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DIGITAL NETWORKS

ERROR PERFORMANCE PARAMETERS AND OBJECTIVES FOR INTERNATIONAL, CONSTANT BIT RATE DIGITAL PATHS AT OR ABOVE THE PRIMARY RATE

ITU-T Recommendation G.826

(Previously "CCITT Recommendation")

FOREWORD

The ITU-T Telecommunication Standardization Sector is a permanent organ of the International Telecommunication Union (ITU). The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation G.826 was prepared by the ITU-T Study Group 13 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 26th of November 1993.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Recommendation G.826

ERROR PERFORMANCE PARAMETERS AND OBJECTIVES FOR INTERNATIONAL, CONSTANT BIT RATE DIGITAL PATHS AT OR ABOVE THE PRIMARY RATE

(Geneva, 1993)

1 List of Acronyms

The following abbreviations are used in this Recommendation:

AAL	ATM Adaptation Layer
AIS	Alarm Indication Signal
ATM	Asynchronous Transfer Mode
B-ISDN	Broadband ISDN
BBE	Background Block Error
BBER	Background Block Error Ratio
BIP	Bit Interleaved Parity
CBR	Constant Bit Rate
CEC	Cell Error Control
CRC	Cyclic Redundancy Check
EB	Errored Block
EDC	Error Detection Code
ES	Errored Second
ESR	Errored Second Ratio
FAS	Frame Alignment Signal
FEBE	Far End Block Error
FERF	Far End Receive Failure
HEC	Header Error Check
HRP	Hypothetical Reference Path
IG	International Gateway
ISDN	Integrated Services Digital Network
ISM	In-Service Monitoring
LOF	Loss of Frame Alignment
LOS	Loss of Signal
MBS	Monitoring Block Size
OAM	Operation and Maintenance
PDH	Plesiochronous Digital Hierarchy
PEP	Path End Point
RAI	Remote Alarm Indication
SDH	Synchronous Digital Hierarchy
SDP	Severely Disturbed Period
SES	Severely Errored Second
SESR	Severely Errored Second Ratio
STM	Synchronous Transport Module
TP	Transmission Path
VC-n	Virtual Container-n

2 Scope

2.1 Application of the Recommendation

Recommendation G.826 is applicable to international, constant bit rate digital paths[1)] at or above the primary rate. These paths may be based on a Plesiochronous Digital Hierarchy (PDH), Synchronous Digital Hierarchy (SDH) or some other transport network such as cell-based. The Recommendation is generic in that it defines the parameters and objectives for paths independent of the physical transport network providing the paths. Compliance with the performance specification of this Recommendation will, in most cases, also ensure that a 64 kbit/s path will meet the requirements laid out in Recommendation G.821. Therefore, G.826 is the only Recommendation required for designing the error performance of transport networks at or above the primary rate. The performance parameters and definitions applied to paths provided using the ATM layer and the AAL for CBR services (Class A, Recommendation I.362) are for further study.

Since the performance objectives are intended to satisfy the needs of the future digital network, it must be recognized that such objectives cannot be readily achieved by all of today's digital equipment and systems. The intent, however, is to encourage equipment design such that digital paths will satisfy the objectives in this Recommendation.

Paths are used to support services such as circuit switched, packet switched and leased line services. The quality of such services, as well as the performance of the network elements belonging to the service layer, is outside of the scope of this Recommendation.

The performance objectives are applicable to each direction of the path. The values apply end-to-end over a 27 500 km Hypothetical Reference Path (HRP) (see Figure 3) which may include optical fibre, digital radio relay, metallic cable and satellite transmission systems. The performance of multiplex and cross-connect functions employing ATM techniques is not included in these values.

The parameter definitions are block-based, making in-service measurement convenient. In some cases, the network fabric is not able to provide the basic events necessary to directly obtain the performance parameters. In these cases, compliance with this Recommendation can be assessed using out-of-service measurements or estimated by measures compatible with this Recommendation, such as those specified in Annexes B, C and D.

2.2 Transport Network Layers

This Recommendation specifies the error performance of paths in a given transport network layer. Two cases have to be considered:

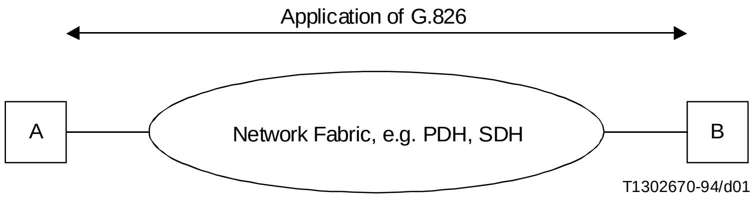
2.2.1 PDH and SDH Transport Networks

Figure 1 gives the intended scope where ATM does not form part of the end-to-end path. lt should be noted that end-to-end performance monitoring is only possible if the monitored blocks together with the accompanying overhead are transmitted transparently to the path end points (PEPs).

2.2.2 ATM Connections

Where the path forms the physical part of an ATM connection (see Figure 2), the overall end-to-end performance of the ATM connection is defined by Recommendation I.356. In this case, this Recommendation can be applied with an appropriate allocation to the performance between the path end points where the physical layer of the ATM protocol reference model (see Recommendation I.321) is terminated by ATM cross-connects or switches. ATM transmission paths in the physical layer correspond to a stream of cells mapped either into a cell-based format or into SDH PDH based frame structures.

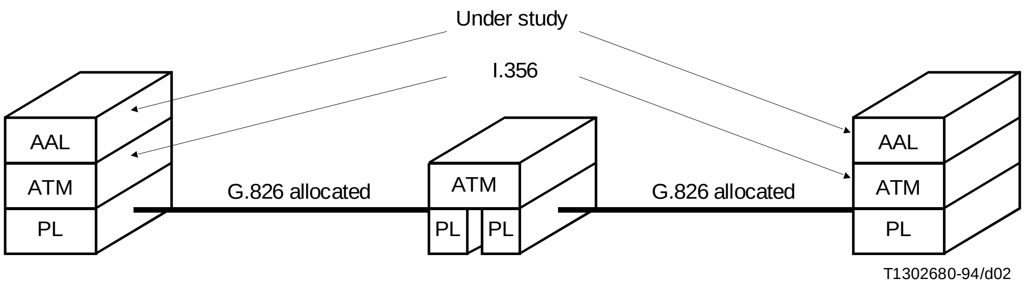
[1)] The term “digital path” is defined in Recommendation M.60.



NOTE – A and B are path end points located at physical interfaces, e.g. in accordance with Recommendation G.703.

FIGURE 1/G.826

Application of Recommendation G.826 for a non-ATM end-to-end transmission path



AAL ATM adaptation layer
ATM ATM layer
PL Physical layer

FIGURE 2/G.826

Architectural relationship between Recommendations G.826 and I.356

2.3 Allocation of End-to-End Performance

Allocations of end-to-end performance of CBR paths are derived using the rules laid out in 5.2 which are length and complexity based. Detailed allocations of this Recommendation performance to the individual components (lines, sections, multiplexers and cross-connects, etc.) are outside the scope of this Recommendation, but when such allocations are performed, the 5.2 national and international allocations should be achieved.

3 The Definition and Measurement of the Block

3.1 Generic Definition of the Block

This Recommendation is based upon the error performance measurement of blocks. This subclause offers a generic definition of the term 'block' as follows:

A block is a set of consecutive bits associated with the path; each bit belongs to one and only one block.

Table 1 specifies the recommended range of the number of bits within each block for the various bit rate ranges. Annexes B, C and D contain information on block sizes of existing system designs.

3.2 In-Service Monitoring of Blocks

Each block is monitored by means of an inherent Error Detection Code (EDC), e.g. Bit Interleaved Parity (BIP) or Cyclic Redundancy Check (CRC). From a monitoring point of view, the EDC is considered to form part of the block even though the bits of the EDC can be physically separated from the block to which they apply. If an error occurs in the EDC, an Errored Block will be counted.

No specific EDC is given in this generic definition but it is recommended that for in-service monitoring purposes, future designs should be equipped with an EDC capability such that the probability of failing to detect an error event is less than 10%. CRC-4 and BIP-8 are examples of EDCs currently used which fulfil this requirement.

Estimation of errored blocks on an in-service basis is dependent upon the network fabric employed and the type of EDC available. Annexes B, C and D offer guidance on how in-service estimates of errored blocks can be obtained from the ISM facilities of the PDH, SDH and cell-based network fabrics respectively.

3.3 Out-of-Service Measurements of Blocks

Out-of-service measurements shall also be block-based. lt is expected that the out-of-service error detection capability will be superior to the in-service capability described in 3.2.

4 Error Performance Events and Parameters

4.1 Definitions

4.1.1 Events

errored block (EB): A block in which one or more bits are in error.

errored second (ES): A one second period with one or more errored blocks. SES defined below is a subset of ES.

severely errored second (SES): A one-second period which contains $\geq$ 30% errored blocks (see Note) or at least one Severely Disturbed Period (SDP).

For out-of-service measurements, an SDP occurs when, over a period of time equivalent to four contiguous blocks or 1 ms, whichever is larger, either all the contiguous blocks are affected by a high bit error density of $\geq 10^{-2}$, or a loss of signal is observed. For in-service monitoring purposes, an SDP is estimated by the occurrence of a network defect. The term defect is defined in the relevant Annexes B, C or D for the different network fabrics PDH, SDH or cell-based respectively.

SDP events may persist for several seconds and may be precursors to periods of unavailability, especially when there are no restoration/protection procedures in use. SDPs persisting for T seconds, where 2 < T < 10 (some Network Operators refer to these events as “failures”), can have a severe impact on service, for example the disconnection of switched services. The only way this Recommendation limits the frequency of these events is through the limit for the SESR.

NOTE – For historical reasons, SESs on some PDH systems are defined with a different percentage of errored blocks (see Annex B).

For maintenance purposes, values different from 30% may be used and these values may vary with transmission rate.

background block error (BBE): An errored block not occurring as part of an SES.

4.1.2 Parameters

Error performance should only be evaluated whilst the path is in the available state. For a definition of the entry/exit criteria for the unavailable state see Annex A.

errored second ratio (ESR): The ratio of ES to total seconds in available time during a fixed measurement interval.

severely errored second ratio (SESR): The ratio of SES to total seconds in available time during a fixed measurement interval.

background block error ratio (BBER): The ratio of errored blocks to total blocks during a fixed measurement interval, excluding all blocks during SES and unavailable time.

4.2 Implications for Error Performance Measuring Devices

There are a large number of devices (test equipments, transmission systems, collecting devices, operating systems, software applications) currently designed to estimate the G.821 parameters % ES and % SES at bit rates up to the fourth level of the PDH. For such devices, the G.826 parameters ESR and SESR may be approximated using the G.821 criteria, but an approximation of BBER is not possible from measurements based on Recommendation G.821. As the block-based concept and the BBER parameter are not defined in Recommendation G.821, converting those devices to measure the G.826 parameters is not required.

Maintenance on specific systems and transport paths may require other parameters. Parameters and values can be found in the M-series Recommendations.

4.3 Performance Monitoring at the Near-End and Far-End of a Path

By monitoring SES events for both directions at a single path end point, a network provider is able to determine the unavailable state of the path (see Annex A). In some cases, it is also possible to monitor the full set of error performance parameters in both directions from one end of the path. Specific in-service indicators for deriving far end performance of a path are listed in Annexes B, C and D.

5 Error Performance Objectives

5.1 End-to-End Objectives

Table 1 specifies the end-to-end objectives for a 27 500 km HRP in terms of the parameters defined in 4.1. An international digital path at or above the primary rate shall meet its allocated objectives for all parameters concurrently. The path fails to meet the error performance requirement if any of these objectives is not met. The suggested evaluation period is 1 month.

lt is noted that SES events may occur in clusters, not always as isolated events. A sequence of ‘n’ contiguous SES may have a very different impact on performance from ‘n’ isolated SES events.

Digital paths operating at bit rates covered by this Recommendation are carried by transmission systems (digital sections) operating at equal or higher bit rates. Such systems must meet their allocations of the end-to-end objectives for the highest bit rate paths which are foreseen to be carried. Meeting the allocated objectives for this highest bit rate path should be sufficient to ensure that all paths through the system are achieving their objective. For example, in SDH, an STM-1 section may carry a VC-4 path and therefore the STM-1 section should be designed such that it will ensure that the objectives as specified in this Recommendation for the bit rate corresponding to a VC-4 path are met.

NOTE – Objectives are allocated in this Recommendation to the national and international portions of a path. In the above example, if the STM-1 section does not form a complete national or international portion, the corresponding national/international allocation must be sub-divided to determine the appropriate allocation for the digital section. This is outside the scope of this Recommendation.

5.2 Apportionment of End-to-End Objectives

The following apportionment methodology specifies the levels of performance expected from the national and international portions of an HRP. Further sub-division of these objectives is beyond the scope of this Recommendation. (See Figure 3.)

TABLE 1/G.826

End-to-end error performance objectives for a 27 500 km international digital HRP at or above the primary rate

Rate Mbit/s	1.5 to 5	> 5 to 15	> 15 to 55	> 55 to 160	> 160 to 3500	> 3500
Bits/block	2000-8000 (Note 1)	2000-8000	4000-20 000	6000-20 000	15 000-30 000 (Note 2)	For further study
ESR	0.04	0.05	0.075	0.16	(Note 3)	For further study
SESR	0.002	0.002	0.002	0.002	0.002	For further study
BBER	3×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	10^{-4}	For further study

NOTES

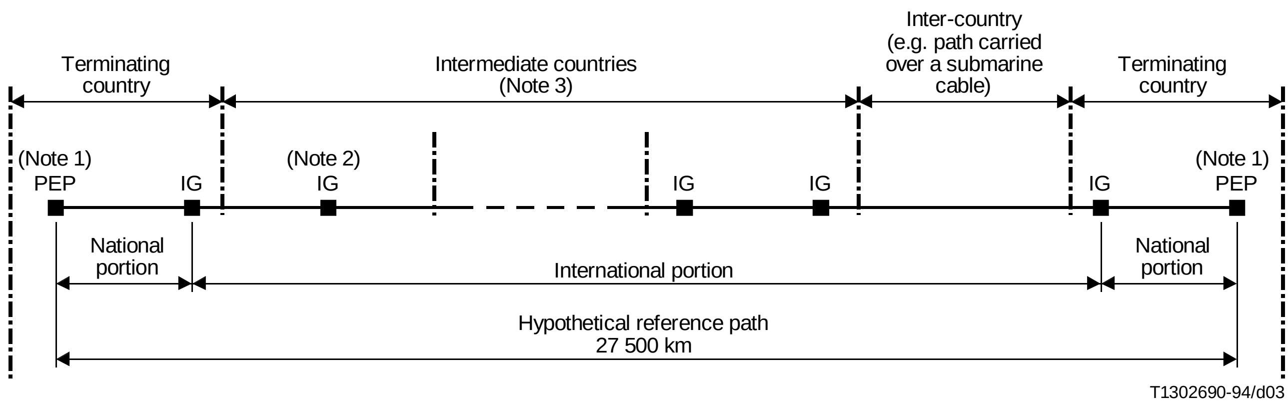
1 VC-11 and VC-12 (see Recommendation G.709) paths are defined with a number of bits/block of 832 and 1120 respectively, i.e. outside of the recommended range for 1.5 to 5 Mbit/s paths. For these block sizes, the BBER objective for VC-11 and VC-12 is 2×10^{-4}.

2 Because bit error ratios are not expected to decrease dramatically as the bit rates of transmission systems increase, the block sizes used in evaluating very high bit rate paths should remain within the range 15 000 to 30 000 bits/block. Preserving a constant block size for very high bit rate paths results in relatively constant BBER and SESR objectives for these paths.

As currenthy defined, VC-4-4c (see Recommendation G.709) is a 601 Mbit/s path with a block size of 75 168 bits/block. Since this is outside the recommended range for 160-3500 Mbit/s paths, performance on VC-4-4c paths should not be estimated in service using this table. The BBER objective for VC-4-4c using the 75 168 bit block size is taken to be 4×10^{-4}. There are currently no paths defined for bit rates greater than VC-4-4c (> 601 Mbit/s).

Digital sections are defined for higher bit rates and guidance on evaluating the performance of digital sections can be found in 5.1.

3 Due to the lack of information on the performance of paths operating above 160 Mbit/s, no ESR objectives are recommended at this time. Nevertheless, ESR processing should be implemented within any error performance measuring devices operating at these rates for maintenance or monitoring purposes.



NOTES

1 If a path is considered to terminate at the IG, only the international portion allocation applies.

2 One or two International Gateways (entry or exit) may be defined per intermediate country.

3 Four intermediate countries are assumed.

FIGURE 3/G.826

Hypothetical reference path

For the purposes of this Recommendation the boundary between the national and international portions is defined to be at an International Gateway which usually corresponds to a cross-connect, a higher-order multiplexer or a switch (ISDN or B-ISDN). lGs are always terrestrially based equipment physically resident in the terminating (or intermediate) country. Higher-order paths (relative to the HRP under consideration) may be used between IGs. Such paths receive only the allocation corresponding to the international portion between the IGs. In intermediate countries, the IGs are only located in order to calculate the overall length of the international portion of the path in order to deduce the overall allocation.

The following allocation methodology applies to each parameter defined in 4.1 and takes into account both the length and complexity of the international path. All paths should be engineered to meet their allocated objectives as described in 5.2.1 and 5.2.2. If the overall allocation exceeds 100%, then the performance of the path may not fulfil the objectives of Table 1. Network Operators should note that if performance could be improved in practical implementations to be superior to allocated objectives, the occurrence of paths exceeding the objectives of Table 1 can be minimized.

NOTE – The allocation methodology used in this Recommendation differs from the methods applied in Recommendation M.2100. Though there are differences, in most cases the requirements of Recommendation G.826 are satisfied if the objectives of Recommendation M.2100 are met. Nevertheless, further harmonization of the two Recommendations is desirable. This requires further consideration.

5.2.1 Allocation to the National Portion of the End-to-End Path

Each national portion is allocated a fixed block allowance of 17.5% of the end-to-end objective. Furthermore, a distance based allocation is added to the block allowance. The actual route length between the PEP and IG should first be calculated if known. If this is not known, then the air-route distance between the PEP and IG should be used and multiplied by an appropriate routing factor [a value of 1.5 (provisional) is suggested]. When both actual and calculated route lengths are known, the smaller value is retained. This distance should then be rounded up to the nearest 500 km. An allocation of 1% per 500 km is then applied to the resulting distance.

Independent of the distance spanned, any satellite hop in the national portion receives a 35% allocation of the objectives in Table 1. When allocating 35% to a satellite hop used in the national portion, the 35% allocation replaces the distance-based allocation for this portion.

5.2.2 Allocation to the International Portion of the End-to-End Path

The international portion is allocated a block allowance of 2% per intermediate country plus 1% for each terminating country. Furthermore, a distance based allocation is added to the block allowance. As the international path may pass through one or more intermediate countries, the actual route length between intermediate IGs (one or two for each intermediate country) should be added to calculate the overall length of the international portion. If the actual route lengths are not known, then the air-route distance between intermediate lGs should be used and multiplied by an appropriate routing factor [a value of 1.5 (provisional) is suggested]. When both actual and calculated route lengths are known, the smaller value is retained for each element between IGs for the calculation of the overall length of the international portion. This overall distance should then be rounded up to the nearest 500 km. An allocation of 1% per 500 km is then applied to the resulting distance.

Independent of the distance spanned, any satellite hop in the international portion receives a 35% allocation of the objectives in Table 1. When allocating 35% to a satellite hop used in the international portion, the distance spanned by the satellite is not included in the calculation of the distance-based allocation for this portion.

Annex A

Criteria for Entry and Exit for the Unavailable State

(This annex forms an integral part of this Recommendation)

A.1 Criteria for a Single Direction

A period of unavailable time begins at the onset of 10 consecutive SES events. These ten seconds are considered to be part of unavailable time. A new period of available time begins at the onset of ten consecutive non-SES events. These 10 seconds are considered to be part of available time.

A.2 Criterion for a Path

A path is in the unavailable state if either one or both directions are in the unavailable state.

A.3 Consequences on Error Performance Measurements

When the path is in the unavailable state, ES SES and BBE counts may be collected in both directions and may be helpful in the analysis of the trouble. However, it is recommended that these ES, SES and BBE counts be excluded from estimates of ESR, SESR and BBER performance (see 4.1.2).

Annex B

Relationship between PDH Path Performance Monitoring and the Block-based Parameters

(This annex forms an integral part of this Recommendation)

B.1 General

In-service anomaly conditions are used to determine the error performance of a PDH path when the path is not in a defect state. The following two categories of anomalies related to the incoming signal are defined:

a_1 An errored frame alignment signal;

a_2 An EB as indicated by an EDC (see Note).

NOTE – The error detection code EDC may correspond to a CRC, a single parity bit or several parity bits obtained by concatenation over several frames depending on the format.

In-service defect conditions are used in the G.730 to G.750-Series Recommendations relevant to PDH multiplex equipment to determine the change of performance state which may occur on a path. The three following categories of defects related to the incoming signal are defined:

d_1 Loss of signal (LOS);

d_2 Alarm indication signal (AIS);

d_3 Loss of frame alignment (LOF).

For the 2 Mbit/s hierarchy, the definition of the LOF defect condition is given in the G.730 to G.750-Series Recommendations.

For some formats of the 1.5 Mbit/s hierarchy, the definition of the LOF defect condition requires further study.

For both hierarchies, the definitions of LOS and AIS defect detection criteria are given in Recommendation G.775.

B.2 Types of Paths

Depending on the type of in-service monitoring ‘ISM’ facility associated with the PDH path under consideration, it may not be possible to derive the full set of performance parameters. Four types of paths are identified:

– *Type 1 – Frame and block structured paths*

The full set of defect indications d_1 to d_3 and anomaly indications a_1 and a_2 are provided by the ISM facilities. Examples of this type of path are:

- Primary rate and second order paths with CRC (4 to 6) as defined in Recommendation G.704;
- Fourth order paths with a parity bit per frame as defined in Recommendation G.755.

– *Type 2 – Frame structured paths*

The full set of defect indications d_l to d_3 and the anomaly indication a_l are provided by the ISM facilities. Examples of this type of path are:

– Primary rate up to the fourth order paths in the 2 Mbit/s hierarchy as defined in Recommendations G.732, G.742 and G.751;

– Primary rate paths in the 1.5 Mbit/s hierarchy as defined in Recommendations G.733 and G.734.

– *Type 3 – Other frame structured paths*

A limited set of defect indications d_l and d_2 and the anomaly indication a_l are provided by the ISM facilities. In addition the number of consecutive errored FAS per second is available. An example of this type of path is:

– Second up to the fourth order paths in the 1.5 Mbit/s hierarchy as defined in Recommendations G.743 and G.752.

– *Type 4 – Unframed paths*

A limited set of defect indications d_l and d_2 is Provided by the ISM facilities which do not include any error check. No FAS control is available. An example of this type of path is:

– End-to-end path (e.g. for a leased line) carried over several higher order paths placed in tandem.

B.3 Estimation of the Performance Parameters

Table B.1 gives information, on which set of parameters should be estimated and the related measurement criteria according to the type of path, considered.

TABLE B.1/G.826

Type	Set of parameters	Measurement criteria
1	ESR	An ES is observed when, during one second, at least one anomaly a_1 or a_2, or one defect d_1 to d_3 occurs.
	SESR	An SES is observed when, during one second, at least 'X' anomalies a_1 ou a_2, or one defect d_1 to d_3 occurs. (Notes 1 and 2)
	BBER	EBs are accumulated as defined in clause 4.
2	ESR	An ES is observed when, during one second, at least one anomaly a_1 or one defect d_1 to d_3 occurs.
	SESR	An SES is observed when, during one second, at least 'X' anomalies a_1 or one defect d_1 to d_3 occurs. (Note 2)
3	ESR	An ES is observed when, during one second, at least one anomaly a_1 or one defect d_1 to d_2 occurs.
	SESR	An SES is observed when, during one second, at least 'X' anomalies a_1 or one defect d_1 or d_2 occurs. (Note 2)
4	SESR	An SES is observed when, during one second, at least one defect d_1 or d_2 occurs. (Note 3)

NOTES

1 If more than one anomaly a_1 or a_2 occur during the block interval, then only one anomaly has to be counted.

2 Values of 'X' can be found in B.4.

3 The estimates of the ESR and SESR will be identical since the SES event is a subset of the ES event.

B.4 In-Service Monitoring Capabilities and Criteria for Declaration of the Performance Parameters

Table B.2 is provided for guidance on the criteria for declaration of an SES event on PDH paths.

The capabilities for the detection of anomalies and defects for the various PDH signal formats are described in Tables 5/M.2100 to 9/M.2100. These tables also indicate the criteria for declaring the occurrence of an ES or an SES condition in accordance with G.821 criteria taking into account existing equipment arrangements.

While it is recommended that ISM capabilities of future systems be designed to permit performance measurements in accordance with this Recommendation, it is recognized that it may not be practical to change existing equipment.

Table B.2 lists examples of the ISM SES criteria x, for signal formats with EDC capabilities, implemented prior to Recommendation G.826.

TABLE B.2/G.826

Bit Rate (kbit/s)	1544	2048	44 736
Recommendation	G.704	G.704	G.752
EDC type	CRC-6	CRC-4	Parity
Blocks/second	333	1000	9396
Bits/block	4632	2048	4704
SES threshold used on equipment developed prior to the acceptance of this Recommendation	x = 320	x = 805	x = 45 or x = 4698 as suggested in Recommendation M.2100
ISM threshold based on G.826 SES (30% Errored Blocks)	(Note 2)	(Note 2)	x = 2444 (Note 3)

NOTES

1 It is recognized that there are discrepancies between the figures above and those given in Table C.1. This requires further study.

2 Due to the fact that there is a large population of systems in service, the criteria for declaration of an SES will not change for the frame formats of these systems.

3 This figure takes into account the fact that, although 30% of the blocks could contain errors, a lesser number will be detected by the EDC due to the inability of the simple parity code to detect even numbers of errors in a block. It should be noted that such a simple EDC is non-compliant with the intent of this Recommendation.

4 Completion of this Table for other bit rates if for further study.

B.5 Estimation of Performance Events at the Far-End of a Path

The available remote in-service indications such as RAI or, if provided, FERF and FEBE are used at the near-end to estimate the number of SES occurring at the far end.

Annex C

Relationship between SDH Path Performance Monitoring and the Block-based Parameters

(This annex forms an integral part of this Recommendation)

C.1 The Relationship between BIP-n and Blocks

Since this Recommendation defines a block as consecutive bits associated with a path, each BIP-n (Bit Interleaved Parity, order ‘n’) in the SDH path overhead pertains to a single defined block. For the purpose of this annex, a BIP-n corresponds to a block. The BIP-n is not interpreted as checking ‘n’ separate interleaved parity check blocks. If any of the ‘n’ separate parity checks fail, the block is assumed to be in error.

C.2 Measurement of Performance Events using Aggregated Parity Error Counts

This subclause offers guidance for equipment designed prior to the development of this Recommendation which provide measurement of Bit Interleaved Parity violations instead of Errored Blocks as recommended in C.1. lt should not be interpreted as a basis for future equipment design.

Aggregate counts of Bit Interleaved Parity violations can be used to estimate the number of errored blocks.

$$E \cong P$$

where:

E is the number of Errored Blocks in the measurement period;

P is the number of individual parity violations in the measurement period.

C.3 Use of BIP Information In estimating EB, ES, SES and BBE

Subclause 4.1.1 describes error performance events used in defining performance parameters. The method of converting BIP measurements into Errored Blocks is described below.

For the ES event, the actual count of EBs is irrelevant, it is only the fact that an EB has occurred in a second which is significant. Any non-zero value of P in a second indicates the occurrence of an ES.

The BIP threshold (P) resulting in an SES is shown in Table C.1 for each SDH path type. These values should be programmable within SDH equipment.

For the calculation of BBER EBs are accumulated as defined in Clause 4.

TABLE C.1/G.826

Threshold (P) for SES for path types

Path type	Threshold P for SES
VC-11	600
VC-12	600
VC-2	600
VC-3	2400
VC-4	2400
VC-2-5c	600
VC-4-4c	2400
NOTE – It is recognized that there are discrepancies between the figures above and those given in Table B.2. This requires further study.	

C.4 Estimation of a Severely Disturbed Period for the Forward Direction

For in-service monitoring purposes, an SDP is estimated by the occurrence of a network defect. A defect is considered to be a condition under which the network has lost its ability to transport bits. During such a condition, the equipment at the receiving end of the path will experience a high bit error ratio.

The nature of defects is very closely related to the specific network fabric being used. In the SDH, the following path layer defects exist:

Path layer defect	Recommendation	Path layer defect	Recommendation
Higher order path AIS	G.709	Higher order path trace identifier mismatch	G.783
Lower order path AIS	G.709	Lower order path trace identifier mismatch	G.783
Loss of AU pointer	G.783	Signal label Mismatch (under study)	G.783
Loss of TU pointer	G.783	Loss of TU mltiframe alignment	G.783

C.5 Estimation of Performance Events at the Far-End of a Path

The following indications available at the near-end are used to estimate the performance events (occurring at the far end) for the reverse direction:

Higher and lower order path FERF and FEBE (Recommendation G.709)

Higher or lower order path FEBEs are anomalies which are used to determine the occurrence of ES, BBE and SES at the far-end.

Higher or lower order path FERFs are defects which estimate the occurrence of SDPs and hence SES at the far-end.

Annex D

Relationship between Cell-Based Network Performance Monitoring and the Block-based Parameters

(This annex forms an integral part of this Recommendation)

D.1 General

The operation and maintenance function for the transmission path is provided by the F3 flow as defined in Recommendation I.610 which deals with the general OAM principles for the B-ISDN.

The F3 maintenance flow corresponds to the ISM facilities and is defined, as well as the monitoring block size, in Recommendation I.432. The block – as defined in G.826 – corresponds to a set of contiguous MBS cells monitored by a BIP-8 EDC. For the purposes of this Recommendation, the BIP-8 is not interpreted as checking 8 separate interleaved parity check blocks. One BIP-8 interleaved parity check cannot lead to more than one errored block. Within one BIP-8 check, if any of the 8 separate parity checks fail, the overall block is assumed to be in error.

The following categories of anomalies related to the incoming signal on an ATM transmission path are defined:

a_1 Errored idle or ATM cell (detected by an EDC in the F3 OAM cell) (see Note 1);

a_2 Errored or corrected header of an idle or ATM cell (see Note 2);

a_3 Errored F3 cell: corrected error in the header or error detected by the Cell Error Control;

a_4 Loss of a single F3 cell.

NOTES

1 An ATM cell is provided by the ATM layer, and corresponds to user cells, F4 OAM cells at the Virtual Path level and F5 OAM cells at the Virtual Channel level.

2 Assuming that the BIP-8 check is executed after the header error check, a single error which occurs in the header of an idle or ATM cell will be corrected by the HEC mechanism and no errors will be detected by the BIP-8 EDC in this case. Nevertheless the corresponding block should be considered as an errored block.

When at least one anomaly a_l to a_4 occurs, an Errored Block should be counted. If more than one anomaly occurs for a given block, only one EB is counted.

The following categories of defects related to the incoming signal on an ATM transmission path are defined:

d_l Loss of two consecutive OAM cells, in accordance with Recommendation I.432;

d_2 Transmission path alarm indication signal;

d_3 Loss of cell delineation;

d_4 Loss of Signal.

D.2 Types of Paths

Two types of ATM transmission paths are identified:

Type 1: Paths corresponding to a stream of cells mapped in a cell-based format;

Type 2: Paths corresponding to a stream of cells mapped into SDH or PDH-based frame structures.

The full set of G826 performance parameters and corresponding objectives is applicable to the ATM transmission path of type 1.

The G.826 performance parameters and corresponding objectives are applied to underlying SDH or PDH paths which support ATM transmission paths of type 2.

The applicability of G.826 performance parameters for type 2 ATM transmission paths require further study.

D.3 Estimation of the Performance Parameters

For type 1 ATM transmission paths, the full set of G.826 performance parameters should be estimated as follows:

ESR An ES is observed when, during one second, at least one anomaly a_1 to a_4, or one defect d_1 to d_4 occurs.

SESR An SES is observed when, during one second, at least 'X' EBs – derived from anomalies al to a_4 – or one defect d_1 to d_4 occur (see Note).

BBER EBs are accumulated as defined in Clause 4.

NOTE – The value of 'x' is obtained by multiplying the number of blocks per second by 0.3 (from the SES definition).

D.4 Estimation of Performance Events at the Far-End of the Path

The TP-FERF defect (see Recommendation I.432) and FEBE indications are used at the near-end to estimate the G.826 performance events occurring at the far-end.

FEBEs are anomalies which are used to determine the occurrence of ES, BBE and SES at the far-end of the path.

TP-FERFs are defects which estimate the occurrence of SDPs and hence SES at the far-end of the path.

References

Rec. G.703 *Physical/electrical characteristics of hierarchical digital interfaces*

Rec. G.704 *Synchronous frame structures used at primary and secondary hierarchical levels*

Rec. G.709 *Synchronous multiplexing structure*

Rec. G.732 *Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s*

Rec. G.733 *Characteristics of primarv PCM multiplex equipment operating at 1544 kbit/s*

Rec. G.734 *Characteristics of svnchronous digital multiplex equipment operating at 1544 kbit/s*

Rec. G.742 *Second order digital multiplex equipment operating at 8448 kbit/s and using positive justification*

Rec. G.743 *Second order digital multiplex equipment operating at 6312 kbit/s and using positive justification*

Rec. G.751 *Digital multiplex equipment operating at the third order bit rate of 34 368 kbit/s and the fourth order bit rate of 139 264 kbit/s and using positive justification*

Rec. G.752 *Characteristics of digital multiplex equipments based on a second order bit rate of 6312 kbit/s and using positive justification*

Rec. G.755 *Digital multiplex equipment operating at 139 264 kbit/s and multiplexing three tributaries at 44 736 kbit/s*

Rec. G.775 *Loss of signal and alarm indication signal defect detection clearance criteria at equipment interfaces described in Recommendation G.703 and operating at bit rates described in Recommendation G.702*

Rec. G.783 *Characteristics of synchronous digital hierarchy equipment functional blocks*

Rec. G.821 *Error performance of an international digital connection forming part of an ISDN*

Rec. I.321 *B-ISDN Protocol reference model and its application*

Rec. I.356 *B-ISDN ATM Layer cell transfer performance*

Rec. I.362 *B-ISDN ATM Adaptation Layer (AAL) functional description*

Rec. I.432 *B-ISDN User Network Interface - Physical layer*

Rec. I.610 *OAM Principles of the B-ISDN access*

Rec. M.60 *Maintenance terminology and definitions*

Rec. M.2100 *Performance limits for bringing-into-service and maintenance of international digital paths, sections and transmission systems*

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