RECOMMENDATION ITU-R F.1491-1

Error performance objectives for real digital radio links used in the national portion of a 27 500 km hypothetical reference path at or above the primary rate

(Question ITU-R 210/9)

(2000-2001)

The ITU Radiocommunication Assembly,

considering

a) that ITU-T has specified the error performance parameters and objectives for national constant bit rate (CBR) digital paths at or above the primary rate in ITU-T Recommendation G.826 and for national, constant bit rate synchronous digital paths in ITU-T Recommendation G.828;

b) that ITU-T has specified the error performance events and the block structures for synchronous digital hierarchy (SDH) multiplex and regenerator sections in ITU-T Recommendation G.829;

c) that Recommendation ITU-R F.1397 provides the error performance objectives for real digital radio links used in the international portion of a 27 500 km hypothetical reference path (HRP) at or above the primary rate;

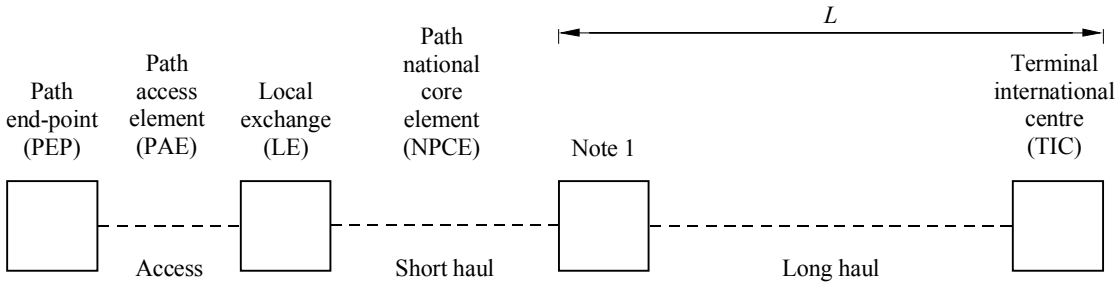
d) that any real path/link for digital data transmission at or above the primary rate may be realized using a linear and/or a redundant topology, depending on the needs of network providers;

e) that there is a need to establish the performance objectives for real digital radio links in order to allow a proper engineering of the radio links;

f) that for the purpose of this Recommendation, the national portion of a 27 500 km HRP can be subdivided into three basic sections (see Fig. 1),

FIGURE 1

Basic sections of the national portion of the HRP



Note 1 – Depending on the country network architecture, this centre may coincide with a primary centre (PC), secondary centre (SC) or tertiary centre (TC) (see ITU-T Recommendation G.801).

Access: Access network section, including the connections between PEP and the corresponding local access switching centre/cross connector (LE). It corresponds to the PAE.

Short haul: Short haul inter-exchange network section, including the connections between a local access switching centre/cross connector (LE) and a PC, SC or TC (depending on the network architecture).

Long haul: Long haul inter-exchange network section, including the connections between a PC, SC or TIC (depending on the network architecture) and the corresponding international gateway (IG).

Note 2 – TIC, PAE and NPCE are defined in ITU-T Recommendation M.1010.

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recommends

1 that the error-performance objectives for the access and short haul sections shall make use only of the block allocation contribution specified in ITU-T Recommendations G.826 and G.828 for the national portion, and that the long haul section shall make use of the distance-based allocation and part of the fixed block allowance allocation;

2 that for the error performance objectives applicable to each direction of any real radio link of length L_{link} belonging to the long haul inter-exchange network sections of the national portion of HRP the values in Table 1a for SDH systems designed according to ITU-T Recommendation G.828 and in Table 1b for other systems designed according to ITU-T Recommendation G.826 should apply. The lower limit of L_{link}, used to scale the objectives to the real case, is L_{min} = 50 km.

TABLE 1a

Error performance objectives for real SDH radio-relay links belonging to the long haul inter-exchange network section of the national portion of the HRP according to ITU-T Recommendation G.828

Rate (Mbit/s)	1 664 (VC-11, TC-11)	2 240 (VC-12, TC-12)	6 848 (VC-2, TC-2)	48 960 (VC-3, TC-3)	150 336 (VC-4, TC-4)
ESR	$0.01 \times A$	$0.01 \times A$	$0.01 \times A$	$0.02 \times A$	$0.04 \times A$
SESR	$0.002 \times A$				
BBER	$5 \times 10^{-5} \times A$				$1 \times 10^{-4} \times A$

BBER: background block error ratio
ESR: errored second ratio
SESR: severely errored second ratio

TABLE 1b

Error performance objectives for real radio-relay links belonging to the long haul inter-exchange network section of the national portion of the HRP at or above the primary rate according to ITU-T Recommendation G.826

Rate (Mbit/s)	1.5 to 5	>5 to 15	>15 to 55	>55 to 160	>160 to 3 500
ESR	0.04 A	0.05 A	0.075 A	0.16 A	For further study
SESR	0.002 A	0.002 A	0.002 A	0.002 A	0.002 A
BBER	$2\ A \times 10^{-4}$ (see Note 10)	$2\ A \times 10^{-4}$	$2\ A \times 10^{-4}$	$2\ A \times 10^{-4}$	$1\ A \times 10^{-4}$

where:

$$A = (A_1 + 0.002)\ L_{link}/100 \qquad \text{for} \quad 50 \text{ km} \leq L_{link} \leq 100 \text{ km}$$

$$A = A_1 + 2 \times 10^{-5}\ L_{link} \qquad \text{for} \quad 100 \text{ km} < L_{link}$$

A_1 has provisionally been agreed to be in the range of 0.01 to 0.02 (1% to 2%) (see Notes 3 and 4);

3 that for the error performance objectives applicable to each direction of any real radio link forming all of the short haul network sections of the national portion of the HRP the values given in Table 2a for SDH systems designed according to ITU-T Recommendation G.828 and in Table 2b for other systems designed according to ITU-T Recommendation G.826 should apply.

TABLE 2a

Error performance objectives for SDH radio-relay paths forming all of the short haul inter-exchange network section of the national portion of the HRP according to ITU-T Recommendation G.828

Rate (Mbit/s)	1 664 (VC-11, TC-11)	2 240 (VC-12, TC-12)	6 848 (VC-2, TC-2)	48 960 (VC-3, TC-3)	150 336 (VC-4, TC-4)
ESR	$0.01 \times B$	$0.01 \times B$	$0.01 \times B$	$0.02 \times B$	$0.04 \times B$
SESR	$0.002 \times B$				
BBER	$5 \times 10^{-5} \times B$				$1 \times 10^{-4} \times B$

TABLE 2b

Error performance objectives for radio-relay links forming all of the short haul inter-exchange network section of the national portion of the HRP at or above the primary rate according to ITU-T Recommendation G.826

Rate (Mbit/s)	1.5 to 5	>5 to 15	>15 to 55	>55 to 160	>160 to 3 500
ESR	0.04 *B*	0.05 *B*	0.075 *B*	0.16 *B*	For further study
SESR	0.002 *B*	0.002 *B*	0.002 *B*	0.002 *B*	0.002 *B*
BBER	$2\ B \times 10^{-4}$ (see Note 10)	$2\ B \times 10^{-4}$	$2\ B \times 10^{-4}$	$2\ B \times 10^{-4}$	$1\ B \times 10^{-4}$

The value of *B* has provisionally been agreed to be in the range of 0.075 to 0.085 (7.5% to 8.5%) (see Notes 3 and 4);

4 that for the error performance objectives applicable to each direction of any real radio link forming all of the access network sections of the national portion of the HRP the values given in Table 3a for SDH systems designed according to ITU-T Recommendation G.828 and in Table 3b for other systems designed according to ITU-T Recommendation G.826 should apply.

TABLE 3a

Error performance objectives for SDH radio-relay paths forming all of the access network section of the national portion of the HRP according to ITU-T Recommendation G.828 (see Note 6)

Rate (Mbit/s)	1 664 (VC-11, TC-11)	2 240 (VC-12, TC-12)	6 848 (VC-2, TC-2)	48 960 (VC-3, TC-3)	150 336 (VC-4, TC-4)
ESR	$0.01 \times C$	$0.01 \times C$	$0.01 \times C$	$0.02 \times C$	$0.04 \times C$
SESR	$0.002 \times C$				
BBER	$5 \times 10^{-5} \times C$				$1 \times 10^{-4} \times C$

TABLE 3b

Error performance objectives for radio-relay links forming all of the access network section of the national portion of the HRP at or above the primary rate according to ITU-T Recommendation G.826 (see Note 6)

Rate (Mbit/s)	1.5 to 5	>5 to 15	>15 to 55	>55 to 160	>160 to 3 500
ESR	0.04 C	0.05 C	0.075 C	0.16 C	For further study
SESR	0.002 C	0.002 C	0.002 C	0.002 C	0.002 C
BBER	$2\ C \times 10^{-4}$ (see Note 10)	$2\ C \times 10^{-4}$	$2\ C \times 10^{-4}$	$2\ C \times 10^{-4}$	$1\ C \times 10^{-4}$

The value of C has provisionally been agreed to be in the range of 0.075 to 0.085 (7.5% to 8.5%) (see Notes 3 and 4);

5 that for the error performance objectives evaluation in *recommends* 1, the error performance parameters for any real link are defined as follows:

– ESR is the ratio of errored second (ES) events to total seconds in the available time during a fixed measurement interval;

– SESR is the ratio of severely errored second (SES) events to total seconds in the available time during a fixed measurement interval;

– BBER is the ratio of background block error (BBE) events to total blocks in the available time during a fixed measurement interval. The count of total blocks excludes all blocks during SESs.

Examples of real links in the national portion of HRP and application to real cases are given in Annex 1.

NOTE 1 – The error performance objectives apply only when the system is considered to be available. The entry and exit criteria into and from the unavailable state are defined in Annex A of ITU-T Recommendation G.826.

NOTE 2 – The objectives given in this Recommendation are understood to be long-term objectives to be met over an evaluation period of typically 30 consecutive days (1 month). These objectives should be respected for any month.

NOTE 3 – The sum of the percentages $A_1\% + B\% + C\%$ shall not exceed 17.5%, in accordance with the allocations to the national portion of an international constant bit rate (CBR) path given in ITU-T Recommendations G.826 and G.828.

NOTE 4 – The provisional values agreed for $B\% + C\%$ are in the range 15.5% to 16.5%.

NOTE 5 – Depending on national network configurations administrations may reallocate the A%, B% and C% block allowances among the sections of the national portion of a radio path.

NOTE 6 – There is a great variety in the architecture of access networks in different countries. If the radio path forms only part of the short haul or access network section, it is at the discretion of administrations to make an appropriate apportionment of the objectives given in Tables 2a, 2b, 3a and 3b as a block allowance to the elements forming the short haul or access network section.

NOTE 7 – In the case of multi-hop links the objectives derived according to this Recommendation apply to the overall links; the allocation of the objectives to each hop is under the responsibility of the network operators.

NOTE 8 – The ES, SES and BBE events and the block structure for SDH multiplex and regenerator sections are defined in ITU-T Recommendation G.829, the ES, SES and BBE events and the block structure for paths are defined in ITU-T Recommendation G.826 (see Annex B).

NOTE 9 – The effect of interference and all other sources of performance degradations are included in Tables 1, 2 and 3.

NOTE 10 – For systems designed prior to 1996, the BBER objective is 3×10^{-4}.

NOTE 11 – In the context of this Recommendation, the link consists in section(s) and/or path(s).

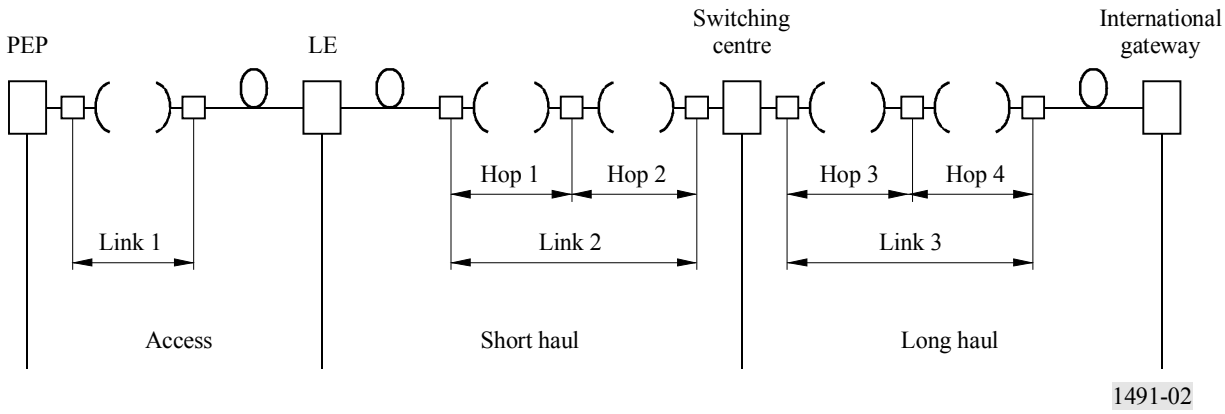
ANNEX 1

Examples of calculation for real links

The examples of calculation below refer to a generic national portion configuration, as shown in Fig. 2.

FIGURE 2

Generic national portion configuration



Example 1: the Access portion of the network is 20 km long and it is formed by a single link:

Link $L_1 = 20$ km

Capacity: 2 Mbit/s.

In this case the objectives are length independent; if $C = 0.075$ is assumed (see *recommends* 4) we have:

$$ESR = 0.04\ C = 3 \times 10^{-3} \text{ (equivalent to 7 776 ES/month)}$$

$$SESR = 0.002\ C = 1.5 \times 10^{-4} \text{ (equivalent to 389 SES/month)}$$

$$BBER = 2 \times 10^{-4} \times C = 1.5 \times 10^{-5} \text{ (equivalent to 77 760 EB/month)}$$

EB : errored block.

Example 2: the short haul portion of the network is 80 km long and it is formed by a single link:

Link $L_2 = 80$ km

Capacity: 34 Mbit/s.

In this case the objectives are length independent; if $B = 0.075$ is assumed (see *recommends* 3) we have:

$$ESR = 0.075\ B = 5.625 \times 10^{-3} \text{ (equivalent to 14 580 ES/month)}$$

$$SESR = 0.002\ B = 1.5 \times 10^{-4} \text{ (equivalent to 389 SES/month)}$$

$$BBER = 2 \times 10^{-4} \times B = 1.5 \times 10^{-5} \text{ (equivalent to 311 040 EB/month)}$$

Example 3: real link in long haul portion of the network, designed according to ITU-T Recommendation G.826:

Link $L_3 = 75$ km

SDH transmission rate: synchronous transport module, STM-1 (155.52 Mbit/s):

$$ESR = 0.16\ A = 0.16\ (A_1 + 0.01) \times 75/100$$

$$SESR = 0.002\ A = 0.002\ (A_1 + 0.01) \times 75/100$$

$$BBER = 0.0002\ A = 0.0002\ (A_1 + 0.01) \times 75/100$$

In this case the objectives are length dependent; in Table 4 the minimum and the maximum limits ($A_1 = 0.01$ and $A_1 = 0.02$) are shown:

TABLE 4

Values for the objectives

A_1 value	ESR	SESR	BBER
0.01	36×10^{-5} (= 932 ES/month)	18×10^{-6} (= 47 SES/month)	9×10^{-7} (= 18 662 EB/month)
0.02	66×10^{-5} (= 1 709 ES/month)	33×10^{-6} (= 85 SES/month)	1.65×10^{-6} (= 34 214 EB/month)

NOTE 1 – Rounding to nearest integer has been used for fractional results.

ANNEX 2

Error performance events for different SDH radio-relay link configurations

1 Introduction

In a radio link the link end-points, which are represented by the radio terminal at the two sides of the link, may terminate a path, multiplex section and regenerator section. All configurations are possible according to definition given in ITU-T Recommendation G.783 and Recommendation ITU-R F.750.

The examples below show the relationship between the main practicable configuration for SDH link and the estimation of error performance events (ES, SES BBE). The radio specific performance monitoring in presence of a protection switching is defined in Recommendation ITU-R F.750.

2 Link-end points are path end-points with and without frequency diversity

The B3 or V5 byte, dealing with high order path and low order path respectively, are calculated/evaluated in both link end-points.

Error performance events are defined in ITU-T Recommendation G.829.

3 Link end-points are SDH multiplex section (MS) end-points

3.1 One hop MS without frequency diversity protection

The B2 byte is calculated/evaluated in both link end-points, while the B3 and V5 byte are passed transparently through the link end-points without modification.

Error performance events are defined in ITU-T Recommendation G.829. The comparison of the values of relative error performance parameters, obtained by means of B2 byte according to ITU-T Recommendations G.829 and G.783, with the objectives defined in this Recommendation could be considered as an estimation. The accuracy depends on the number of errors per burst.

3.2 One hop MS with frequency diversity protection

The error performance monitoring functionalities of the protected section, i.e. the section outside the protection switching depends on the allocation of SDH radio protection switching (RPS) function blocks, as described in Recommendation ITU-R F.750.

In case of type C allocation, defined in Recommendation ITU-R F.750, the B1 byte is calculated/evaluated in both link end-points per each channel (i.e. working channels and protecting channel). The B2 is calculated/evaluated in both link end-points outside the protection section, so it gives directly the performance of the protected section. The B3 and V5 byte are passed through the link end-points without modification.

Error performance events are defined in ITU-T Recommendation G.829. The comparison of the values of relative error performance parameters, obtained by means of B2 byte according to ITU-T Recommendations G.829 and G.783, with the objectives defined in this Recommendation could be considered as an estimation. The accuracy depends on the number of errors per burst.

In case of type B allocation, defined in Recommendation ITU-R F.750, the B1 and B2 bytes are calculated/evaluated in both link end-points per each channel (i.e. working channels and protecting channel). The B3 and V5 byte are passed through the link end-points without modification.

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 by means of not intrusive monitoring of B3 bytes and to let management system provide the difference;

– the second one is to send forward, through a media dependent byte of the regenerator section overhead passed transparently through any intermediate repeater acting as MS, the bit interleaved parity, BIP-8 equivalent information of input EB towards the far end terminal. The far-end terminal may evaluate the difference with the output quality and directly providing management system with the actual quality of the protected radio section.

This methodology of MS tandem connections monitoring, is in principle similar to the high order tandem connections monitoring defined by ITU-T Recommendations G.707 and G.783, but no parity recovery algorithm, as that of N1 byte of VC-4 path overhead, is required. More details on performance monitoring of radio implementing a protection switch can be found in Recommendation ITU-R F.750.

4 Link end-points are SDH regenerator section (RS) end-points

4.1 One hop RS without frequency diversity protection

The B1 byte is calculated/evaluated in both link end-points, while the B2, B3 and V5 byte are passed through the link end-points without modification.

Error performance events are defined in ITU-T Recommendation G.829.

4.2 RS with frequency diversity protection switching

The error performance monitoring functionalities of the protected section, i.e. the section outside the protection switching depends on the allocation of SDH RPS function blocks, as described in Recommendation ITU-R F.750.

The B1 byte is calculated/evaluated in both link end-points per each channel (i.e. working channels and protecting channel), while the B2, B3 and V5 bytes are passed through the link end-points without modification.

The error performance monitoring should be performed using the same methodologies described in § 3.2 based on not intrusive monitoring of B2 byte or by means of an RS tandem connection monitoring methodology.

Error performance events are defined in ITU-T Recommendation G.829. The compatibility with this Recommendation of the values of relative error performance parameters, obtained by means of one of the two previous methods according to Recommendation ITU-R F.750, need further investigations.

4.3 Multihop RS without frequency diversity protection

The B1 byte is calculated/evaluated in both link end-points per each channel (i.e. working channels and protecting channel), while the B2, B3 and V5 bytes are passed through the link end-points without modification.

Error performance events are defined in ITU-T Recommendation G.829. The quality of the whole link may be evaluated using the same methodologies described in § 3.2.

5 Link end-points are combinations from the previous ones

The evaluation of error performance events is possible only for the relevant section terminated in both link end-points.