electrical or internal (proprietary) interface; in the last case the connection is not considered a section.

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FIGURE 5

Tandem connection type

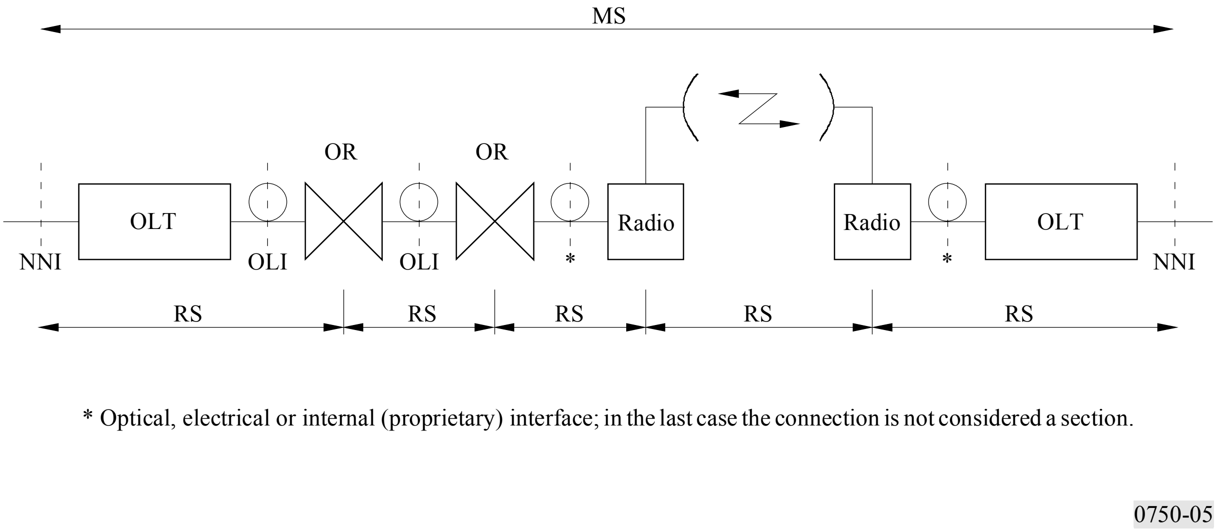
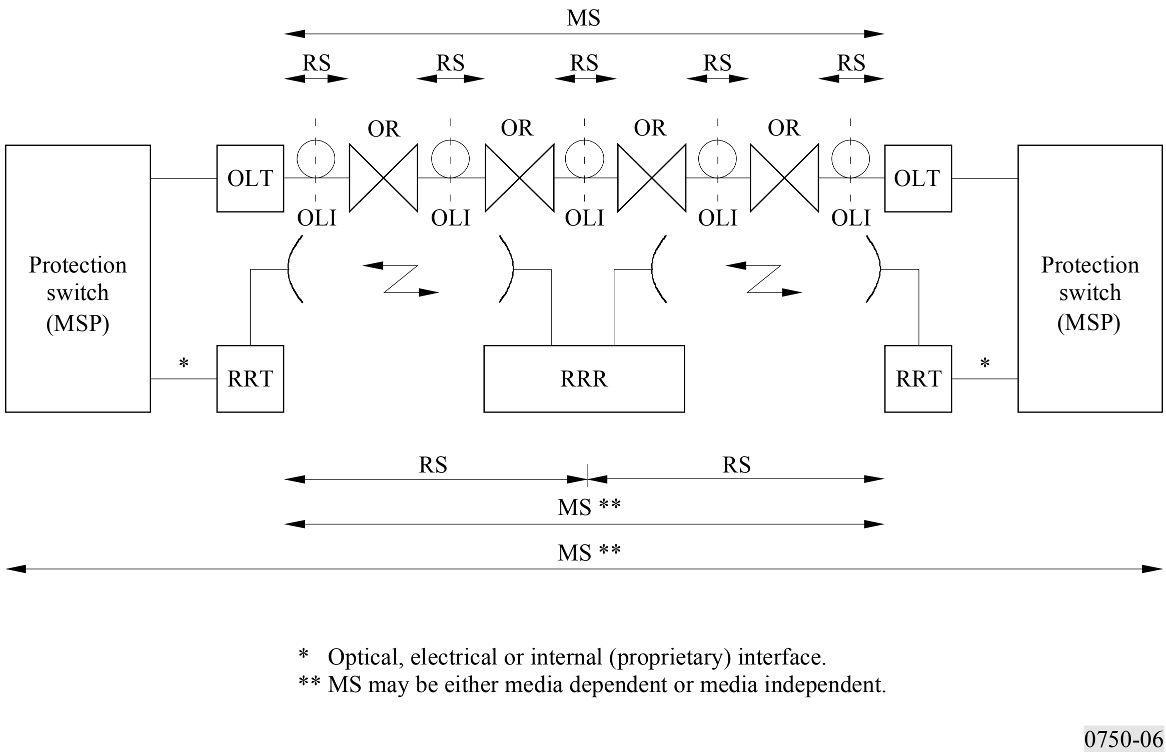


FIGURE 6

Multi-media protection



3.1.1 Interfaces

Unless a radio-relay system is integrated with another SDH equipment, it shall interface to the SDH network at the NNI.

Radio-relay systems can provide either an electrical or an optical interface. The electrical interface is defined in ITU-T Recommendation G.703 while the optical interface is defined in ITU-T Recommendation G.957 (see Table 1/G.957).

3.1.2 Mid-air interconnectivity

It is not practicable for radio systems to provide a radio-frequency interface for mid-air interconnectivity. Mid-air compatibility would require standardization of many additional parameters such as the modulation and coding method, filtering arrangements, diversity combining and protection switching methods and associated control algorithms, adaptive equalizers, overhead bit patterns, FEC, adaptive transmitter power control, etc. Such detailed specifications and standardization would stifle future innovation and would not leave the freedom for different modulation schemes to be used for different applications. Therefore, standardization of a mid-air interface is not required.

3.2 Multiplex and regenerator sections

Within a network based on the synchronous digital hierarchy, connections made by radio-relay systems shall form either a multiplex section or a regenerator section. In the former case both RSOH and MSOH within the STM-*N* signal are accessible. In the latter case the RSOH is accessible (see also § 3.3 and Figs. 8 and 10).

3.3 Functional block diagrams of STM-*N* digital radio-relay systems

The partitioning into functional blocks is used to simplify and generalize the description and it does not imply any physical partitioning and/or implementation.

The functional block diagram is intended to be used, in conjunction with ITU-T Recommendation G.783, for a "formal" description of the main functionality of an SDH radio equipment.

Figure 7 is taken as a generalized block diagram for STM-*N* systems. In Fig. 7, for clear distinction from ITU-T Recommendation G.783 (1994) definitions, U*x*, K*x* and S*x* reference points numbering, for radio specific blocks, has been taken starting from 50 onward.

In Fig. 7 only the most common ITU-T Recommendation G.783 defined functional blocks are reported, together with the radio specific ones. Nevertheless other actual or future ITU-T Recommendation G.783 defined functional blocks may be implemented, if applicable, into SDH DRRS.

In Fig. 7, where other references are taken from ITU-T Recommendation G.783, it may be noted that the following additional radio specific functional blocks, reference points and interfaces, with respect to those defined by ITU-T, are included:

– RSPI: radio synchronous physical interface (functional block)

– RPS: radio protection switch (functional block)

– ROHA: radio overhead access (functional block)

– R: reference point at RSPI radio-frequency interface

– XT: reference point at RPS input/output interfaces (tributary side)

– XL: reference point at RPS input/output interfaces (line side)

– U50: reference point for RFCOH (if used) at RSPI/ROHA interconnection

– S50: reference point of RSPI management and supervisory information, accessed by SEMF function for equipment internal functionality and TMN

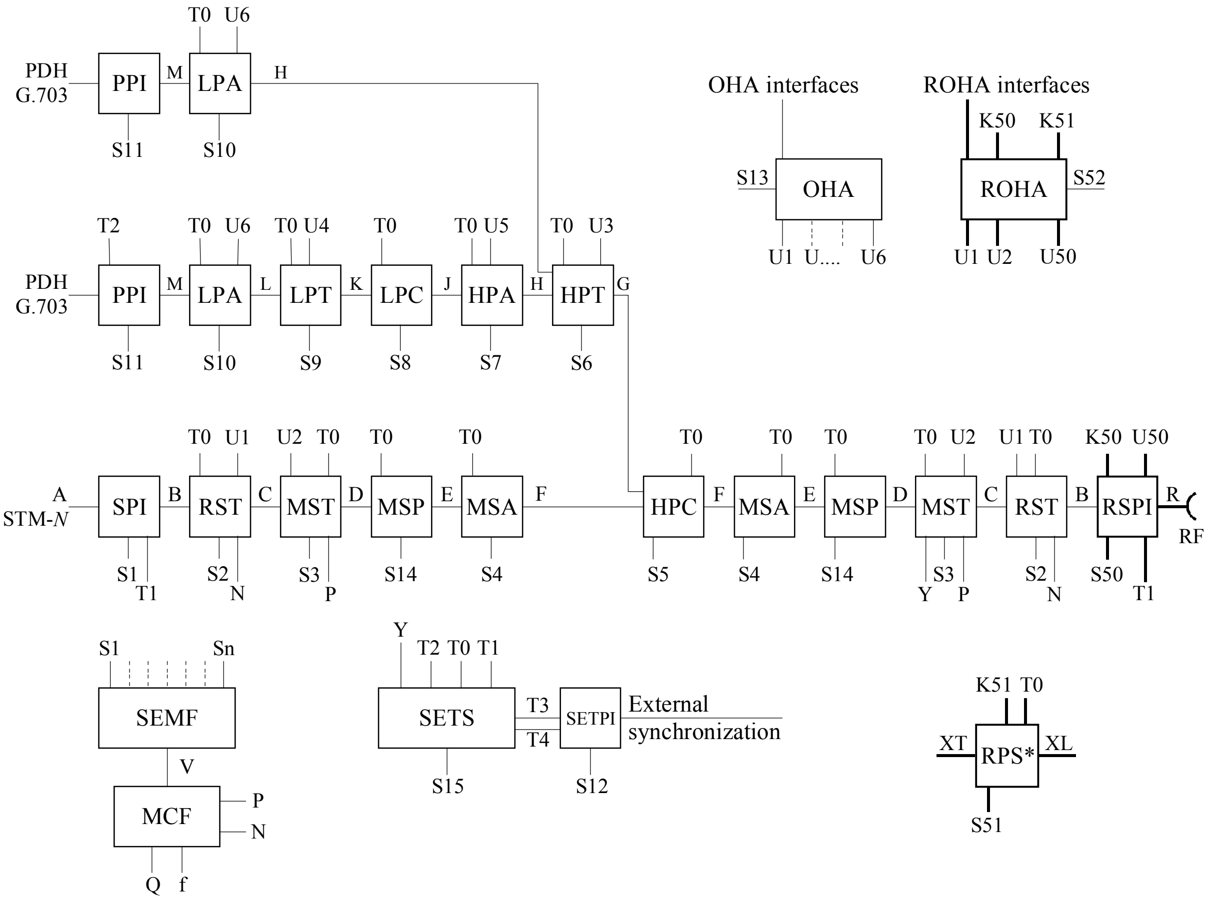
– S51: reference point of RPS management and supervisory information, accessed by SEMF function for equipment internal functionality and TMN

– K50: interface point of communication byte(s) for radio specific functions (e.g. ATPC) between RSPI and ROHA to be addressed on U1 (media bytes) or U50 (RFCOH) for far end transmission

– K51: interface point of communication byte for multiline $n + m$ RPS switching protocols between RPS and ROHA to be addressed on U1 (media bytes) or U50 (RFCOH) for far end transmission.

FIGURE 7

Generalized SDH-DRRS logical and functional block diagram



* The RPS functional block is composed of a connection type function which, for implementation purposes, can be inserted in between any other functional block to perform specific ($n + m$) line protection for the radio section. XL and XT are functionally the same interface and always fit any interface where the RPS may be inserted (see Appendix 3 for examples).

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The main functionality of each of the three newly introduced radio specific functional blocks follows:

– RSPI is the radio equivalent of optical SPI defined in ITU-T Recommendations G.783 and G.958; it takes care of translating the fully formatted STM-*N* signal at reference point B, into a radio-frequency modulated signal at reference point R and *vice versa*. Reference point R differs from ITU-T Recommendation G.783 reference point A by the non-standardized use of media specific RSOH bytes and, if used, by an arbitrary added RFCOH.

– RPS performs the radio protection functions which may not be accommodated by the MSP function; as a matter of fact K1 and K2 protocols are not suitable for hitless functionality, to counteract multipath phenomena; consequently RPS will use a non-standardized, high efficiency, communication protocol on dedicated interface K51.

Moreover, when mixed media MS may be foreseen, RPS function may be used also in regenerator sections which coincide with a radio switching section terminal.

The RPS functional block is composed of a connection type function (see Note 1) which input/output interfaces, XL and XT, are functionally the same, and fit to any interface where the RPS function may be inserted (namely B, C, D, E and F reference points). For implementation dependent reasons, RPS may be inserted between any other functional blocks to perform specific $n + m$ line protection for the radio section.

NOTE 1 – A connection function does not operate on the content of the signal, but acts as a matrix function (e.g. HPC functional block in ITU-T Recommendation G.783).

– ROHA is a functional block which is introduced to "formally" take care of the transmission and interconnection of the media specific information flow between RSPI and RPS at radio terminals and repeaters.

It manages the media specific functions required by RPS and RSPI, at interfaces K50 and K51 respectively, and the related transmission data channels in media-specific bytes or RFCOH, at reference points U1 and U50 respectively.

The formal descriptions in the following § 3.3.1, 3.3.2 and 3.3.3 will correspond to the methodology used by ITU-T Recommendation G.783 (1994) for those aspects in regard to definitions relating to these three radio-specific functional blocks; the definition of equivalent atomic functions is for further study.

Refer to Appendix 2 for a migration strategy from PDH to SDH-based networks.

3.3.1 SDH radio synchronous physical interface function (RSPI)

The RSPI function provides the interface between the radio physical medium at reference point R and the RST function at reference point B.

Data at R is a radio-frequency signal containing an STM-N signal with no media-dependent bytes and (if used) an additional arbitrary RFCOH (radio frame complementary overhead). Therefore mid-air interconnectivity between transmitters and receivers from different vendors is not required.

The information flows associated with the RSPI function are described with reference to Fig. 8a. This functional block is expanded in Fig. 8b.

FIGURE 8a

RSPI functional block

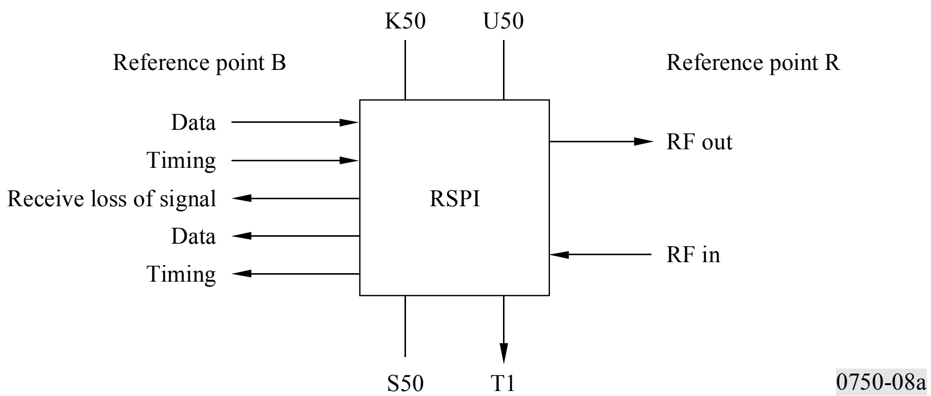
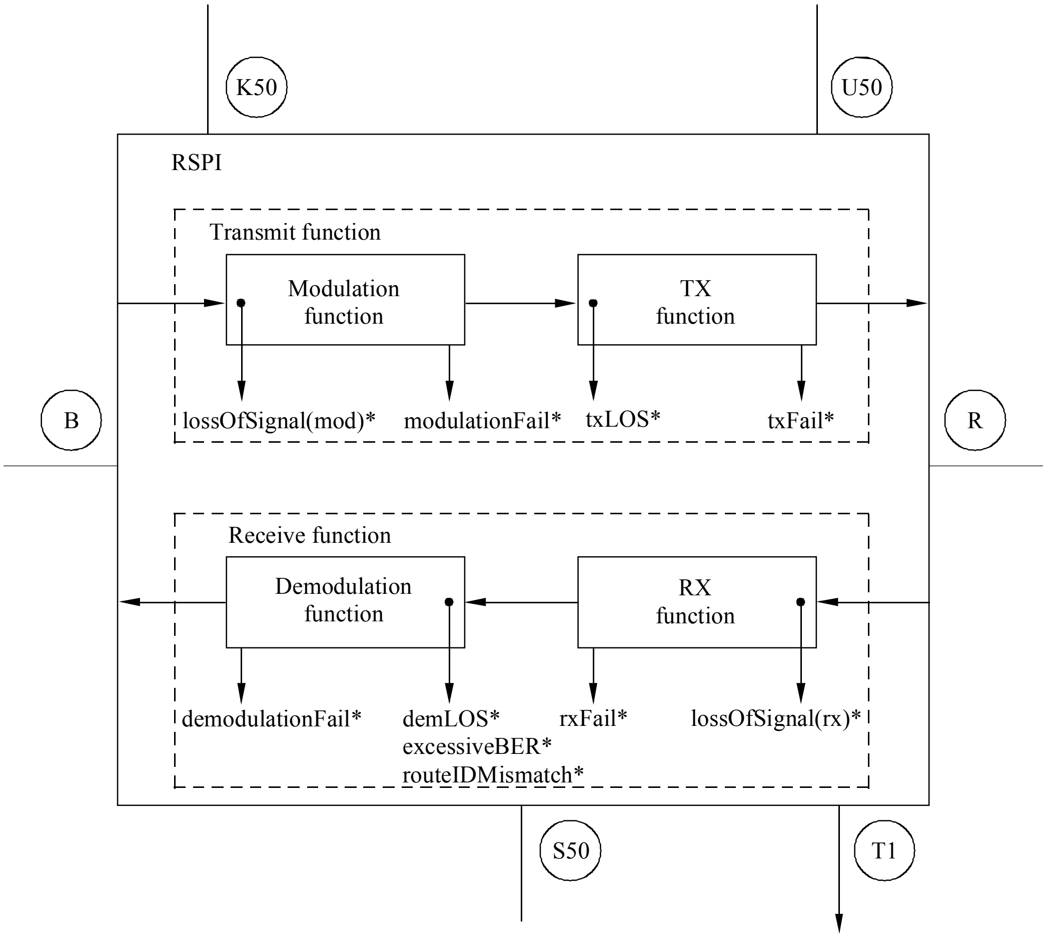


FIGURE 8b

RSPI functional block (detail)



* See § 7.2.1.

0750-08b

K50 is an interface for any radio-specific control and monitoring use (e.g. ATPC) making use of the media specific bytes of RSOH or of RFCOH extracted through reference points U1 or U50 respectively and made available by the ROHA functional block.

The RSPI function is subdivided into transmit and receive functions; these may be subdivided into two smaller sub-blocks, as shown in Fig. 8b, namely:

– transmit function → modulation function
TX function

– receive function → demodulation function
RX function

These functions may be described as follows:

– The modulation function may include all the processing to transfer the STM-*N* data signal at reference point B into a suitable IF or RF signal (whichever is applicable), including any digital processing (e.g. scrambling, channel-coding and RFCOH insertion).

– The TX function represents the process of power amplifying the signal, filtering and optionally up-converting the signal coming from the modulation function for presentation at reference point R.

– The RX function represents any signal processing (including propagation countermeasures, e.g. space diversity reception) between the receiver input, at reference point R, and the demodulation function input.

– The demodulation function represents the process of converting the IF or RF signal (whichever is applicable), into a STM-*N* data signal for presentation at reference point B. The demodulation function may include any analogue and digital processing (e.g. filtering, carrier and timing recovery, descrambling, RFCOH extraction and propagation countermeasures like equalizer, cross-polar interference canceller, error correction).

In multicarrier STM-*N* system applications (where the STM-*N* signal is split to more than one modem set) the overall sets of modulation and demodulation "functions" will be regarded as a single one.

Figure 8b also shows a minimum set of indications for maintenance purpose, descriptions of which are given in § 7.2.1.

The indicators excessiveBER and routeIDMismatch shown in Fig. 8b are requested only to radio-relay systems that implement RPS function according to the type D, reported in Appendix 3, which may require to perform these standard SDH functionalities (related to J0 and B1 management as described in ITU-T Recommendations G.707 and G.783) by means of other equivalent proprietary functions in the RSPI, see § 1.4 of Appendix 3 for more details.

Indications relating to the physical status of the interface shall be reported at S50 to the SEMF functional block (see § 7.2.1 and Appendices 5 and 6); the management information model for the network element view is reported in ITU-T Recommendation G.774.

3.3.1.1 Signal flow from B to R

Data flow at B is the fully formatted STM-*N* data as specified in ITU-T Recommendation G.707. Data is presented together with associated timing at B by the RST function. The RSPI function multiplexes these data together with the RFCOH (if used) and adapts them for transmission over the radio-frequency medium (by means of a suitable modulation format, carrier frequency and output power) and presents it at R.

Data for inclusion in RFCOH (if used) are inserted at reference point U50.

Radio-specific management data (e.g. ATPC increase/decrease power request from the far end receiver function to control the local transmitter function) will be shown at K50 from ROHA functional block, which provides proper extraction from the media-specific byte of RSOH or from RFCOH through reference point U1 or U50 respectively (see ROHA functional block description in § 3.3.3).

3.3.1.2 Signal flow from R to B

The RF signal received at R may be either a single signal or a doubled (or multiplied) signal for a space and/or angle diversity protection against adverse propagation phenomena.

The RF signal at R contains STM-*N* signal together with an arbitrary RFCOH (if used). The RSPI function recovers at B data and associated timing from the RF signal. The recovered timing is also made available at reference point T1 to the SETS for the purpose of synchronizing the synchronous equipment reference clock if selected. The RFCOH, if present, is made available at reference point U50.

When the relevant receiver thresholds are exceeded (e.g. by receiver power level or by error correction activity), radio-specific management data (e.g. ATPC increase/decrease power request from the local receiver function to be sent to the far end transmitter function or early warning (EW) switching request to the local RPS or to be forwarded from a regenerative repeater to the next one) will be shown at K50 to ROHA functional block, which will provide for proper insertion in the media-specific byte of RSOH or in RFCOH through reference point U1 or U50 respectively.

Fast detection time of EW thresholds is of high importance for hitless operation of the RPS.

If the signal fails at R, or the input signal to the demodulation function fails (see § 7.2.1), then the receive loss of signal (LOS) condition is generated and passed to the reference point S50 and to the RST function at B. The signal at R is considered to be failing when the receive function (whatever its redundant physical implementation) cannot provide a signal to enable the demodulation function to distinguish and recover the transmitted symbols.

3.3.1.3 Application to the transmission of *N* times STM-*N*

The case of systems carrying more than one STM-*N* either by a multicarrier technique or by a single carrier with a bit rate *N* times STM-*N*, will be represented, from the functional point of view, by duplicating up to *N* times the RSPI functional block. It has to be noted however that this does not imply any relationship with physical hardware implementation.

3.3.2 Radio protection switching (RPS)

The RPS function provides "*m*" protection channels for "*n*" STM-*N* signals against channel-associated failures for both hardware failures and temporary signal degradations or losses due to propagation effects (e.g. rain or multipath phenomena) within a radio section composed of a number of regenerative repeater sections (see Note 1).

NOTE 1 – The status information coming from S2, S3, S4, S50 and S52 of RST, MST, MSA, RSPI and ROHA respectively are shared through the SEMF function. This switching information has, in general, dedicated hardware interfaces for real time operation, but for a logical description they are here considered as supervisory primitives at the S51 interface. Information from S2, S3 and S4 may not be applicable due to the logical blocks sequence of some practical implementations (see Appendix 3).

The two RPS functions, to activate the switching procedures and to share information on the channels status at both ends of the connection, communicate with each other via a non-standardized protocol transmitted on a data communication channel at interface K51 made available by ROHA function, which provides proper insertion/extraction in one of the "media-specific bytes" or, as an alternative, in one of the RFCOH bytes available at reference points U1 or U50 respectively.

For a 1 + 1 architecture, when no occasional traffic facility is foreseen, communication between the two corresponding RPS functions is not required, being the working tributary permanently bridged to both working and protection lines.

In any case the RPS function may be considered as a specific connection matrix (somewhat like the HPC at VC-4 or STM-*N* level), whose "XT" (tributary side) and "XL" (line side) reference points on either side are the same and may match any other reference point along the functional block chain described in ITU-T Recommendation G.783 (1994) because its process does not affect the nature of the characteristic information of the signal.

The signal flow associated with the RPS function is described with reference to a generic description of the RPS functional block shown in Fig. 9.

Indications relating to the physical status of the interface shall be reported at S51 to the SEMF functional block (see § 7.2.1 and Appendices 5 and 6); the management information model for the network element view is reported in ITU-T Recommendation G.774.

3.3.2.1 Signal flow

RPS provides a facility for re-addressing the "*n*" working signals, W, and the "*m*" occasional signals, O, at reference point XT to the "*n*" working signals, W, and the "*m*" protection signals, P, at reference point XL and *vice versa* without affecting the content of the signal concerned. The RPS connection matrix allows interconnectivity as given in Table 1.

3.3.2.2 Additional functionality on the signal flow from XT (tributary side) to XL (line side)

The "*n*" tributary signals (W_i/XT) are doubled and sent to the corresponding working lines and to a distributor (TxD) respectively.

When protection is required on a specific working channel, the local RPS bridges it from the TxD to one of the "*m*" protection lines.

3.3.2.3 Additional functionality on the signal flow from XL (line side) to XT (tributary side)

When one of the working lines (W_i/XT) is degraded or fails, the local RPS detects this condition through the S51 reference point which shares the information of EW thresholds exceeded, signal degrade, signal fail and RSPI failure available for SEMF on the S2, S3, S50 and S52 reference points.

Consequently the local RPS sends the request, on a data channel at interface K51, to the far end corresponding RPS to activate the switching procedure.

FIGURE 9

RPS functional block

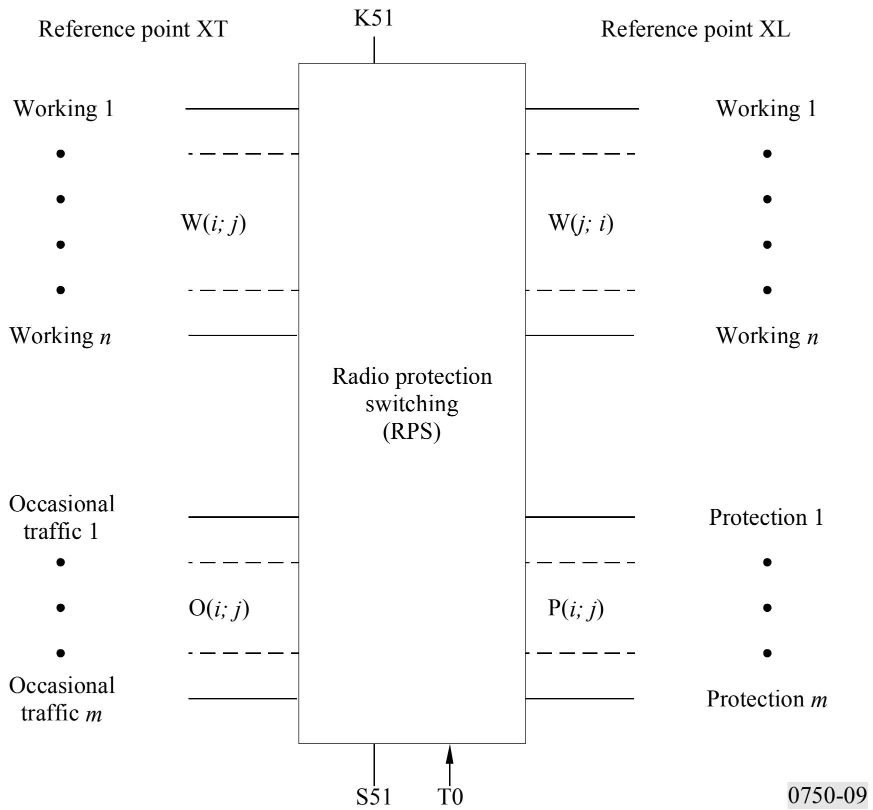


TABLE 1

Connection matrix interconnectivity for RPS

Output \ Input		W_i XL	W_i XT	P_i XL	O_j XT
W_j	XL	–	$i = j$	–	–
	XT	$i = j$	–	☒	–
P_j	XL	–	☒	–	$i = j$
O_j	XT	–	–	$i = j$	–

☒: Connection is possible for any j and i

$i = j$: Connection is possible for the case that $j = i$ only

–: No connection is possible.

3.3.2.4 Switching initiation criteria

Various levels of switching initiation may be foreseen. In any case they are described and prioritized according to proprietary schemes. Appendix 5 gives one example of a set of switching initiation criteria.

The switching criteria have, in general, dedicated hardware interfaces for real time operation, but for a logical description, they are considered as supervisory primitives at the S51 interface.

3.3.2.5 Switching performance

When used to improve the transmission performance in multipath fading conditions, RPS performance shall be such that from the detection of a propagation induced switching criteria a hitless switch shall be performed.

In any other case, the switching performance shall comply with ITU-T Recommendation G.783, § 2.4.4 (Switching time).

3.3.2.6 Switch restore

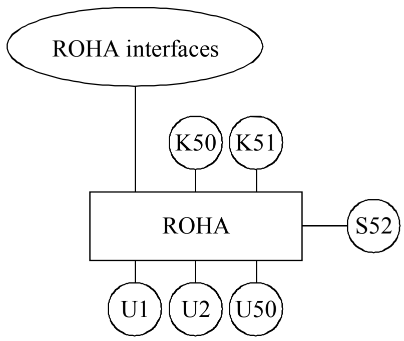
The switch restore procedure is performed by the RPS function on the basis of proprietary operation priority; an example of a set of switch restore requests is reported in Appendix 5.

3.3.3 ROHA (radio overhead access)

The description of this function makes reference to Fig. 10a.

FIGURE 10a

ROHA functional block



0750-10a

This function gives external access to RFCOH bytes (from reference point U50) and to the SOH unused bytes (i.e. bytes reserved for future international standardization, media-specific bytes and, in agreement with the National User, the National Use bytes available from reference points U1 and U2) in order to provide radio specific controls, monitoring interfaces and wayside traffic.

Moreover, it supplies transmission interfaces K50 and K51 to the RSPI and RPS functional blocks respectively, allowing the required information exchange between corresponding radio terminals or regenerators for managing specific functions (e.g. ATPC) and the unstandardized switching control protocol to operate the RPS in the $n + m$ configuration.

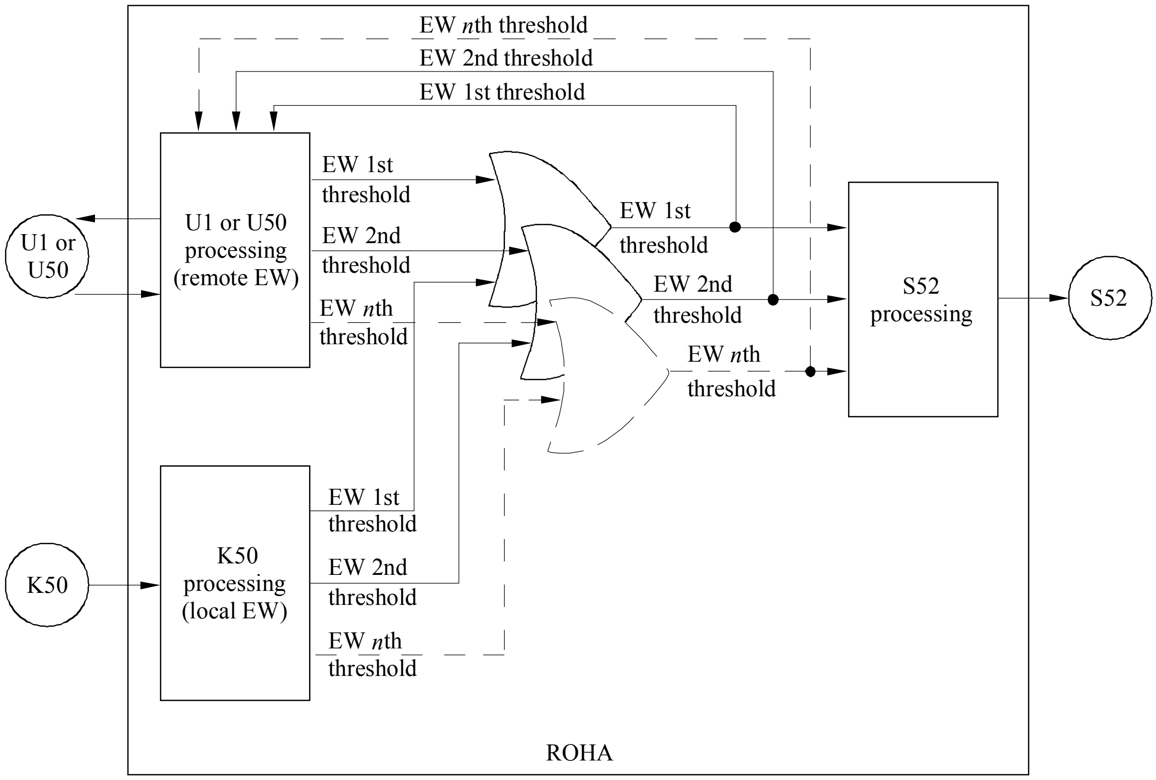
Data at the K50 and K51 interfaces will be inserted/extracted into/from the dedicated media-specific bytes of RSOH (available at reference point U1) or of RFCOH (available at reference point U50).

ROHA function can provide 1 + 1 protection for the above-mentioned signals.

The ROHA function recovers early warning (EW) switching requests of any foreseen threshold coming through the relevant bytes at U1 or U50 reference points, processes this information with the equivalent ones coming through K50 from the local receiver and makes the results available for further forwarding to the next repeater (through the relevant bytes at U1 or U50) in the regenerative repeaters or to RPS functional block (through reference point S52) in the radio terminals (see Fig. 10b).

FIGURE 10b

ROHA managing of early warning (EW) switching request



0750-10b

Indications related to the physical status shall be reported at S52 to the SEMF functional block (see § 7.2.1 and Appendix 5).

3.4 Radio terminals and repeaters arrangement of STM-*N* DRRS

3.4.1 Radio repeater arrangement

Two possibilities, from the point of view of the network management, can be envisaged:

3.4.1.1 radio repeaters may be configured as SDH optical regenerators are, provided that SPI would be substituted by RSPI;

3.4.1.2 radio repeaters may be configured as SDH optical repeaters. In this case RST is not provided and the RSPI cannot be seen as a manageable functional block unless it is included in the same network element with the radio terminals (case of NE made of a complete end-to-end radio connection described in § 7.1).

3.4.2 Radio protection switching (RPS) and radio terminals arrangement

A radio terminal may be configured either as a regenerator section (as part of a mixed-media multiplex section) or as a multiplex section.

The multiplex section protection (MSP) defined in ITU-T Recommendation G.783 is not suitable for the improvement of transmission quality as required by radio-relay systems when multipath activity is present. Therefore three separate levels of protection are possible:

– radio protection switching (RPS) for radio section protection (either at RS or MS level);

– multiplex section protection (MSP) for multimedia MS protection;

– path protections (HPC or LPC).

Because K1 and K2 bytes are used for network protection and their protocol is not suitable for radio switching, a communication channel for the control signals of a multi-line ($n + m$) radio protection switching is needed (see § 4).

In the case of twin path (1 + 1) RPS the STM-1 signals on the operating and standby channels are synchronized both in frequency and in phase as the two channels are continuously fed in parallel by the same signal.

In multiline ($n + m$) RPS, if the STM-1 signals of the working and protection channels are not synchronized, both in frequency and in phase, the switching operation causes synchronization losses on the standby channel and consequently an increase of the switching time, when hitless functionality is required to counteract multipath activity, may impair the performance of RPS. To avoid this, radio terminals may incorporate MSA functions, becoming coincident with a multiplex section, otherwise proper non-G.783 standardized resynchronizing techniques have to be adopted, in any repeater, with respect to the dynamics of the fading to reduce the global switching operation time.

Mixed-media MS, with hitless RPS functionality in regenerator sections, may be possible in cases of § 3.4.1.1 and 3.4.1.2 with the following limitation: when 1 + 1 RPS is implemented or, in $n + m$ application, when the number of cascaded regenerative repeaters is so limited that the efficiency of the hitless RPS functionality will not be essentially degraded by the total time for A1/A2 frame recovery added up along the regenerator chain.

In some applications (e.g. when hitless operation is not required or when a fast unstandardized A1/A2 alignment recovery procedure is implemented) RPS function may also be used in regenerator sections without the restrictions mentioned above (see Appendix 3 for details).

As reported in the "formal" description of radio specific functional blocks of § 3.3 and 3.3.3, various radio terminal actual block diagrams may be derived from Fig. 7, pointing out the RPS position which may vary for implementation dependent reasons.

In Appendix 3 some of these are described. These are not part of the Recommendation and are reported for reference only. Other implementations are possible.

3.5 Synchronization

Synchronization requirements for SETS functional block of SDH digital radio networks are to follow the requirements of ITU-T Recommendation G.783.

Primary reference and slave clocks are specified in ITU-T Recommendations G.811 and G.812 respectively. Slave clocks for SDH applications are specified in ITU-T Recommendation G.813.

Timing references may be derived from external synchronization interfaces (SETPI), tributary interfaces, or STM-*N* interfaces.

Requirements for jitter and wander performances for SDH radio-relay systems can be found in Recommendation ITU-R F.751.

4 Function and usage of section overhead (SOH) bytes

The frame structure of STM-*N* signals provides a payload area and a SOH. The multiplexing method is such that a variety of signals may be combined to form the payload by building up tributaries into packages within the STM-*N* frame as given in Fig. 1 for STM-1. The SOH is divided into a number of bytes for various system and network operator functions. The definition of the function, usage and position of SOH bytes are defined in ITU-T Recommendation G.707.

4.1 Multiplex and regenerator section overheads (SOH)

The concepts of multiplex sections and regenerator sections are described in § 3. Associated with each of those sections is an overhead (MSOH and RSOH). Rules for access to specific rows are given in ITU-T Recommendation G.707 and in § 3.3.

Figure 11 shows the designation of STM-1 overhead bytes, as recommended by ITU-T Recommendation G.707, which may be summarized as follows:

– 6 bytes (A1, A2) for frame alignment,
– 2 bytes (E1, E2) for order wire channels,
– 3 bytes (B2) for multiplex section bit error monitoring,
– 1 byte (J0 or C1) for STM identification,
– 1 byte (B1) for regenerator section bit error monitoring,
– 1 byte (F1) for user channel,
– 2 bytes (K1, K2) for automatic protection switching,
– 12 bytes (D1, . . . D3, D4, . . . D12) for data communication channels,
– 6 bytes reserved for national use,
– 4 bytes (Z1, Z2) not yet defined,
– 1 byte (S1) for synchronization,
– 1 byte (M1) for section far end block error reporting (FEBE),
– 6 bytes for media-specific usage,
– 26 bytes reserved for future international standardization.

SDH radio systems shall both transport and utilize the appropriate SOH functions in accordance with ITU-T Recommendation G.707, such that radio systems can be fully integrated into a managed transmission network.

4.2 Media-specific bytes

ITU-T Recommendation G.707 allows, in the STM-1 format, for a total of six bytes for media-specific usage in rows 1 to 3 of the SOH, designated S(2,2,1), S(2,3,1), S(2,5,1), S(3,2,1), S(3,3,1) and S(3,5,1). These bytes are shown in Fig. 11.

Equivalent bytes, for every STM-1 in STM-4, STM-16 and STM-64 SOH formats, are also provided.

4.3 Reduced SOH functionality for intra-station sections

Intra-station sections (defined for the optical case by ITU-T Recommendation G.958) offering reduced functionality should be terminated by an intra-station section termination (see Fig. 4).

ITU-T Recommendation G.707 reports the required and the reduced SOH functionality of the MS intra-station interface (ISI).

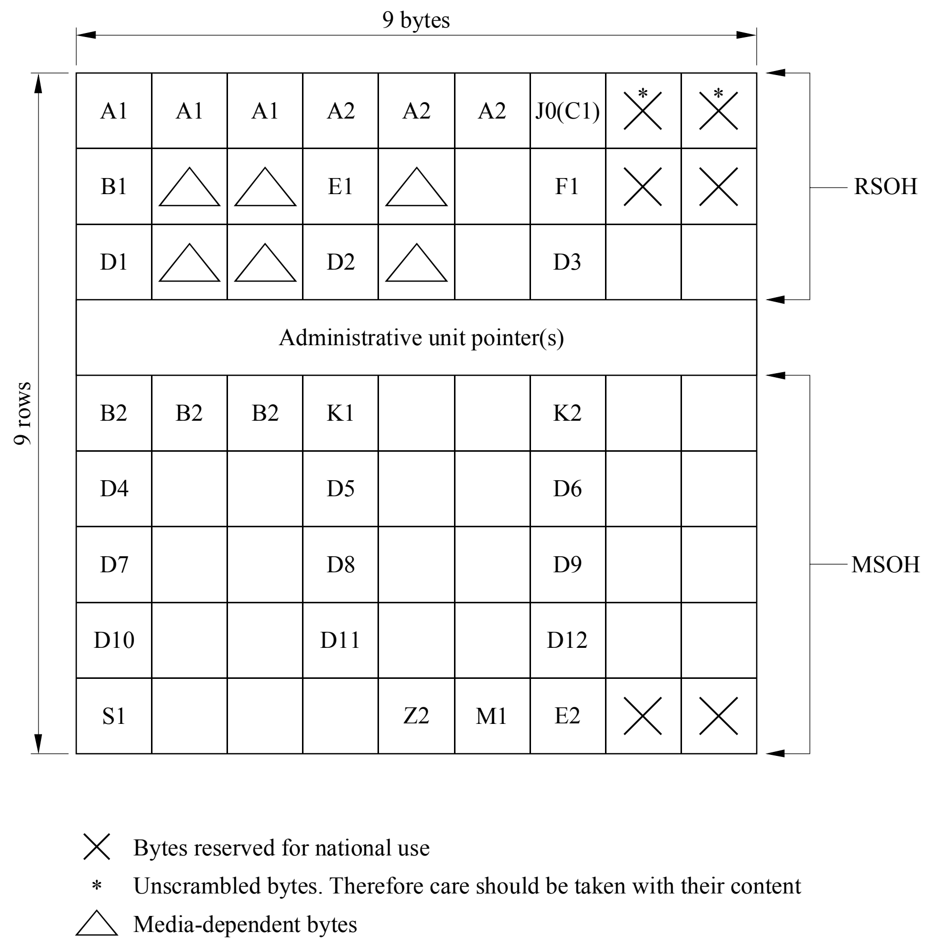
5 Radio-relay specific functions

SDH-DRRS may provide auxiliary capacity necessary for radio-specific functions, e.g. supervisory functions, order wire, radio protection switching, etc.

The radio-specific functions and the possible techniques used to transport the related data channels, e.g. using the SOH bytes of the STM-1 or the STM-0 frames or radio frame complementary overhead (RFCOH), are discussed in § 4 of Recommendation ITU-R F.751.

FIGURE 11

STM-1 SOH
(from ITU-T Recommendation G.707)



Note 1 – All unmarked bytes are reserved for future international standardization (for media-dependent, additional national use and other purposes).

0750-11

6 STM-0 transmission rate SDH radio-relay systems

This section proposes the integration of STM-0 digital radio-relay systems (DRRS) to transport VC-3 payload with standard interfaces within a synchronous digital hierarchy (SDH) telecommunications network.

The definition of STM-0 transmission rate is reported in ITU-T Recommendation G.861, while ITU-T Recommendation G.707 gives the recommended frame structure recommended for 51.84 Mbit/s.

This area is of particular interest in cases where the required traffic payload is below that available within an STM-1 signal.

When the STM-1 signal is partly filled, there is the opportunity for the radio-relay to transport only a part of the STM-1 signal with the necessary SOH. This can provide savings in radio spectrum and/or reduced modulation complexity.

Radio-relay systems at STM-0 bit rates to be integrated in an SDH network have to guarantee functional transparency of SDH networks between two STM-1 network node interfaces (see Note 1).

NOTE 1 – Functional transparency may be obtained if MSOH functions of STM-1 are passed through STM-0 section without changing the informative content. B2 parity recalculation and VC-3/4 pointer adjustment will be performed anyway.

6.1 Network interfaces

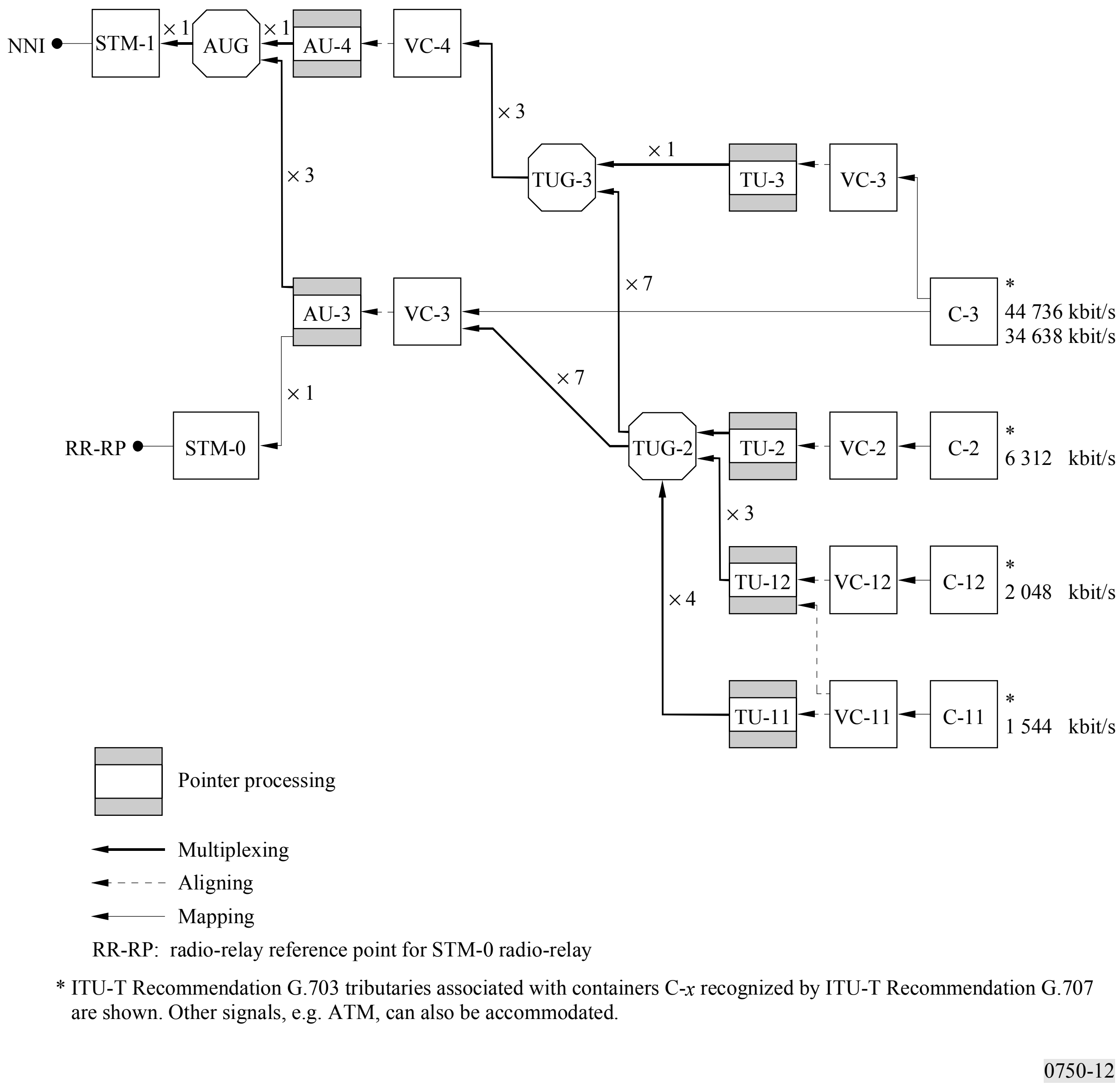
STM-0 SDH radio-relay systems shall employ network interfaces at the STM-1 level as described in ITU-T Recommendation G.707 and at the tributary plesiochronous rates described in ITU-T Recommendations G.702 and G.703 and recognized by ITU-T Recommendation G.707.

6.2 Multiplexing schemes

The SDH multiplexing route to form the STM-0 synchronous transport module of order 0 is deduced from the SDH multiplexing route. The STM-0 signal can be derived from the STM-1 signal, or from tributary rates below the C-4 level as defined in ITU-T Recommendation G.703. These routes can be seen in Fig. 12.

FIGURE 12

STM-0 radio-relay system multiplexing scheme



The following definitions apply to Fig. 12:

– *Radio-relay reference point for STM-0 radio-relay (RR-RP):* a functional reference point within a STM-0 radio system where the STM-0 is assembled;

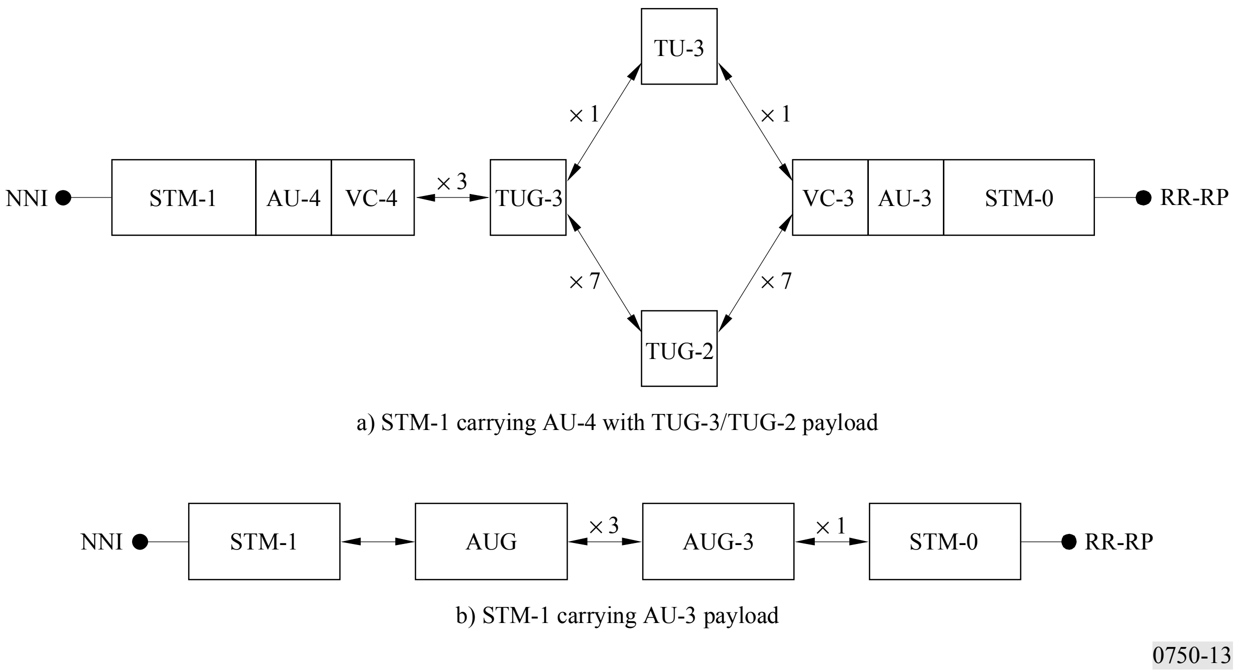
– *Synchronous transport module for STM-0 radio-relay:* a frame structure at 51.84 Mbit/s rate with overhead and payload mapping as recommended in Annex A of ITU-T Recommendation G.707 and in ITU-T Recommendation G.861.

The interconnections of STM-1 and STM-0 are shown in Fig. 13a) and Fig. 13b) respectively for AU-4-based SDH networks and AU-3 based SDH networks.

In the case of AU-4-based SDH networks, the information structure AU-3 does not represent an administrative unit and is not managed as such at network interfaces.

FIGURE 13

Interconnection of STM-1 and STM-0



6.3 Multiplex and regenerator radio sections

This section identifies three configurations for STM-0 SDH radio-relay systems as shown in Figs. 14, 15 and 16. In each case the allocations of the multiplex section and regenerator section are shown. These functions are analogous to the MST and RST functions of ITU-T Recommendation G.783.

The configuration shown in Fig. 14 employs ITU-T Recommendation G.707 network node interfaces at each radio terminal, whilst providing an STM-0 transport capability.

The configuration shown in Fig. 15 employs a single ITU-T Recommendation G.707 NNI, a STM-0 transport capability, and integral multiplexing functionality to provide tributary payload access.

The configuration shown in Fig. 16 employs ITU-T Recommendation G.703 tributary payload access at each terminal with integral multiplexing with an STM-0 transport capability.

6.4 Functional block diagrams of STM-0 digital radio-relay systems

This section contains functional block diagrams for the system configurations identified in § 6.3 for STM-0 SDH radio-relay systems.

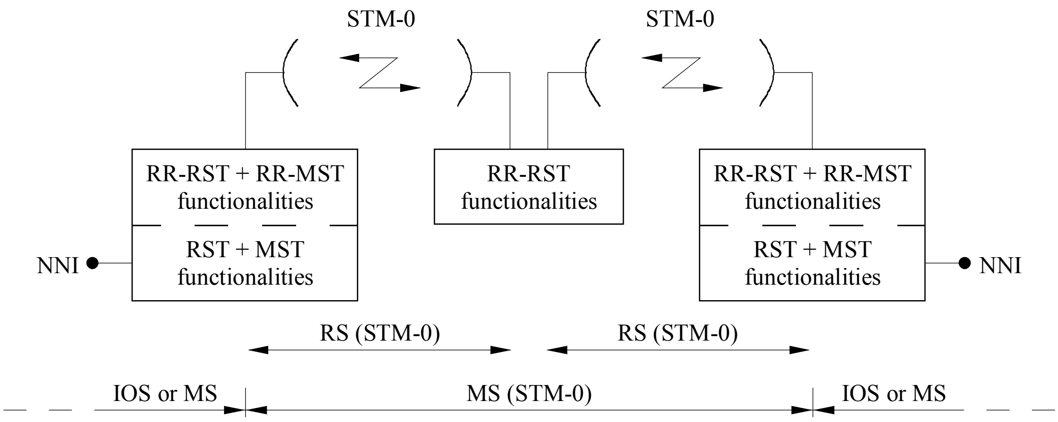
The partitioning into functional blocks is used to simplify and generalize the description and it does not imply any physical partitioning and/or implementation.

The functional block diagram is intended to be used, in conjunction with ITU-T Recommendation G.783, for a "formal" description of the main functionality of an SDH radio equipment.

Figure 17 is taken as a generalized block diagram for STM-0 systems. As in previous Fig. 7 for STM-*N*, in Fig. 17, for clear distinction from ITU-T Recommendation G.783 (1994) definitions, U*x*, K*x* and S*x* interfaces numbering, for radio-specific blocks, has been taken starting from 50 onward.

FIGURE 14

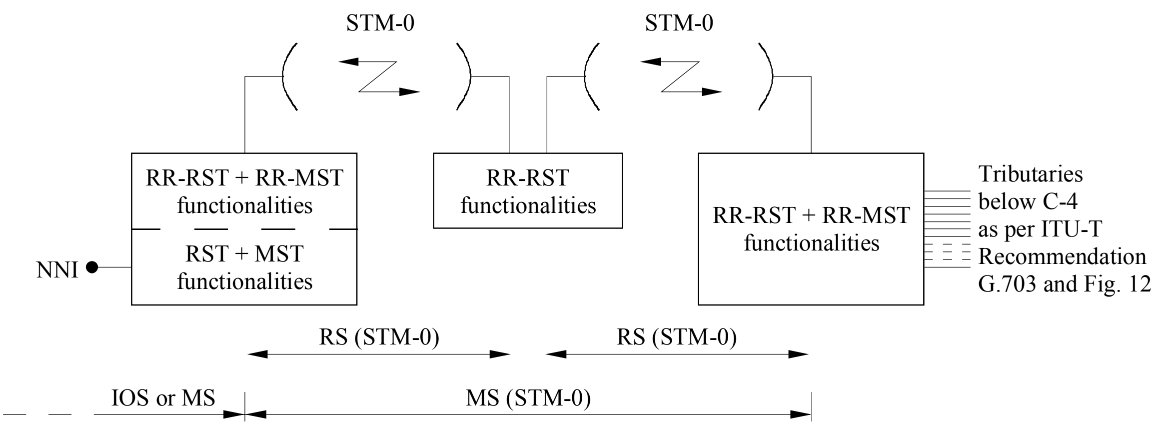
NNI/NNI configuration



0750-14

FIGURE 15

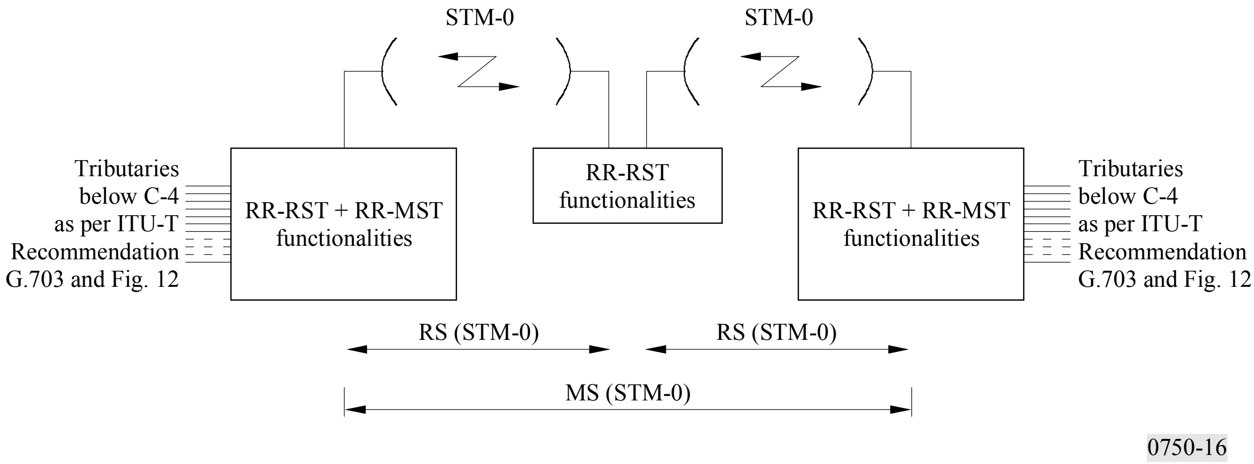
NNI/tributary rate configuration



0750-15

FIGURE 16

Tributary rate/tributary rate configuration



In Fig. 17, where other references are taken from ITU-T Recommendation G.783 (1994), it may be noted that the following additional radio-specific functional blocks, reference points and interfaces, with respect to those defined by ITU-T or already introduced in Fig. 7 and § 3.3, are included:

– RR-RSPI: radio STM-0 synchronous physical interface (functional block)
– RR-RST: regenerator section termination for STM-0 radio-relay (functional block) (see Note 1)
– RR-MST: multiplex section termination for STM-0 radio-relay (functional block) (see Note 1)
– RR-MSA: multiplex section adaptation for STM-0 radio-relay (functional block) (see Note 1)
– RR-SPI: synchronous physical interface STM-0 radio-relay (functional block)
– RR-EI: reference point at radio-relay equipment interface
– Rs: reference point at RR-RSPI radio-frequency interface
– Bs: reference point between RR-RSPI and RR-RST (see Note 1)
– Cs: reference point between RR-RST and RR-MST (see Note 1)
– Es: reference point between RR-MST and RR-MSA or RR-SPI (see Note 1).

NOTE 1 – ITU-T Recommendation G.707 specifies the frame structure for STM-0 at 51.84 Mbit/s rate. The required functional blocks, like RR-RST, RR-MST and RR-MSA (together with their related interfaces B, C and D), are similar to the RST, MST and MSA functional blocks defined by ITU-T Recommendation G.783 (1994), but not identical. Hence their differences are described in § 6.4.2 to 6.4.4; the definition of equivalent atomic functions is for further study.

6.4.1 Radio-relay STM-0 synchronous physical interface (RR-RSPI) function

The RR-RSPI function provides the interface between the radio physical medium at reference point Rs and the RR-RST function at reference point Bs.

Data at Rs is a radio-frequency signal containing an STM-0 signal with an unstandardized use of SOH media-dependent bytes and (if used) an additional arbitrary radio frame complementary overhead (RFCOH). Therefore mid-air interconnectivity between transmitters and receivers from different vendors is not required.

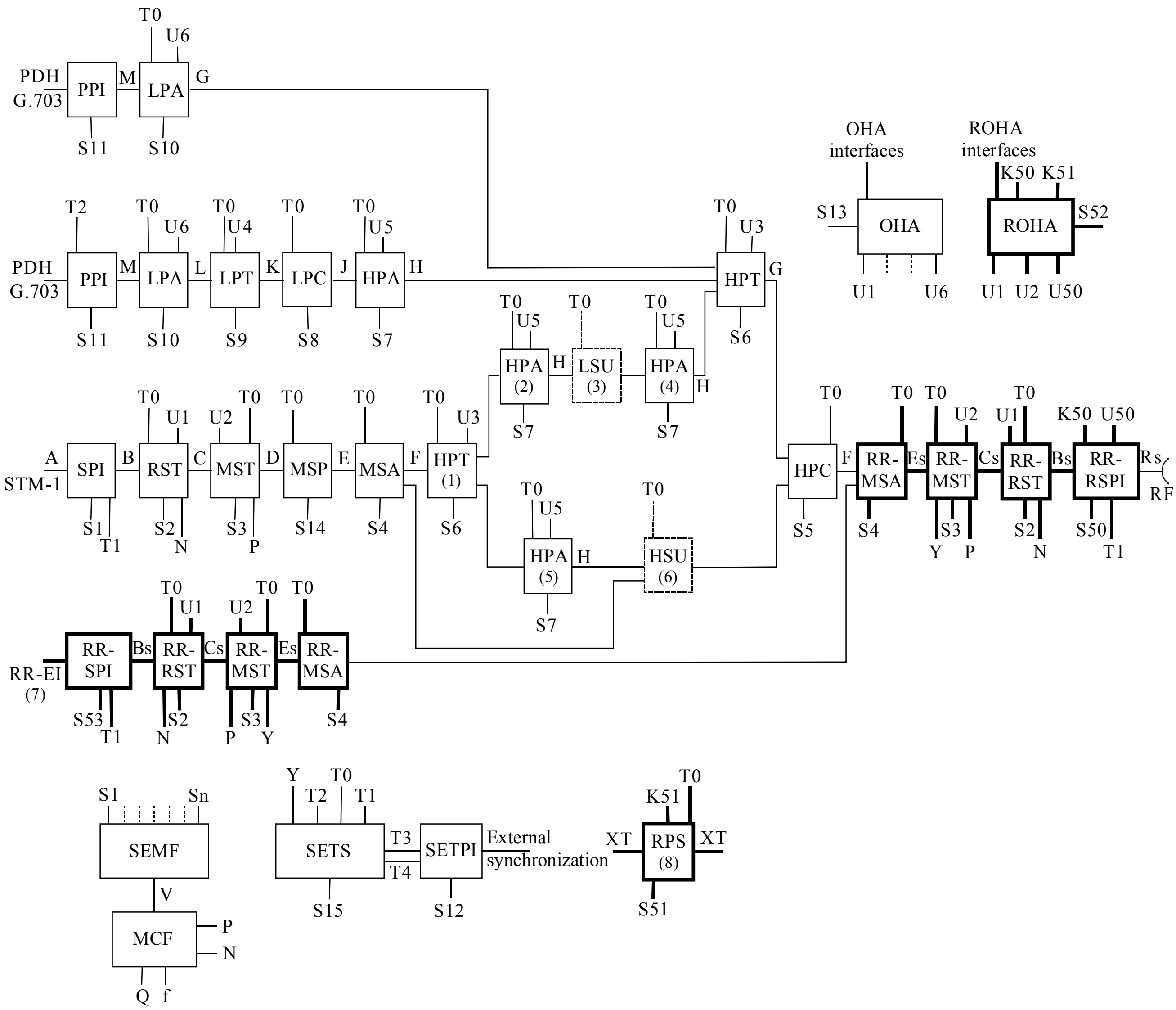
The function description of this block is identical to the RSPI of § 3.3.1 apart from the different input/output reference points.

6.4.2 Radio-relay STM-0 regenerator section termination (RR-RST)

The description of this block is identical to the RST described in ITU-T Recommendation G.783 apart from the input/output reference points Bs and Cs which are analogous to B and C of ITU-T Recommendation G.783 (1994) but at a bit rate of STM-0; RSOH processed at U1 reference point is limited only to RR-RSOH relevant columns.

FIGURE 17

Generalized SDH-STM-0 DRRS logical and functional block diagram



(1) Termination.

(2) TUG-3/TUG-2 adaptation.

(3) Unequipped VC-3 or VC-2 or VC-11 or VC-12 generation (reduced functionality, these unequipped VC being permanently unused, their monitoring is not required).

(4) TUG-2/VC-3 adaptation.

(5) TUG-3/TU-3/VC-3 adaptation.

(6) Unequipped VC-3 generation (reduced functionality, these unequipped VC being permanently unused, their monitoring is not required).

(7) This is not an NNI, see § 6.4.5.

(8) The RPS functional block is composed by a connection type function which, for implementation purposes, can be inserted in between any other functional block to perform specific ($n + m$) line protection for the radio section. XL and XT are functionally the same interface and always fit any interface where it may be inserted.

0750-17

6.4.3 Radio-relay STM-0 multiplex section termination (RR-MST)

The description of this block is identical to the MST described in ITU-T Recommendation G.783 apart from the input/output reference points Cs and Es which are analogous to C and E of ITU-T Recommendation G.783 (1994) but at a bit rate of STM-0; MSOH processed at U2 reference point is limited only to RR-MSOH relevant columns.

6.4.4 Radio-relay STM-0 multiplex section adaptation (RR-MSA)

The description of this block is identical to the MSA described in ITU-T Recommendation G.783 apart from the input/output reference points Es which is analogous to E of ITU-T Recommendation G.783 (1994) but at a bit rate of STM-0; moreover AU grouping functionality is not performed.

6.4.5 STM-0 radio-relay synchronous physical and equipment interface (RR-SPI and RR-EI)

In some cases, it may be desirable to connect radio-relay equipment at a STM-0 interface rate of 51.84 Mbit/s. This interface applies at the RR-RP and is not an NNI; rather it is intended as an optional interface between STM-0 radio-relay equipment.

The electrical characteristics of the STM-0 RR-EI are found in Appendix 1.

An application of the RR-EI is shown in Fig. 18, where inter-operability of equipment from different suppliers within MS can be pursued.

The functional block diagram of a STM-0 regenerator is shown in Fig. 19. The RR-SPI function converts the internal logical level STM-0 into an RR-EI line interface signal.

6.5 Radio protection switching

STM-0 radio-relay systems may have radio protection switching (RPS). If the STM-0 multiplex section contains radio-relay equipment connected through the RR-EI, then RPS may be implemented independently on either side of the RR-EI.

A communication channel, if required, for the STM-0 radio protection switching should be implemented using RFCOH, or depending on implementations, bytes C1, F1 and/or one of the data communication channels may be used. The K1 and K2 bytes are reserved for network protection switching.

6.6 Section overhead (SOH) for STM-0 DRRS

Figure 20 shows the section overhead (SOH) bytes in the STM-0. The STM-0 SOH information is classified into regenerator section overhead (RSOH) which is terminated at regenerator functions and multiplex section overhead (MSOH) which passes transparently through regenerators and is terminated where STM-0 is assembled and disassembled (see Note 1).

NOTE 1 – There may be a requirement of functional transparency of MSOH information contents even through radio terminals (see § 6).

The description and the function of the STM-0 bytes are analogous to the corresponding bytes of the STM-1 SOH.

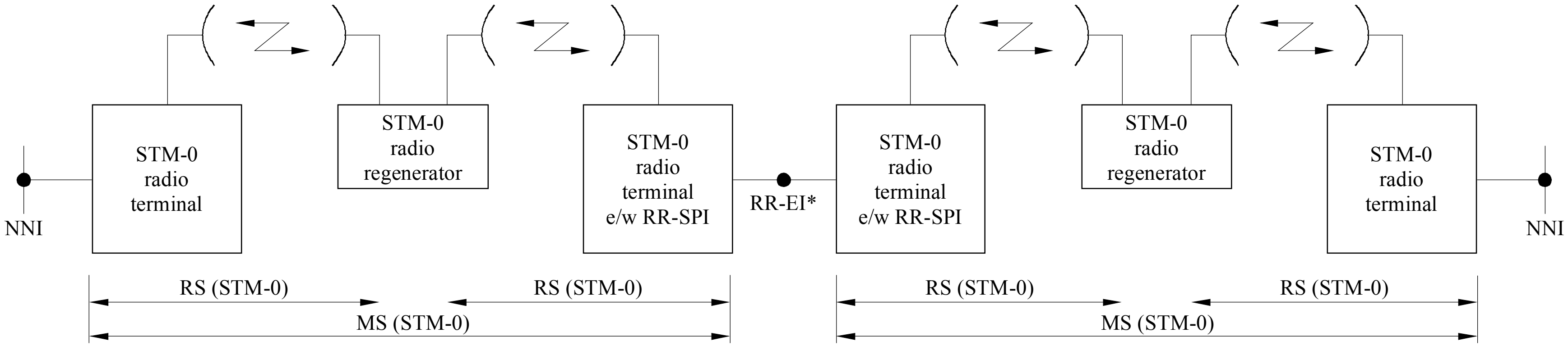
The need for radio-specific SOH bytes for STM-0 radio-relay applications has been identified.

The MS-FEBE (far end block error, renamed as REI) function provided by the M1 byte which has been introduced in the 51.84 Mbit/s frame by ITU-T Recommendation G.707 (version 1995) and in a different position with respect to STM-1 SOH. As a consequence STM-0 DRRS may have provided this functionality within RFCOH.

Media-specific SOH bytes have not been assigned. However, depending on the STM-0 radio-relay applications, some of the SOH bytes may be available because their standard function as in ITU-T Recommendation G.707 may not be necessary or may be achieved by other means, e.g. use of FEC indications for radio performance monitoring. Depending on the implementations, bytes C1, F1 and/or one of the data communication channels may be used. However, RFCOH could also be used to perform media-specific functions.

FIGURE 18

NNI/NNI connection with RR-EI

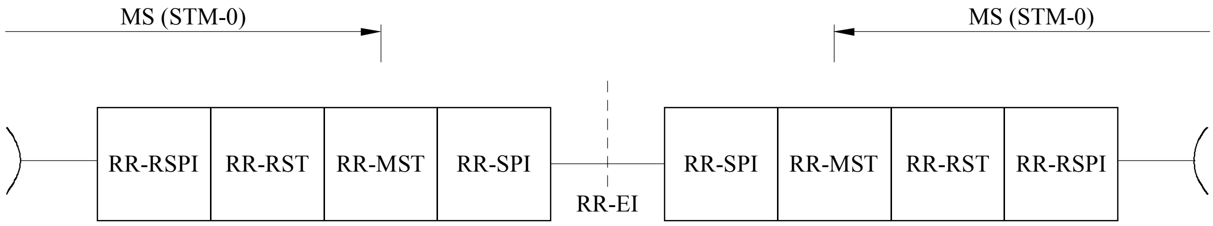


* Optional STM-0 radio-relay equipment interface.

0750-18

FIGURE 19

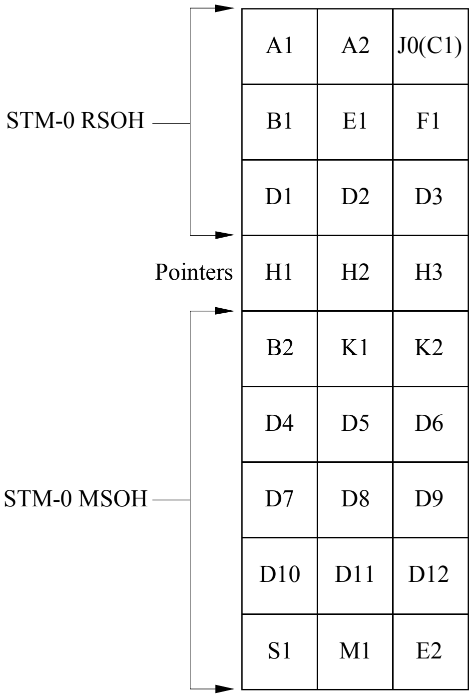
Functional block diagram of STM-0 regenerator using RR-EI



0750-19

FIGURE 20

SOH of STM-0



0750-20

6.7 Techniques for transport of media-specific functions

A description of possible radio-relay specific functions is found in § 4 of Recommendation ITU-R F.751. The technique adopted to provide these functions may be implementation dependent; examples of possibilities are:

– use of STM-0 SOH as in § 6.6;

– the transmission of an unstandardized arbitrary radio frame complementary overhead (RFCOH); this may be used for the transmission of other functions which ITU-T provides into the missed 6 columns of STM-1 SOH;

– the transmission, as a well identified case of RFCOH, of the missed 6 columns of a full STM-1 SOH as a radio complementary section overhead (RCSOH). An example of this application is shown in Appendix 4.

7 Operation and maintenance aspects

The operation, administration and maintenance features of SDH radio systems should be designed in accordance with ITU-T Recommendations M.20 (Maintenance philosophy for telecommunications networks), M.3010 (Principles for a telecommunications management network) and G.784 (SDH management).

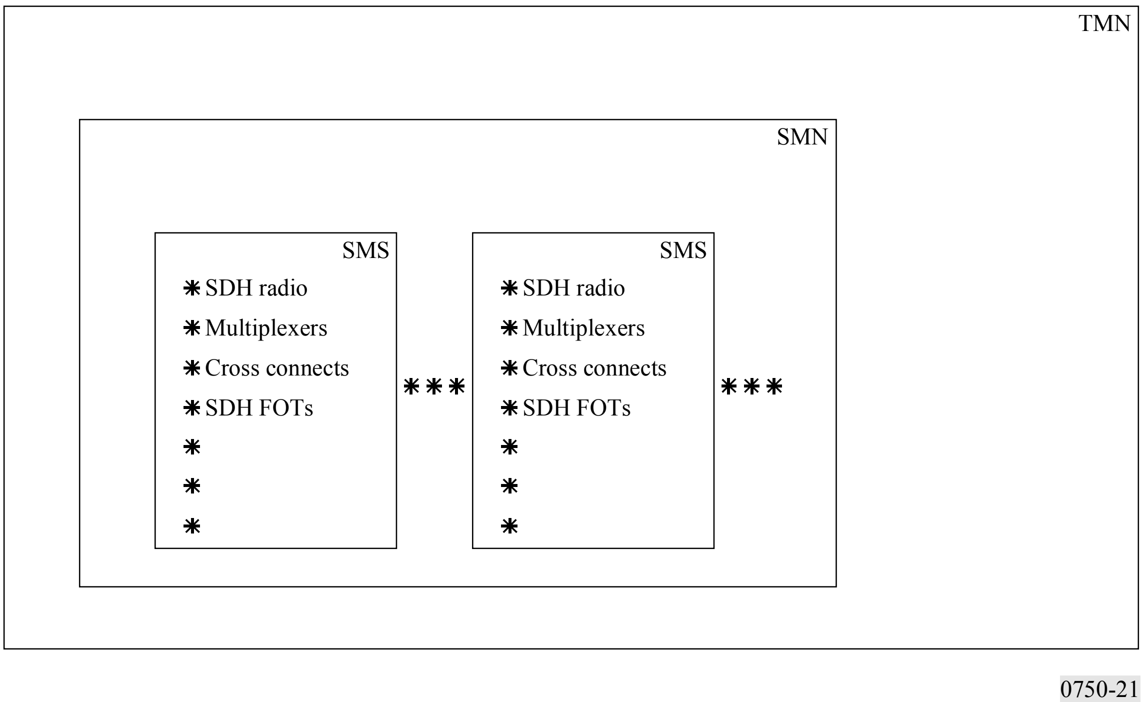
7.1 Management functions

SDH radio-relay systems will be part of an overall managed telecommunications network. In particular, these radio systems will be part of a managed synchronous network.

ITU-T Recommendation G.784 allows the SDH management network (SMN) to consist of various managed SDH sub-networks. SDH radio-relay systems will be managed within an SDH management sub-network (SMS) as shown in Fig. 21.

FIGURE 21

Relationship between SMS, SMN and TMN



ITU-T Recommendation G.784 defines the NE as: "A stand-alone physical entity that supports at least NEFs and may also support OSF/MFs. It contains managed objects, a MCF and a MAF."; this means that NE definition is not intended for standardization but is related to the practical implementation of the SDH equipments.

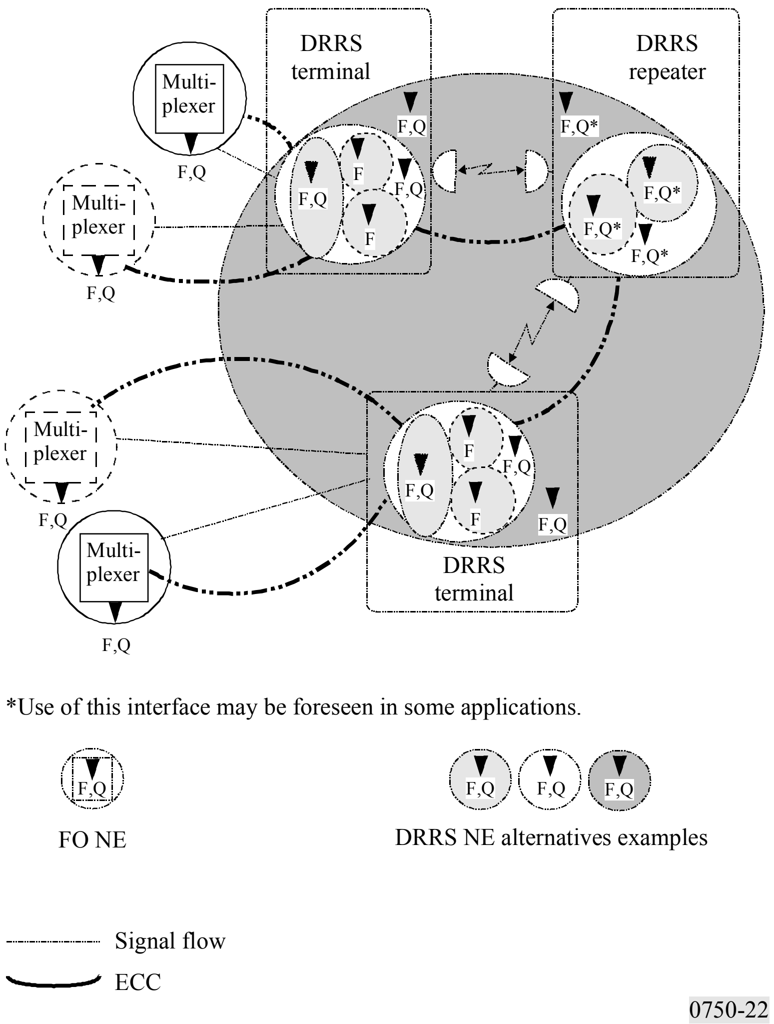
SDH NEs may be formed by a suitable interconnection of the various functional blocks as described in ITU-T Recommendation G.783 or, for radio-specific equipment, in § 3.3 or 6.4; therefore, according to implementation, radio NEs may be formed by a single radio or switching equipment, or by a set of these equipment forming more complex functions (up to a full $n + m$ radio terminal or repeater or to a complete end-to-end radio connection).

A generic example of an SMS consisting of a radio system connected to multiplex equipment is shown in Fig. 22. Examples of the network elements (NEs) to be managed are also shown.

As an SDH-NE, the radio-relay terminal or repeater may have a work-station interface F and/or a Q interface. It may be linked to other NEs according to the architecture of Figure 3.4 of ITU-T Recommendation G.784. One NE in the SMS should be a gateway NE to facilitate communication with a mediation device or the operations system.

FIGURE 22

Examples of a mixed radio/FO SMS



7.2 Maintenance functions

Radio-specific alarms and a standardized message set have to be defined within Q protocols (ITU-T Recommendations G.783, G.784 and G.831).

This section describes parameters which should be monitored in SDH digital radio systems (see Note 1).

NOTE 1 – The parameters reported in this Recommendation are related to network operation and maintenance only, they are not intended to cover specific hardware units decomposition which, in any case, are equipment oriented and, in consequence, may not be standardized.

From a management point of view several primitives or events may be collected in the NE, but only the aggregate or derivative suitable information as required by this Recommendation should be forwarded to management system.

The radio-specific functional blocks, namely RSPI, RR-RSPI, RPS and ROHA, will give to the SEMF functional block, through S50, S51 and S52 reference points respectively, the anomalies and defects indications that are reported in §§ 7.2.1, 7.2.2, and 7.2.3 and resumed in Tables 2 and 3 together with the consequent actions.

7.2.1 RSPI and RR-RSPI maintenance functions

The set of indications of RSPI and RR-RSPI functional block (see Fig. 8b) may be described as follows:

– lossOfSignal(mod) This indication shall indicate a loss of the incoming data for the modulation function. This indication is used in case of split indoor/outdoor functions of RSPI and RR-RSPI, therefore this indication is optional.

– modulationFail This indication shall report the internal failures of the modulation function affecting the modulated signal, and the loss of incoming data to the modulation function.

– txFail This indication shall indicate a failed transmitted signal caused by internal failures of the transmitting function (TX).

– txLOS This indication shall indicate a loss of the incoming signal for the transmitting function (TX). When the distinction between txFail and txLOS cannot be carried out with a sufficient degree of confidence, the use of txFail indication should be preferred, therefore this indication is optional.

– lossOfSignal(rx) This indication shall report a loss of the incoming signal at reference point R for the RX function. When the distinction between rxFail and lossOfSignal(rx) cannot be carried out with a sufficient degree of confidence, the use of rxFail indication should be preferred, therefore this indication is optional.

– rxFail This indication should report the internal failures of the RX-function affecting the received signal.

– demLOS This indication shall indicate a loss of the incoming data for the demodulation function. When the distinction among demodulationFail, demLOS, excessivBER and routeIDMismatch cannot be carried out with a sufficient degree of confidence, the use of demodulationFail indication shall be preferred, therefore this indication is optional.

– excessiveBER Radio-relay system, which implements RPS function according to the type D, reported in Appendix 3, may require to perform error event functionality using this indication. This indication should show a degradation of the incoming data from the demodulation function. When the distinction among demodulationFail, demLOS, excessivBER and routeIDMismatch cannot be carried out with sufficient degree of confidence, the use of demodulationFail indication should be preferred, therefore this indication is optional.

– routeIDMismatch Radio-relay system, which implements RPS function according to the type D, reported in Appendix 3, may require to perform the radio hop trace functionality using this indication. This indication should show a wrong incoming data from the demodulation function. When the distinction among demodulationFail, demLOS, excessivBER and routeIDMismatch cannot be carried out with sufficient degree of confidence, the use of demodulationFail indication should be preferred, therefore this indication is optional.

– demodulationFail This indication should report the internal failures of the demodulation function affecting the demodulated signal.

In Table 2 the related SEMF filtering and consequent actions are reported.

TABLE 2

RSPI and RR-RSPI maintenance function

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions
		S50	Alarm	Performance	All Ones (AIS) inserted at reference point B
From R to B and from Rs to Bs	lossOfSignal(rx)[(1)]	Yes	Yes		Yes
	rxFail	Yes	Yes		Yes
	demLOS[(1)]	Yes	Yes		Yes
	excessiveBER[(1), (2)]	Yes	Yes		
	routeIDMismatch[(1), (2)]	Yes	Yes		Yes
	demodulationFail	Yes	Yes		Yes
From B to R and from Bs to Rs	lossOfSignal(mod)[(1)]	Yes	Yes		
	modulationFail	Yes	Yes		
	txFail	Yes	Yes		
	txLOS[(1)]	Yes	Yes		

(1) These indications are optional, see description above.

(2) These indications may be required especially in case of radio-relay system with RPS type D described in Appendix 3.

In addition to the above defined set of "formal" indications other primitives may also be envisaged to be accessed via reference point S50 for maintenance and RPS operation purposes; in Appendix 5 an example is reported; the management information model for the network element view is reported in ITU-T Recommendation G.774.

7.2.2 RPS maintenance functions

The set of indications of RPS functional block may be described as follows:

– RPSFail (Failure of RPS)

  RPSFail should be declared when RPS function is no more able to supply protection to one or more of the protected channels.

Primitives may also be envisaged to be accessed via reference point S51 for maintenance and operation purposes; in Appendix 5 an example is reported; the management information model for the network element view is reported in ITU-T Recommendation G.774.

In Table 3 the related SEMF filtering and consequent actions are reported.

TABLE 3

Radio protection switch anomalies and defects

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions
		S51	Alarm	Performance	
From XT to XL and from XL to XT	RPSFail	Yes	Yes		

7.2.3 ROHA maintenance functions

In Appendix 5 an example of possible operation and maintenance indication is reported.

7.2.4 Performance monitoring functions

SDH radio network elements (NE) may terminate, depending on applications, regenerator and multiplex sections and also high/low order paths. For each one of the above SDH layers implemented inside a SDH radio NE, the associated standardized PM should be implemented.

Signal transmission on microwave radios may be affected by mid-air propagation phenomena that may result in transmission quality degradation. In order to counteract such typical radio feature several countermeasures are or may be implemented inside radio transmission equipment. The close relationship between transmission quality and radio link propagation cannot be well understood if the PM is limited only to QoS. In particular it is not possible, for a given measured quality, to discriminate among errors due to equipment degradations, countermeasure unefficiency and unusual or unpredicted bad propagation. From such a reason it needs to have radio specific performance parameters to be used in close conjunction with the ordinary ones related to quality transmission: severely errored second (SES), errored second (ES), background block error (BBE) and unavailable second (UAS).

Radio specific PM defines new radio specific performance primitives, events and parameters with associated requirements for data collection, threshold and history treatment.

Radio specific PM deals with monitoring of the radio specific functional blocks RSPI and RPS as defined in this Recommendation. All of these radio specific performance parameters do not need to have quality objectives to meet. Their meaning is consistent only in the hops or link. Comparisons among different hops or links are not meaningful. A true performance comparison among different hops or links can be done only on the base of the generic SDH QoS parameters like ES, SES, BBE and UAS.

Some performance parameters, reported in this Recommendation, are labelled as optional; these options are only intended for covering possible different hardware implementations, therefore, depending on the equipment actual implementation, some of these parameters may not be available.

See Appendices 5 and 6.

APPENDIX 1

TO ANNEX 1

RR-EI electrical characteristics

Nominal bit rate (STM-0): 51.840 Mbit/s

Bit rate tolerance

During synchronized operation, the bit rate tolerance shall be that of the network clock. In a mode without any synchronization to a network clock (e.g. self-timed, free running), the bit rate tolerance shall not exceed 1 037 bit/s (20 ppm).

Line code: B3ZS

Termination

One coaxial line shall be used for each direction of transmission.

Impedance

A resistive test load of 75 Ω ± 5% shall be used at the interface for the evaluation of pulse shape and the electrical parameters specified below.

Power level

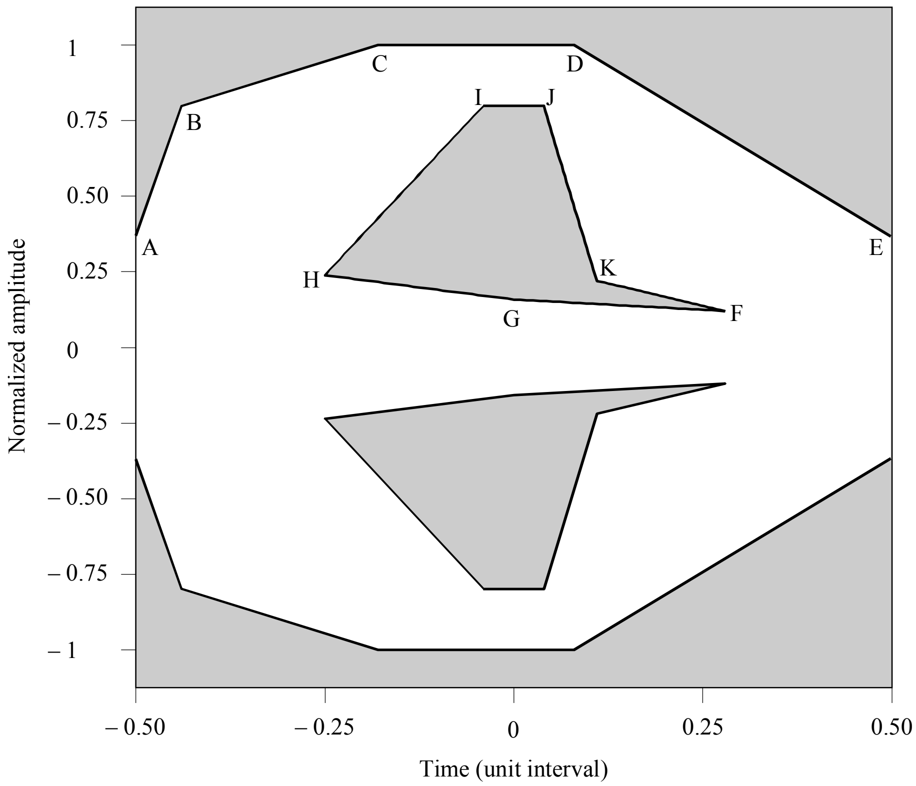
A wideband power measurement using a power level sensor with a working frequency range of at least four times the bit rate frequency shall be between –2.7 dBm and +4.7 dBm, accounting for both transmitter variations and a range of connecting cable lengths between 68.6 m and 137 m. A filter with a characteristic equivalent to a Butterworth low pass filter with a cut-off frequency of 207.360 MHz shall be used.

Eye diagram

An eye diagram mask based on the maximum and minimum power levels and cable lengths given above is shown in Fig. 23 where the voltage amplitude has been normalized to one, and the time scale is specified in terms of the unit interval T. Exclusionary regions are shown as shaded areas on the Figure. The corner points of these regions are listed below the Figure.

FIGURE 23

RR-EI eye diagram



0750-23

Outer region corner points			Inner region corner points		
Point	Time	Amplitude	Point	Time	Amplitude
A	–0.50	0.37	F	0.28	0.12
B	–0.44	0.80	G	0.00	0.16
C	–0.18	1.00	H	–0.25	0.24
D	0.08	1.00	I	–0.04	0.80
E	0.50	0.37	J	0.04	0.80
			K	0.11	0.22

NOTE 1 – Both inner and outer regions are symmetric about the zero amplitude axis.

DC offset

There shall be no DC power flow across the interface.

Frame structure

The signal shall have the frame structure and scrambling as defined in ITU-T Recommendation G.708.

Jitter

This requires further study.

APPENDIX 2

TO ANNEX 1

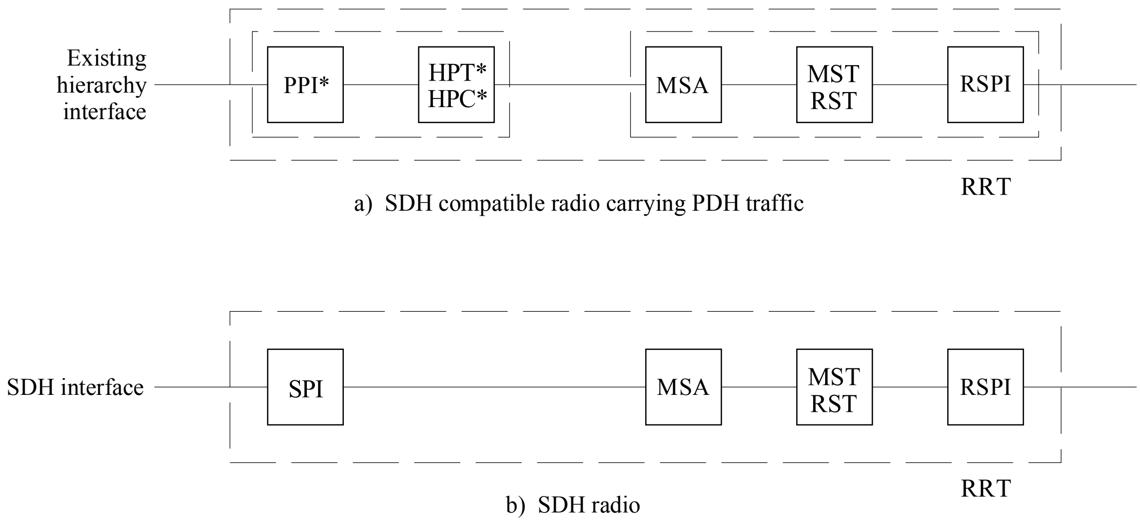
Migration strategy from an existing PDH to SDH-based networks

In the case of migration from an existing PDH (e.g. 140 Mbit/s) to SDH, one possibility is to have SDH-compatible radio systems during the transition period, which have the ability to transport SDH bit rates, although carrying PDH traffic. This can be done by providing special hardware marked by an asterisk (*) in Fig. 24a), which will convert the PDH signal to an SDH signal according to the mapping rules of ITU-T Recommendation G.707. When the need to transport real SDH signals arises, the extra hardware will be discarded as shown in Fig. 24b) and replaced by a synchronous physical interface module.

The radio equipment would result in a radio system with full SDH functionality.

FIGURE 24

Simplified block diagram



HPC: higher order path connection
HPT: higher order path termination
MSA: multiplex section adaptation
MST: multiplex section termination
PPI: plesiochronous physical interface
RRT: radio-relay terminal
RSPI: radio synchronous physical interface
RST: regenerator section termination
SPI: SDH physical interface

Note 1 – Only functions are shown. Radio protection switching is not shown.

*These modules will be discarded after migration to SDH.

0750-24

APPENDIX 3

TO ANNEX 1

Examples of practical implementations of the RPS function

In this Appendix some possible implementations of RPS with hitless functionality are described together with some comments about its functionality and characteristics.

The more common types of RPS may be observed in the four block diagrams reported in Fig. 25. These may be more detailed as reported in the following Fig. 26.

FIGURE 25

Possible logical allocation of the RPS functional block

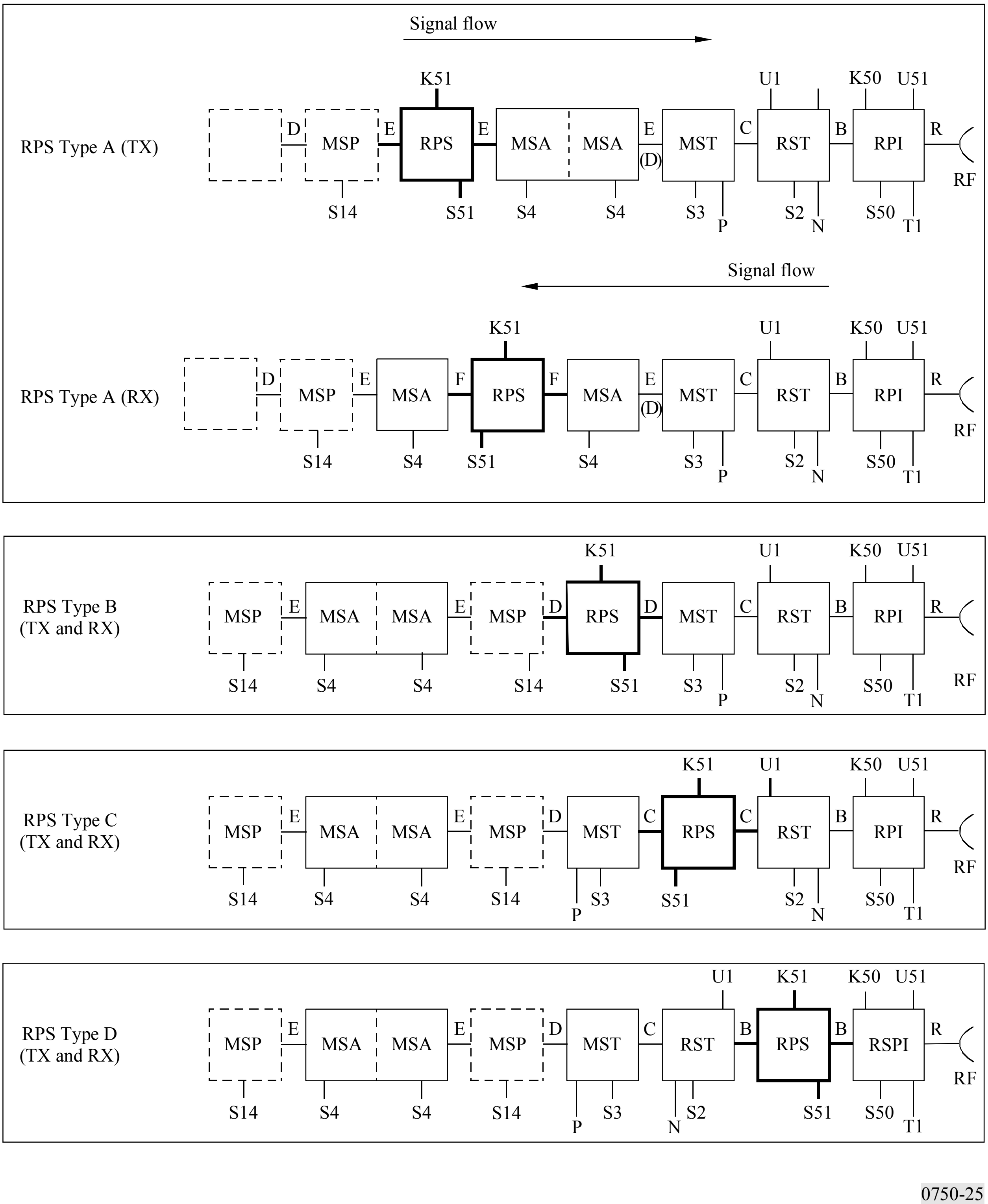
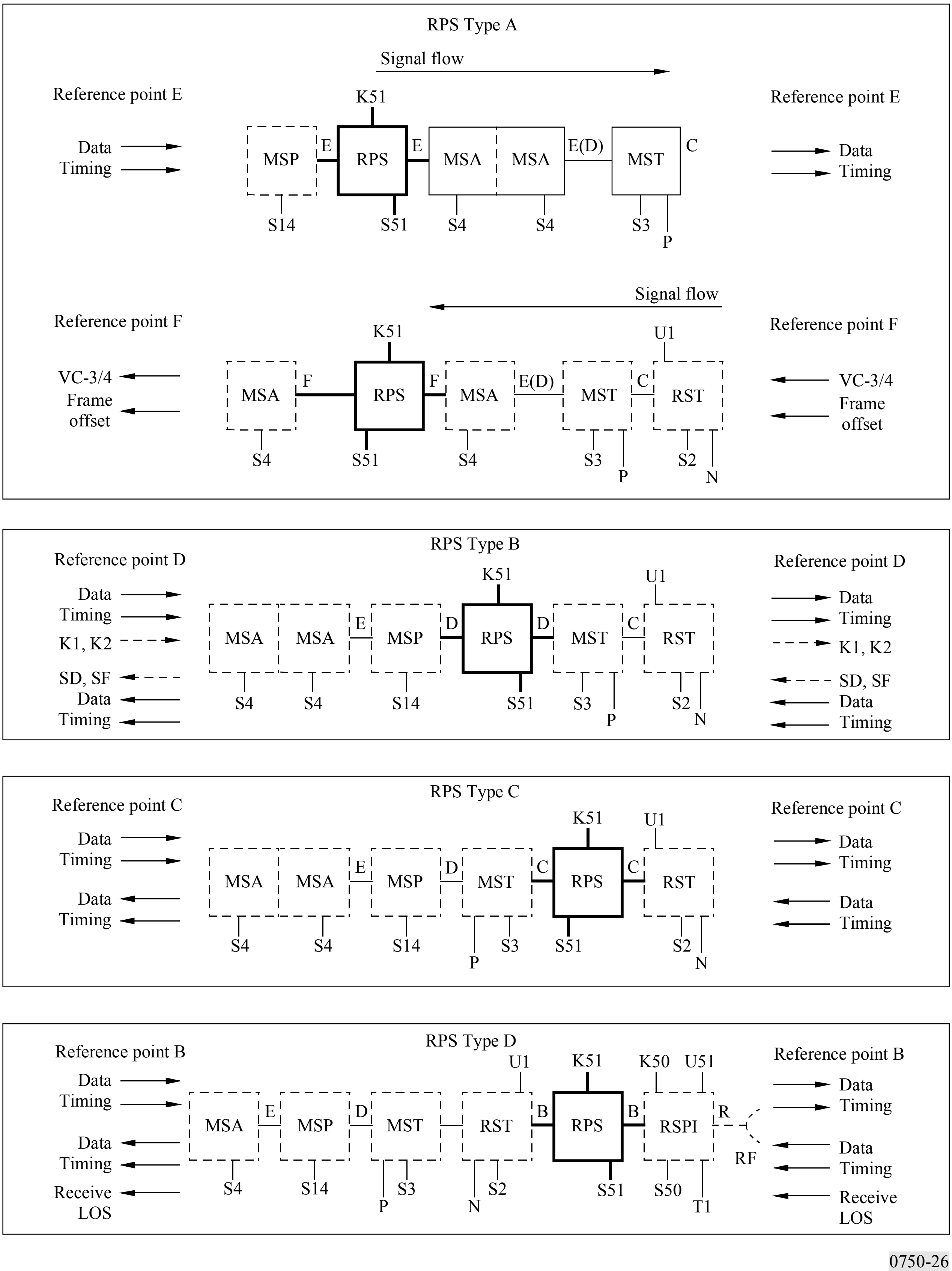


FIGURE 26

Possible reference points of the RPS functional block



1 Signal flow and main functionality

1.1 RPS type A

The signal splitting and distribution in the TX side is performed before the MSA function so that, when the protection channel is required, the change of payload on the protection channel is recovered by the pointer adjustment mechanism without affecting the SOH location.

As a consequence, with the content of the working and standby signal different to the STM level, the receiver side alignment and switching of working and standby channels is performed at VC level, in a similar way to that performed by the HPC function.

Due to the logical allocation of the RPS function this type A is not suitable for use in conjunction with the MSP function, but network protection, if required, will be performed at VC-*n* level by HPC or LPC functions.

1.2 RPS type B

The TX-side MSA functions are all synchronized, both in frequency and frame phase, so that the standby channel frame alignment is never affected when different signals are sent on it.

As an alternative special, not G.783 standardized, frame alignment/disalignment procedures have to be implemented in every radio terminal or regenerator.

The receiver side alignment and switching between working and standby channels is performed at STM level taking suitable cautions against the possible difference in the content of SOH (e.g. skipping the bit-to-bit comparison during the time-frame of SOH location).

1.3 RPS type C

When the radio switching section coincides with the multiplex section, the TX-side MSA functions are all synchronized, both in frequency and frame phase, so that the standby channel frame alignment is never affected when different signals are sent on it.

The receiver-side alignment and switching between working and standby channels is performed at STM level taking suitable cautions against the possible difference in the content of SOH (e.g. skipping the bit-to-bit comparison during the time-frame of SOH location).

This type of RPS may not use switching initiation extracted from BIP-24 evaluation criterion so that no SDH path quality criteria may be used for switching initiation, unless RPS performs B2 parity evaluation monitoring as its internal functionality.

Provided that the number of regenerators between the two corresponding RPS is kept to a reduced amount, this type C RPS is suitable for $n + m$ protection with hitless functionality also in SDH regenerator sections (without MSA and MST functions; in this case the multiplex section may not be terminated in the radio terminals allowing mixed media MS).

1.4 RPS type D

When RPS is inserted at reference point B, all switching initiation criteria are derived from the RSPI. This type of RPS cannot have functionality of a section trace (J0) or an error detection (B1) for each channel in a radio hop, because there is not RST or MST inside a radio protected hop. Therefore it would be effective that RSPI performs equivalent functionality such as route ID or quality monitoring for a single radio hop. In this case, these radio specific defects and the number of errors detected in RSPI may be reported at reference point S50 in accordance with the concept about RST and MST defined in ITU-T Recommendation G.783.

This RPS type refers to the radio repeater structure described in § 3.4.1.2. When radio repeaters without RST are required, the link connection made up of several radio hops may be considered a single regenerator section.

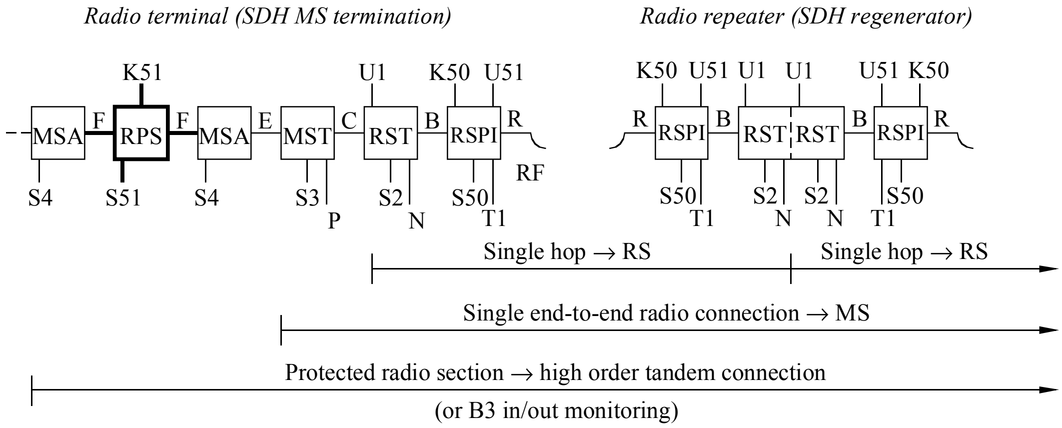
2 Radio specific performance monitoring at reference point XT dependent on the allocation of RPS functional block

Figures 27, 28, 29 and 30 correspond to the RPS Type A, B, C and D respectively. For the purpose of performance monitoring the evaluation of the quality of the protected section as shown in Figs. 27 through 30, in order to evaluate this quality a radio specific performance monitoring functionality may be used with methodology suitable to the allocation of the RPS functional block.

RPS of types A and B are suitable only in radio terminals which terminate a MS, meanwhile types C and D may be used in both cases of radio terminals which are seen as terminals of a MS or a RS only.

FIGURE 27

Allocation of RPS functional block type A



0750-27

In case of RPS functional block allocation as shown in Fig. 28, single radio connections are monitored hop by hop as RSs and end-to-end as MS.

When it is required to monitor the performance after reference point F, as there is no possibility given by RST or MST to monitor the performance of the protected section, two processes may, in this case, be possible:

– The first one is to evaluate separately the quality of the VC-4 through B3 parity monitoring at the input and at the output from the protected radio section and to let management system provide the difference.

– The second one is to implement a high order (HO) tandem connection monitoring as foreseen by ITU-T Recommendations G.707 and G.783.

NOTE 1 – In case the radio connection is embedded into one already in operation, longer HO tandem connection for the radio section monitoring may still be performed, in agreement with the management system operator, as an additional HO tandem connection using one of the user bytes of the VC-4 POH (i.e. F2 and F3) in place of N1.

In case of RPS functional block allocation as shown in Fig. 28, it may be necessary to monitor the performance at reference point E, as there is no possibility given by RST or MST to monitor the performance of the protected section, the same methodology of RPS type A shown in Fig. 27 may be applied.

In case of RPS functional block allocation as shown in Fig. 29, it may be necessary to monitor the performance at reference point C. If the radio terminal is configured as MST as shown in Fig. 29a), the performance of the protected section are coincident with that of the MS itself.

If the radio terminal is configured simply as an RS, as shown in Fig. 29b), the performance of the protected section may be monitored through B2 bytes at the input and output of the RPS.

FIGURE 28

Allocation of RPS functional block type B

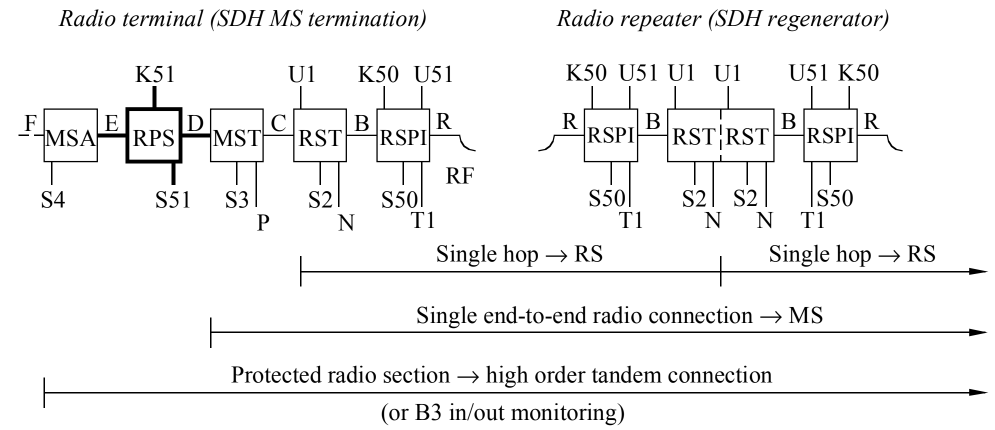
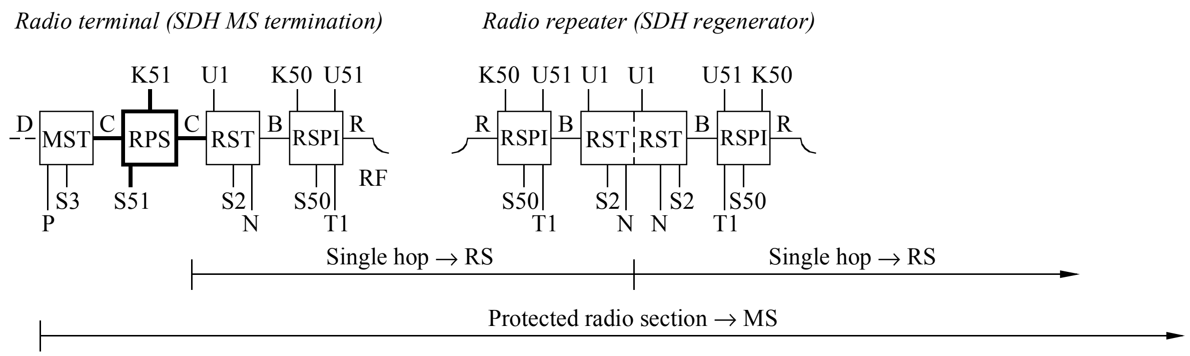
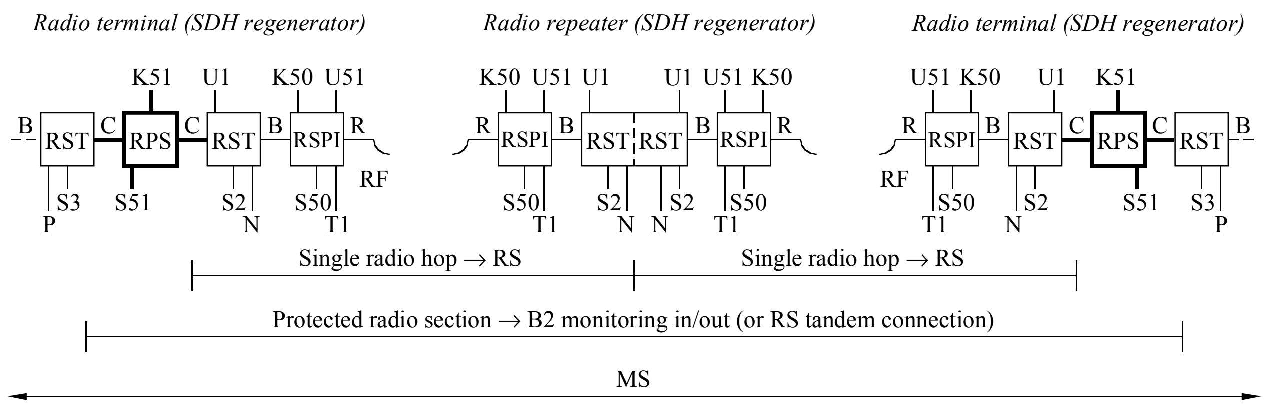


FIGURE 29

Allocation of RPS functional block type C



a) Case with termination of MS



b) Case without termination of MS

0750-29

Two processes may, in this case, be possible for the radio protected section quality:

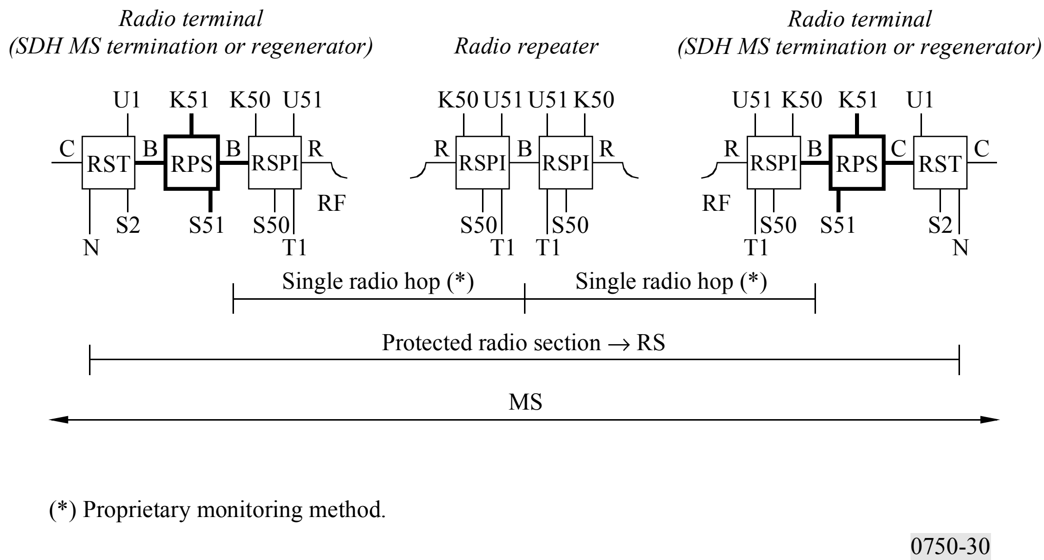
– The first one is to evaluate separately the quality of the STM-*N* signal at the input and at the output from the protected radio section and to let the management system provide the difference.

– The second one is to send forward, through a media dependent byte of the RSOH, which transparently passes through any RST of intermediate radio repeaters, a BIP-8 equivalent information of input errored blocks to the far end terminal. The far end terminal may evaluate the difference with the output quality and directly provide the management system with the actual quality of the protected radio section.

This methodology of RS tandem connections, is in principle similar to the HO tandem connections foreseen by ITU-T Recommendations G.707 and G.783 but no parity recovery algorithm, as that of N1 byte of VC-4 POH, is required.

FIGURE 30

Allocation of RPS functional block type D



In case of RPS functional block allocation as shown in Fig. 30, regardless of the radio terminal configuration as RS or MS, the performance of the protected radio section is coincident with that of the RS.

However in this implementation, the radio repeater cannot support standard RST functionality (due to the conflict of two RS terminated by a single RST function). If quality monitoring of single radio hop is required, it may be provided only in a proprietary way, e.g. through FEC activity.

APPENDIX 4

TO ANNEX 1

Transmission of media-specific functions of STM-0 DRRS through radio complementary section overhead (RCSOH)

The transmission of media-specific functions in STM-0 DRRS may be accomplished by the transmission as a well identified case of RFCOH of a full STM-1-like SOH format, in which six columns may be regarded as a byte synchronous radio complementary section overhead (RCSOH); also in this way other STM-1 standardized functions (e.g. national use bytes or M1 byte) may be transported.

For this solution Fig. 31 shows an example of possible usage of the bytes.

FIGURE 31

Mixed SOH and RCSOH for STM-0 (full STM-1 compatibility)

S	1								9
1	A1	A1 (*)	A1 (*)	A2	A2 (*)	A2 (*)	J0(C1)	NU	NU
	B1			E1		◆	F1	NU	NU
	D1			D2		◆	D3	◆	◆
	H1	Stuff	Stuff	H2	Stuff	Stuff	H3	Stuff	Stuff
	B2	◆	◆	K1	◆	◆	K2	◆	◆
	D4	◆	◆	D5	◆	◆	D6	◆	◆
	D7	◆	◆	D8	◆	◆	D9	◆	◆
	D10	◆	◆	D11	◆	◆	D12	◆	◆
9	S1	Z1	Z1	M1	Z2	M1(**)	E2	NU	NU

	SOH byte columns STM-0
	RCSOH byte columns (byte synchronous insertion)
	RCSOH bytes for media specific functions
	Other RCSOH bytes available for media specific functions or wayside traffic
◆	RCSOH bytes reserved for future applications or available for wayside traffic
NU	RCSOH bytes available for national use or wayside traffic
(*)	RCSOH bytes for frame alignment and parity control
(**)	Alternative position for M1

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APPENDIX 5

TO ANNEX 1

Additional primitives for operation and maintenance purpose of RSPI/RR-RSPI, RPS and ROHA functional blocks

This Appendix reports additional primitives which are possibly reported through interfaces S50, S51 and S52 for operation and maintenance purpose.

1 RSPI additional primitives

1.1 Performance primitives

This section describes other performance primitives to be accessed via reference point S50 in addition to primitives in Table 2.

1.1.1 Received level (RL)

The RL is the level of the estimated received power at the input of the receiver, which is referenced to point R. It may be used to determine if a predefined period has been affected by fading activity. It may also be used to identify some permanent loss of received power due to hardware failures.

It must be outlined that this level is an estimation of the received power and that it may be affected by a certain amount of inaccuracy that is system dependent.

Moreover the interpretation of the associated values depend on several factors:

– type of transmission used (e.g. bi-carriers, mono carrier systems);

– measurement bandwidth (wideband averaging);

– radio-frequency band.

The RL should be a performance primitive available at S50 reference point of the RSPI functional block. This level should be readable by the management system on request.

The parameter unit should be expressed in dBm and represented by rounding to the nearest integer.

In the case that two or more antennas and/or an intermediate frequency (IF) combiner are used as a fading countermeasure, this RL primitives may be monitored per each receiver/antenna, but to the management system only the aggregate or more suitable performance primitive, for example represented either by the level of the combined signal or by the level of the highest single received input signal according to their availability should be forwarded.

NOTE 1 – In the case that STM-4 transmission is implemented by several transceivers, more than one RLs could be monitored at several receivers. Only the aggregate information should be forwarded to the management system.

1.1.2 Transmitted level (TL)

The TL is the level of the estimated transmitted power at the output of the transmitter, which is referenced to point R. This TL primitive is optional.

It may be used to identify permanent degradation of received power at the far end due to transmitter failures at the near end. When the ATPC is present, it may also be useful to monitor the ATPC of a transmitter and identify periods of fading activity.

NOTE 1 – Currently implemented ATPC controls are of two kinds:

– *Continuous power tracking* where a control loop keeps the receiver level constant from the activation threshold down to a fading attenuation equal to the ATPC range; in this case the TL may assume any value within the ATPC range.

– *Step control power* where only one or more power steps may be activated by the receiver level thresholds; in this case the TL assumes discrete values within the ATPC range.

It should be emphasized that this level is an estimation of the transmitted power and that it may be affected by a certain amount of inaccuracy that is system dependent.

Moreover the interpretation of the associated values depends on several factors:

– type of transmission used, e.g. bi-carriers, mono carrier systems;

– radio-frequency band.

Only if a TL primitive is implemented, the TL should be a performance primitive available at S50 reference point of the RSPI functional block and it should be readable by the management system on request.

The TL level is represented by an absolute value or by two values:

– Representation by an absolute value:

  – an integer fixed value expressed in dBm representing the transmitted level directly.

– Representation by two values:

  – an integer fixed value expressed in dBm defining the nominal transmitted power value which is equipment dependent;

  – an integer offset value expressed in dB representing the variation with respect to the nominal value.

NOTE 2 – In the case that STM-4 transmission is implemented by several transceivers, more than one TL could be monitored at several transmitters. Only the aggregate information should be forwarded to the management system.

1.1.3 Number of errors detected in RSPI

A transmission quality in RSPI may be monitored using a proprietary performance monitoring methodology, especially in case of RPS type D shown in Appendix 3. The number of errors detected in RSPI is reported at the reference point S50 for SEMF. A method of error measurement in RSPI is out of the scope of this Recommendation.

1.2 Information flow across S50 reference point

When applicable the following optional command, configuration and provisioning on a GET or SET basis as reported in Table 4 may be provided.

TABLE 4

Command, configuration and provisioning information flow over S50 reference point

S reference point	GET	SET
S50 (RSPI)	ATPC status	ATPC enable
	Transmitted level	
	Received level	

1.2.1 ATPC status

Returns the ATPC status of the TX-function as “ATPC implemented/not implemented” and “ATPC enabled/disabled”.

1.2.2 ATPC enable

Command to enable/disable ATPC for the TX-function, provided when ATPC is implemented.

2 Supervisory switching initiation primitives

The following switching initiation criteria (see Table 5) may represent a complete set of practical cases.

TABLE 5

Example of switching initiation criteria

Priority	RPS request
1 (higher)	Lockout
2	Forced switch
3	Autoswitch signalfail (SF)
4	Autoswitch highBER (HBER)
5	Autoswitch lowBER (LBER)
6	Autoswitch earlywarning (EW)
7	Manual switch
8	Exercise

The use of some of the autoswitch requests is conditioned by the logical allocation of the RPS function. Depending on implementation, switching initiations coming from functional blocks (e.g. MSA and/or MST) logically allocated outside the RPS section are not applicable.

For RPS without hitless capability autoswitch LBER and EW requests are optional.

Lockout

Lockout RPS request is applicable to a working and to a protection channel. In the first case it prevents a working channel from being protected and in the second case it prevents a protection channel from being used for protection. Lockout RPS request is generated by command from the local F interface (local lockout) or from the Q interface by TMN/OS (remote lockout) and is consequently forwarded to the RPS function by the MCF and SEMF functions via management reference point S51.

Forced switch

Forced switch RPS request is generated by command from the local F interface (local forced switch) or from the Q interface by TMN/OS (remote forced switch) and is consequently forwarded to the RPS function by the MCF and SEMF functions via management reference point S51.

Autoswitch signalfail

An autoswitch signalfail request may be generated by detection of a logical OR of the following defects: RSPI lossOfSignal and fails, A1/A2 LOF, MS-AIS, AU-AIS and LOP. Depending on the application a subset of these criteria could be used. Other proprietary indications that have an equivalent weight could also be used.

Autoswitch HBER and LBER

Autoswitch HBER and LBER RPS requests may be generated by excessive error and SD information respectively as derived from local MST. For RPS purposes equivalent HBER and LBER indications (as for example derived from the RSPI along the radio switching section with EW methodology) may alternatively be used as switch initiation criteria. The detection thresholds for HBER and LBER should, in this case, not be worse than the excessive error and SD thresholds respectively.

Autoswitch EW

An Autoswitch EW RPS request is generated by proprietary early warning threshold crossing detected by local or remote RSPI along the radio switching section. EW requests may be also generated by detection of a logical OR of different EW types.

Manual switch

Manual switch RPS request is generated by command from the local F interface (local manual switch) or from the Q interface by TMN/OS (remote manual switch) and is consequently forwarded to the RPS function by the MCF and SEMF functions via management reference point S51.

Exercise

Exercise is an optional RPS request which may be used to test the RPS function by initiating an RPS process without actual switching. Exercise may be initiated either by the local control terminal at the F interface or by TMN/OS at the Q interface and is consequently forwarded to the RPS function by MCF and SEMF functions via management reference point S51.

3 Supervisory switch restore primitives

The following switch restore criteria may represent a complete set of practical cases.

Priority	RPS switch restore request
1	Forced restore of a channel in protection
2	Automatic forced restore of a channel in protection
3	Automatic switch restore request from a channel in protection

Forced restore

Forced restore RPS request is generated by command from the local F interface (local forced restore) or from the Q interface by TMN/OS (remote forced restore), which is consequently forwarded to the RPS function by the MCF and SEMF functions via management reference point S51.

Automatic forced restore

Automatic forced restore of a channel in protection occurs when all protection channels are occupied and another working channel, with an RPS request priority higher than one of the currently protected working channels, requires access to protection channel. In this case the protected channel with the lowest RPS request priority will be restored to its normal working channel.

Automatic switch restore

The RPS automatic switch restore request occurs, for the channel in protection, as soon as none of the RPS requests are active in its corresponding regular working channel. Upon this request, the RPS functional block performs the switch restore.

4 RPS additional primitives

4.1 Performance primitives

This section describes other performance primitives to be accessed via reference point S51 in addition to primitives in Table 3.

4.1.1 Protection switch actual (PSA)

A PSA represents any actual automatic switch from a protected (working) channel to a protecting (stand-by) channel.

This performance primitive should be reported to the SEMF at the reference point S51 of the RPS functional block.

4.1.2 Protection switch request (PSR)

A PSR represents any activation of a switch initiation criteria which may lead to automatic switches from a protected channel to a protecting channel (see Note 1).

NOTE 1 – For non-revertive 1 + 1 protection systems, the PSR should be required for both activation from a protected channel to a protecting channel and vice versa.

This performance primitive should be reported to the SEMF at the reference point S51 of the RPS functional block.

4.2 Information flow over S51 reference point

When applicable the following optional command, configuration and provisioning on a GET or SET basis as reported in Table 6 may be provided.

TABLE 6

Command, configuration and provisioning information flow over S51 reference point

S reference point	GET	SET
S51 (RPS)	Switch status	
	Channel status	
		Lockout
		Forced switch
		Manual switch
		Exercise

4.2.1 Switch status

This information shows the current protection switching status for each channel.

4.2.2 Channel status

This information shows a request of protection switching for each channel. This should include the kind of request (e.g. failure, forced switch or manual switch).

5 ROHA primitives

The following primitives may be reported to interface S52, to SEMF alarm filtering, for service/wayside channel network maintenance:

– lossOfSignal#(in).

This indication reports the loss of input signal (TX side) for service/wayside channel number #.

APPENDIX 6

TO ANNEX 1

Performance event for RSPI, RPS and ROHA functional block

1 RSPI performance management

1.1 Performance events

The definition of performance events is based on the RL and TL primitives defined in Appendix 5.

1.1.1 Received level threshold second (RLTS)

The RLTS event is defined as a 1 s period during which the detected RL value is below a selected threshold.

If there are multiple RL primitives, RLTSs may be multiple. Also the number of these RL thresholds is allowed to be single or multiple. To the management system, only one selected or suitably derived RLTS should be forwarded.

The associated selected threshold should be given in dBm and it is a characteristic of the event definition. The facility of selecting the threshold value by the management system should be mandatory and may also be settable locally.

For any RL performance primitive at least two RLTS events are required corresponding to two different threshold values. A number, *n*, of RLTS events with *n* greater than two is optional.

The current value of the counter associated with a RLTS should be readable by the management system on request.

In the case that a threshold associated to a RLTS counter is changed then the current value of the counter is allowed to be reset to zero or to remain unchanged.

1.1.2 Received level tide mark (RLTM)

The RLTM is a mechanism that records the maximum and the minimum value reached by the RL during a measurement period. The tide mark values are automatically reset to the RL current value at the beginning of each measurement period.

The RLTM is therefore composed by two values: the RLMax for the maximum value and the RLMin for the minimum one.

The comparison between the RL current value and the RLMax and RLMin values should be performed on a second by second basis.

When the current RL value is greater than the RLMax value then the RLMax value is updated equal to the RL current value. When the current RL value is lower than the RLMin value then the RLMin value is updated equal to the RL current value.

The RLTM is an optional feature.

1.1.3 Transmitted level threshold second (TLTS)

The TLTS event is defined as a 1 s period during which the detected TL value is greater than a selected threshold.

The unit of threshold should be consistent with the chosen TL unit, i.e. it should expressed in dBm when a TL primitive is represented by an absolute value and it should be expressed in dB when a TL primitive is represented by two values. The facility of selecting the threshold value by the management system should be mandatory and may also be settable locally.

NOTE 1 – When ATPC is implemented by one or more transmitter power steps (see Note 1 in § 1.1.2 in Appendix 5) the threshold assignment to any value within one power step will give the same results. For example, in the case of one step, the result is the activation time of the ATPC.

For any TL performance primitive one TLTS event is required, only if a TL primitive is implemented.

One additional TLTS event could be implemented as an option, only if a TL primitive is implemented.

The current value of the counter associated with a TLTS should be readable by the management system on request, only if a TL primitive is implemented.

In the case that a threshold associated to a TLTS counter is changed then the current value of the counter is allowed to be reset to zero or to remain unchanged.

1.1.4 Transmitted level tide mark (TLTM)

The TLTM is a mechanism that records the maximum or minimum value reached by the TL during a measurement period. The tide mark values are automatically reset to the TL current value at the beginning of each measurement period.

This TLTM could be implemented, only if a TL primitive is implemented.

The TLTM is therefore composed of two values: the TLMax for the maximum value and the TLMin for the minimum one.

The comparison between the TL current value and the TLMax and TLMin values should be performed on a second by second basis.

When the current TL value is greater than the TLMax value then the TLMax value is updated equal to the TL current value. When the current TL value is lower than the TLMin value then the TLMin value is updated equal to the TL current value.

The TLTM is an optional feature.

1.2 Performance data collection and history treatment

Storage requirements of RSPI performance events in the 15 min and 24 h current and history registers are given in Table 7.

1.3 Performance data threshold treatment

Threshold treatment requirements for performance events are given in Table 8.

1.4 Transmission quality monitoring treatment

A transmission quality in RSPI may be monitored using a proprietary performance monitoring methodology. This quality information may be forwarded to the management system only if a protection scheme is RPS type D defined at Appendix 3. A method of error performance measurement is out of the scope of this Appendix.

Monitoring items are managed with the same philosophy of the standard defined for the generic SDH, such as ES, SES, BBE and UAS. But their meaning is consistent only in the hops or link which they refer to. Comparisons among different hops or links are not meaningful.

TABLE 7

Storage requirements for RSPI performance events

Performance event	Current value	15 min current register	15 min history register	24 h current register	24 h history register
RL	R	–	–	–	–
RLTS-1	–	R	R	R	R
RLTS-2	–	R	R	R	R
RLTS-*n*	–	O	R*	R*	R*
RLTM	–	O	R*	R*	R*
TL	O	–	–	–	–
TLTS-1	–	O(1)	R*	R*	R*
TLTS-2	–	O(2)	R*	R*	R*
TLTM	–	O(2)	R*	R*	R*

R: Required –: Not applicable O: Optional

R*: Required only if supported in the 15 min current register.

(1) TLTS-1 is required only if TL is implemented.

(2) TLTS-2 or TLTM could be implemented as an option only if TL and TLTS-1 are implemented.

TABLE 8

Threshold control requirement for RSPI performance events

Performance event	15 min threshold control	24 h threshold control
RL	NR	NR
RLTS-1	R	R
RLTS-2	O	R*
RLTS-*n*	O	R*
RLTM	NR	NR
TL	NR	NR
TLTS-1	O(1)	R*
TLTS-2	O(2)	R*
TLTM	NR	NR

R: Required NR: Not required O: Optional

R*: Required only if supported in the 15 min threshold control.

(1) TLTS-1 is required only if TL is implemented.

(2) TLTS-2 could be implemented as an option only if TL and TLTS-1 are implemented.

2 RPS performance management

2.1 Performance events

The definition of performance events is based on the PSA and PSR primitives defined in Appendix 5.

2.1.1 Protection switch actual count (PSAC)

A PSAC represents the number of PSA occurrences in a time period.

This time period can vary between zero and 15 min or 24 h for the 15 min or 24 h current register respectively and represents the elapsed time since the last reset of the counter.

This time period is 15 min or 24 h for 15 min or 24 h history registers respectively.

A PSAC is defined for any protected or protecting channel involved in a m:n protection scheme where m is the number of the protecting channels and n is the number of the protected ones.

For a protected channel the PSAC is the number of automatic switch events from this channel to any protecting channel. For a protecting channel the PSAC is the number of automatic switch events from any protected channel to this channel.

For m:n protection scheme the PSAC is required also for the protecting channel.

The current value of the counter associated with a PSAC should be readable by the management system on request.

Table 9 summarizes the required conditions for generating the PSAC event of the RPS functional block.

TABLE 9

PSAC event generation requirements

Channel	Protection scheme		
	1 + 1	1:n	m(m > 1):n
Protected (working)	R	R	R
Protecting (stand-by)	NR	O	R

R: Required NR: Not required O: Optional

2.1.2 Failed switch request count (FSRC)

A FSRC represents the number of the occurrences in a time period of the following events:

– A PSR is activated on a protected channel and the protecting channels are not available.

– A protected channel is restored from a protecting channel while a PSR is still active on the channel.

This time period can vary between zero and 15 min or 24 h for the 15 min or 24 h current register respectively and represents the elapsed time since the last reset of the counter.

This time period is 15 min or 24 h for 15 min or 24 h history registers respectively.

A FSRC is not required when a PSRC is implemented. A FSRC is defined only for working channels.

For 1 + 1 protection scheme this event is optional.

When an activation criterion is already present on a channel, the activation of another one will not increment the counter.

The current value of the counter associated with a FSRC should be readable by the management system on request.

Table 10 summarizes the required conditions for generating the FSRC event of the RPS functional block.

TABLE 10

FSRC event generation requirements*

Channel	Protection scheme	
	1 + 1	*m*:*n*
Protected (working)	O	R
Protecting (stand-by)	NR	NR

R: Required NR: Not required O: Optional

* An FSRC is not required when a PSRC is implemented.

2.1.3 Protection switch request count (PSRC)

A PSRC represents the number of the occurrences of PSR in a time period.

This time period can vary between zero and 15 min or 24 h for the 15 min or 24 h current register respectively and represents the elapsed time since the last reset of the counter.

This time period is 15 min or 24 h for 15 min or 24 h history registers respectively.

A PSRC is not required when an FSRC is implemented. A PSRC is defined for protected and protecting channels.

For protecting channel of *n*:*m* protection scheme the PSRC represents the total number of PSRC at each protected channel.

PSRC is defined as optional for protecting channel of *m*:*n* protection scheme.

The current value of the counter associated with a PSRC should be readable by the management system on request.

In case of switches arising from management operations an output of this event should not be generated.

Table 11 summarizes the required conditions for generating the PSRC event of the RPS functional block.

TABLE 11

PSRC event generation requirements*

Channel	Protection scheme	
	1 + 1	*m*:*n*
Protected (working)	O	R
Protecting (stand-by)	O	O

R: Required NR: Not required O: Optional

* An PSRC is not required when a FSRC is implemented.

2.1.4 Protection switch actual duration (PSAD)

A PSAD event count is the number of seconds, in a time period, for which a channel is in the switched status rounded up to a second.

For a protected channel the switched status means that its associated traffic is carried on a protecting channel.

For a protecting channel the switched status means that it is carrying traffic from a protected channel.

This time period can vary between zero and 15 min or 24 h for the 15 min or 24 h current register respectively and represents the elapsed time since the last reset of the counter.

This time period is 15 min or 24 h for 15 min or 24 h history registers respectively.

A PSAD event is defined for any protected or protecting channel involved in a *m*:*n* protection scheme.

For 1 + 1 protection scheme PSAD is optional.

In the case of fixed 1 + 1 non revertive switching schemes this event has no meaning and is not required.

In the case of selectable revertive/non revertive 1 + 1 switching schemes PSAD is optional. However, if the non revertive mode is active, an output for PSAD should not be generated.

In case of switches arising from management operations an output of this event should not be generated.

The current value of the counter associated with a PSAD should be readable by the management system on request.

Table 12 summarizes the required conditions for generating the PSAD event of the RPS functional block.

TABLE 12

PSAD event generation requirements

Channel	Protection scheme		
	1 + 1 revertive	1 + 1 non-revertive	*m*:*n*
Protected (working)	O	NR	R
Protecting (stand-by)	O	NR	R

R: Required NR: Not required O: Optional

2.1.5 Failed switch request duration (FSRD)

A FSRD event is the count of the number of seconds in a time period for which, rounded up to a second, a PSR is detected active on a channel carrying regular traffic and the request cannot be serviced.

This time period can vary between zero and 15 min or 24 h for the 15 min or 24 h current register respectively and represents the elapsed time since the last reset of the counter.

This time period is 15 min or 24 h for 15 min or 24 h history registers respectively.

An FSRD is not required when a PSRD is implemented. An FSRD event is defined only for protected channels.

For 1 + 1 protection scheme FSRD is optional.

The current value of the counter associated with an FSRD should be readable by the management system on request.

Table 13 summarizes the required conditions for generating the FSRD event of the RPS functional block.

TABLE 13

FSRD event generation requirements*

Channel	Protection scheme	
	1 + 1	*m*:*n*
Protected (working)	O	R
Protecting (stand-by)	NR	NR

R: Required NR: Not required O: Optional

* An FSRD is not required when a PSRD is implemented.

2.1.6 Protection switch request duration (PSRD)

A PSRD event count is the number of seconds, in a time period, for which a channel is in the PSR status rounded up to a second.

This time period can vary between zero and 15 min or 24 h for the 15 min or 24 h current register respectively and represents the elapsed time since the last reset of the counter.

This time period is 15 min or 24 h for 15 min or 24 h history registers respectively.

For protecting channel of *m*:*n* protection scheme the PSRD means the duration of the switching request from any protected channel to the protecting channel. It is not a total time of PSRD of each protected channel.

A PSRD is not required when an FSRD is implemented. PSRD is defined as optional for protecting channel of *m*:*n* protection scheme.

In case of switches arising from management operations an output of this event should not be generated.

The current value of the counter associated with a PSRD should be readable by the management system on request.

Table 14 summarizes the required conditions for generating the PSRD event of the RPS functional block.

TABLE 14

PSRD event generation requirements*

Channel	Protection scheme	
	1 + 1	*m*:*n*
Protected (working)	O	R
Protecting (stand-by)	O	O

R: Required NR: Not required O: Optional

* A PSRD is not required when an FSRD is implemented.

2.2 Performance data collection and history treatment

Performance data collection and history treatment principles are described in ITU-T Recommendation G.784.

Storage requirements of RPS performance events in the 15 min and 24 h current and history registers are reported in Table 15.

TABLE 15

Storage requirements for RPS performance events

Performance event	15 min current register	15 min history register	24 h current register	24 h history register
PSAC	R	R	R	R
FSRC/PSRC	R	R	R	R
PSAD	R	R	R	R
FSRD/PSRD	R	R	R	R

R: Required

Storage requirements apply only for those events that are generated according to Tables 9, 10, 11, 12, 13 and 14.

2.3 Performance data threshold treatment

Threshold treatment requirements for performance events are reported in Table 16.

TABLE 16

Threshold control requirements for RPS performance events

Performance event	15 min threshold control	24 h threshold control
PSAC	O	R*
PSAD (working)	O	R*
PSAD (stand-by)	O	R*
FSRC/PSRC	O	R*
FSRD/PSRC	O	R*

R: Required O: Optional

R*: Required only if supported in the 15 min threshold control.

Threshold treatment requirements apply only for those events that are generated according to Tables 9, 10, 11, 12, 13 and 14.

3 ROHA performance management

There are no performance requirements for the ROHA functional block.

4 Radio specific transmission quality monitoring

SDH DRRS are parts of the SDH network and may be used to implement RS and MS functions.

Performance parameters of the radio link section are needed for monitoring in order to compare the performance of different sections of the network (for example radio link and optical link). The information derived for each type of section should be comparable, therefore the parameters and the methodology used to evaluate them should be consistent and should be the results of similar calculation processes.

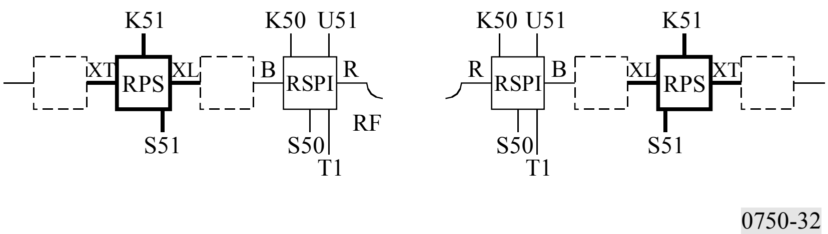
For the RS and MS implemented by DRRS the parameters and the methodology used to provide performance monitoring are defined in ITU-T Recommendations G.783 and G.784. The evaluation of these parameters is required for RS and MS.

To monitor the performance of a protected section it may be useful to have a radio specific performance monitoring at reference point XT of the RPS functional block as an option. Due to the fact that the allocation of the RPS functional block can be different, the use and implementation of this performance monitoring functionality can also be different.

Figure 32 shows the location of reference point XT, not depending on the allocation of the RPS functional block.

FIGURE 32

Location of reference point XT at the RPS functional block



The parameters and methodology used to provide this performance monitoring should be the same as for RS and MS.

5 Application of additional performance parameters for fault management and error performance management

In this section some examples of applications of additional performance parameters are given.

The following applications may be considered:

– Maintenance application

  The presence of the 15 min counters with associated threshold crossing control may be used to trigger threshold crossing notifications to the management system. This process may be helpful to indirectly localize possible degradations of hardware devices such as ATPC circuitry, feeders and antennas.

– SDH transmission quality parameters qualification

  The presence of the 15 min and 24 h current counters such as SES, ES, BBE and UAS associated with each RS and MS terminated in a radio NE allows having transmission quality monitoring of the same sections. The association of radio specific counters for the same period allows for correlation analysis.

In particular, the values of radio specific counters may give indications on occurrence of fading and switching activity during these periods assisting in the segregation of quality degradation due to equipment or propagation.

– Long-term statistics

The presence of 24 h history counters for radio specific parameters, together with the possibility to transfer their associated values to the management system allows the collection of long-term statistics at operation system level.

This information may also be used to verify the existing propagation prediction methods used for link design or development of new methods.

5.1 Examples of RSPI and RPS events and counter behaviour

5.1.1 RL performance primitive, RLTM and RLTS performance events

Figure 33a) shows one possible behaviour of the RL performance primitive as a result of the variation of the power level in a receiver.

The RL is associated to a threshold whose value determines the activation condition of the counter RLTS as shown in Figure 33b).

For a given observation period, this counter defines the time in seconds for which the RL has exceeded the given threshold.

A second threshold (see Figure 33b)) may be associated to the RLTS counter for triggering a threshold crossing alarm indication.

FIGURE 33

RL performance primitive and RLTS event counter

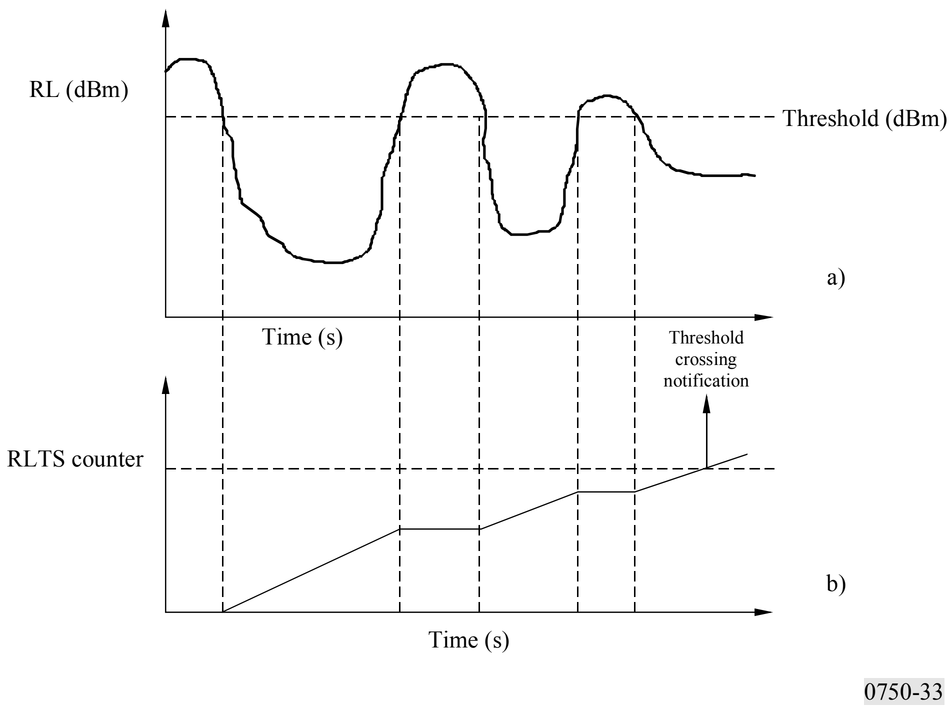


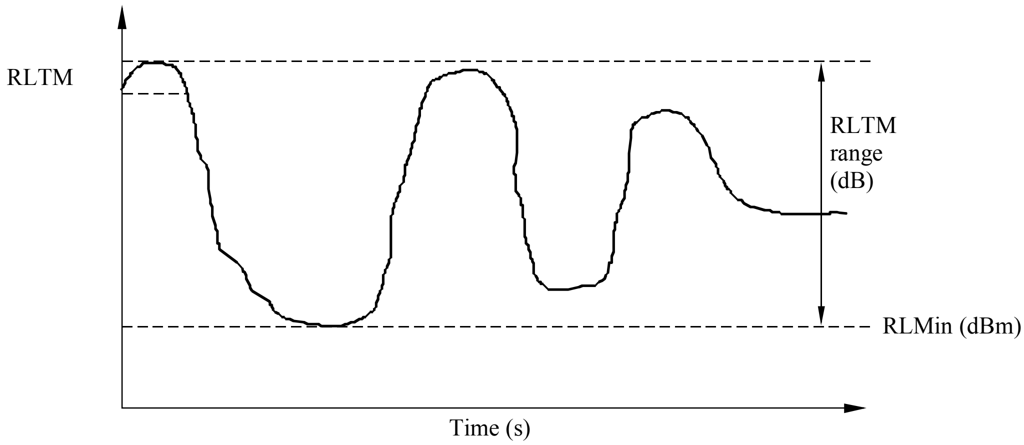
Figure 34 shows the behaviour of the RLTM event associated to the RL behaviour defined in Figure 33a).

For a given observation period the RLTM is represented by two values indicating the maximum and minimum values assumed by the RL in that period.

Similar considerations are applied for the definition of the TL primitive, the TLTS, and TLTM events.

FIGURE 34

RLTM performance event



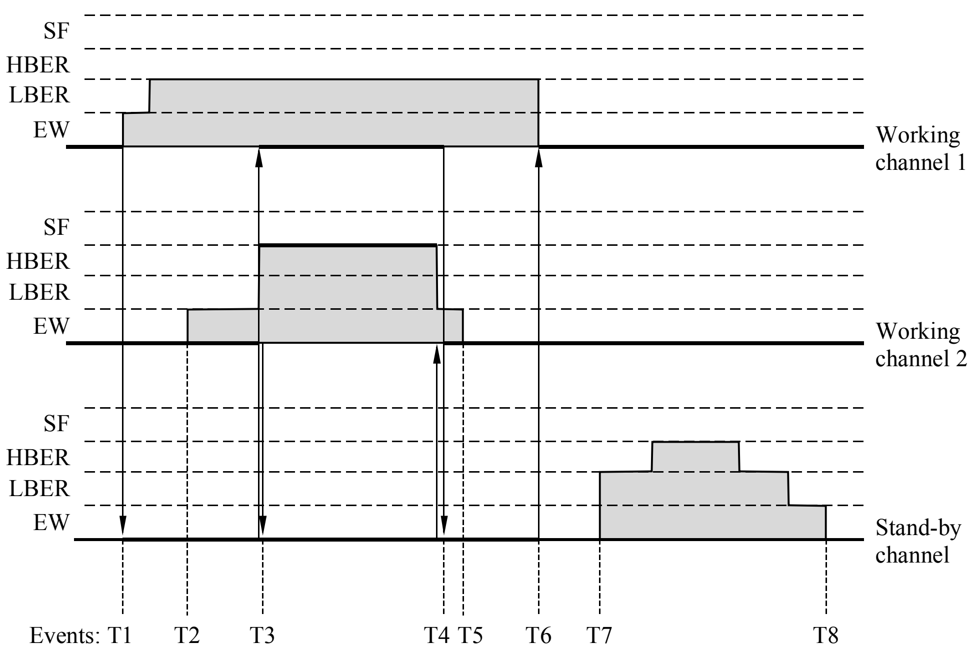
0750-34

5.1.2 RPS performance events

Figure 35 shows one possible behaviour of a 2 + 1 switch in terms of channel automatic switching requests and actual switching between working and stand-by channels.

FIGURE 35

Behaviour of a 2 + 1 switch



0750-35

For each channel, switching requests are represented by histograms indicating all the switching criteria that are active at a given time.

The traffic status of a channel is represented by a line depicted in bold if it is carrying regular traffic, and by a thin line if it is not.

Actual switching between working and the stand-by channels are indicated by arrows.

Tables 17, 18 and 19 define, for the working channels 1 and 2, and the stand-by channel respectively, the behaviours of the counters associated to each channel.

TABLE 17

Switch counters behaviour for working channel 1

Events	Working channel 1 counters					
	PSAC	PSAD	FSRC	FSRD	PSRC	PSRD
T1	+ 1				+1	
T1 < *t* < T2		+ *n* s				+ *n* s
T2						
T2 < *t* < T3		+ *n* s				+ *n* s
T3			+1			
T3 < *t* < T4				+ *n* s		+ *n* s
T4	+ 1					
T4 < *t* < T5		+ *n* s				+ *n* s
T5						
T5 < *t* < T6		+ *n* s				+ *n* s
T6						
T6 < *t* < T7						
T7						
T7 < *t* < T8						
T8						

NOTE 1 – FSRC or PSRC is implemented. FSRD or PSRD is implemented.

TABLE 18

Switch counters behaviour for working channel 2

Events	Working channel 2 counters					
	PSAC	PSAD	FSRC	FSRD	PSRC	PSRD
T1						
T1 < *t* < T2						
T2			+1		+1	
T2 < *t* < T3				+ *n* s		+ *n* s
T3	+ 1					
T3 < *t* < T4		+ *n* s				+ *n* s
T4			+ 1			
T4 < *t* < T5				+ *n* s		+ *n* s
T5						
T5 < *t* < T6						
T6						
T6 < *t* < T7						
T7						
T7 < *t* < T8						
T8						

NOTE 1 – FSRC or PSRC is implemented. FSRD or PSRD is implemented.

TABLE 19

Switch counters behaviour for the stand-by channel

Events	Stand-by channel counters			
	PSAC	PSAD	PSRC	PSRD
T1	+ 1		+1	
T1 < *t* < T2		+ *n* s		+ *n* s
T2			+1	
T2 < *t* < T3		+ *n* s		+ *n* s
T3	+ 1			
T3 < *t* < T4		+ *n* s		+ *n* s
T4	+ 1			
T4 < *t* < T5		+ *n* s		+ *n* s
T5				
T5 < *t* < T6		+ *n* s		+ *n* s
T6				
T6 < *t* < T7				
T7				
T7 < *t* < T8				
T8				

5.2 Example of usage of additional performance parameters in evaluation of fading phenomena and equipment fault

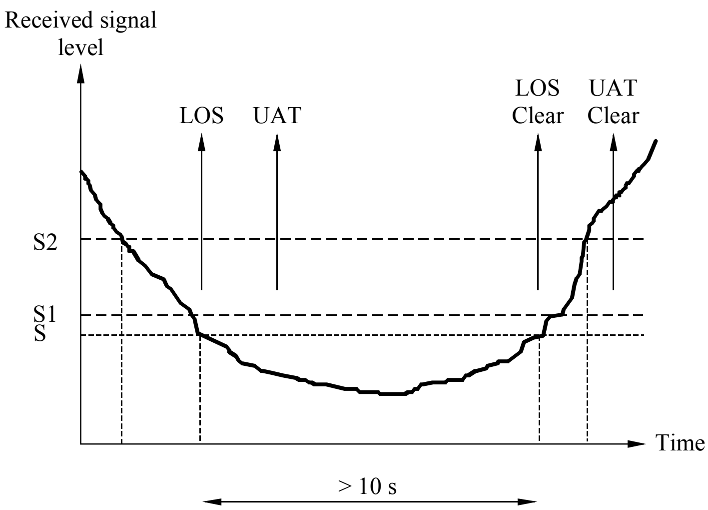
5.2.1 Rain induced fading event

5.2.1.1 DRRS without ATPC

The SDH-DRRS considered for this case is a high frequency link in 1 + 0 configuration.

FIGURE 36

Fading event on a high frequency DRRS due to precipitation



UAT: unavailable time

0750-36

A LOS communication alarm is sent to indicate the threshold S has been crossed.

In the case that it is not possible to discriminate between dLOS and dRxFail, an RxFail equipment alarm notification is sent instead of a LOS notification.

After ten consecutive SES a UAT notification is optionally sent to indicate entering of the RS into the unavailability state.

After signal recovery from threshold S a LOS or RxFail clearing notification is sent.

The occurrence of the alarm clearing notification indicate that no immediate maintenance actions are required.

Before and after the notifications the following additional indications of a fading event may be found in the 15 min registers:

– RLTM values close to each other (reduced RLTM range);
– RLTS-*n* counters with zero or very low values;
– SES counter close to zero value.

During the 15 min period alarmed, the following indications may be found in the 15 min registers:

– RLTS-2 counter (associated to threshold S2) value greater than the RLTS-1 counter (associated to threshold S1) value, with RLTS-1 counter value close to the UAT counter value;
– ES counter with a value different from zero (ES occurred in an available time);
– SES counter with a value close to zero.

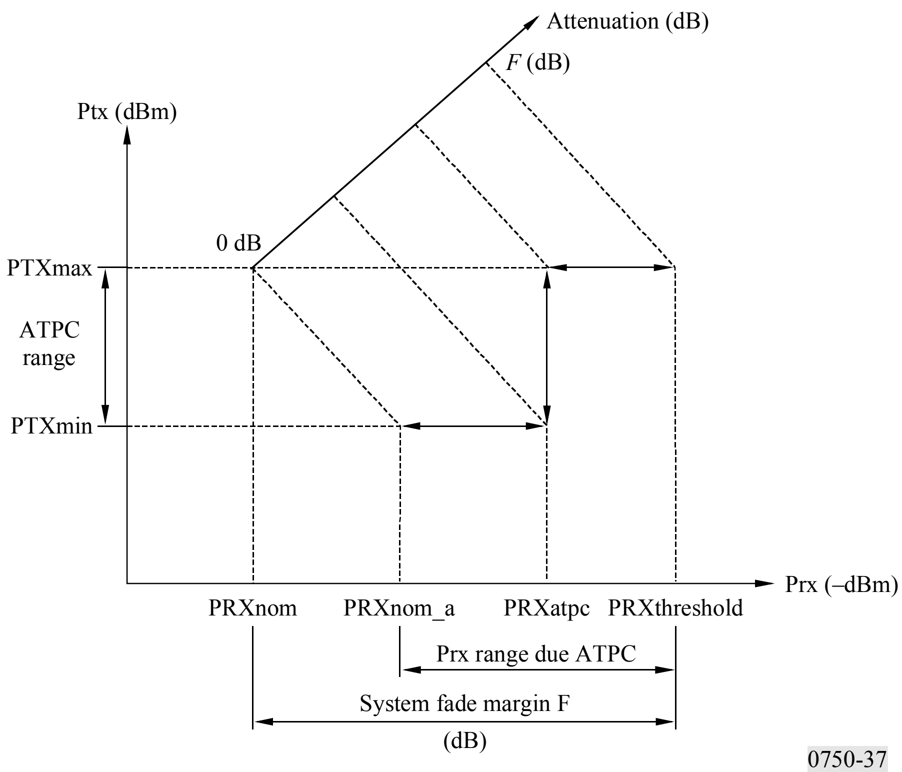
Additionally these types of events affect both directions of transmission.

5.2.1.2 Rain induced fading event: DRRS with the ATPC

The ATPC functionality, whether be continuous or discrete step mode, has the effect to reduce the received power level range as depicted in Fig. 37.

FIGURE 37

Relationship between received and transmitted power level as function of attenuation in systems with continuous ATPC



The ATPC is characterized by the ATPC range which is defined as the difference between the maximum and minimum value of transmitted power.

At the receive side, the nominal value of the received power level (PRXnom) that would be obtained if the ATPC is not implemented (PTX equal to the maximum value), is replaced by a lower nominal value (PRXnom_a) when ATPC is present and enabled.

This value defines the received power level obtainable in unfaded conditions.

Under fading conditions, when the received level crosses certain levels (PRXatpc for the case in Fig. 37) the ATPC operates by changing the transmitted power level to counteract the changes in the received power level.

With Ptx at its maximum value, higher path attenuations will cause decreasing of received power level as it would be obtained without ATPC.

The case represented in Fig. 36 is same as the case where ATPC is implemented.

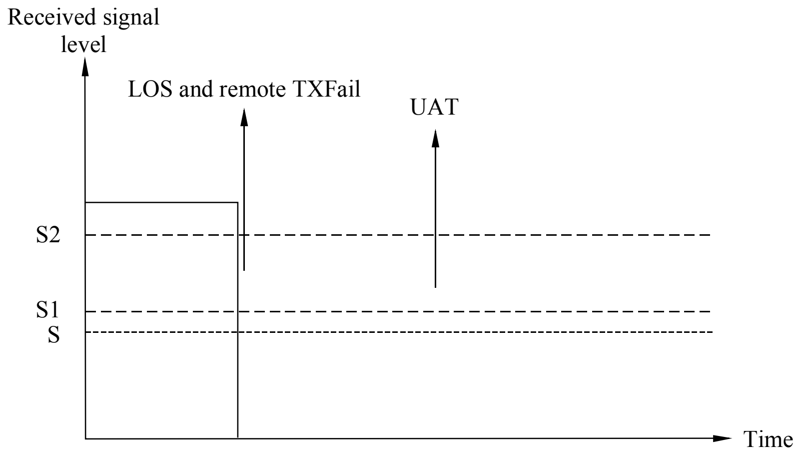
If thresholds S1 and S2 have values lower than the PRXatpc value, the same behaviour is obtained in term of alarm notifications and clearing.

It can be verified that during the period of the fading event the full range of Ptx is spanned. This can be easily obtained by reading the TLTM values of the event period.

5.2.2 Far end equipment failure at TX side

FIGURE 38

Received power level behaviour in the case of far end TX equipment fail



0750-38

Figure 38 represents the behaviour of the received power level at near end when the far end terminal suffers a transmitter equipment failure.

The following considerations may be applied for any type of DRRS.

In this case at near end (receive side) the same alarm notifications are sent as in § 5.2.1.

Additionally the following occurrences indicate the necessity of rapid maintenance actions:

– TXFail alarm notification coming from propagation domain on the far end terminal.

– Transmitter failure alarm notification coming from the equipment domain on the far end terminal.

– Asymmetrical behaviour on the two transmission directions (no notifications coming from the opposite direction).

– RLTS-1 and RLTS-2 counter values with near identical values indicating a sudden decrease of the received power.

– Near end SES and ES counter values close to zero (due to unavailability).

– Absence of alarm clearing notifications as time goes on.

5.2.3 Unexpected bad quality in a high frequency SDH-DRRS

The DRRS layout is the same as in § 5.2.1.

There may exist situations when a radio link may suffer from bad quality transmission, as indicated by ES/SES/BBE and UAS counter values, even if it is not significantly affected by atmospheric fadings.

This may be the case when equipment degradations or fade margin reductions (due to interference or additional signal loss) occur.

It should be clear that neither the definition of an exhaustive list of cases is possible nor, for a given case, an exact cause can be found with certainty.

An analysis with a higher degree of confidence can be performed only with the availability of several measurement periods.

5.2.3.1 Interference

Interferences from external sources act on a given link by reducing the system fade margin.

The exact effects in terms of consequent reduction in quality of transmission depend on the ratio between the levels of the wanted and interference signals and on the temporal variations of them.

A typical situation may be:

– No ES/SES/BBE or UAS events during unfaded periods indicated by low values of TLTM and RLTM ranges and zero values of those RLTS event counters with threshold values set close to the reference threshold that give an ES or SES event.

– Presence of ES/SES/BBE or even UAS events during shallow fading periods indicated by TLTM and RLTM range values not fully spanned and RLTS event counts with values such that they do not correlate with the performance quality counter values.

– Interference may behave asymmetrically in the two directions of transmission, and as a result, while TL and RL events would be similar, performance counter values would differ.

5.2.3.2 Additional signal loss

The received power level value is not an indication of the only atmospheric attenuation.

The antenna gains and losses due to feeders and branching filters also affect the receive power level.

Permanent additional losses due to degradations of these devices result in a reduction of fade margin.

In this condition a typical situation may be:

– During unfaded periods (RLTM and TLTM range values close to zero) the RLTM maximum value is permanently kept at a value lower than the expected one, and ATPC may be permanently active at a level higher than the normal value.

– Depending on the set threshold value, RLTS and TLTS events may be permanently present indicated by counter values close to the number of seconds of the observation period.

– Depending on where the additional loss takes place, the above behaviour can affect one direction or both.

5.2.3.3 Equipment degradation

Equipment degradations, distinct from equipment failures, which are permanent, may be the cause of sporadic additional ES/SES/BBE performance events.

These occurrences are generally implementation dependent, and generally, a wide variety of cases may be related to equipment degradations.

A typical situation may be:

– Isolated ES/SES/BBE events with random distribution.

– Lack of correlation of ES/SES/BBE events with RL and TL events.

– Asymmetrical behaviour in the two transmission directions.

– In some cases these events may be correlated to alarm notifications coming from equipment domain.

5.2.4 Fading effects in a low frequency SDH-DRRS

Low frequency DRRS also known as long-haul systems may suffer from fading events which are frequency selective. These events may cause degradation of quality even if the received power level is not below a certain threshold. As a consequence, ES/SES/BBE events cannot be strictly correlated with RLTS events as in the case of high frequency radio links.

However periods of signal fading may be identified by:

– TLTM and RLTM range values completely spanned;

– TLTS and RLTS event counts not equal zero;

– in some cases presence of LOS or DemFail alarm notifications.

Long haul DRRS are often implemented in 1:*n* or 2:*n* switching configuration with the switching section composed by two terminals with or without intermediate repeaters.

If this is the case ES/SES/BBE events may be referred to:

– each hop: there are $(n + m) \times (r + 1)$ hops in a m:n system with r intermediate repeaters.

– each protected section: there are n protected sections in a m:n system.

– each unprotected section (channel links): there are $n + m$ unprotected sections in an m:n system.

While RL and TL events are always referred to single hops, the additional performance parameters defined for the RPS can be correlated with the quality parameters of the protected and unprotected sections.

For such a system periods of fading activity may be identified by:

– simultaneous single hop RL and TL events as defined above and switching activity identified by the associated channel event counters.

Additionally, even if selective fading, for short periods, is uncorrelated on a second-by-second basis among different frequencies, some correlation is observed for longer periods i.e. 15 min, and to a larger extent for periods of 24 h.

This means that fading activity periods generally are reflected by similar behaviours of TL and RL event values on the hops associated with the same stations and on the RPS counter values of the different channels.

Moreover, fading activity periods tend to affect similarly both transmission directions.

To the contrary, isolated ES/SES/BBE events always associated with a single hop and/or a single protected section may represent a valid indication of equipment malfunction or interference problems.

5.2.5 Unexpected poor quality in a low frequency SDH-DRRS

For the case in question it is assumed to have a generic $n + 1$ system composed of two terminal stations with an unspecified number of repeaters in between.

It is also assumed that quality performance monitoring is available for all the hops and the protected sections.

The cause of this unexpected poor quality can be traced to a single hop or to a protected section.

5.2.5.1 Single hop

For the unexpected presence of ES/SES/BBE events on a single hop the same considerations and sub-cases as given in § 5.2.3 and sub-clauses may apply.

The effect on the protected section may be indicated by:

– presence of PSAC and PSAD events on the channel served by this hop;

– absence or lower counter values of the same events on the other channels.

5.2.5.2 Protected section

Under normal conditions the switching mechanism is able to counteract all types of performance quality events occurring on single hops.

The presence of ES/SES/BBE events on a protected section (after the switching) may be caused by:

– simultaneous presence of error events on two channels;

– malfunction of the switching process.

The first case may be indicated by the presence of FSRC and FSRD events on the errored section.

The second may be indicated by the absence (or low counter values) of FSRC and FSRD events with the presence of PSAC and PSAD events, indicating switching activity with probable errors during the switching process.

5.3 Example of maintenance principles

This section gives some examples of usage of error performance counters, defects and additional specific performance parameters.

5.3.1 High frequency digital radio-relay in configuration without protection switching

In this example, a high frequency DRRS without protection switching is considered.

5.3.1.1 DRRS implemented as an RS

The system is described in Fig. 39. The DRRS is setup as an RS with no protection switching. The working frequency is greater than 13 GHz, so it is mainly effected by flat fading due to hydrometeors (rain).

The defects available are listed in Table 20. While in Table 21, the error performance parameters defined in ITU-T Recommendations G.783, G.784 and in this Appendix are shown.

FIGURE 39

Example of RS DRRS in configuration 1 + 0

TABLE 20

Defects for the DRRS shown in Fig. 39

Functional blocks	Defect
RST	LOF
RSPI	lossOfSignal(rx)
	rxFail
	demLOS
	demodulationFail
	lossOfSignal(mod)
	modulationFail
	txFail
	txLOS

TABLE 21

Error performance parameters and additional performance parameters defined for the DRRS shown in Fig. 39

General error performance parameters for RS	Additional performance parameters for RSPI functional block
SES	RL
BBE	RLTS-1
ES	RLTS-2
UAS	RLTM
	TL
	TLTS-1
	TLTS-2
	TLTM

The available information may be used for:

– fault detection and fault analysis;

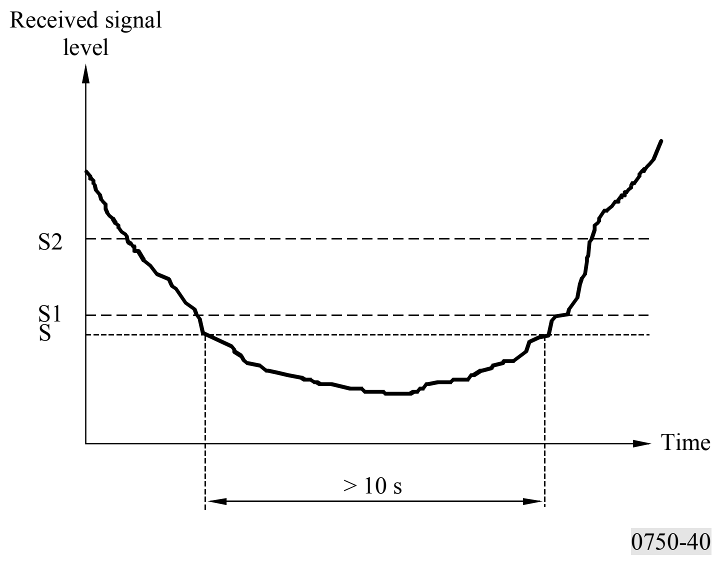
– performance management for maintenance purpose.

5.3.1.1.1 Fault detection and fault analysis

The considered DRRS is affected by the attenuation of received signal due to rain. An example of variation in time of received signal level is shown in Fig. 40. If the received signal level goes down below level S, the system enters in unavailable state, because of the occurrence of more than 10 consecutive SES. At the same time a LOS defect occurs.

FIGURE 40

Received signal level vs time due to flat fading



According to maintenance principles defined in ITU-T Recommendation M.20 and according to fault management procedure defined in ITU-T Recommendation G.784, the defect occurrence has to be considered in order to undertake the corrective maintenance procedure and to detect the fault cause. In this case the fault is due to a propagation event, so no maintenance action needs to be taken.

The additional performance parameters help us to detect the cause of the fault. In the following, an example of a procedure for fault analysis is described.

– DRRS without ATPC: The threshold S1 is set close to the value S of received signal for which a SES event occurs.

When a LOS defect is declared the following situations are possible:

– cLOS defect declared in the receiver terminal, AND no defect detected in the transmission side of the far-end terminal, AND RL lower than S1, AND value of 15 min current register RLTS-1 different from zero; THEN the LOS defect is due to rain;

– cLOS defect declared in the receiver terminal, AND a defect detected in the transmission side of the far-end terminal; THEN the LOS defect is due to a transmission fault;

– cLOS defect declared in the receiver terminal, AND no defect detected in the transmission side AND, no cLOS detected on the far end terminal; THEN the LOS defect is due to a receiver fault.

– DRRS with ATPC: The threshold S1 is set close to the value S of received signal for which a SES event occurs and threshold S2 is set to a higher value. In addition, a value of threshold greater than 10 s is set on the 15 min register RLTS-1 for the threshold crossing notification.

At the transmit site a threshold on the transmitter level is set at the limit of the range of ATPC; for example the threshold for TLTS-1 is set to indicate that the ATPC has reached the maximum value.

One example of the usage of TLTS counter is described in the following situation:

cLOS defect declared in the receiver terminal, AND no defect detected in the transmission side, AND RL lower than S1 AND, the value of 15 min current register TLTS-1 is different from zero; THEN the LOS defect is probable due to rain.

The case of malfunctioning of ATPC is more complex. In fact, if the ATPC does not work and the output power is retained at the minimum value, the fade margin is reduced and the transmission quality may be degraded. This situation is detected by mean of analysis of error performance parameters (SES and BBE) in 15 min and/or 24 h history registers. If the output power is retained at the maximum value only by means of analysis of additional performance parameters (such as RLTS and TLTS) 15 min and 24 h counter history registers a determination of the condition can be made.

5.3.1.1.2 Maintenance procedure based on error performance parameters

ITU-T Recommendation G.784 defines the error performance management for maintenance purpose and the thresholding mechanism on 15 min and 24 h SES, ES and BBE registers

This mechanism based on 15 min and 24 h register allows to identify the following situations:

a) failure not indicated by a defect;

b) errors in link design;

c) interference from other source;

d) ATPC that does not work correctly.

The analysis should be based on history registers and on threshold crossing notification of error performance current registers.

The previous example of malfunctioning may be recognized by means of the following considerations:

Case a) This situation may be indicated by periods affected by error performance degradation without fading activity, i.e. some periods with SES and/or BBE may be registered, but in the same period the analysis of the values stored in RLTS and TLTS history registers indicate no fading activity.

Case b) A wrong link design implies a system gain (margin) lower than needed, so an excessive number of SES, BBE and ES are detected and they are caused only by propagation phenomena. This situation can be identified using the history registers SES, BBE, ES, RLTS, TLTS. In the 15 min and 24 h periods affected by excessive SES, BBE and ES the value stored in the corresponding 15 min and 24 h registers RLTS and TLTS would be different from zero (high values), while in the other 15 min and 24 h period this value would be zero.

Case c) The interference from other sources can be identified considering that periods with error performance degradation, do not correspond to periods of fading activity, as in Case a). But interference may also reduce fade margin, so an excessive number of SES and/or BBE/ES is registered without indications of excessive attenuation of the received signal. This situation is detected considering the values stored in the RLTS and TLTS history registers.

Case d) The use of TLTS in conjunction with RLTS history registers allow to detect if the ATPC does not work properly.

5.3.1.2 DRRS implemented as an MS

The defects available are listed in Table 22, while in Table 23 the error performance parameters defined in ITU-T Recommendation G.783, G.784 and in this Appendix are shown.

FIGURE 41

Example of MS DRRS in configuration 1 + 0

TABLE 22

Defects for the DRRS shown in Fig. 41

Functional blocks	Defect
MST	AIS
	MS-DEG
	MS-RDI
RST	LOF
RSPI	lossOfSignal(rx)
	rxFail
	demLOS
	demodulationFail
	lossOfSignal(mod)
	modulationFail
	txFail
	txLOS

TABLE 23

Error performance parameters and additional performance parameters defined for the DRRS shown in Fig. 41

General error performance parameters for RS	General error performance parameters for MS	Additional performance parameters for RSPI functional block
SES	SES	RL
BBE	BBE	RLTS-1
ES	ES	RLTS-2
UAS	UAS	RLTM
		TL
		TLTS-1
		TLTS-2
		TLTM

5.3.1.2.1 Fault detection and fault analysis

The relation between LOS defect and additional performance parameters is the same as in § 5.3.1.1.1.

5.3.1.2.2 Maintenance procedure based on error performance parameters

The error performance monitoring for maintenance purpose should be based on the error performance parameters (SES, ES and BBE) at MS layer.

The considerations given in § 5.3.1.1.2 are still valid.

5.3.2 Digital radio-relay with 1 + 1 protection switching

The radio protection switch may be implemented according to four different topology.

5.3.2.1 DRRS implementing protection Type C

In this example is considered the DRRS described in Fig. 42. The DRRS is configured as an RS with 1 + 1 protection switching type C. The working frequency is lower than 13 GHz, so it is mainly affected by selective fading.

The defects available are listed in Table 24, while in Table 25 the error performance parameters defined in ITU-T Recommendations G.783, G.784 and in this Appendix are shown (the subscripts w and p indicate the defect and error performance parameters on the working channel and on the stand-by channel).

FIGURE 42

Example of RS DRRS in 1 + 1 configuration

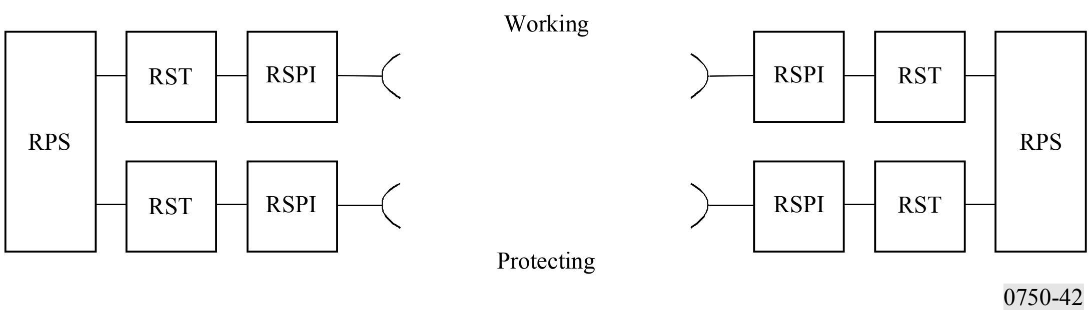


TABLE 24

Defects for the DRRS shown in Fig. 42

Functional blocks	Defect
RST_w	LOF_w
$RSPI_w$	lossOfSignal(rx)$_w$
	$rxFail_w$
	$demLOS_w$
	$demodulationFail_w$
	lossOfSignal(mod)$_w$
	$modulationFail_w$
	$txFail_w$
	$txLOS_w$
RST_p	LOF_p
$RSPI_p$	lossOfSignal(rx)$_p$
	$rxFail_p$
	$demLOS_p$
	$demodulationFail_p$
	lossOfSignal(mod)$_p$
	$modulationFail_p$
	$txFail_p$
	$txLOS_p$

NOTE 1 – The subscriber w and p indicate the defect on the working and on the stand-by radio-connection respectively.

TABLE 25

Error performance parameters and additional performance parameters defined for the DRRS shown in Fig. 42

General error performance parameters	Additional performance parameters for RPS functional block	Additional performance parameters for RSPI functional block
SES_w	PSAC (Note 2)	RL_w, RL_p
BBE_w	FSRC (Notes 2 and 4)	RLTS-1$_w$, RLTS-1$_p$
ES_w	PSAD (Notes 3)	RLTS-2$_w$, RLTS-2$_p$
UAS_w	FSRD (Notes 2 and 5)	$RLTM_w$, $RLTM_p$
SES_p	$PSRC_w$, $PSRC_p$ (Note 4)	TL_w, TL_p
BBE_p	$PSRD_w$, $PSRD_p$ (Note 5)	TLTS-1$_w$, TLTS-1$_p$
ES_p		TLTS-2$_w$, TLTS-2$_p$
UAS_p		$TLTM_w$, $TLTM_p$
SES_{sw}		
BBE_{sw}		
ES_{sw}		
UAS_{sw}		

NOTE 1 – The subscriber w and p indicate the defect on the working and on the stand-by, radio channels respectively, while the subscript sw the switching protected section.

NOTE 2 – The additional performance parameter is defined only for the working radio channel in a 1 + 1 revertive protection scheme.

NOTE 3 – The additional performance parameter is not required in a 1 + 1 non-revertive protection scheme.

NOTE 4 – FSRC or PSRC is implemented.

NOTE 5 – FSRD orPSRD is implemented.

5.3.2.1.1 Maintenance procedure based on error performance parameters

ITU-T Recommendation G.784 defines the error performance management for maintenance purpose and the thresholding mechanism on 15 min and 24 h SES, ES and BBE registers.

This mechanism based on 15 min and 24 h register allows to identify the following situations:

a) switch malfunctioning;

b) errors in link design.

The analysis should be based on a statistical analysis of history registers.

The previous examples of malfunctions may be identified by means of the following considerations:

Case a) The switch malfunction may produce an anomalous number of SES, ES and BBE events outside the switching section correlated with fading activity. In addition, the quality of the single RS (stored in the error performance history registers of a single channel) is comparable with the quality of the protected section (stored in the error performance history registers of switching section). No correlation between SES/ES/BBE and FSRC and FSRD counters should appear.

Case b) An underestimation of the propagation activity may produce:

b.1) a greater number of switching events;

b.2) less than expected improvement from the protection system;

b.3) correlations between error performance parameters and FSRC and FSRD events.