RECOMMENDATION ITU-R F.1668-1

Error performance objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections

(Question ITU-R 210/9)

(2004-2007)

Scope

This Recommendation provides updated information on error-performance objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections. It is the only Recommendation defining error-performance objectives for all real digital fixed wireless links. Performance events and objectives for connections using equipment designed prior to approval of ITU-T Recommendation G.826 in December 2002 are given in ITU-T Recommendation G.821 and Recommendations ITU-R F.634, ITU-R F.696 and ITU-R F.697. Recommendations ITU-R F.1397 and ITU-R F.1491 are superseded by this Recommendation. Example of a connection, path, link and hop are given in Annex 1. Definitions of the error performance events, derived from ITU-T Recommendations G.826 and G.828, are given in Annex 2. Examples of calculations of the error performance parameters are given in Annex 3.

The ITU Radiocommunication Assembly,

considering

a) that ITU-T has specified the error performance parameters and objectives for international constant bit rate (CBR) digital paths and connections in ITU-T Recommendation G.826[1], and for international CBR synchronous digital paths in ITU-T Recommendation G.828[2];

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

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

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[1] It is not required to apply this Recommendation to connections which operate below the primary rate using equipment designed prior to the approval (December 2002) of ITU-T Recommendation G.826 – End-to-end error performance parameters and objectives for international constant bit rate digital paths and connections.

[2] ITU-T Recommendation G.826 deals with performance of PDH paths and of those SDH paths using equipment designed prior to the approval of ITU-T Recommendation G.828 in March 2000. ITU-T Recommendation G.828 deals with performance of SDH paths using equipment designed as of or after the adoption of ITU-T Recommendation G.828 in March 2000.

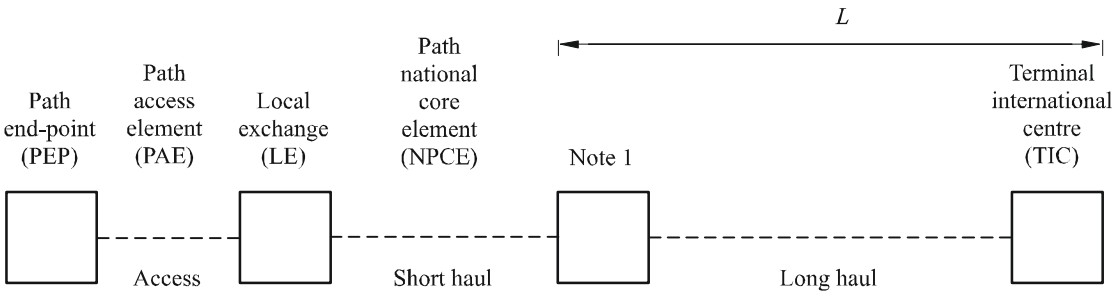
e) that for the purpose of this Recommendation, the national portion of a 27 500 km hypothetical reference path (HRPs) or hypothetical reference connection (HRCs) can be subdivided into three basic sections (see Fig. 1),

recommends

1 that the error performance objectives (EPOs) applicable to each direction of any real fixed wireless link of length L_{link} used in the international portions of a 27 500 km HRP and HRC can be derived by means of equation (1) and using the values in Tables 1a and 1b for SDH systems designed according to ITU-T Recommendation G.828 and values in Tables 2a and 2b for systems designed according to ITU-T Recommendation G.826.

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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The lower limit of L_{link} used to scale the objectives to the real case is $L_{min} = 50$ km.

$$EPO = B_j \times (L_{link} \,/\, L_R) + C_j \qquad (1)$$

where:

$j = 1$	for $L_{min} \le L_{link} \le 1\,000$ km	for intermediate country
$j = 2$	for $1\,000 \text{ km} < L_{link}$	for intermediate country
$j = 3$	for $L_{min} \le L_{link} \le 500$ km	for terminating country
$j = 4$	for $500 \text{ km} < L_{link}$	for terminating country.

EPO is substituted by the parameters errored second ratio (ESR), severely errored second ratio (SESR) and background block error ratio[3] (BBER) as appropriate.

L_R is the reference length, $L_R = 2\,500$ km

B_R is a block allowance ratio, $B_R = (0 < B_R \leq 1)$;

TABLE 1a

Parameters for the EPO for intermediate countries according to ITU-T Recommendation G.828

Parameter	Bit rate (kbit/s)	$L_{min} \leq L_{link} \leq 1\,000$ km		1 000 km < L_{link}	
		B1	C1	B2	C2
ESR	1 664	$5 \times 10^{-4} (1 + B_R)$	0	5×10^{-4}	$2 \times 10^{-4} \times B_R$
ESR	2 240	$5 \times 10^{-4} (1 + B_R)$	0	5×10^{-4}	$2 \times 10^{-4} \times B_R$
ESR	6 848	$5 \times 10^{-4} (1 + B_R)$	0	5×10^{-4}	$2 \times 10^{-4} \times B_R$
ESR	48 960	$1 \times 10^{-3} (1 + B_R)$	0	1×10^{-3}	$4 \times 10^{-4} \times B_R$
ESR	150 336	$2 \times 10^{-3} (1 + B_R)$	0	2×10^{-3}	$8 \times 10^{-4} \times B_R$
SESR	1 664-150 336	$1 \times 10^{-4} (1 + B_R)$	0	1×10^{-4}	$4 \times 10^{-5} \times B_R$
BBER	1 664-48 960	$2.5 \times 10^{-6} (1 + B_R)$	0	2.5×10^{-6}	$1 \times 10^{-6} \times B_R$
BBER	150 336	$5 \times 10^{-6} (1 + B_R)$	0	5×10^{-6}	$2 \times 10^{-6} \times B_R$

TABLE 1b

Parameters for the EPO for terminating countries according to ITU-T Recommendation G.828

Parameter	Bit rate (kbit/s)	$L_{min} \leq L_{link} \leq 500$ km		500 km < L_{link}	
		B3	C3	B4	C4
ESR	1 664	$5 \times 10^{-4} (1 + B_R)$	0	5×10^{-4}	$1 \times 10^{-4} \times B_R$
ESR	2 240	$5 \times 10^{-4} (1 + B_R)$	0	5×10^{-4}	$1 \times 10^{-4} \times B_R$
ESR	6 848	$5 \times 10^{-4} (1 + B_R)$	0	5×10^{-4}	$1 \times 10^{-4} \times B_R$
ESR	48 960	$1 \times 10^{-3} (1 + B_R)$	0	1×10^{-3}	$2 \times 10^{-4} \times B_R$
ESR	150 336	$2 \times 10^{-3} (1 + B_R)$	0	2×10^{-3}	$4 \times 10^{-4} \times B_R$
SESR	1 664-150 336	$1 \times 10^{-4} (1 + B_R)$	0	1×10^{-4}	$2 \times 10^{-5} \times B_R$
BBER	1 664-48 960	$2.5 \times 10^{-6} (1 + B_R)$	0	2.5×10^{-6}	$5 \times 10^{-7} \times B_R$
BBER	150 336	$5 \times 10^{-6} (1 + B_R)$	0	5×10^{-6}	$1 \times 10^{-6} \times B_R$

[3] BBER parameter is applicable only to paths.

TABLE 2a

Parameters for the EPO for intermediate countries according to ITU-T Recommendation G.826

Parameter	Bit rate (Mbit/s)	$L_{min} \leq L_{link} \leq 1\,000$ km		$1\,000$ km $< L_{link}$	
		B1	C1	B2	C2
ESR	<primary rate	$2 \times 10^{-3} (1 + B_R)$	0	2×10^{-3}	$8 \times 10^{-4} \times B_R$
ESR	1.5-5	$2 \times 10^{-3} (1 + B_R)$	0	2×10^{-3}	$8 \times 10^{-4} \times B_R$
ESR	>5-15	$2.5 \times 10^{-3} (1 + B_R)$	0	2.5×10^{-3}	$1 \times 10^{-3} \times B_R$
ESR	>15-55	$3.75 \times 10^{-3} (1 + B_R)$	0	3.75×10^{-3}	$1.5 \times 10^{-3} \times B_R$
ESR	>55-160	$8 \times 10^{-3} (1 + B_R)$	0	8×10^{-3}	$3.2 \times 10^{-3} \times B_R$
ESR	>160-400	Not applicable	Not applicable	Not applicable	Not applicable
SESR	≤400	$1 \times 10^{-4} (1 + B_R)$	0	1×10^{-4}	$4 \times 10^{-5} \times B_R$
BBER	1.5-400	$1 \times 10^{-5} (1 + B_R)$	0	1×10^{-5}	$4 \times 10^{-6} \times B_R$

TABLE 2b

Parameters for the EPO for terminating countries according to ITU-T Recommendation G.826

Parameter	Bit rate (Mbit/s)	$L_{min} \leq L_{link} \leq 500$ km		500 km $< L_{link}$	
		B3	C3	B4	C4
ESR	<primary rate	$2 \times 10^{-3} (1 + B_R)$	0	2×10^{-3}	$4 \times 10^{-4} \times B_R$
ESR	1.5-5	$2 \times 10^{-3} (1 + B_R)$	0	2×10^{-3}	$4 \times 10^{-4} \times B_R$
ESR	>5-15	$2.5 \times 10^{-3} (1 + B_R)$	0	2.5×10^{-3}	$5 \times 10^{-4} \times B_R$
ESR	>15-55	$3.75 \times 10^{-3} (1 + B_R)$	0	3.75×10^{-3}	$7.5 \times 10^{-4} \times B_R$
ESR	>55-160	$8 \times 10^{-3} (1 + B_R)$	0	8×10^{-3}	$1.6 \times 10^{-3} \times B_R$
ESR	>160-400	Not applicable	Not applicable	Not applicable	Not applicable
SESR	≤400	$1 \times 10^{-4} (1 + B_R)$	0	1×10^{-4}	$2 \times 10^{-5} \times B_R$
BBER	1.5-400	$1 \times 10^{-5} (1 + B_R)$	0	1×10^{-5}	$2 \times 10^{-6} \times B_R$

2 that the EPOs for the access and short haul sections should make use only of the block allocation contribution specified in ITU-T Recommendations G.826 and G.828 for the national portion of a 27 500 km HRP and HRC, and that the long haul section should make use of the distance-based allocation and part of the fixed block allowance allocation;

3 that for the EPOs applicable to each direction of any real fixed wireless link of length L_{link} belonging to the long haul inter-exchange network sections of the national portion of HRP and HRC the values 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. The lower limit of L_{link}, used to scale the objectives to the real case, is L_{min} = 50 km.

TABLE 3a

EPOs for real SDH fixed wireless 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	$5 \times 10^{-5} \times A$				$1 \times 10^{-4} \times A$

TABLE 3b

EPOs for real fixed wireless links belonging to the long haul inter-exchange network section of the national portion of the HRP and HRC according to ITU-T Recommendation G.826

Rate (Mbit/s)	<primary rate	1.5 to 5	>5 to 15	>15 to 55	>55 to 160	>160 to 400
ESR	0.04 A	0.04 A	0.05 A	0.075 A	0.16 A	Not applicable
SESR	0.002 A	0.002 A	0.002 A	0.002 A	0.002 A	0.002 A
BBER[1]	Not applicable	$2 A \times 10^{-4}$	$2 A \times 10^{-4}$	$2 A \times 10^{-4}$	$2 A \times 10^{-4}$	$1 A \times 10^{-4}$

(1) BBER parameter is applicable only to paths.

where:

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

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

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);

4 that for the EPOs applicable to each direction of any real fixed wireless link forming all of the short haul network sections of the national portion of the HRP and HRC the values given in Table 4a for SDH systems designed according to ITU-T Recommendation G.828 and in Table 4b for other systems designed according to ITU-T Recommendation G.826 should apply.

TABLE 4a

EPOs for SDH fixed wireless links forming all of the short haul inter-exchange network section of the national portion of the HRP and HRC 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 4b

EPOs for fixed wireless links forming all of the short haul inter-exchange network section of the national portion of the HRP and HRC according to ITU-T Recommendation G.826

Rate (Mbit/s)	<primary rate	1.5 to 5	>5 to 15	>15 to 55	>55 to 160	>160 to 400
ESR	0.04 *B*	0.04 *B*	0.05 *B*	0.075 *B*	0.16 *B*	Not applicable
SESR	0.002 *B*	0.002 *B*	0.002 *B*	0.002 *B*	0.002 *B*	0.002 *B*
BBER	Not applicable	$2\ B \times 10^{-4}$	$2\ B \times 10^{-4}$	$2\ B \times 10^{-4}$	$2\ B \times 10^{-4}$	$1\ B \times 10^{-4}$

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);

5 that for the EPOs applicable to each direction of any real fixed wireless link forming all of the access network sections of the national portion of the HRP and HRC the values given in Table 5a for SDH systems designed according to ITU-T Recommendation G.828 and in Table 5b for other systems designed according to ITU-T Recommendation G.826 should apply.

TABLE 5a

EPOs for SDH fixed wireless links 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 5b

EPOs for fixed wireless links forming all of the access network section of the national portion of the HRP and HRC according to ITU-T Recommendation G.826 (see Note 6)

Rate (Mbit/s)	<primary rate	1.5 to 5	>5 to 15	>15 to 55	>55 to 160	>160 to 400
ESR	0.04 C	0.04 C	0.05 C	0.075 C	0.16 C	Not applicable
SESR	0.002 C	0.002 C	0.002 C	0.002 C	0.002 C	0.002 C
BBER	Not applicable	$2\ C \times 10^{-4}$	$2\ C \times 10^{-4}$	$2\ C \times 10^{-4}$	$2\ C \times 10^{-4}$	$1\ C \times 10^{-4}$

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);

6 that for the EPOs evaluation in *recommends* 1 to 5 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.

NOTE 1 – The EPOs 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 Recommendations G.826 and G.828.

NOTE 2 – The objectives given in this Recommendation are understood to be long-term objectives to be met over an evaluation period of a month, which is understood to be any period of 28 to 31 (typically 30) consecutive 24 h intervals. These objectives should be respected for any month (see Recommendation ITU-R P.581). To be able to compare measurement results taken by different parties on the same path, start time and duration of the performance evaluation period need to be agreed between the parties concerned.

NOTE 3 – The sum of the percentages $A_1\% + B\% + C\%$ should not exceed 17.5%, in accordance with the allocations to the national portion of an international CBR path or connection 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 – A real link is defined as a portion of a path or connection coming from partitioning and it is characterized by its real length L_{link}.

NOTE 7 – 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 4a, 4b, 5a and 5b as a block allowance to the elements forming the short haul or access network section.

NOTE 8 – In the case of multi-hop links the objectives derived according to this Recommendation apply to the overall links (irrespective of the date when each hop was brought into service and of the number of independent operators involved); the allocation of the objectives to each hop is under the responsibility of the network operators.

NOTE 9 – 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 and connections are defined in Annex A of ITU-T Recommendation G.826.

NOTE 10 – The effect of interference and all other sources of performance degradations are included in Tables 1-5.

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

NOTE 12 – Annexes 1, 2 and 3 may be used for additional guidance in the application of this Recommendation.

Annex 1

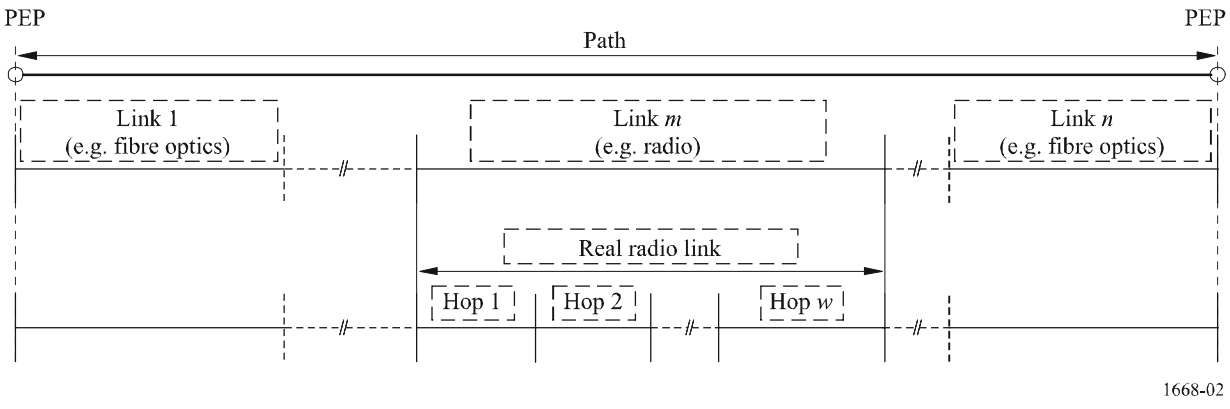
Example of a connection, path, link, hop

This Annex clarifies the meaning of some terms related to the connection, used in the body of the Recommendation.

The definitions of path and connection are given in ITU-T Recommendation G.826; an example of a fixed wireless link forming a portion of a path is given in Fig. 2.

FIGURE 2

Example of a portion of path



Annex 2

Error performance events for different SDH fixed wireless link configurations

1 Introduction

In a fixed wireless link the link end-points, which are represented by the fixed wireless terminal at the two sides of the link, may terminate a path, multiplex section and regenerator section. All configurations are possible according to the definition given in ITU-T Recommendation G.783 and Recommendation ITU-R F.750. The examples in this Annex show the relationship between the main practicable configuration for SDH link and the estimation of error performance events (ES, SES and BBE). The fixed wireless specific performance monitoring in the 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 end-points

3.1 One hop multiplex section 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 multiplex section 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 fixed wireless 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 fixed wireless protected section quality:

– the first one is to evaluate separately the quality of the synchronous transport module of order (STM-*N*) signal at the input and at the output from the protected radio fixed wireless section by means of not intrusive monitoring of B3 bytes and to let the/a 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 the/a management system with the actual quality of the protected fixed wireless section.

This methodology of multiplex section 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 fixed wireless 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 Multi-hop 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.

Annex 3

Examples of calculations of the error performance parameters ESR, SESR and BBER

This Annex shows some examples of the application of this Recommendation to real links, in order to derive the objectives.

I International portion

An intermediate country is assumed.

A link length, L_{link}, = 105 km.

B_R is assumed to be equal to 1.

The evaluation time is one month (30 days).

Example 1:

Bit rate: 150 336 kbit/s (VC-4, TC-4), i.e. objectives according to ITU-T Recommendation G.828.

The objectives are calculated from equation (1) and with B1 and C1 from Table 1a.

$ESR = 2 \times 10^{-3} (1 + 1) \times 105/2\,500 + 0 = 168 \times 10^{-6}$ Number of ES/month = 435

$SESR = 1 \times 10^{-4} (1 + 1) \times 105/2\,500 + 0 = 84 \times 10^{-7}$ Number of SES/month = 22

$BBER = 5 \times 10^{-6} (1 + 1) \times 105/2\,500 + 0 = 4.2 \times 10^{-7}$ Number of BBE/month = 8 709

Example 2:

Bit rate: 140 Mbit/s, i.e. objectives according to ITU-T Recommendation G.826.

The objectives are calculated from equation (1) and with B1 and C1 from Table 2a.

$ESR = 8 \times 10^{-3} (1 + 1) \times 105/2\,500 + 0 = 672 \times 10^{-6}$ Number of ES/month = 1 741

$SESR = 1 \times 110^{-4} (1 + 1) \times 105/2\,500 + 0 = 84 \times 10^{-7}$ Number of SES/month = 22

$BBER = 1 \times 10^{-5} (1 + 1) \times 105/2\,500 + 0 = 8.4 \times 10^{-7}$ Number of BBE/month = 17 418

Example 3:

Bit rate: 64 kbit/s, i.e. objectives according to ITU-T Recommendation G.826.

The objectives are calculated from equation (1) and with B1 and C1 from Table 2a.

ESR = 2×10^{-3} (1 + 1) × 105/2 500 + 0 = 168×10^{-6} Number of ES/month = 436

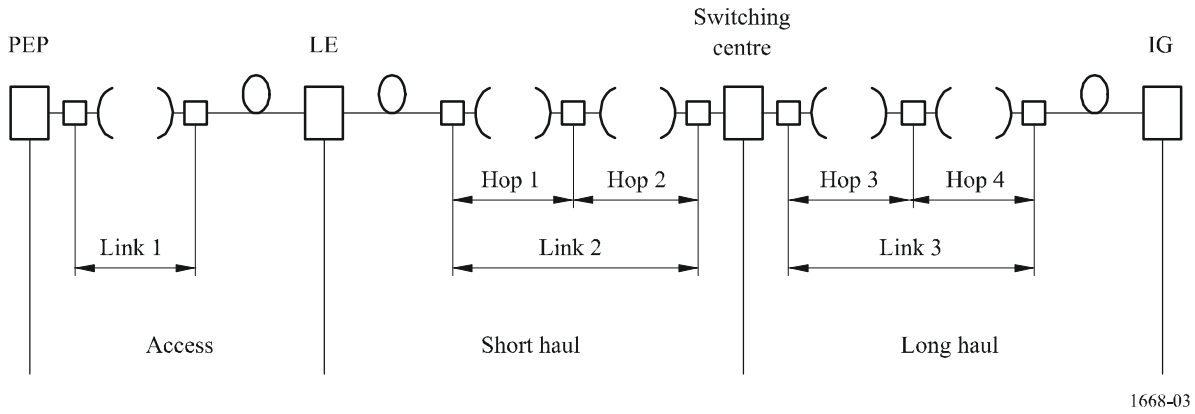
SESR = 1×10^{-4} (1 + 1) × 105/2 500 + 0 = 84×10^{-7} Number of SES/month = 22

II National portion

The examples of calculation below refer to a generic national portion configuration, as shown in Fig. 3.

FIGURE 3

Generic national portion configuration



Example 4: 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* 5) we have:

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

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

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

Example 5: 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* 4) 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 6: real link in the long haul portion of the network, using equipment designed according to ITU-T Recommendation G.826, prior to the adoption of ITU-T Recommendation G.828 in March 2000 (see *recommends* 3):

Link $L_3 = 75$ km

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

$$ESR = 0.16\ A = 0.16\ (A_1 + 0.002) \times 75/100$$

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

$$BBER = 0.0002\ A = 0.0002\ (A_1 + 0.002) \times 75/100$$

In this case the objectives are length dependent; in Table 6 the minimum and the maximum limits ($A_1 = 0.01$ and $A_1 = 0.02$) are shown:

TABLE 6

Values for the objectives

A_1 value	ESR	SESR	BBER
0.01	144×10^{-5} (= 3 733 ES/month)	18×10^{-6} (= 47 SES/month)	18×10^{-7} (= 37 324 EB/month)
0.02	264×10^{-5} (= 6 843 ES/month)	33×10^{-6} (= 86 SES/month)	33×10^{-7} (= 68 429 EB/month)

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

Example 7: real link in the long haul portion of the network, using equipment designed after the adoption of ITU-T Recommendation G.828 in March 2000 (see *recommends* 3):

Link $L_3 = 75$ km

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

$$ESR = 0.04\ A = 0.04\ (A_1 + 0.002) \times 75/100$$

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

$$BBER = 0.0001\ A = 0.0001\ (A_1 + 0.002) \times 75/100$$

In this case the objectives are length dependent; in Table 7 the minimum and the maximum limits ($A_1 = 0.01$ and $A_1 = 0.02$) are shown:

TABLE 7

Values for the objectives

A_1 value	ESR	SESR	BBER
0.01	36×10^{-5} (= 933 ES/month)	18×10^{-6} (= 47 SES/month)	9×10^{-7} (= 18 662 EB/month)
0.02	66×10^{-5} (= 1 711 ES/month)	33×10^{-6} (= 86 SES/month)	165×10^{-8} (= 34 214 EB/month)

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

Example 8: the connection consists of the access portion of the network formed by a single link L_1 with length 10 km and the short haul portion of the network formed by a single link L_2 with length 100 km

Overall link length = $L_1 + L_2 = 110$ km

Capacity: 64 kbit/s.

In this case the objectives are length independent; if $B + C = 0.16$ is assumed (see *recommends* 4 and 5 and Note 4) we have:

$$ESR = 0.04\ (B + C) = 6.4 \times 10^{-3}$$ (equivalent to 16 589 ES/month)

$$SESR = 0.002\ (B + C) = 3.2 \times 10^{-4}$$ (equivalent to 830 SES/month).