RECOMMENDATION ITU-R F.751-2

TRANSMISSION CHARACTERISTICS AND PERFORMANCE REQUIREMENTS OF RADIO-RELAY SYSTEMS FOR SYNCHONOUS DIGITAL HIERARCHY-BASED NETWORKS

(Question ITU-R 160/9)

(1992-1994-1997)

The ITU Radiocommunication Assembly,

considering

a) that ITU-T Recommendations G.707, G.708 and G.709 specify the bit rates, the multiplexing structure and the detailed mappings associated with the synchronous digital hierarchy (SDH);

b) that ITU-T Recommendations G.781, G.782 and G.783 specify 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 Recommendation ITU-R F.750 specifies architectures and functional aspects of SDH digital radio-relay systems (DRRSs);

e) that specific transmission features of the radio-relay systems may be required for the transport of SDH bit rates meeting the performance requirements and efficient spectrum utilization;

f) that the coexistence of SDH-DRRSs with the existing radio systems is required in the present radio channelling schemes,

recommends

1 that SDH-DRRSs comply with the requirements described in Annex 1.

ANNEX 1

1 Introduction

1.1 Scope

Annex 1 defines the transmission characteristics and performance requirements for the SDH-DRRSs.

2 Applications of SDH digital radio-relay systems (SDH-DRRSs)

2.1 Network interfaces

The connection between radio and SDH networks shall be at standardized interface points. The preferred connection is to make the TT′ points (Recommendation ITU-R F.596) coincide with the network node interface (NNI) points identified in ITU-T Recommendation G.708.

2.2 Transport capacity

2.2.1 High capacity SDH-DRRSs

SDH-DRRSs in the long-haul or core network typically operate at STM-1, $n \times$ STM-1 or STM-n transmission rates. They are typically deployed in the lower (2-12 GHz) frequency bands.

High capacity SDH-DRRSs in short-haul or access networks typically operate at the STM-1 or $n \times$ STM-1 transmission rates. They are usually deployed in frequency bands higher than 12 GHz.

2.2.2 Medium capacity SDH-DRRSs

In circumstances when traffic requirements are below those of an STM-1 signal, and to most effectively utilize the available radio bandwidth, radio-relay systems typically operate at the STM-RR transmission rate with a VC-3 traffic payload (see § 6 of Annex 1 to Recommendation ITU-R F.750).

2.2.3 Low capacity SDH-DRRSs

SDH-DRRSs with payload transport capacity below VC-3, e.g. $n \times$ VC-12, are under study.

3 Radio-frequency channel arrangements and compatibility with existing systems

3.1 High capacity SDH-DRRSs

SDH-DRRSs shall be compatible with the existing radio-frequency channelling arrangements (see Recommendation ITU-R F.746). This will allow administrations to introduce new synchronous digital radio systems without major disruption of existing radio networks employing analogue radio systems and/or plesiochronous digital radio systems. These have generally been based on analogue radio systems and digital systems operating at bit rates up to 140 Mbit/s. The transmission of 155 Mbit/s signals within these channelling arrangements requires an increase in the bits/Hz spectrum efficiency of radio equipment which may have a consequential impact on the choice of modulation method and on the design of filter circuits.

Examples of possible arrangements which allow transmission of the basic STM-1 rate and multiple STM-1 rates within existing radio-frequency channel plans are given in Table 1.

TABLE 1

Examples of possible arrangements which allow transmission of the basic STM-1 rate and multiple STM-1 rates within existing radio-frequency channel spacing

Channel spacing (MHz)	Capacity	Examples of modulation method (1), (2)
20	1 × STM-1	256-QAM, 512-QAM
28, 29, 29.65, 30	1 × STM-1	64-QAM, 128-QAM, 256-QAM
28, 29, 29.65, 30	2 × STM-1	128-QAM (CC), 256-QAM (CC)
40	1 × STM-1	32-QAM, 64-QAM
40	2 × STM-1	32-QAM (CC), 64-QAM (CC), 512-QAM
55, 56, 60	1 × STM-1	16-QAM, 32-QAM
55, 56, 60	2 × STM-1	16-QAM (CC), 32-QAM (CC) 64-QAM (CC), 256-QAM
80	2 × STM-1	64-QAM
80	4 × STM-1, 1 × STM-4	64-QAM (CC)
110, 112	1 × STM-1	QPSK (4-QAM)
110, 112	2 × STM-1	16-QAM, 32-QAM
110, 112	4 × STM-1, 1 × STM-4	16-QAM (CC), 32-QAM (CC)
220	4 × STM-1, 1 × STM-4	16-QAM, 32-QAM

(1) The term QAM is intended to also encompass forward error correction or coded modulation techniques (like TCM).
(2) In this table CC is used as the abbreviation for “band re-use in the co-channel mode”.

3.2 Medium capacity SDH-DRRSs

Examples of possible arrangements which allow STM-RR transmission rates within existing radio-frequency channel plans are given in Table 2.

TABLE 2

Examples of possible arrangements which allow transmission of STM-RR rates within existing radio-frequency channel spacing

Channel spacing (MHz)	Capacity	Examples of modulation method (1)
10	1 × STM-RR	64-QAM, 128-QAM
14	1 × STM-RR	16-QAM, 32-QAM
20	2 × STM-RR	64-QAM, 128-QAM
27.5, 28	1 × STM-RR	4-QAM, 16-QAM
30	1 × STM-RR	9 QPR, 16-QAM
40	1 × STM-RR	QPSK

(1) The term QAM is intended to also encompass forward error correction or coded modulation techniques (like TCM).

4 Media-specific functions

Radio-relay systems may require transmission capacity between NNIs to allow for the implementation of a range of radio specific functions (media specific functions).

The following functions have currently been identified:

a) *Early warning radio protection switch activation*

In order to activate "early warning switching" of radio protection switching equipment during adverse propagation events, an effective method can be derived from the fast detection of error activity (if present) on each separate hop. This is essential in order to achieve "error free" switching operation.

b) *Automatic transmitter power control (ATPC)*

ATPC may be advantageous in reducing nodal interference between radio-relay systems. In addition, it can be used to improve linearity or increase the dynamic range of multi-level modulation radio equipment. It is anticipated that when ATPC is implemented, it will be on a hop-by-hop basis.

c) *Radio protection switching information and control*

The control signal may need to be accessed at equipment sites providing functions for either multiplex section overhead (MSOH) or regenerator section overhead (RSOH) depending on the physical implementation of radio protection switching (see § 3.4 of Annex 1 to Recommendation ITU-R F.750).

d) *Propagation monitoring*

This control signal may be needed to collect data on propagation conditions prevalent on the radio route.

e) *Wayside traffic, auxiliary maintenance and monitoring functions*

In many applications radio-relay systems offer a variety of auxiliary functions. Examples of such functions are as follows:

– wayside traffic, up to $n \times 1.5$ Mbit/s or $n \times 2$ Mbit/s,

– forward error detection and correction,

– propagation data collection,

– auxiliary 64 kbit/s data channels,

– auxiliary maintenance functions, e.g. station alarms,

– temporary data/voice channels for maintenance purposes.

f) *End-to-end performance monitoring for radio connections composed of multiple SDH regenerative repeaters (RS) without MS termination*

In this application it may be useful to forward the far-end radio terminal errored blocks information (evaluated on the incoming B2 parity) entering into the radio system from outside, using dedicated bytes. This will allow the far-end terminal to provide the TMN with the correct end-to-end error performance monitoring without additional processing.

4.1 Techniques for transport of media specific functions

Several techniques are available to provide the functions outlined above. The choice of technique may depend on the method of implementation. Two examples are given below.

4.1.1 Radio frame complementary overhead (RFCOH)

Radio-relay systems may in some applications require a RFCOH in order to implement the functions outlined above. The RFCOH is added to the STM-1 signal and is accessible at both radio terminal and repeater equipments.

4.1.2 Section overhead (SOH)

Radio-relay systems may in some applications make use of bytes within the SOH in order to implement the functions outlined above using the media specific bytes referred to in § 4.2 of Annex 1 to Recommendation ITU-R F.750, bytes reserved for national usage and the bytes reserved for future international standardization. In this case a way-side traffic up to 2 Mbit/s can be transported. However, in the event that ITU-T defines the function of those bytes reserved for future international standardization, SDH radio-relay systems will comply with ITU-T Recommendation G.708.

5 Transmission techniques

SDH-DRRSs will require tighter filtering or a higher number of modulation levels to accommodate the former capacity within the same radio channel.

A number of proven techniques like error correction, coded modulation, multi-carrier systems, ATPC, adaptive equalization, hit-less or error-less protection switching, space and frequency diversity and cross-polarization cancellation are available to combat various impairments such as multipath dispersive fading, radio interference, thermal noise, timing errors, etc.

Specific items of SDH-DRRSs on transmission techniques are mentioned below.

5.1 Error correction

SOH capacity is not sufficient to accommodate error correction schemes currently in use. The implementation of error correction may further increase the gross bit rate of the radio system.

5.2 Scrambling

ITU-T Recommendation G.709 specifies that a 7-stage frame synchronous scrambler shall be used at the STM-*n* signal level. For radio systems employing certain modulation methods (e.g. 64-QAM) which are envisaged especially for long-haul high capacity radio systems, such a scrambler is not sufficient for the purposes of demodulation and timing extraction and may not be adequate to ensure a uniform spectral distribution in order to allow compatibility with analogue systems. In addition, short scramblers can lead to data-dependent performance. The radio design should ensure that adequate scrambling is provided in the radio system.

6 Performance requirements

SDH-DRRSs will be integrated in managed SDH networks. Radio performance requirements which should be met by SDH-DRRSs are given in the relevant ITU-T and ITU-R Recommendations. Achieving this performance involves providing both high quality equipment and adhering to appropriate route engineering guidelines. This section identifies ITU-T and ITU-R texts applicable to successful integration of SDH digital radio systems into the SDH network.

6.1 Error performance

ITU-T Recommendation G.821 provides error performance requirements which should be met at the 64 kbit/s level. Recommendation ITU-R F.594 gives performance objectives for high grade digital radio links. For medium and local grade circuits, Recommendations ITU-R F.696 and ITU-R F.697, respectively, apply.

The requirements for transport networks at or above the primary level are contained in ITU-T Recommendation G.826.

The error performance objectives of SDH-DRRSs shall comply with ITU-T Recommendation G.826. This will also ensure that the SDH-DRRSs meet the ITU-T Recommendation G.821 requirements.

6.2 Timing and synchronization

SDH-DRRSs shall be designed to operate in a synchronized network. The general principles and applications guidelines for synchronization of SDH multiplexing equipment are given in ITU-T Recommendation G.782. Derived timing and synchronization specifications are given in ITU-T Recommendation G.783.

SDH-DRRSs may derive the timing reference from three types of inputs:

– ITU-T Recommendation G.703, external synchronization interface;

– ITU-T Recommendation G.703, plesiochronous digital hierarchy (PDH) signal interface (carrying reference synchronization);

– STM-*n* interface.

Depending on the types of SDH-DRRS, one or more timing reference inputs may be available. SDH-DRRSs should have the capability to switch automatically to another timing reference if the selected timing reference is lost (see ITU-T Recommendation G.782).

6.3 Jitter and wander

SDH jitter and wander are specified at both STM-*n* and ITU-T Recommendation G.703 interfaces, in order to control the accumulation of jitter within SDH systems.

The jitter and wander characteristics of SDH-based multiplex equipment are given in ITU-T Recommendation G.783 and those of SDH-based line systems are given in ITU-T Recommendation G.958.

6.4 Availability

Availability objectives for digital radio systems are given in Recommendation ITU-R F.557. For medium and local grade circuits, Recommendations ITU-R F.696 and ITU-R F.697, respectively, apply.