application note

ITU-T G.826 and M.2100 Error Analysis

Implementation in 284X and 285X series digital analyzers

The relative merits of ITU-G recommendations G.821, G.826 and M2100 are discussed and their implementation in the 284X and 285X instruments are described

Introduction

ITU-T recommendation G.821 has been in use for many years for assessing the error performance of 64 kbit/s ISDN channels, but has a number of drawbacks when used at higher rates such as 2048 kbit/s and above. Since the introduction of G.821 there have been vast changes in digital network infrastructures with the introduction of transport systems such as SDH (Synchronous Digital Hierarchy) and ATM (Asynchronous Transfer Mode). As a consequence ITU-T has developed recommendations which are more appropriate for higher rate data, namely G.826 and M.2100.

G.826 is suitable for measurements at 2048 kbit/s and above for a variety of transport systems, and is essentially block based.

M.2100 establishes performance limits for bringing into service and maintenance of PDH digital links.

RECOMMENDATION G.821 REVIEW

In order to appreciate G.826 and M.2100 it is useful to review the key parameters of G.821 which were developed for testing the error performance of 64 bit/s digital links in terms of performance parameters related to performance objectives. The three basic parameters are:

Errored Seconds (ES)
Any second which contains an error.

Severely Errored Seconds (SES)
Any second during which the error ratio exceeds 10^{-3}.

Degraded Minutes (DM)
Any minute during which the error ratio exceeds 10^{-6}.

There is also the concept of Available and Unavailable time. Time is normally Available, and Unavailable time starts when the error ratio exceeds 10^{-3} for ten consecutive seconds. It terminates when the error ratio is less than 10^{-3} for ten consecutive seconds, signifying the restart of Available time.

Since these parameters apply to 64 kbit/s, Annex D of G.821 defined a method by which the % ES parameter could be scaled for measurements at higher bit rates such as 2048 kbit/s, a technique which many regarded as not being entirely satisfactory.

G.821 measurements using the above parameters are made out-of-service normally for qualifying a digital link prior to putting into service. They do not lend themselves to in-service monitoring for checking degradation of link performance.

RECOMMENDATION G.826

This recommendation was developed to be generic, and applicable to digital paths at or above primary rate. They could be based on traditional Plesiochronous Digital Hierarchy (PDH), Synchronous Digital Hierarchy (SDH), or other transport networks such as cell based ATM (Asynchronous Transfer Mode). Conformance to G.826 would in most cases mean that the requirements of G.821 would be met. In addition the parameter definitions are block based which means that both out-of-service and in-service measurements can be made, a distinct advantage over G.821. For example CRC4 errors can be monitored in-service for newer 2048 kbit/s systems and expressed in terms of G.826 parameters.

G.826 EVENT AND PARAMETER DEFINITIONS

EVENTS

There are four events which become the basis of G.826 parameters:

Errored Block (EB)

A block in which one or more bits are in error. This can be a CRC block or some other block such as parity.

Errored Second (ES)

Any second during which an errored block occurs. There may also be other events which cause Errored Seconds called anomalies and defects which will be considered later.

Severely Errored Seconds (SES)

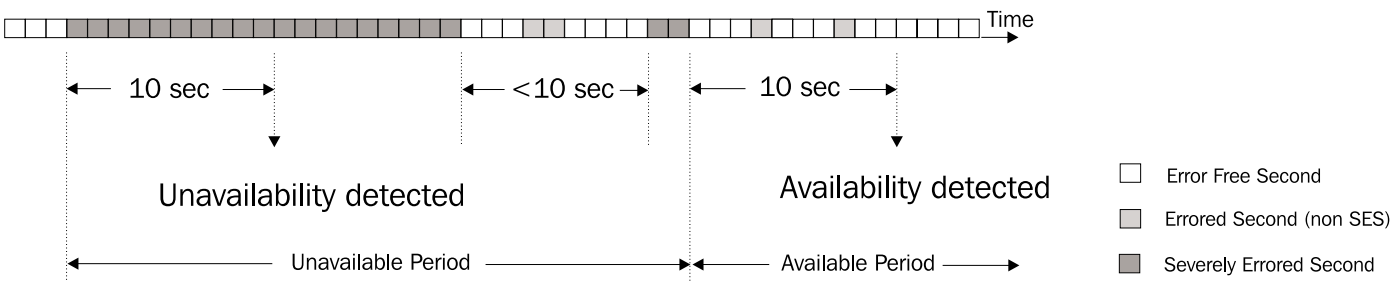
Any second which contains ≥30% errored blocks or one or more defects.

Background Block Error (BBE)

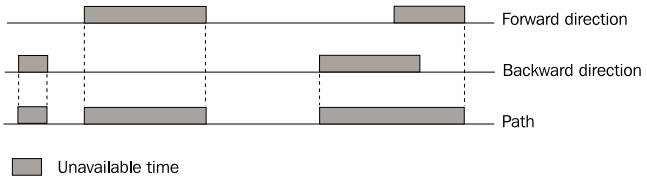
An errored block which is not part of a SES.

PARAMETERS

The above events are processed to give the following parameters, and are expressed only for Available time. Examples of Available and Unavailable time are shown below.



Example of available/unavailable time for a single direction



Example of Available/Unavailable time for a bidirectional path

Errored Second Ratio (ESR)

The ratio of ES to total seconds.

Severely Errored Second Ratio (SESR)

The ratio of SES to total seconds.

Background Block Error Ratio (BBER)

The ratio of BBE to total seconds.

ANOMALIES AND DEFECTS

As well as errors in blocks such as CRC, other events such as frame alignment word errors and loss of signal are made to contribute towards ES and SES. Anomalies cause an ES, and defects a SES. Where anomalies are occurring at a high rate, crossing a threshold value per second may also cause a SES. For a PDH path such as 2048 kbit/s, the following applies:

Anomalies

Errored frame alignment word.
Errored Block (EB)

Defects

Loss of signal
AIS (Alarm Indication Signal)
Loss of frame alignment

Where the path under test is not block based, then a subset of the anomalies is used to estimate the G.826 performance.

ERROR PERFORMANCE OBJECTIVES

End to end objectives

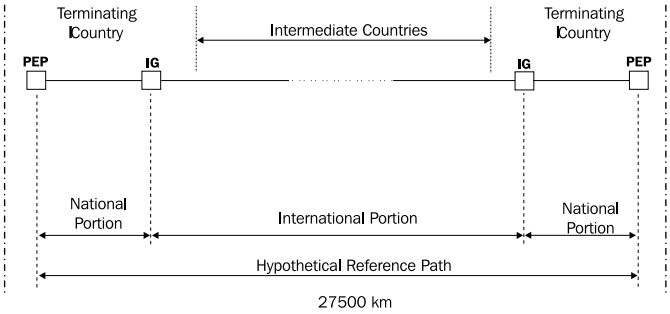
The end-to-end error performance objectives are defined for a 27500 km Hypothetical Reference Path (HRP) comprising National and International digital sections. The objectives vary depending on the transmission rate, and are shown below for 2048 kbit/s.

G.826 Parameter	*HRP Objective*
ESR	0.04
SESR	0.002
BBER	2×10^{-4} *

* This is relaxed to 3×10^{-4} for systems prior to 1996.

Allocation of end to end objectives

The objectives are allocated between the National and International portions as follows.



PEP Path End Point
IG International Gateway

Hypothetical reference path

National Portion Allocation

Each national portion is allocated a fixed block allowance of 17.5% of the end-to-end objective plus a distance based allocation of 1% per 500 km calculated as below:

Distance	< 1000 km	≥ 1000 km < 1200 km	≥ 1200 km
Multiplier	1.5	1500 km fixed	1.25

The calculated distance is then rounded up to the nearest 500 km. For example, for a national portion length of 100 km the allocation would be:

Fixed allocation	17.5%
100 km x 1.5 = 150 km rounded up to 500 km at 1% per 500 km	1%
Total	**18.5%**

The G.826 parameter limits would therefore be 18.5% of the HRP objectives:

G.826 Parameter	*HRP Objective*	*100 km national portion*
ESR	0.04	0.0074
SESR	0.002	0.00037
BBER	2×10^{-4}	3.7×10^{-5}

When a satellite link is included the total allowance is 42%.

International Portion Allocation

Each international portion is allocated a fixed block allowance of 2% per intermediate country plus 1% per terminating country, of the end to end objective, plus a distance based allocation of 1% per 500 km calculated as for the national portion, subject to a minimum total allocation of 6%. The total allocation becomes 35% when a satellite link is included.

RECOMMENDATION M.2100

M.2100 provides limits for bringing into service and maintenance of PDH international digital links, paths and systems from 64 kbit/s to 140 Mbit/s. Both in-service and out-of-service measurements are catered for. The objectives include error performance given in Recommendations G.821 and G.826.

The basic parameters which are used to assess error performance are ES and SES, defined as:

ES Any second with ≥ 1 bit errors.
SES Any second with a bit error rate of ≥ 10^{-3}.

Similarly, as for G.826, anomalies and defects also come into play for initiating ES and SES events. Tables B.2 to B.6 of M.2100 define anomalies and defects and their relation to ES and SES for each PDH rate up to 140 Mbit/s. For example the following is an extract from table B.2 for 2048 kbit/s with CRC4. This shows the various parameters and overhead bits that are monitored or detected to initiate ES and SES events. Most events give an indication of the state of the line being monitored (receive direction) while the E and A bits are the remote end's indication of the state of the transmit line (send direction). This enables the overall path status to be assessed.

Anomaly and defect derivation	*Anomalies and defects in 1 second*	*Interpretation for receive direction*	*Interpretation for send direction*
CRC4	≥ 1 LOF	ES + SES	-
E-bits	≥ 1 LOS	ES + SES	-
FAS	≥ 1 AIS	ES + SES	-
A-bit	≥ 1 CRC error	ES	-
	≥ 805 CRC errors	ES + SES	-
	≥ 1 E-bit	-	ES
	≥ 805 E-bits	-	ES + SES
	≥ 1 RDI	-	ES + SES

ERROR PERFORMANCE OBJECTIVES

End-to-end Reference Performance Objectives (RPO)

Errored Second (ES)

Bit Rate	*ES RPO*	*Comments*
64 kbit/s	4%	Based on M.1340 (G.821 is 8%)
2 Mbit/s	2%	Based on 50% of G.826 value
8 Mbit/s	2.5%	Based on 50% of G.826 value
34 Mbit/s	3.75%	Based on 50% of G.826 value
140 Mbit/s	8%	Based on 50% of G.826 value

Severely Errored Second (SES)

Bit Rate	*SES RPO*	*Comments*
64 kbit/s	0.1%	Based on G.821 value
2 Mbit/s	0.1%	Based on G.826 value
8 Mbit/s	0.1%	Based on G.826 value
34 Mbit/s	0.1%	Based on G.826 value
140 Mbit/s	0.1%	Based on G.826 value

M.2100 Reference Performance Objectives (RPO)

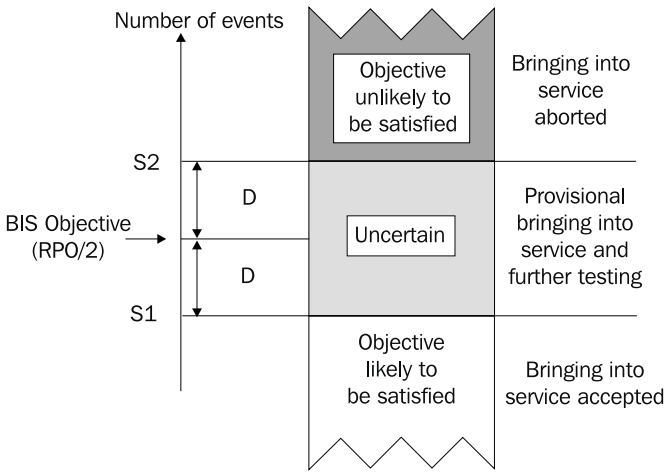
The RPOs for M.2100 are 40% of the end-to-end RPO shown above for 64 kbit/s, and 63% for the higher PDH rates.

Allocation of end-to-end objectives

Allocation is done on a similar principle to that for G.826, except that different routing factors (multipliers) are applied to the route lengths. A number of route length ranges carry different allocations and depend on type of route, such as terrestrial, satellite, optical and non-optical undersea cable.

PERFORMANCE LIMITS FOR BRINGING INTO SERVICE (BIS)

When the RPO has been calculated for the link or path to be tested, Bringing Into Service limits can be calculated on the basis of a BIS objective which is two times better than the RPO, the difference being known as the ageing margin. Two limits, S1 and S2, relative to the BIS objective are then used for testing. These limits can be calculated from formulae shown in paragraph 6 of M.2100, but for convenience tables are provided to enable the limits to be read for ES and SES, depending on bit rate, path allocation (RPO) and duration of test.



BIS Limits and Conditions

Implementation in 285X Series

When the limits have been calculated for each of the G.826 parameters for the length and type of link to be tested, these limits can be programmed into the instrument on the TEST-MENU, Performance G.826 Limits page. In the page shown below the limits for ESR, SESR and BBER are those calculated above for a 100 km national digital section. Each of the parameters is independently controllable for activation of the threshold alarm. The forward path contribution to the overall path performance can also be enabled or disabled as required. A threshold for % Unavailable seconds is included for convenience, although this does not form part of the G.826 or M.2100 recommendations.

```
TEST-PERF G.826 LIMITS

ESR    : 7.4E-3     ..: ON
SESR   : 3.7E-4     ..: ON
BBER   : 3.7E-5     ..: ON
% US   : 0.0095     ..: ON
Forward Path          : OFF
```

The G.826 results are displayed and compared to the thresholds with an alarm being shown if the thresholds are enabled. This can also be a print event, if selected. In addition the top line message is shown on all pages to highlight the alarm condition, with the detail shown as below.

```
RESULTS-PERFORMANCE G.826    G.826>LIMIT
                          --- LIMITS ---
ESR    : 1.2E-5                      ON
SESR   : 2.4E-6                      ON
BBER   : 4.0E-5          > limit     ON
% US   : 0.000876                    ON
```

Indication that BBER threshold limit has been exceeded

Set up of limits and display for M.2100 is shown in the sample screens below.

```
TEST-PERF M2100 LIMITS
         ---- S1 -----    ---- S2 -----
ES     : 259    ..: ON     328    ..: ON
SES    : 7      ..: ON     22     ..: ON
US     : 1      ..: OFF    2      ..: OFF
Forward Path     : OFF
```

```
RESULTS-PERFORMANCE M2100

                    -- LIMITS -- S1   S2
ES     : 29                      ON   ON
SES    : 4                       ON   ON
US     : 0                       OFF  OFF
```

Implementation in 284X Series

Implementation in 284X series is consistent with that in the 285X series, the main differences being in the displays. The thresholds are set in the G.826 and M.2100 THRESHOLDS pages, which also show the current and history status as to whether the parameters have exceeded the thresholds. The thresholds can also be activated or deactivated. The value for each of the parameters is shown on the MAJOR ERROR RESULTS page.

```
TX ON      G.826 THRESHOLDS 382      TEST ON

  Parameter  Active  Threshold  Status
     ESR   : 1  [X]     7.4E-3
    SERS   : 2  [X]     3.7E-4
    BBER   : 3  [X]     3.7E-5
     %US   : 4  [X]     0.0095
 Forward    : 5  [ ]
    Path
   Reset    : 5  [ ]          History
 History
                                 Current
```

```
TX ON      M.2100 THRESHOLDS 383     TEST ON

  Parameter  Active  Threshold  Status
  ES(S1)   : 1  [X]     259
  ES(S2)   : 2  [X]     328
 SES(S1)   : 3  [X]       7
 SES(S2)   : 4  [X]      22
  US(S1)   : 5  [ ]       1
  US(S2)   : 6  [ ]       2
 Forward    : 5  [ ]
    Path
```

```
TX ON      MAJOR ERROR RESULTS 31     TEST OFF

Error Type: CRC4          | Performance G.826
Err nonSES:       29      |    ERS: 1.2 E-05
     LTMER: 1.5 E-06      |   SESR: 2.4 E-06
Current ER: 0.0 E-12      |   BBER: 3.0 E-05
 Resid. ER: 9.8 E-07      |    %US:    0.00000

       TIMING             | Performance M.2100

     Start:               |     ES:        29
 14/01/99 11:27:45
      Stop:               |    SES:         4
 14/01/99 13:37:47
Total Test:               |     US:         0
 00 02:10:02

 <<    >>    DOWN    UP    ZOOM
```

Conclusions

Both 285X and 284X provide implementations of ITU-T Recommendations G.826 and M.2100, which, together with the traditional G.821 capability, offer the error performance measurements required for the full range of PDH bit rates from 64 kbit/s to 140 Mbit/s. Full programmability of parameter threshold limits, with the ability to report threshold alarms both on-screen and as part of Autoprint routines, eases the burden on network installation and maintenance engineers.

IFR, 10200 West York Street, Wichita, Kansas
67215-8999, USA. E-mail: info@ifrsys.com
Tel: +1 316 522 4981 Toll Free USA: 1 800 835 2352 Fax: +1 316 522 1360

IFR, Longacres House, Norton Green Road, Stevenage, Herts
SG1 2BA, United Kingdom. E-mail: info@ifrsys.com
Tel: +44 (0) 1438 742200 Freephone UK: 0800 282 388 Fax: +44 (0) 1438 727601

Part no. 46891/853
Revision A