

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

- 1 Introduction
 - 1.1 Scope
 - 1.2 Abbreviations
 - 1.3 Definitions
- 2 Features and layering of the SDH-based networks
 - 2.1 SDH description
 - 2.2 SDH layering
 - 2.2.1 Layering
 - 2.2.2 Layering and the SDH frame structure
 - 2.3 Network node interfaces (NNI)
 - 2.4 Functional blocks of SDH equipment

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

- 3 Application of radio-relay systems to SDH-based networks
 - 3.1 General considerations
 - 3.1.1 Interfaces
 - 3.1.2 Mid-air interconnectivity
 - 3.2 Multiplex and regenerator sections
 - 3.3 Functional block diagrams of STM-*N* digital radio-relay systems
 - 3.3.1 SDH radio synchronous physical interface function (RSPI)
 - 3.3.1.1 Signal flow from B to R
 - 3.3.1.2 Signal flow from R to B
 - 3.3.1.3 Application to the transmission of *N* times STM-*N*
 - 3.3.2 Radio protection switching (RPS)
 - 3.3.2.1 Signal flow
 - 3.3.2.2 Additional functionality on the signal flow from XT (tributary side) to XL (line side)
 - 3.3.2.3 Additional functionality on the signal flow from XL (line side) to XT (tributary side)
 - 3.3.2.4 Switching initiation criteria
 - 3.3.2.5 Switching performance
 - 3.3.2.6 Switch restore
 - 3.3.3 ROHA (Radio OverHead Access)
 - 3.4 Radio terminals and repeaters arrangement of STM-*N* DRRS
 - 3.4.1 Radio repeater arrangement
 - 3.4.2 Radio protection switching (RPS) and radio terminals arrangement
 - 3.5 Synchronization
- 4 Function and usage of section overhead (SOH) bytes
 - 4.1 Multiplex and regenerator section overheads (SOH)
 - 4.2 Media-specific bytes
 - 4.3 Reduced SOH functionality for intra-station sections
- 5 Radio-relay specific functions
- 6 STM-0 transmission rate SDH radio-relay systems
 - 6.1 Network interfaces
 - 6.2 Multiplexing schemes
 - 6.3 Multiplex and regenerator radio sections
 - 6.4 Functional block diagrams of STM-0 digital radio-relay systems
 - 6.4.1 Radio-relay STM-0 synchronous physical interface (RR-RSPI) function
 - 6.4.2 Radio-relay STM-0 regenerator section termination (RR-RST)
 - 6.4.3 Radio-relay STM-0 multiplex section termination (RR-MST)
 - 6.4.4 Radio-relay STM-0 multiplex section adaptation (RR-MSA)
 - 6.4.5 STM-0 radio-relay synchronous physical and equipment interface (RR-SPI and RR-EI)
 - 6.5 Radio protection switching
 - 6.6 Section overhead (SOH) for STM-0 DRRS
 - 6.7 Techniques for transport of media-specific functions
- 7 Operation and maintenance aspects
 - 7.1 Management functions
 - 7.2 Maintenance functions
 - 7.2.1 RSPI and RR-RSPI maintenance functions
 - 7.2.2 RPS maintenance functions
 - 7.2.3 ROHA maintenance functions
 - 7.2.4 Performance monitoring functions

Appendix 1 – RR-EI electrical characteristics

Appendix 2 – Migration strategy from an existing PDH to SDH-based networks

Appendix 3 – Examples of practical implementations of the RPS function

Appendix 4 – Transmission of media-specific functions of STM-0 DRRS through radio complementary section overhead (RCSOH)

Appendix 5 – Additional primitives for operation and maintenance purpose of RSPI/RR-RSPI, RPS and ROHA functional blocks

Appendix 6 – Performance event for RSPI, RPS and ROHA functional blocks

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.

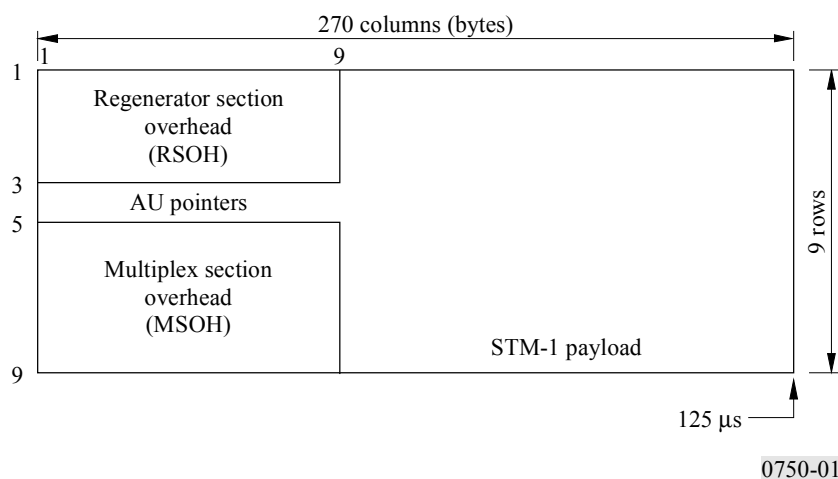
2 Features and layering of the SDH-based networks

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

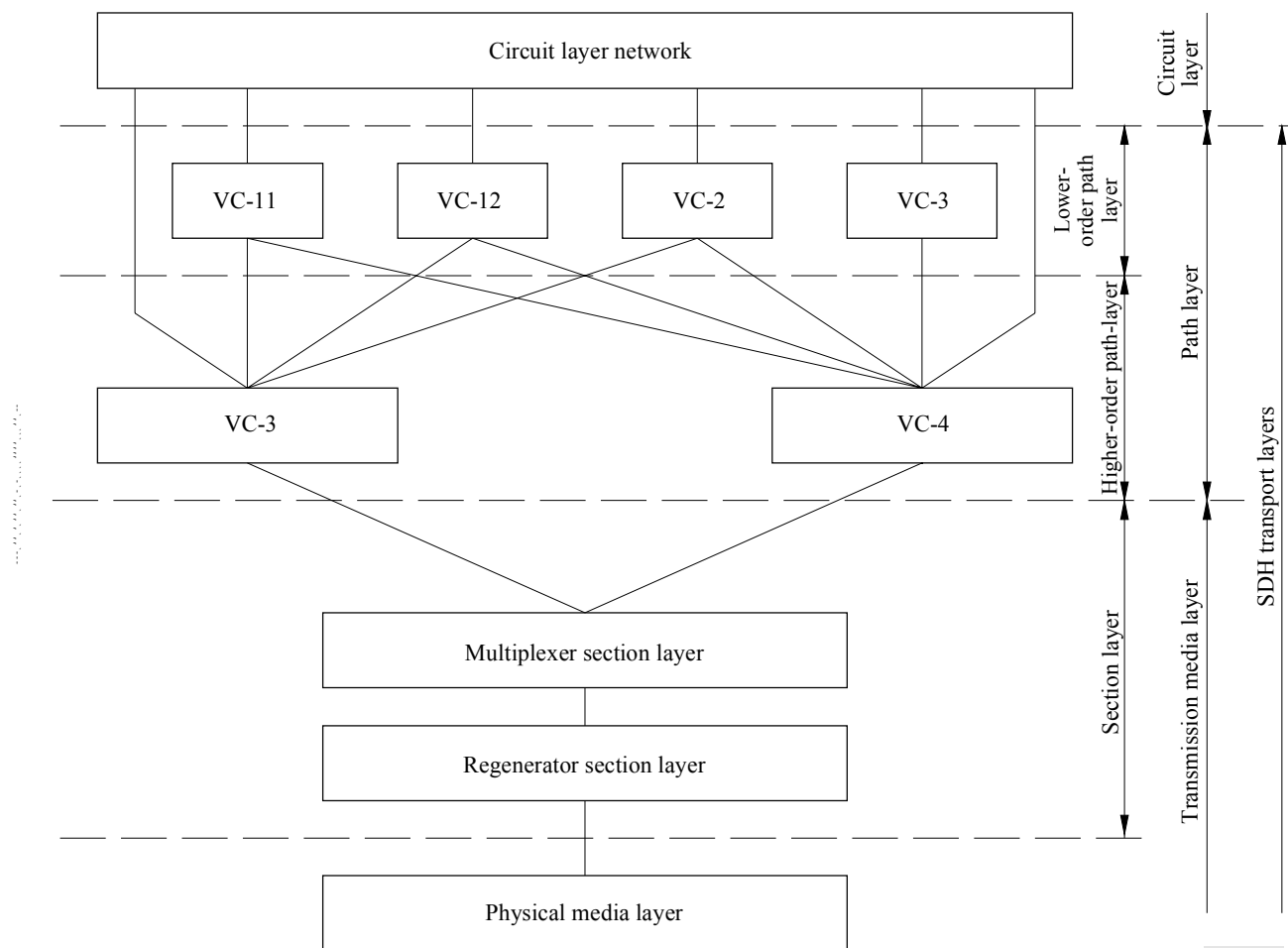
2.2.1 Layering

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



0750-02

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).

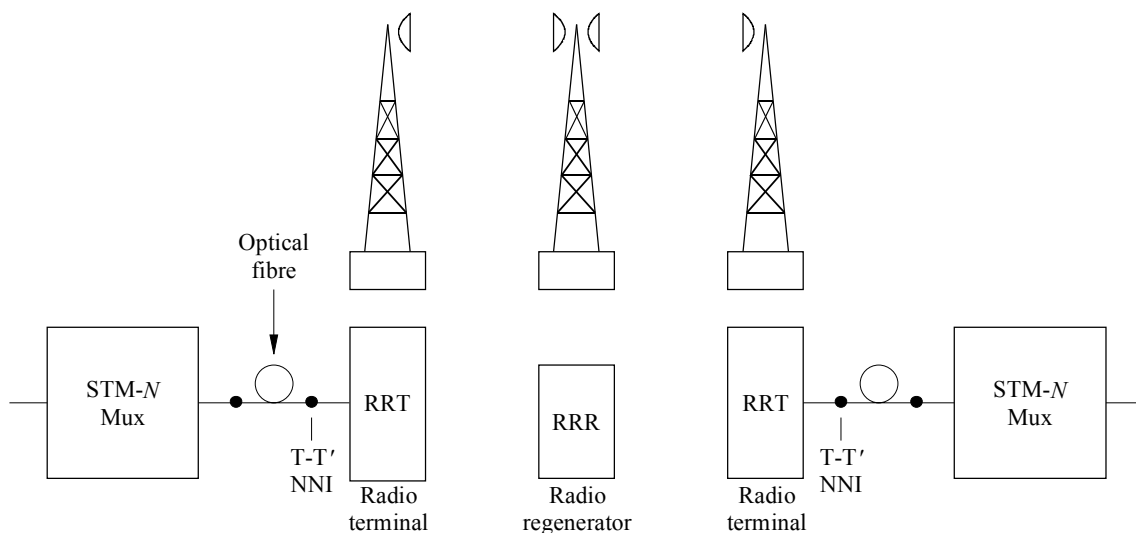
The RS is media dependent, the MS may be media dependent with a restricted point-to-point topology, while the LOVC and HOVC are designed to be media independent with a wide, complex meshed topology.

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



0750-03

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.

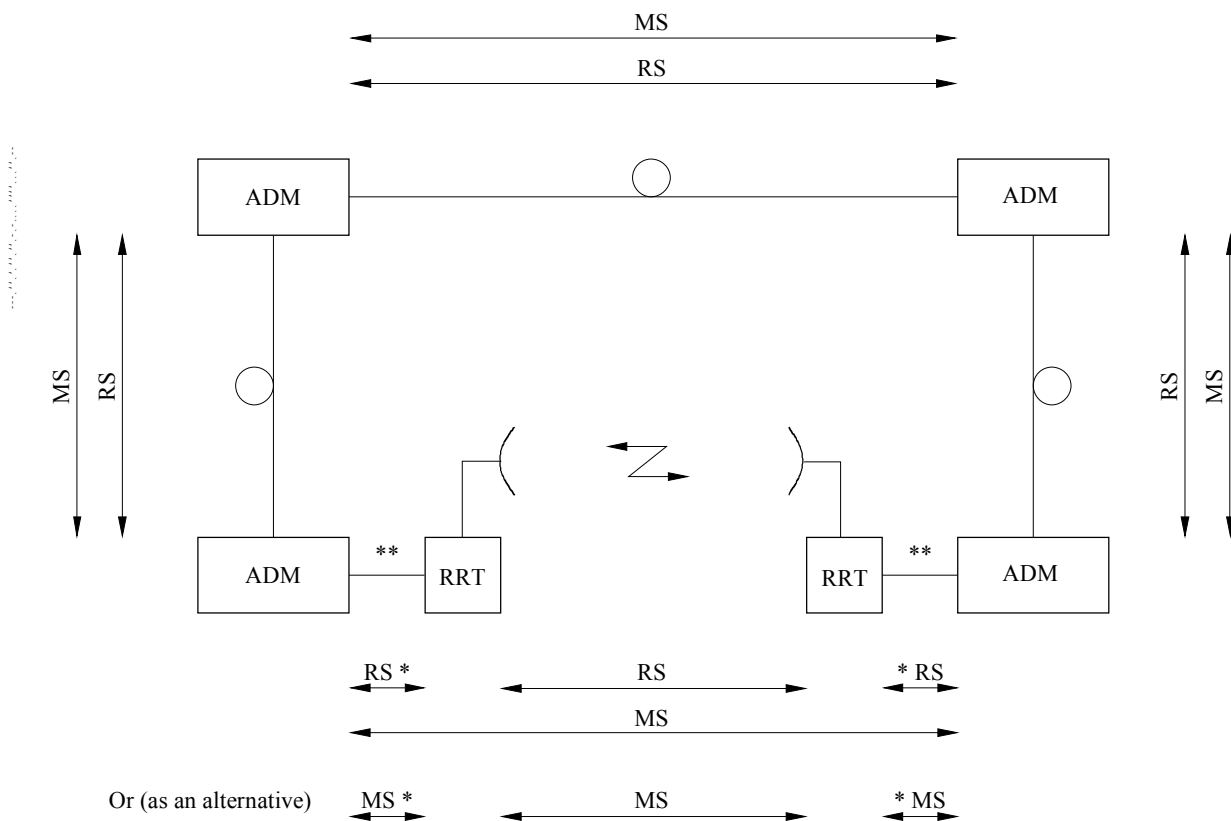
Media independent multiplex sections are possible only if all different media use the MSOH for the same overhead functions (with no media-dependent functions).

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

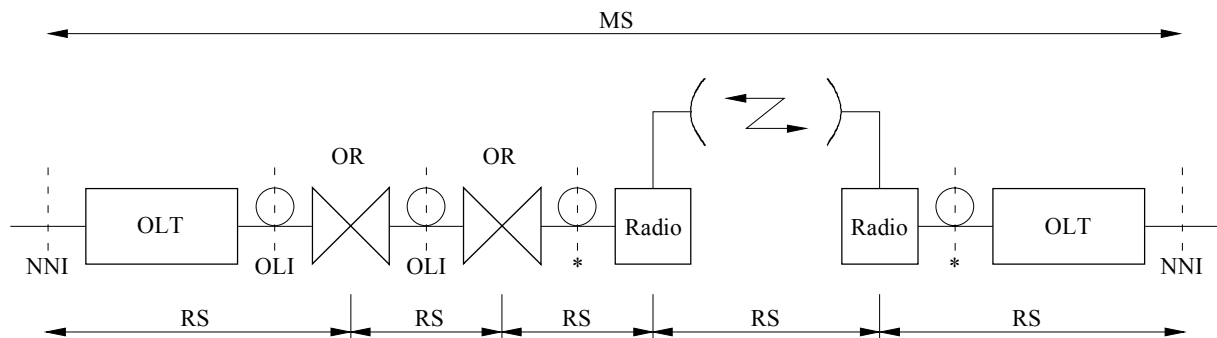


* With possible reduced functionality of an intra-station section (see ITU-T Recommendation G.958) or with the functionality of an intra-station interface (see ITU-T Recommendation G.707).

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

0750-04

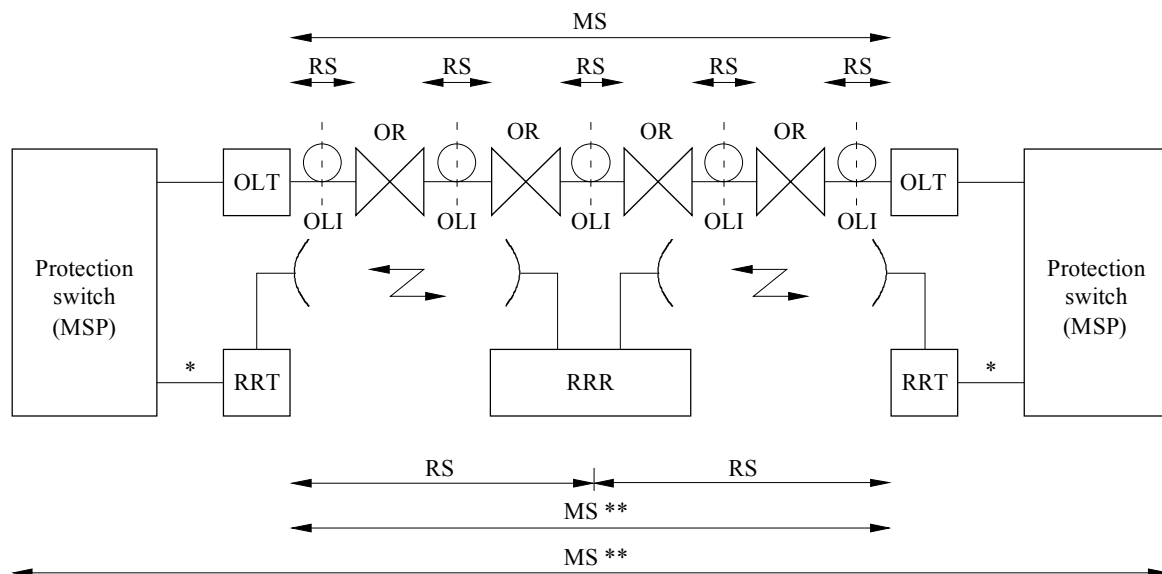
FIGURE 5
Tandem connection type



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

0750-05

FIGURE 6
Multi-media protection



* Optical, electrical or internal (proprietary) interface.

** MS may be either media dependent or media independent.

0750-06

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.

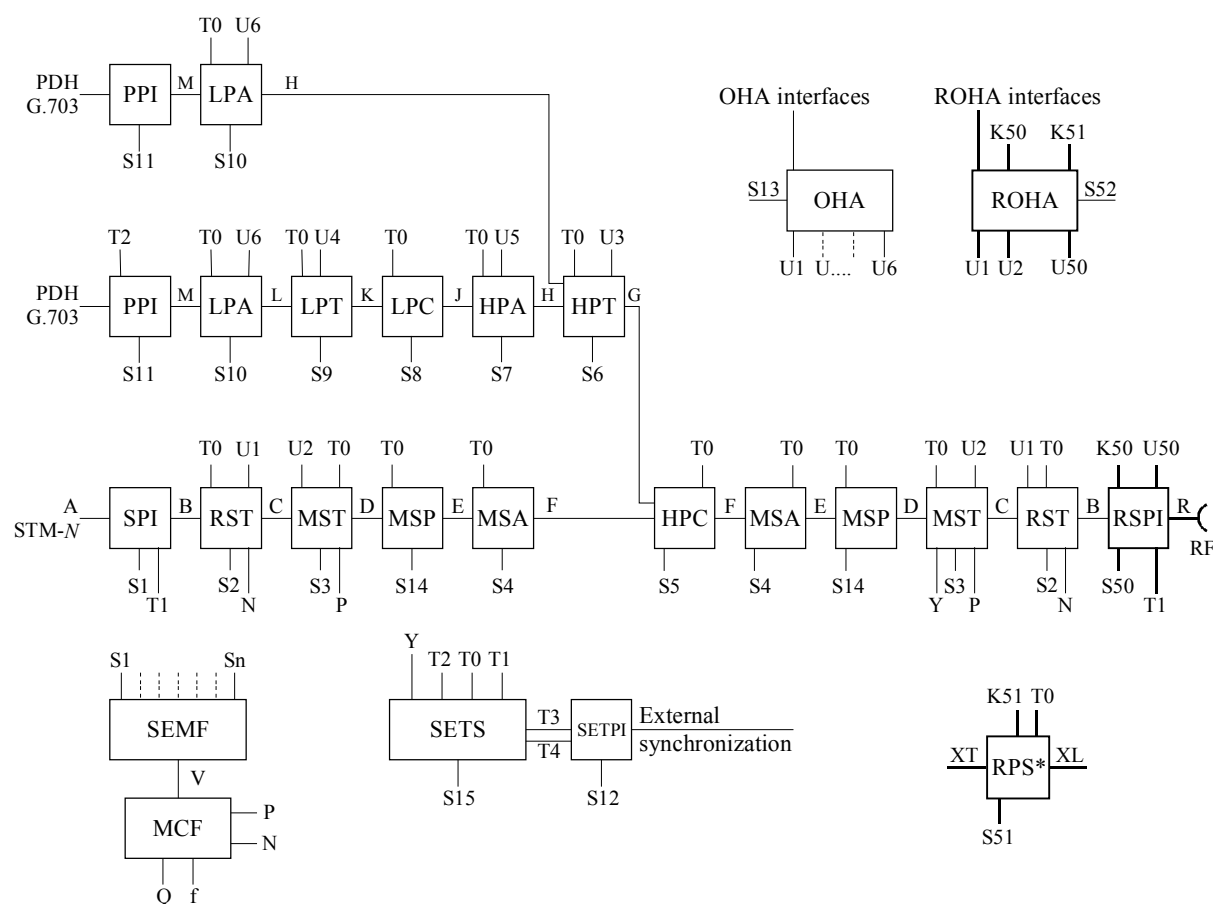
In Fig. 7 only the most common ITU-T Recommendation G.783 defined functional blocks are reported, together with the radio specific ones. Nevertheless other actual or future ITU-T Recommendation G.783 defined functional blocks may be implemented, if applicable, into SDH DRRS.

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).

0750-07

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.

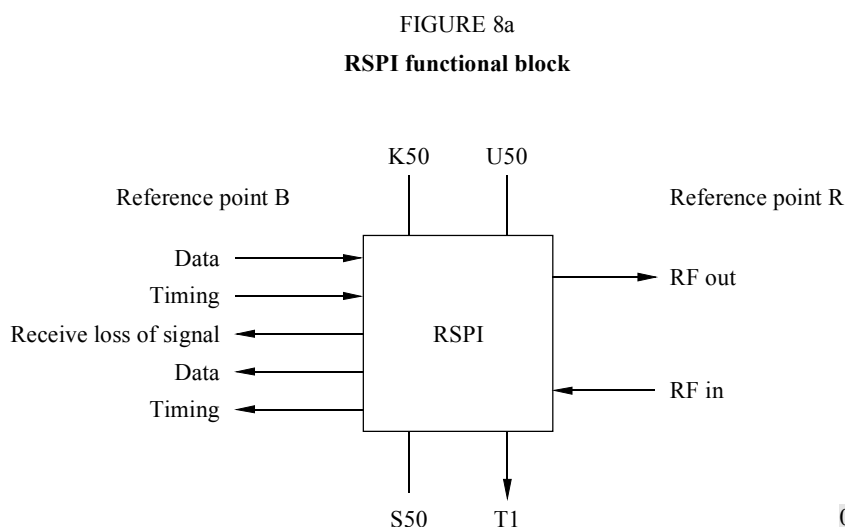
Refer to Appendix 2 for a migration strategy from PDH to SDH-based networks.

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.

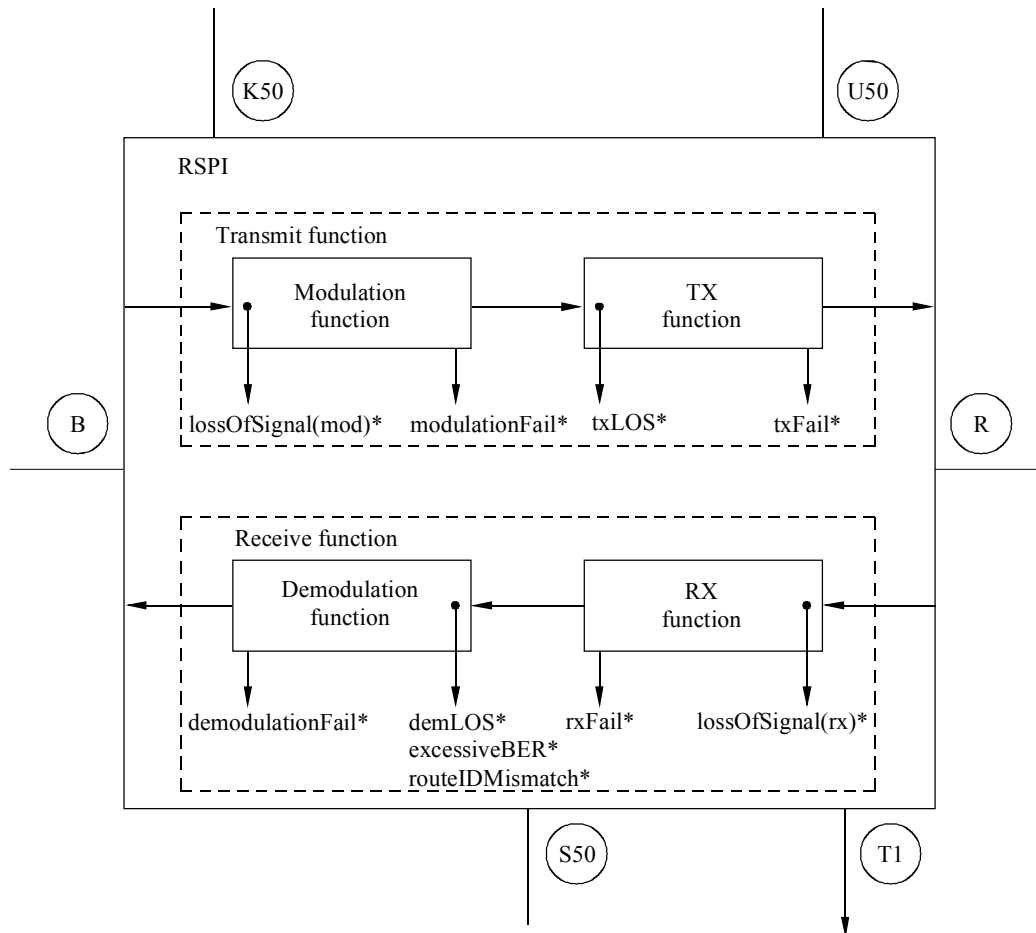
Data at R is a radio-frequency signal containing an STM- N signal with no media-dependent bytes and (if used) an additional arbitrary RFCOH (radio frame complementary overhead). Therefore mid-air interconnectivity between transmitters and receivers from different vendors is not required.

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



0750-08a

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

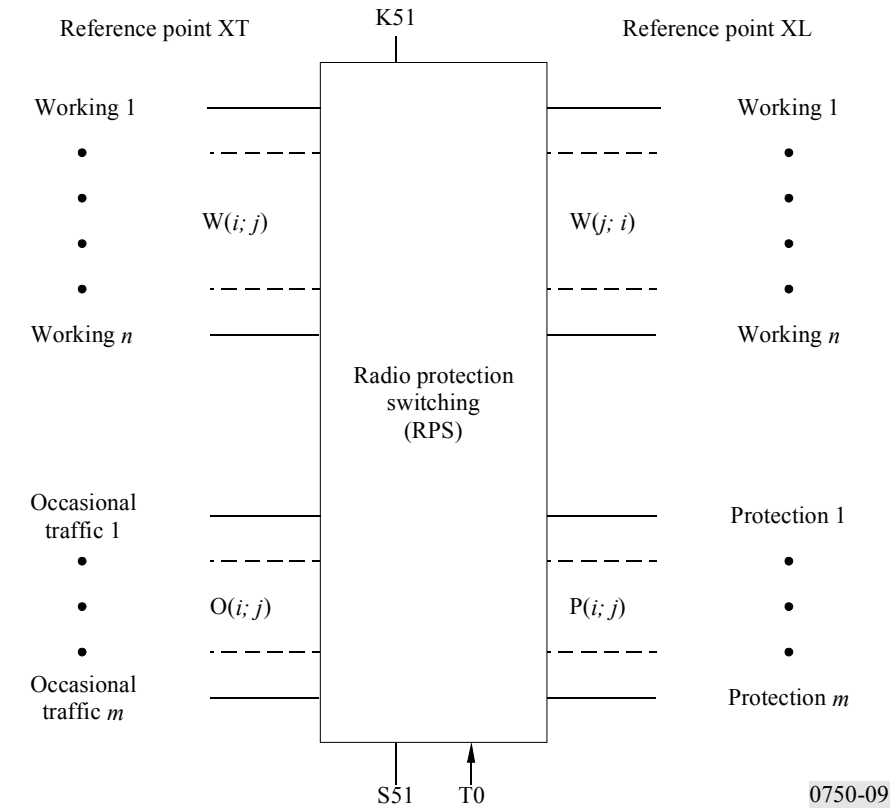


TABLE 1

Connection matrix interconnectivity for RPS

Output \ Input		W_i		P_i	O_j
		XL	XT	XL	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).

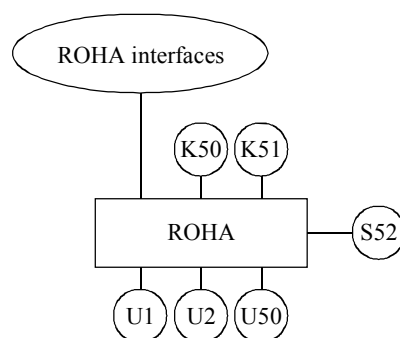
3.3.2.6 Switch restore

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.

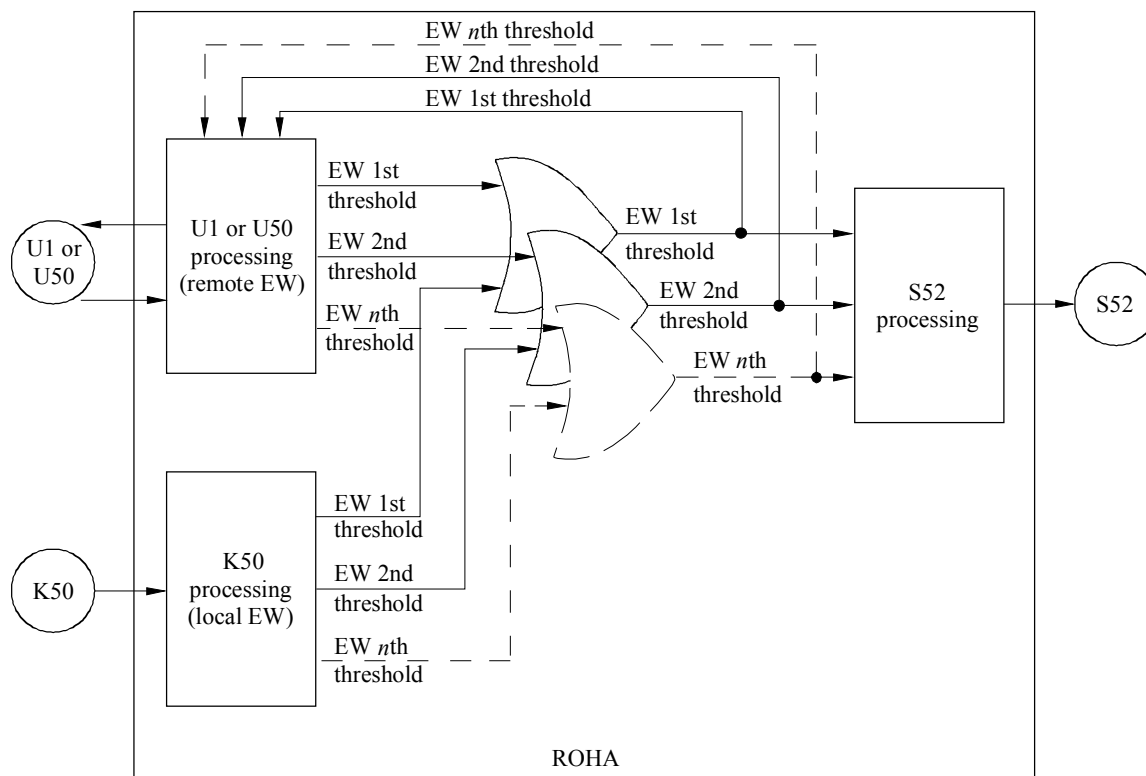
Moreover, it supplies transmission interfaces K50 and K51 to the RSPI and RPS functional blocks respectively, allowing the required information exchange between corresponding radio terminals or regenerators for managing specific functions (e.g. ATPC) and the unstandardized switching control protocol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