

## RECOMMENDATION ITU-R F.1397-1

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

(Question ITU-R 210/9)

(1999-2001)

The ITU Radiocommunication Assembly,

*considering*

- a) that the ITU-T has specified the error performance parameters and objectives for international constant bit rate digital paths at or above the primary rate in ITU-T Recommendation G.826, and for international constant bit rate synchronous digital paths in ITU-T Recommendation G.828;
- b) that the 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.1491 provides the 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;
- 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,

*recommends*

**1** that for the error performance objectives (EPOs) applicable to each direction of any real radio link of length  $L_{link}$  can be derived by means of equation (1) and using the values in Tables 1a and 1b for SDH system design according to ITU-T Recommendation G.828 and values in Tables 2a and 2b for system design according to ITU-T Recommendation G.826.

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

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

where:

- |         |  |                          |
|---------|--|--------------------------|
| $j = 1$ | for $L_{min} \leq L_{link} \leq 1\,000$ km | for intermediate country |
| $j = 2$ | for $1\,000$ km $< L_{link}$               | for intermediate country |
| $j = 3$ | for $L_{min} \leq L_{link} \leq 500$ km    | for terminating country  |
| $j = 4$ | for $500$ 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 (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	$5 \times 10^{-4}$	$2 \times 10^{-4} \times B_R$
ESR	2 240	$5 \times 10^{-4} (1 + B_R)$	0	$5 \times 10^{-4}$	$2 \times 10^{-4} \times B_R$
ESR	6 848	$5 \times 10^{-4} (1 + B_R)$	0	$5 \times 10^{-4}$	$2 \times 10^{-4} \times B_R$
ESR	48 960	$1 \times 10^{-3} (1 + B_R)$	0	$1 \times 10^{-3}$	$4 \times 10^{-4} \times B_R$
ESR	150 336	$2 \times 10^{-3} (1 + B_R)$	0	$2 \times 10^{-3}$	$8 \times 10^{-4} \times B_R$
SESR	1 664-150 336	$1 \times 10^{-4} (1 + B_R)$	0	$1 \times 10^{-4}$	$4 \times 10^{-5} \times B_R$
BBER	1 664-48 960	$2.5 \times 10^{-6} (1 + B_R)$	0	$2.5 \times 10^{-6}$	$1 \times 10^{-6} \times B_R$
BBER	150 336	$5 \times 10^{-6} (1 + B_R)$	0	$5 \times 10^{-6}$	$2 \times 10^{-6} \times B_R$

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	$5 \times 10^{-4}$	$1 \times 10^{-4} \times B_R$
ESR	2 240	$5 \times 10^{-4} (1 + B_R)$	0	$5 \times 10^{-4}$	$1 \times 10^{-4} \times B_R$
ESR	6 848	$5 \times 10^{-4} (1 + B_R)$	0	$5 \times 10^{-4}$	$1 \times 10^{-4} \times B_R$
ESR	48 960	$1 \times 10^{-3} (1 + B_R)$	0	$1 \times 10^{-3}$	$2 \times 10^{-4} \times B_R$
ESR	150 336	$2 \times 10^{-3} (1 + B_R)$	0	$2 \times 10^{-3}$	$4 \times 10^{-4} \times B_R$
SESR	1 664-150 336	$1 \times 10^{-4} (1 + B_R)$	0	$1 \times 10^{-4}$	$2 \times 10^{-5} \times B_R$
BBER	1 664-48 960	$2.5 \times 10^{-6} (1 + B_R)$	0	$2.5 \times 10^{-6}$	$5 \times 10^{-7} \times B_R$
BBER	150 336	$5 \times 10^{-6} (1 + B_R)$	0	$5 \times 10^{-6}$	$1 \times 10^{-6} \times B_R$

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	1.5-5	$2 \times 10^{-3} (1 + B_R)$	0	$2 \times 10^{-3}$	$8 \times 10^{-4} \times B_R$
ESR	>5-15	$2.5 \times 10^{-3} (1 + B_R)$	0	$2.5 \times 10^{-3}$	$1 \times 10^{-3} \times B_R$
ESR	>15-55	$3.75 \times 10^{-3} (1 + B_R)$	0	$3.75 \times 10^{-3}$	$1.5 \times 10^{-3} \times B_R$
ESR	>55-160	$8 \times 10^{-3} (1 + B_R)$	0	$8 \times 10^{-3}$	$3.2 \times 10^{-3} \times B_R$
ESR	>160-3 500	See Note 6	See Note 6	See Note 6	See Note 6
SESR	1.5-3 500	$1 \times 10^{-4} (1 + B_R)$	0	$1 \times 10^{-4}$	$4 \times 10^{-5} \times B_R$
BBER	1.5-3 500	$1 \times 10^{-5} (1 + B_R)$	0	$1 \times 10^{-5}$	$4 \times 10^{-6} \times B_R$

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	1.5-5	$2 \times 10^{-3} (1 + B_R)$	0	$2 \times 10^{-3}$	$4 \times 10^{-4} \times B_R$
ESR	>5-15	$2.5 \times 10^{-3} (1 + B_R)$	0	$2.5 \times 10^{-3}$	$5 \times 10^{-4} \times B_R$
ESR	>15-55	$3.75 \times 10^{-3} (1 + B_R)$	0	$3.75 \times 10^{-3}$	$7.5 \times 10^{-4} \times B_R$
ESR	>55-160	$8 \times 10^{-3} (1 + B_R)$	0	$8 \times 10^{-3}$	$1.6 \times 10^{-3} \times B_R$
ESR	>160-3 500	See Note 6	See Note 6	See Note 6	See Note 6
SESR	1.5-3 500	$1 \times 10^{-4} (1 + B_R)$	0	$1 \times 10^{-4}$	$2 \times 10^{-5} \times B_R$
BBER	1.5-3 500	$1 \times 10^{-5} (1 + B_R)$	0	$1 \times 10^{-5}$	$2 \times 10^{-6} \times B_R$

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

- ESR is the ratio of ES events to total seconds in the available time during a fixed measurement interval;
- SESR is the ratio of SES events to total seconds in the available time during a fixed measurement interval;
- BBER is the ratio of BBE events to total blocks in the available time during a fixed measurement interval. The count of total blocks excludes all blocks during SES.

In Annex 1 some examples of application of the proposed method are shown.

In Annex 2 an example of real path, links and hops is shown.

In Annex 3 an example of the relationship between bit error ratio (BER) and errored blocks (EBs) is shown.

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

NOTE 2 – A real link is defined as a portion of a path coming from partitioning and it is characterized by its real length  $L_{link}$ .

NOTE 3 – The effects of interference and all other sources of performance degradations are included in the values in Tables 1a and 1b.

NOTE 4 – 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 the relevant Recommendation (see ITU-T Recommendation G.826).

NOTE 5 – According to ITU-T Recommendations G.826 and G.828 the suggested evaluation period is one month for any parameter. In radio-relay links these objectives should be respected for any month (see Recommendation ITU-R P.581).

NOTE 6 – The ESR objective for higher bit rate paths is still under study.

NOTE 7 – The link fails to meet the error performance requirement if any of the objectives is not met.

NOTE 8 – In the context of this Recommendation, the link consists in section(s) and/or path(s).

NOTE 9 – In the case of multihop 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 10 – Annexes 1, 2 and 3 may be used for additional guidance in the application of this Recommendation.

## ANNEX 1

### **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.

The calculations are made for ESR, SESR and BBER for a link length,  $L_{link}$ , of 105 km.

Furthermore:

An intermediate country is assumed.

$B_R$  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
$SESR = 1 \times 10^{-4} (1 + 1) \times 105/2\,500 + 0 = 84 \times 10^{-7}$	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

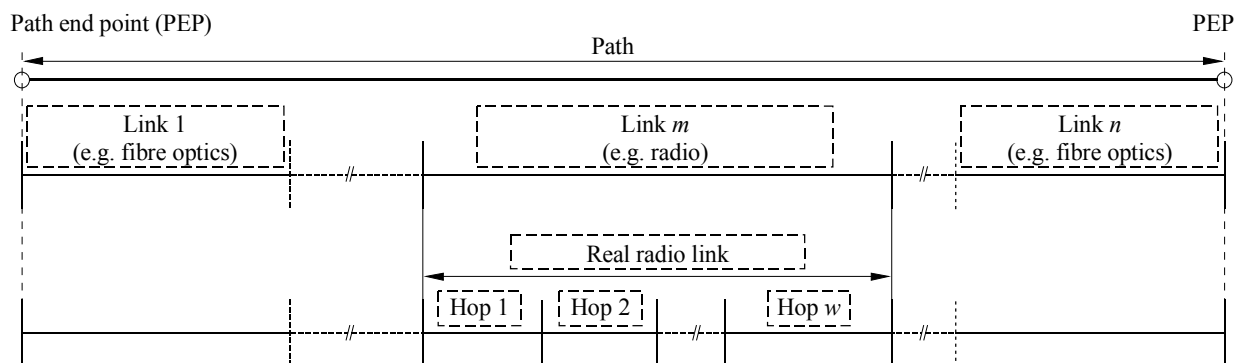
## ANNEX 2

### Example of a path, link, hop

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

The definition of path is given in ITU-T Recommendation G.826; an example of a radio link forming a portion of a path is given in Fig. 1.

FIGURE 1  
Example of a portion of path



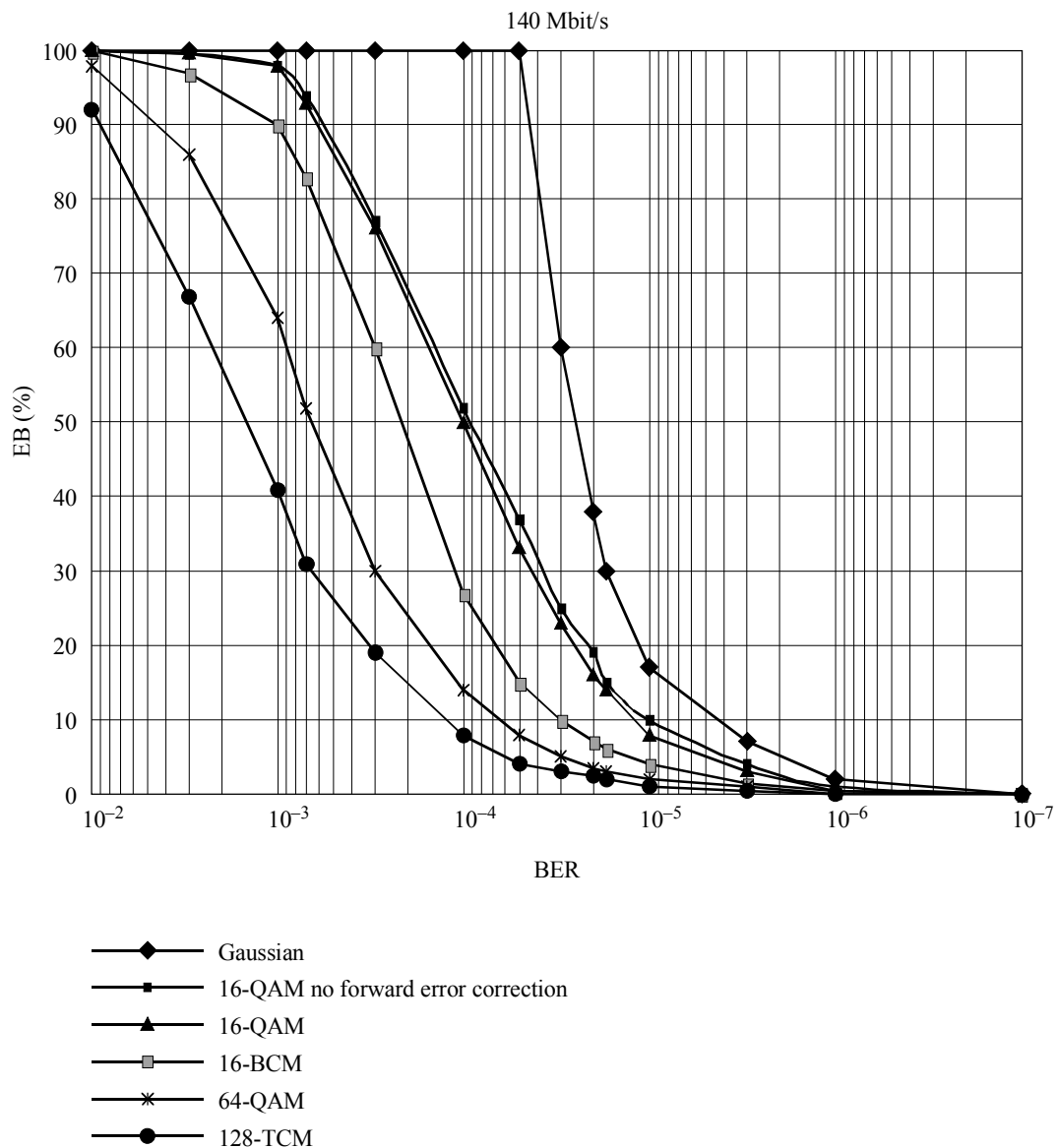
## ANNEX 3

**Relationship between BER and EB**

In order to find the relationship between BER (ITU-T Recommendation G.821) and the percentage of EB (ITU-T Recommendation G.826), some measurements have been carried out on several digital radio-relay systems, with different modulation codes.

The results, obtained in the laboratory by setting the BER value by means of a variable attenuator on a simulated hop are reported in Fig. 2, showing on the horizontal axis the BER and on the vertical axis the percentage of EB.

FIGURE 2  
Relationship between BER and EB



BCM: block code modulation.

Figure 2 gives the percentage of EB related to each BER value for each system, in particular it is possible to read which value of BER corresponds to the ITU-T Recommendation G.826 SES threshold (30% EB).

As far as the SES parameter is concerned, the design of radio links according to this Recommendation (and according to ITU-T Recommendation G.826) could be made by following the usual methods adopted up to now, provided that the value of BER corresponding to 30% EB is used instead of the  $1 \times 10^{-3}$  BER value that was used for design of links according to ITU-T Recommendation G.821.

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