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SERIES O: SPECIFICATIONS OF MEASURING EQUIPMENT

Equipment for the measurement of digital and analogue/digital parameters

Equipment to assess error performance on STM-N interfaces

ITU-T Recommendation O.181

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ITU-T Recommendation O.181

Equipment to assess error performance on STM-N interfaces

Summary

This Recommendation specifies the measuring equipment and the related test signal structures to perform in-service or out-of-service error performance measurements on STM-N interfaces.

Source

ITU-T Recommendation O.181 was revised by ITU-T Study Group 4 (2001-2004) and approved under the WTSA Resolution 1 procedure on 29 May 2002.

Keywords

Error performance, in-service, measuring equipment, measurement mode, out-of-service, test signal structure.

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Introduction

The requirements for the characteristics of the error performance measuring equipment which are described below must be adhered to in order to ensure compatibility between equipment produced by different manufacturers.

While requirements are given for the equipment, the realization of the equipment configuration is not covered and should be given careful consideration by the designer and user. In particular, it is not required that all features listed below shall be provided in one piece of equipment. Users may select those functions which correspond best to their applications.

ITU-T Recommendation O.181

Equipment to assess error performance on STM-N interfaces

1 Scope

This Recommendation specifies the functions of a measuring equipment capable of assessing SDH error performance at STM-N interfaces.

ITU-T Rec. G.707 [3] defines the STM-N signals applicable to these measurements. ITU-T Rec. G.703 [1], G.957 [10] and G.691 [17] define the STM-N physical interface characteristics.

Measurement modes and functions defined in this Recommendation enable:

- any measuring equipment to analyze information provided by another measuring equipment (e.g. measurement modes and test sequences are common to all measuring equipment);
- any two measuring equipments to provide the same means to analyze the error performance of a given digital transmission path or path segment.

With regard to the numerous possibilities to make measurements on STM-N signals, a set of measurements modes are defined (see clause 5). Each measurement mode depends on the type of network entity under test, i.e. on the type of measured STM-N signal and on the type of SDH network elements crossed by the measured signal.

In addition, the required functions of the Generator and Receiver part of the error performance measuring equipment are described below (see clauses 6 and 7).

2 References

The following Recommendations and other references contain provision which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

[1] ITU-T Recommendation G.703 (2001), *Physical/electrical characteristics of hierarchical digital interfaces*.

[2] ITU-T Recommendation G.706 (1991), *Frame alignment and Cyclic Redundancy Check (CRC) procedures relating to basic frame structures defined in Recommendation G.704*.

[3] ITU-T Recommendation G.707/Y.1322 (2000), *Network node interface for the synchronous digital hierarchy*.

[4] ITU-T Recommendation G.772 (1993), *Protected monitoring points provided on digital transmission systems*.

[5] ITU-T Recommendation G.775 (1998), *Loss of Signal (LOS), Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) defect detection and clearance criteria for PDH signals* .

[6] ITU-T Recommendation G.783 (2000), *Characteristics of Synchronous Digital Hierarchy (SDH) equipment functional blocks*.

[7] ITU-T Recommendation G.784 (1999), *Synchronous Digital Hierarchy (SDH) management*.

[8] ITU-T Recommendation G.825 (2000), *The control of jitter and wander within digital networks which are based on the Synchronous Digital Hierarchy (SDH)*.

[9] ITU-T Recommendation G.826 (1999), *Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate*.

[10] ITU-T Recommendation G.957 (1999), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*.

[11] ITU-T Recommendation M.2101 (2000), *Performance limits and objectives for bringing-into-service and maintenance of international SDH paths and multiplex sections*.

[12] ITU-T Recommendation O.150 (1996), *General requirements for instrumentation for performance measurements on digital transmission equipment*.

[13] ITU-T Recommendation O.3 (1992), *Climatic conditions and relevant tests for measuring equipment*.

[14] ITU-T Recommendation V.24 (2000), *List of definitions for interchange circuits between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE)*.

[15] ITU-T Recommendation V.28 (1993), *Electrical characteristics for unbalanced double-current interchange circuits*.

[16] ITU-T Recommendation G.813 (1996), *Timing characteristics of SDH equipment slave clocks (SEC)*.

[17] ITU-T Recommendation G.691 (2000), *Optical interfaces for single-channel STM-64, STM-256 systems and other SDH systems with optical amplifiers*.

[18] ITU-T Recommendation G.806 (2000), *Characteristics of transport equipment – Description methodology and generic functionality*.

[19] ITU-T Recommendation G.828 (2000), *Error performance parameters and objectives for international, constant bit rate synchronous digital paths.*

[20] ITU-T Recommendation G.829 (2000), *Error performance events for SDH multiplex and regenerator sections*.

3 Definitions

This Recommendation defines the following terms:

- **Test Sequence Error (TSE)**: See Annex A.
- **Test Signal Structure (TSS)**: See Annex C.
- **End-to-End Transparency**: See 5.3.

4 Abbreviations

This Recommendation uses the following abbreviations.

EUT Entity Under Test

PDH Plesiochronous Digital Hierarchy

SDH Synchronous Digital Hierarchy

TSS Test Signal Structure

See also 5.2.1 and Annex A for anomalies and defect abbreviations.

5 Measurement modes and events to be monitored

This clause gives a list of the measurement modes which can be provided by one or more measuring equipments.

5.1 Definition of the measurement modes

Two sets of measurement modes are identified:

1) *Out-of-service measurement modes*

   After setting up a path through the Entity Under Test (EUT) by appropriate means, a suitable test sequence is applied to the input at one side of the EUT. The received information is analyzed at an access point at the same or the other side of the EUT.

2) *In-service measurement modes*

   The digital signal transported by the SDH elements under test is analyzed at a given access point of the EUT.

Both measurement modes can be used simultaneously: It is possible to apply the in-service measurement mode to a test path which has been set up in order to perform out-of-service measurements.

The measurement modes are defined according to the different types of SDH network entities under test (e.g. multiplex section, regenerator section, path, etc.), i.e. according to the structure of the measured STM-N signal at the connection point and according to the characteristics of the SDH network elements passed by the measuring signal.

In order to specify the error performance measurement procedure for each measurement mode, it is necessary to define the network events to be monitored. Moreover, the test signal structures with associated test sequences to be used in case of out-of-service measurements need to be defined.

The Test Signal Structures named TSSX (X being a number) which shall be used for such measurement modes are defined in Annex C.

5.2 Events to be monitored

This subclause lists the defects, anomalies and the other events related to error performance which can be detected by the measuring equipment on STM-N signals. Criteria for detecting anomalies and defects are given in Annex A.

Annex B classifies the indications available in SDH, according to those defined in ITU-T Recs. G.783 [6] and G.784 [7]. It separates events related or not related to error performance.

A subset of these events is selected for each measurement mode according to the SDH network entity under test.

5.2.1 Network events

Network anomalies

– Out of Frame alignment (OOF).
– B1 error.
– B2 error.
– B3 error.
– Higher-order Path Remote Error Indication (HP-REI).
– Lower-order Path Remote Error Indication (LP-REI).
– Multiplex Section Remote Error Indication (MS-REI).
– BIP-2 error.

Network defects

- Loss of Signal (LOS).
- Loss of Frame alignment (LOF).
- Multiplex Section Alarm Indication Signal (MS-AIS).
- Multiplex Section Remote Defect Indication (MS-RDI).
- Administrative Unit Loss of Pointer (AU-LOP).
- Administrative Unit Alarm Indication Signal (AU-AIS).
- Higher-order Path Remote Defect Indication (HP-RDI).
- Higher-order Path Tandem Connection Remote Defect Indication (HPTC RDI).
- Higher-order Path Loss of Multiframe alignment (HP-LOM).
- Tributary Unit Loss of Pointer (TU-LOP).
- Tributary Unit Alarm Indication Signal (TU-AIS).
- Lower-order Path Tandem Connection Remote Defect Indication (LPTC RDI).
- Lower-order Path Remote Defect Indication (LP-RDI).
- Regenerator Section Trace Identifier Mismatch (RS-TIM).
- Higher-order Path Tandem Connection Loss of Tandem Connection Monitoring (HPTC-LTC).
- Higher-order Path Trace Identifier Mismatch (HP-TIM).
- Higher-order Path Tandem Connection Trace Identifier Mismatch (HPTC-TIM).
- Lower-order Path Tandem Connection Loss of Tandem Connection Monitoring (LPTC-LTC).
- Lower-order Path Trace Identifier Mismatch (LP-TIM).
- Lower-order Path Tandem Connection Trace Identifier Mismatch (LPTC-TIM).
- Higher-order Path Unequipped (HP-UNEQ).
- Higher-order Path Tandem Connection Unequipped (HPTC-UNEQ).
- Lower-order Path Unequipped (LP-UNEQ).
- Lower-order Path Tandem Connection Unequipped (LPTC-UNEQ).
- Higher-order Path PayLoad Mismatch (HP-PLM).

NOTE 1 – The list of network defects and anomalies given above shall conform to the last agreed versions of the relevant SDH Recommendations such as G.707/Y.1322 [3] and G.783 [6].

NOTE 2 – The list of other events being neither defects nor anomalies is for further study.

5.2.2 Test signal structure events

Monitoring of network events shall be complemented by the following events directly related to the test signal structure when performing out-of-service measurements.

- Loss of Sequence Synchronization (LSS).
- Test Sequence Error (TSE).

5.3 Out-of-service measurement modes

For each measurement mode, a subset of network events to be monitored is taken from the list given in 5.2. In addition, several test signal structures which shall be used for error performance measurement are defined.

For some measurement modes, two test signal structures can be used: one non-mapped test signal structure (TSS1 to TSS4) and one mapped test signal structure (TSS5 to TSS8) as defined in Annex C.

Mapped test signal structures can always be used whatever the measurement mode for error performance measurement purpose.

Non-mapped test signal structures may be used for certain measurement modes for error performance measurement purpose except:

– when cross-testing or interworking is required between PDH and SDH ports of the entity under test; or

– if the network elements crossed by the test signal structure do not manage the specific signal labels defined for these non-mapped test signal structures within ITU-T Rec. G.707/Y.1322 [3].

For a given test, measurement mode selection depends on the type of SDH network entity under test which is considered to transport transparently, from end-to-end, an SDH signal structure as defined in ITU-T Rec. G.707/Y.1322 [3] (VC-N, C-N, etc.).

An SDH signal structure is considered to be end-to-end transparent if, not taking into account any performance impairments, a digital signal is transmitted from end-to-end without any bit change, with each bit of this signal allowed to take any value at the input of the entity under test.

5.3.1 Mode with higher-order container (C-4) end-to-end transparency

This mode shall be used when there is an end-to-end transparency at the C-4 level. In this case the C-4 within a VC-4 is associated with a AU-4 SDH multiplexing structure as defined in ITU-T Rec. G.707/Y.1322 [3].

5.3.1.1 For an STM-N Regenerator section

For an STM-N Regenerator section when N > 1, the test sequence still applies to only one C-4 container. The contents of the C-4 containers not filled with the test sequence shall be different from the test sequence. Examples of the filling bits are: fixed repetitive byte such as 00H or 6AH (Hexadecimal values) or a mapped PRBS. Alternatively, an unequipped VC-4 signal may be applied to containers not filled with the test sequence.

An example of measuring equipment connected to network entities according to this measurement mode is given in Figure I.1.

5.3.1.1.1 Events to be monitored

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B1 errors, TSE
Defects	LOS, LOF, RS-TIM, LSS

5.3.1.1.2 Test signal structures to be used

For this measurement mode, test signal structures TSS1 (see Note) and TSS5 apply.

NOTE – The use of non-mapped test sequences such as TSS1 is limited (see 5.3).

5.3.1.2 For an STM-N Multiplex section

For an STM-N Multiplex section when N > 1, the test sequence still applies to only one C-4 container. The contents of the C-4 containers not filled with the test sequence shall be different from the test sequence. Examples of the filling bits are: fixed repetitive byte such as 00H or 6AH (Hexadecimal values) or a mapped PRBS. Alternatively, an unequipped VC-4 signal may be applied to containers not filled with the test sequence.

An example of measuring equipment connected to network entities according to this measurement mode is given in Figure I.2.

5.3.1.2.1 Events to be monitored

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B2 errors, MS-REI (Note), TSE
Defects	LOS, LOF, MS-AIS, MS-RDI, LSS
NOTE – When supported by the EUT.	

5.3.1.2.2 Test signal structures to be used

For this measurement mode, test signal structures TSS1 (see Note) and TSS5 apply.

NOTE – The use of non-mapped test sequences such as TSS1 is limited (see 5.3).

5.3.1.3 For a higher-order VC-4 path

An example of measuring equipment connected to network entities according to this measurement mode is given in Figure I.3.

5.3.1.3.1 Events to be monitored

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B3 errors (Note), HP-REI, TSE
Defects	LOS, LOF, MS-AIS, MS-RDI, AU-LOP (Note), AU-AIS (Note), HP-RDI, HP-TIM, LSS, HPTC RDI, HPTC-LTC
NOTE – B3 errors are related to the VC-4 SDH structure while AU-LOP and AU-AIS are related to the AU-4.	

5.3.1.3.2 Test signal structures to be used

For this measurement mode, test signal structures TSS1 (see Note) and TSS5 apply.

NOTE – The use of non-mapped test sequences such as TSS1 is limited (see 5.3).

5.3.2 Mode with higher-order container (C-3) end-to-end transparency

This mode shall be used when there is an end-to-end transparency at the C-3 level. In this case the C-3 within a VC-3 is associated with an AU-3 SDH multiplexing structure as defined in ITU-T Rec. G.707/Y.1322 [3].

5.3.2.1 For an STM-N Regenerator section

For an STM-N Regenerator section, the test sequence applies to only one C-3 container. The contents of the C-3 containers not filled with the test sequence shall be different from the test sequence. Examples of the filling bits are: fixed repetitive byte such as 00H or 6AH (Hexadecimal values) or a mapped PRBS. Alternatively, an unequipped VC-3 signal may be applied to containers not filled with the test sequence.

5.3.2.1.1 Events to be monitored

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B1 errors, TSE
Defects	LOS, LOF, RS-TIM, LSS

5.3.2.1.2 Test signal structures to be used

For this measurement mode, test signal structures TSS2 (see Note) and TSS6 apply.

NOTE – The use of non-mapped test sequences such as TSS2 is limited (see 5.3).

5.3.2.2 For an STM-N Multiplex section

For an STM-N Multiplex section, the test sequence applies to only one C-3 container. The contents of the C-3 containers not filled with the test sequence shall be different from the test sequence. Examples of the filling bits are: fixed repetitive byte such as 00H or 6AH (Hexadecimal values) or a mapped PRBS. Alternatively, an unequipped VC-3 signal may be applied to containers not filled with the test sequence.

5.3.2.2.1 Events to be monitored

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B2 errors, MS-REI (Note), TSE
Defects	LOS, LOF, MS-AIS, MS-RDI, LSS
NOTE – When supported by the EUT.	

5.3.2.2.2 Test signal structures to be used

For this measurement mode, test signal structures TSS2 (see Note) and TSS6 apply.

NOTE – The use of non-mapped test sequences such as TSS2 is limited (see 5.3).

5.3.2.3 For a higher-order VC-3 path

An example of measuring equipment connected to network entities according to this measurement mode is given in Figure I.3.

5.3.2.3.1 Events to be monitored

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B3 errors (Note), HP-REI, TSE
Defects	LOS, LOF, MS-AIS, MS-RDI, AU-LOP (Note), AU-AIS (Note), HP-RDI, HP-TIM, HP-LOM, HPTC-TIM, HPTC RDI, HPTC-LTC, LSS
NOTE – B3 errors are related to a VC-3 within an AU-3 SDH structure while AU-LOP and AU-AIS are related to an AU-3.	

5.3.2.3.2 Test signal structures to be used

For this measurement mode, test signal structures TSS2 (see Note) and TSS6 apply.

NOTE – The use of non-mapped test sequences such as TSS2 is limited (see 5.3).

5.3.3 Mode with lower-order container (C-3) end-to-end transparency

This mode shall be used when there is an end-to-end transparency at the C-3 lower-order container level. In this case the C-3 within a VC-3 is associated with an AU-4 SDH multiplexing structure as defined in ITU-T Rec. G.707/Y.1322 [3].

An example of measuring equipment connected to network entities according to this measurement mode is given in Figure I.4.

5.3.3.1 Events to be monitored

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B3 errors (Note), LP-REI, TSE
Defects	LOS, LOF, MS-AIS, MS-RDI, AU-LOP (Note), AU-AIS (Note), HP-RDI, HP-TIM, HP-LOM, HPTC-TIM, HPTC RDI, HPTC-LTC, LP-RDI, TU-LOP, TU-AIS, LP-TIM, LPTC-TIM, LPTC RDI, LPTC-LTC, LSS
NOTE – B3 errors are related to the VC-3 SDH structure while AU-LOP and AU-AIS are related to the AU-4.	

5.3.3.2 Test signal structures to be used

For this measurement mode, test signal structures TSS3 (see Note) and TSS7 apply.

NOTE – The use of non-mapped test sequences such as TSS3 is limited (see 5.3).

5.3.4 Mode with lower-order container (C-11/C-12/C-2) end-to-end transparency

An example of measuring equipment connected to network entities according to this measurement mode is given in Figure I.4.

5.3.4.1 Events to be monitored

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, BIP-2 errors, LP-REI, TSE
Defects	LOS, LOF, MS-AIS, MS-RDI, AU-LOP, AU-AIS, HP-RDI, HP-TIM, HP-LOM, HPTC-TIM, HPTC RDI, HPTC-LTC, LP-RDI, TU-LOP, TU-AIS, TU-LOM, LP-TIM, LPTC-TIM, LPTC RDI, LPTC-LTC, LSS

5.3.4.2 Test signal structures to be used

For this measurement mode, test signal structures TSS4 (see Note) and TSS8 apply.

NOTE – The use of non-mapped test sequences such as TSS4 is limited (see 5.3).

5.3.5 Mode with plesiochronous tributary mapping in a higher-order container (C-4)

This mode shall be used when there is an end-to-end transparency at the plesiochronous tributary level mapped in the C-4 container. In this case the C-4 within a VC-4 is associated with an AU-4 SDH multiplexing structure as defined in ITU-T Rec. G.707/Y.1322 [3].

An example of measuring equipment connected to network entities according to this measurement mode is given in Figure I.5.

5.3.5.1 Events to be monitored

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B3 errors (Note), HP-REI, TSE
Defects	LOS, LOF, MS-AIS, MS-RDI, AU-LOP (Note), AU-AIS (Note), HP-RDI, HP-TIM, , HP-LOM, HPTC-TIM, HPTC-TC-RDI, HPTC-LTC, LSS
NOTE – B3 errors are related to the VC-4 SDH structure while AU-LOP and AU-AIS are related to the AU-4.	

5.3.5.2 Test signal structures to be used

For this measurement mode, test signal structure TSS5 applies.

5.3.6 Mode with plesiochronous tributary mapping in a higher-order container (C-3)

This mode shall be used when there is an end-to-end transparency at the plesiochronous tributary level mapped in the C-3 container. In this case the C-3 within a VC-3 is associated with an AU-3 SDH multiplexing structure as defined in ITU-T Rec. G.707/Y.1322 [3].

An example of measuring equipment connected to network entities according to this measurement mode is given in Figure I.5.

5.3.6.1 Events to be monitored

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B3 errors (Note), HP-REI, TSE
Defects	LOS, LOF, MS-AIS, MS-RDI, AU-LOP (Note), AU-AIS (Note), HP-RDI, HP-TIM, HP-LOM, HPTC-TIM, HPTC RDI, HPTC-LTC, LSS
NOTE – B3 errors are related to the VC-3 within an AU-3 SDH structure while AU-LOP and AU-AIS are related to the AU-3.	

5.3.6.2 Test signal structures to be used

For this measurement mode, test signal structure TSS6 applies.

5.3.7 Mode with a plesiochronous tributary mapping in a lower-order container (C-3)

This mode shall be used when there is an end-to-end transparency at the plesiochronous tributary level mapped in the C-3 container. In this case the C-3 within a VC-4 is associated with an AU-4 SDH multiplexing structure as defined in ITU-T Rec. G.707/Y.1322 [3].

An example of measuring equipment connected to network entities according to this measurement mode is given in Figure I.6.

5.3.7.1 Events to be monitored

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B3 errors (Note), LP-REI, TSE
Defects	LOS, LOF, MS-AIS, MS-RDI, AU-LOP (Note), AU-AIS (Note), HP-RDI, HP-TIM, HP-LOM, HPTC-TIM, HPTC RDI, HPTC-LTC, LP-RDI, TU-LOP, TU-AIS, LP-TIM, LPTC-TIM, LPTC RDI, LPTC-LTC, LSS
NOTE – B3 errors are related to the VC-3 within an AU-4 SDH structure while AU-LOP and AU-AIS are related to the AU-4.	

5.3.7.2 Test signal structures to be used

For this measurement mode, test signal structure TSS7 applies.

5.3.8 Mode with a plesiochronous tributary mapping in a lower-order container (C-11/C-12/C-2)

This mode shall be used when there is an end-to-end transparency at the plesiochronous tributary level mapped in the C-11/C-12/C-2 container.

An example of measuring equipment connected to network entities according to this measurement mode is given in Figure I.6.

5.3.8.1 Events to be monitored

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, BIP-2 errors, LP-REI, TSE
Defects	LOS, LOF, MS-AIS, MS-RDI, AU-LOP, AU-AIS, HP-RDI, HP-TIM, HP-LOM, HPTC-TIM, HPTC RDI, HPTC-LTC, LP-RDI, TU-LOP, TU-AIS, TU-LOM, LP-TIM, LPTC-TIM, LPTC RDI, LPTC-LTC, LSS

5.3.8.2 Tests signal structures to be used

For this measurement mode, test signal structure TSS8 applies.

5.3.9 Mode with contiguous concatenated structures (VC-2-Xc and VC-4-Xc) end-to-end transparency

5.3.9.1 Events to be monitored

For VC-2-Xc the events to be monitored are defined in 5.3.4.1.

For VC-4-Xc the events to be monitored are defined in 5.3.1.3.1.

5.3.9.2 Tests signal structures to be used

For the measurement mode with VC-4-Xc, test signal structure TSS9 applies.

For the measurement mode with VC-2-Xc, test signal structure TSS10 applies.

5.4 In-service measurement modes

For each measurement mode, and according to the type of STM-N signal considered, a subset of network events to be monitored is taken from the list given in 5.2.

5.4.1 Events to be monitored for a STM-N Regenerator section

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B1 errors
Defects	LOS, LOF, RS-TIM

5.4.2 Events to be monitored for a Multiplex section

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B2 errors, MS-REI (Note)
Defects	LOS, LOF, MS-AIS, MS-RDI
NOTE – When supported by the EUT.	

5.4.3 Events to be monitored for a higher-order container (C-4)

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B3 errors (Note), HP-REI
Defects	LOS, LOF, MS-AIS, MS-RDI, AU-LOP (Note), AU-AIS (Note), HP-RDI, HP-TIM
NOTE – B3 errors are related to a VC-4 SDH structure while AU-LOP and AU-AIS are related to an AU-4.	

5.4.4 Events to be monitored for a higher-order container (C-3)

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B3 errors (Note), HP-REI
Defects	LOS, LOF, MS-AIS, MS-RDI, AU-LOP (Note), AU-AIS (Note), HP-RDI, HP-TIM, HP-LOM, HPTC-TIM, HPTC RDI, HPTC-LTC,
NOTE – B3 errors are related to the VC-3 within an AU-3 SDH structure while AU-LOP and AU-AIS are related to the AU-3.	

5.4.5 Events to be monitored for a lower-order container (C-3)

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, B3 errors (Note), LP-REI
Defects	LOS, LOF, MS-AIS, MS-RDI, AU-LOP (Note), AU-AIS (Note), HP-RDI, HP-TIM, HP-LOM, HPTC-TIM, HPTC RDI, HPTC-LTC, LP-RDI, TU-LOP, TU-AIS, LP-TIM, LPTC-TIM, LPTC RDI, LPTC-LTC
NOTE – B3 errors are related to the VC-3 within an AU-4 SDH structure while AU-LOP and AU-AIS are related to the AU-4.	

5.4.6 Events to be monitored for a lower-order container (C-11/C-12/C-2)

Type of event	List of monitored events for this measurement mode
Anomalies	OOF, BIP-2 errors, LP-REI
Defects	LOS, LOF, MS-AIS, MS-RDI, AU-LOP, AU-AIS, HP-RDI, HP-TIM, HP-LOM, HPTC-TIM, HPTC RDI, HPTC-LTC, LP-RDI, TU-LOP, TU-AIS, TU-LOM, LP-TIM, LPTC-TIM, LPTC RDI, LPTC-LTC

5.4.7 Events to be monitored for VC-2-Xc and VC-4-Xc contiguous concatenated structures

For VC-2-Xc the events to be monitored are defined in 5.4.6.

For VC-4-Xc the events to be monitored are defined in 5.4.3.

6 Generator

6.1 Synchronization of the generator

The measuring equipment shall have its generator synchronized to one of the different possible synchronization sources listed below:

- internal clock (its accuracy shall comply with ITU-T Rec. G.703 [1]);
- external clock input;
- STM-N input signal from the receiver part of the measuring equipment.

6.2 Bit rates

The bit rates delivered by the generator of the measuring equipment shall be in accordance with those defined in ITU-T Rec. G.707/Y.1322 [3].

6.3 Test signal structures

The generator of the measuring equipment shall generate different test signal structures in order to simulate real STM-N signals.

Depending on the type of STM-N signal and on the measurement mode, test signal structures are defined for different SDH frame structures. Test signal structures to be used are given in Annex C.

6.4 Digital signal outputs

6.4.1 Digital interfaces

The output signals generated by the generator of the measuring equipment shall be in accordance with the relevant SDH Recommendations (clause 15/G.703 [1] for an electrical STM-1 signal, ITU-T Rec. G.957 [10] for an optical STM-N signal up to N = 16 and G.691 [17] for N = 64 and 156).

6.4.2 Output jitter

The output jitter of the STM-N signal delivered by the generator of the measuring equipment shall comply with ITU-T Rec. G.783 [6].

7 Receiver

7.1 Digital signal inputs

7.1.1 Digital interfaces

The receiver of the measuring equipment shall accept input signals which are in accordance with the relevant SDH Recommendations (clause 15/G.703 [1] for an electrical STM-1 signal, ITU-T Rec. G.957 [10] for an optical STM-N signal up to N = 16 and G.691 [17] for N = 64 and 156).

7.1.2 Input jitter tolerance

With an STM-N input signal, the receiver of the measuring equipment shall tolerate an input jitter in accordance with ITU-T Rec. G.825 [8].

7.1.3 Protected monitoring points

7.1.3.1 Electrical protected monitoring points

The receiver of the measuring equipment may be able to perform measurements on electrical protected monitoring points. In this case, input signals which are in accordance with ITU-T Rec. G.772 [4] shall be accepted.

7.1.3.2 Optical protected monitoring points

For further study.

7.2 Test signal structures

The receiver of the measuring equipment shall analyze different test signal structures in order to perform error measurements.

Test signal structures to be used are given in Annex C.

7.3 Error performance measurement

This contains the definitions of the performance parameters for different measurement configurations and describes the use of the parameters for performance measurements, bringing-into-service and maintenance purposes.

7.3.1 Error performance measurement using ISM facilities only

This subclause is based on ITU-T Recs. G.826 [9], G.828 [19], G.829 [20] and G.784 [7]. For the purpose of this Recommendation, the "In-Service Monitoring facilities" correspond to the use of the overheads (POH and SOH) for monitoring tasks.

Typical measurement modes for error measurement are described in clause 5.

7.3.1.1 Type of measurement

In-Service error performance measurements are no longer based on the calculation of Bit Error Ratio. One of the underlying concepts of error performance is the notion of **Errored Blocks**, i.e. blocks in which one or more bits are in error. A block is a set of consecutive bits associated with the path or section monitored by means of an Error Detection Code (EDC), e.g. Bit Interleaved Parity (BIP). Tables 7-1 to 7-3 give for each type of SDH entity (path, multiplex section, regenerator section) the length of the block (expressed in terms of number of bits per block) and the related EDC.

Table 7-1/O.181 – Length of blocks and choice of the EDC for different paths

VC Type	Bits/Block	EDC	Blocks/s
VC-11	832	BIP-2	2000
VC-12	1120	BIP-2	2000
VC-2	3424	BIP-2	2000
VC-2-nc (Note)	3424 × n	BIP-2	2000
VC-3	6120	BIP-8	8000
VC-4	18 792	BIP-8	8000
VC-4-4c	75 168	BIP-8	8000
VC-4-16c	300 672	BIP-8	8000
VC-4-64c	1 202 688	BIP-8	8000
NOTE – Applies to contiguous concatenation.			

Table 7-2/O.181 – Length of blocks and choice of the EDC for multiplex sections

STM Type	Bits/Block	EDC	Blocks/s
STM-1	801	24 × BIP-1	192 000
STM-4	801	96 × BIP-1	768 000
STM-16	801	384 × BIP-1	3 072 000
STM-64	801	1 536 × BIP-1	12 288 000

Table 7-3/O.181 – Length of blocks and choice of the EDC for regenerator sections

STM Type	Bits/Block	EDC	Blocks/s
STM-1	19 440	BIP-8	8000
STM-4	19 440	4 × BIP-8	4 × 8000
STM-16	19 440	16 × BIP-8	16 × 8000
NOTE – The EDC for SDH regenerator sections is a media specific indicator, which is under study in other ITU Study Groups for media-specific error performance purposes. The assessment of these block errors is an optional requirement for test equipment according to ITU-T Rec. O.181.			

7.3.1.2 Error performance events

The following error performance events are defined in accordance with ITU-T Recs. G.826 [9] and G.828 [19]:

- Errored Block (EB);
- Errored Second (ES);
- Severely Errored Second (SES);
- Background Block Error (BBE).

An optional error performance event is defined in accordance with ITU-T Recs. G.828 [19]

- Severely Errored Period (SEP).

SDH equipment provides information on occurrences such as anomalies and defects. The indications related to performance measurements are listed in 5.2 and defined in Annex A.

In addition, Tables B.1 to B.3 classify for each type of SDH entities these anomalies and defects. Some of this information is not related to performance measurements but is used for maintenance purposes.

Indications not related to error performance shall be registered for later use, such as display on demand.

Only the anomalies and defects related to error performance are taken into account in the following subclause.

7.3.1.3 Error performance parameters

Error performance parameters should only be evaluated during **available time**. Availability and unavailability conditions are defined in ITU-T Recs. G.826 [9] and G.828 [19]. The three-error performance parameters defined in ITU-T Rec. G.826 and G.828 [19] which are used in this Recommendation are:

- Errored Second Ratio (ESR);
- Severely Errored Second Ratio (SESR);
- Background Block Error Ratio (BBER).

An optional error performance parameter is defined in ITU-T Rec. G.828 [19]

- Severely Errored Period Intensity (SEPI).

Clauses A.1 to A.3 list events detected in the signal sent from one end (the far end) of a bidirectional path and received at the other end (the near end). Most of these events are used to assess the performance of this signal, but some of them are used to assess the performance of the reverse direction. Tables 7-4 to 7-6 specify for each event which parameter shall be evaluated at the near end and indicate the direction (with regard to the near end) of the signal to which the performance evaluation is related. Figure 7-1 illustrates these conventions.

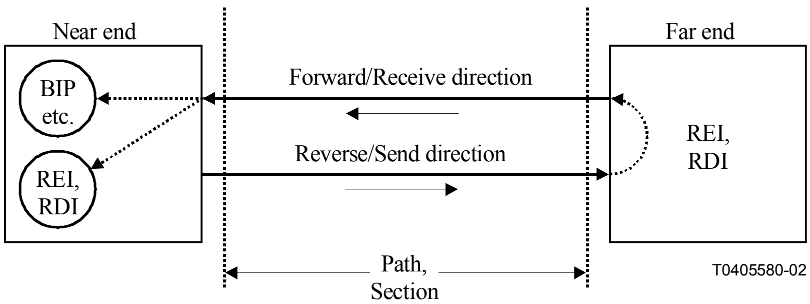


Figure 7-1/O.181 – Evaluation of the forward and reverse direction of a path or section

Table 7-4/O.181 – Use of SDH network events on paths for performance measurement

Indication	Direction	Parameter
B3 errors	Receive	ESR/SESR/BBER/SEPI
HP-REI	Send	ESR/SESR/BBER/SEPI
LP-REI	Send	ESR/SESR/BBER/SEPI
BIP-2 errors	Receive	ESR/SESR/BBER/SEPI
AU-LOP	Receive	ESR/SESR/SEPI
AU-AIS	Receive	ESR/SESR/SEPI
HP VC-AIS	Receive	ESR/SESR/SEPI
HP-UNEQ	Receive	ESR/SESR/SEPI
HP-RDI	Send	ESR/SESR/SEPI
TU-LOP	Receive	ESR/SESR/SEPI
TU-AIS	Receive	ESR/SESR/SEPI
HP-PLM	Receive	ESR/SESR/SEPI
HP-LOM	Receive	ESR/SESR/SEPI
HP-TIM	Receive	(Note 1)
LP-TIM	Receive	(Note 1)
LP VC-AIS	Receive	ESR/SESR/SEPI
LP-UNEQ	Receive	ESR/SESR/SEPI
LP-RDI	Send	ESR/SESR/SEPI
NOTE 1 – For in-service or out-of-service measurements, HP-TIM and LP-TIM can be retained for information purposes and, in context of the measurement, used for evaluating ESR/SESR parameters. This choice should be offered to the user. NOTE 2 – SEPI is an optional parameter.		

Table 7-5/O.181 – Use of SDH network events on multiplex sections for performance measurement

Indication	Direction	Event (Note 2)
B2 errors	Receive	ES/SES/BBE
MS-AIS	Receive	ES/SES
MS-RDI	Send	ES/SES
MS-REI (Note 1)	Send	ES/SES/BBE
NOTE 1 – When supported by the EUT. NOTE 2 – ITU-T Rec. G.829 [20] defines only performance events.		

Table 7-6/O.181 – Use of SDH network events on regenerator sections for performance measurement

Indication	Direction	Event (Note)
OOF	Receive	ES/SES/BBE
B1 errors	Receive	ES/SES/BBE
LOS	Receive	ES/SES
RS-TIM	Receive	ES/SES
LOF	Receive	ES/SES
NOTE – ITU-T Rec. G.829 [20] defines only performance events.		

7.3.2 Error measurement using both ISM facilities and test sequence information

The block definition depending on the EDC monitoring this block shall not be altered if test sequences are applied to the entity under test in addition to using the ISM facilities. Whatever facility is used to detect the errors, only one errored block shall be counted regardless of the actual number of detected errors. It is not necessary that the instrument provides more detailed information about the way it detected the errors. Analysis of discrepancies between the two means of measurement (ISM facilities only and ISM facilities/test sequence information) is not required.

When using a test sequence for performance measurements, the events listed in Table 7-7 shall be monitored in addition to those listed in the relevant network events table (Tables 7-4 to 7-6).

Table 7-7/O.181 – Use of additional events when using test sequence

Indication	Direction	Parameter
TSE	Receive	ESR/BBER/SESR
LSS	Receive	ESR/SESR

7.3.3 Use of the performance parameters

Error performance figures are normally obtained as a result of long-term measurements (e.g. over a period of one month). For bringing-into-service, however, shorter tests are suggested. In this case, guidance can be found in ITU-T Rec. M.2101 [11]. When providing performance information for digital paths, the instrumentation shall operate in accordance with ITU-T Rec. G.826 [9], G.828 [19] and G.829 [20].

7.3.4 Additional error measurement

In addition to error performance measurements based upon the evaluation of errored blocks, the measurement equipment may provide a count of binary errors on the test sequences and/or a count of errors detected on the received STM-N signal by an EDC.

8 Miscellaneous functions

These functions do not directly influence the error performance measurement definitions and shall be considered as optional for the measuring equipment.

8.1 Display

The measuring equipment may include a display to provide easier access to the configuration and measurement parameters.

8.2 Anomaly and defect addition on the output signal

The measuring equipment may add anomalies and defects to the output signal of the generator to simulate impairments.

8.3 Alarm and error indication

The measuring equipment may display the most important anomalies and defects detected by its receiver.

8.4 Access to overhead bytes

The measuring equipment may display the most important SOH and POH bytes of the STM-N signal analyzed by its receiver.

8.5 Demultiplexing capability

The measuring equipment may provide a demultiplexing capability in order to output a tributary from the received STM-N signal.

8.6 Events time stamping

The measuring equipment may provide the facility to time stamp the different monitored events during error performance measurements. A convenient time stamping resolution is one second.

8.7 Output to external recording devices

The measuring equipment may provide the facility to connect an external recording device (e.g. a printer) using an interface in accordance with ITU-T Recs. V.24 [14] and V.28 [15].

8.8 Remote control port

The measuring equipment may be remotely controlled using an interface in accordance with IEEE 488.1/IEC 60625 Specification or ITU-T Recs. V.24 [14] and V.28 [15].

8.9 TMN interface

The measuring equipment may have an appropriate Q interface providing TMN facilities.

8.10 Access to Data Communication Channels

The measuring equipment may provide error performance capabilities on the Data Communication Channels (DCC: D1 to D3 or D4 to D12 bytes of the SOH of the SDH frame).

9 Operating conditions

9.1 Environmental conditions

To perform the functions listed in this Recommendation, the measuring equipment shall operate under conditions according to ITU-T Rec. O.3 [13].

9.2 Behaviour in case of power failure

A power interruption shall be indicated by the measuring equipment.

Annex A

Criteria for detecting anomalies and defects

NOTE – The list of network defects and anomalies found in this annex shall conform to the last agreed versions of the relevant SDH Recommendations such as G.707/Y.1322 [3] and G.783 [6].

A.1 Anomalies related to performance measurements

A.1.1 Out of Frame (OOF)

The criteria for the detection of an OOF anomaly shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6].

A.1.2 B1 errors

The parity errors evaluated by byte B1 (BIP-8) of an STM-N shall be monitored. If any of the eight parity checks fails, the corresponding block is assumed to be in error.

A.1.3 B2 errors

The parity errors evaluated by bytes B2 (BIP-24 × N) of an STM-N shall be monitored. If any of the N times twenty four parity checks fails, the corresponding block is assumed to be in error.

A.1.4 B3 errors

The parity errors evaluated by byte B3 (BIP-8) of a VC-n (n = 3, 4) shall be monitored. If any of the eight parity checks fails, the corresponding block is assumed to be in error.

A.1.5 Multiplex Section Remote Error Indication (MS-REI)

The indication of MS-REI, when supported by the EUT, contained in bits 1 to 8 of byte M1 and M0 (in the case of STM-64 and STM-256) of the MSOH shall be monitored.

A.1.6 Higher-order Path Remote Error Indication (HP-REI)

The indication of HP-REI contained in bits 1 to 4 of byte G1 of a VC-n (n = 3, 4) shall be monitored.

A.1.7 Lower-order Path Remote Error Indication (LP-REI)

The indication of LP-REI contained in bits 1 to 4 of byte G1 of a VC-3 shall be monitored.

The indication of LP-REI contained in bit 3 of byte V5 of a VC-m (m = 11, 12, 2) shall be monitored.

A.1.8 BIP-2 errors

The parity errors contained in bits 1 and 2 (BIP-2: Bit Interleaved Parity-2) of byte V5 of a VC-m (m = 11, 12, 2) shall be monitored. If any of the two parity checks fails, the corresponding block is assumed to be in error.

A.1.9 Test Sequence Error (TSE)

A TSE occurs when one or more bit errors are detected on the test sequence in the set of consecutive bits associated with the path and corresponding to one block monitored by the related BIP.

A.2 Defects related to performance measurements

A.2.1 Loss of Signal (LOS)

Criteria are defined for both optical and electrical interfaces.

The criteria for the detection of an LOS defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6].

Measuring equipment shall be able to detect LOS at its G.703 [1] PDH interfaces, when provided. Related criteria are defined in ITU-T Rec. G.775 [5].

A.2.2 Loss of Frame (LOF)

The criteria for the detection of an LOF defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6].

NOTE – When the byte synchronous mapping of an external 1.5 or 2 Mbit/s signal is implemented within the measuring equipment, it shall be able to detect a loss of frame alignment condition for that signal according to the strategy described in ITU-T Rec. G.706 [2].

A.2.3 Regenerator Section Trace Identifier Mismatch (RS-TIM)

The criteria for the detection of an RS-TIM defect using the information contained in byte J0 of the RSOH shall be in accordance with the criteria defined in ITU-T Rec. G.806 [18].

A.2.4 Multiplex Section Alarm Indication Signal (MS-AIS)

The criteria for the detection of an MS-AIS defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6].

A.2.5 Multiplex Section Remote Defect Indication (MS-RDI)

The criteria for the detection of an MS-RDI defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6].

A.2.6 Administrative Unit Loss of Pointer (AU-LOP)

The criteria for the detection of an AU-LOP defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6].

A.2.7 Administrative Unit Alarm Indication Signal (AU-AIS)

The criteria for the detection of an AU-AIS defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6].

A.2.8 Higher-order Path Remote Defect Indication (HP-RDI)

The criteria for the detection of an HP-RDI defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6].

A.2.9 Higher-order Path Trace Identifier Mismatch (HP-TIM)

The criteria for the detection of an HP-TIM defect using the information contained in byte J1 of a VC-n (n = 3, 4) shall be in accordance with the criteria defined in ITU-T Rec. G.806 [18].

A.2.10 Higher-order Path Loss of Multiframe (HP-LOM)

The criteria for the detection of a HP-LOM defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6].

A.2.11 Tributary Unit Loss of Pointer (TU-LOP)

The criteria for the detection of a TU-LOP defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6].

A.2.12 Tributary Unit Alarm Indication Signal (TU-AIS)

The criteria for the detection of a TU-AIS defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6].

A.2.13 Lower-order Path Remote Defect Indication (LP-RDI)

The criteria for the detection of an LP-RDI defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6].

A.2.14 Lower-order Path Trace Identifier Mismatch (LP-TIM)

The criteria for the detection of an LP-TIM defect using the information contained in byte J1 of a VC-3 shall be in accordance with the criteria defined in ITU-T Rec. G.806 [18].

The criteria for the detection of an LP-TIM defect using the information contained in byte J2 of a VC-m (m = 11, 12, 2) shall be in accordance with the criteria defined in ITU-T Rec. G.806 [18].

A.2.15 Loss of Sequence Synchronization (LSS)

The criteria for LSS shall be in accordance with the criteria defined in ITU-T Rec. O.150 [12].

A.3 Other events not related to performance measurement

A.3.1 Higher-order Path PayLoad Mismatch (HP-PLM)

The criteria for the detection of an HP-PLM defect using the information contained in byte C2 of a VC-n (n = 3, 4) are under study.

A.3.2 Lower-order Path PayLoad Mismatch (LP-PLM)

The criteria for the detection of an LP-PLM defect using the information contained in byte C2 of a VC-3 are under study.

The criteria for the detection of an LP-PLM defect using the information contained in bits 5, 6 and 7 of byte V5 of a VC-m (m = 11, 12, 2) are under study.

A.3.3 Higher-order Path unequipped (HP-UNEQ)

The criteria for the detection of an HP-UNEQ defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [6]

A.3.4 Lower-order Path unequipped (LP-UNEQ)

The criteria for the detection of an LP-UNEQ defect shall be in accordance with the criteria defined in ITU-T Rec. G.783 [7]

A.3.5 Loss of timing input

When a measuring equipment is synchronized via an external synchronization interface, it shall be capable to detect a loss of timing input.

A.3.6 Lower-order Path Remote Failure Indication (LP-RFI)

An LP-RFI shall be declared when the bit 4 of the V5 byte of a VC-2/VC-1 path overhead is set to 1. The LP-RFI shall be cleared when this bit 4 is set to zero.

A.4 Other information

This clause lists items which are not yet classified depending on whether they are affecting error performance or not.

A.4.1 Pointer Justification Counts (PJC+, PJC–)

The necessity to monitor PJC+ and PJC– is for further study.

Annex B

Classification of SDH available indications

B.1 Anomaly and defect indications

This annex classifies anomaly and defect indications, whether they are related to error performance or not, according to the type of SDH entity under error performance measurement. See Tables B.1 to B.3.

NOTE – The list of network defects and anomalies found in this annex shall conform to the last agreed versions of the relevant SDH and error performance Recommendations such as G.707/Y.1322 [3], G.783 [6], G.806 [18], G.826 [9], G.828 [19], G.829 [20].

Table B.1/O.181 – Classification of indications available on SDH paths

Indication	Type of indication	Indication related to error performance	Indication not related to error performance
PJC+, PJC–	Under study	Under study	Under study
B3 errors	Anomaly	X	
HP-REI	Anomaly	X	
LP-REI	Anomaly	X	
BIP-2 errors	Anomaly	X	
AU-LOP	Defect	X	
AU-AIS	Defect	X	
HP VC-AIS	Defect	X	
HP-PLM	Defect	X	
HP-TIM	Defect	X	
HP-RDI	Defect	X	
HP-UNEQ	Defect	X	
HPTC-UNEQ	Defect	X	
HPTC-LTC	Defect	X	
HP-LOM	Defect		X
TU-LOP	Defect	X	
TU-AIS	Defect	X	
LP VC-AIS	Defect	X	
LP-PLM	Defect		X
LP-TIM	Defect	X	
LPTC-TIM	Defect	X	
LP-RDI	Defect	X	
LP-UNEQ	Defect	X	
LPTC-UNEQ	Defect	X	

Table B.2/O.181 – Classification of indications available on SDH multiplex sections

Indication	Type of indication	Indication related to error performance	Indication not related to error performance
B2 errors	Anomaly	X	
MS-AIS	Defect	X	
MS-RDI	Defect	X	
MS-REI	Anomaly	X	
.			

Table B.3/O.181 – Classification of indications available on SDH regenerator sections

Indication	Type of indication	Indication related to error performance	Indication not related to error performance
OOF	Anomaly		X
B1 errors	Anomaly	X	
LOS	Defect	X	
LOF	Defect	X	
RS-TIM	Defect	X	

Annex C

List of test signal structures

A test signal structure is a test sequence which is applied to a given SDH signal structure as defined in ITU-T Rec. G.707/Y.1322 [3].

All AU-n or TU-m included in a test signal structure and not used for performance measurement shall be configured with correct settings of the overhead bytes and valid pointers according to ITU-T Rec.G.707/Y.1322 [3]. This shall not preclude the insertion of an AU-AIS or TU-AIS on those AU-n or TU-m.

The use of the test signal structures TSS1 up to TSS4 is optional and limited as defined in 5.3.

When cross-testing is required between PDH and SDH ports of an entity under test, signal structures TSS5 to TSS8 shall be used. Interworking with PDH test equipment according to ITU-T Rec. O.150 [12] is then possible.

To ensure compatibility with SDH network equipment when transporting test signals, unique signal labels have been assigned according to ITU-T Rec.G.707/Y.1322 [3]. A value of FEH (byte C2) shall be used for HO paths and a value of 110 (bits 5, 6, 7 of byte V5) shall be used for LO paths when applying TSS1 to 4 or other O.181 test signals such as fixed repetitive byte mappings not defined in ITU-T Rec.G.703/Y.1322 [3].

C.1 Test signal structure TSS1 applied to all bytes of a C-4 higher-order container

For testing NEs providing HPC and using an AU-4 structure, the test signal structure TSS1 is a PRBS (Pseudo Random Binary Sequence) test sequence with a length of $2^{23} - 1$ bits according to 5.6/O.150 [12] which is applied to all bytes of a C-4 container. See Figure C.1.

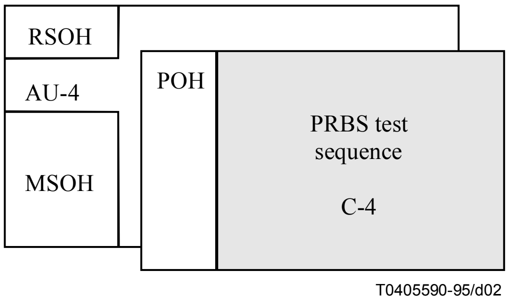


Figure C.1/O.181 – TSS1 test signal structure

C.2 Test signal structure TSS2 applied to all bytes of a C-3 higher-order container

For testing NEs providing HPC and using an AU-3 structure, the test signal structure TSS2 is a PRBS test sequence with a length of $2^{15} – 1$ bits according to 5.3/O.150 [12] which is applied to all bytes of a C-3 higher-order container. See Figure C.2.

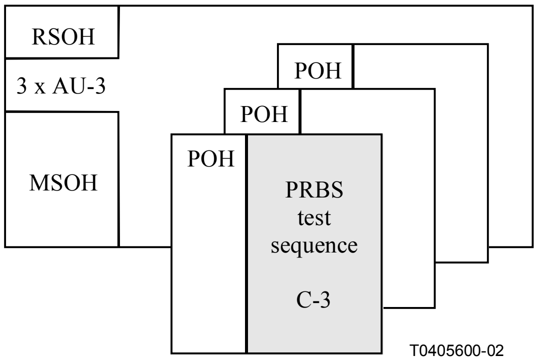


Figure C.2/O.181 – TSS2 test signal structure

C.3 Test signal structure TSS3 applied to all bytes of a C-3 lower-order container

For testing NEs providing HPC and LPC functions, the test signal structure TSS3 is a PRBS test sequence with a length of $2^{23} – 1$ bits according to 5.6/O.150 [12] which is applied to all bytes of a C-3 lower-order container. See Figure C.3.

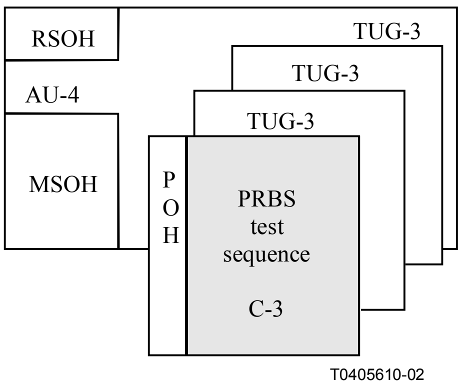


Figure C.3/O.181 – TSS3 test signal structure

C.4 Test signal structure TSS4 applied to all bytes of (C-2, C-12, C-11) lower-order containers

For testing NEs providing HPC and LPC functions, the test signal structure TSS4 is a PRBS test sequence with a length of $2^{15} - 1$ bits according to 5.3/O.150 [12] which is applied to all bytes of a (C-2, C-12 or C-11) lower-order container. See Figure C.4.

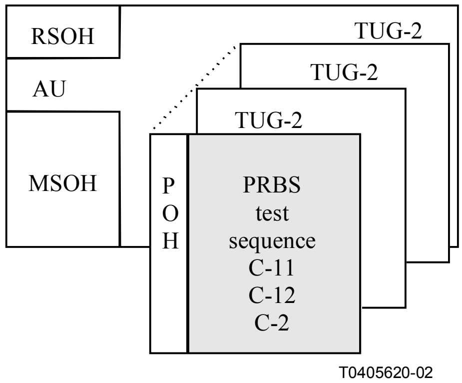


Figure C.4/O.181 – TSS4 test signal structure

C.5 Test signal structure TSS5 applied to all PDH tributary bits mapped in a C-4 container

For testing NEs providing LPA-4 functions only and using an AU-4 structure, the test signal structure TSS5 is a PRBS test sequence with a length of $2^{23} - 1$ bits according to 5.6/O.150 [12] which is applied to all PDH tributary bits mapped in a C-4 container. See Figure C.5.

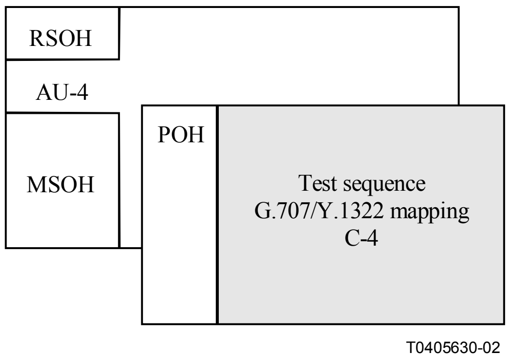


Figure C.5/O.181 - TSS5 test signal structure

C.6 Test signal structure TSS6 applied to all PDH tributary bits mapped in a higher-order C-3 container

For testing NEs providing LPA-3 functions only and using an AU-3 structure, the test signal structure TSS6 is a PRBS test sequence with a length of $2^{15} - 1$ bits according to 5.3/O.150 [12] which is applied to all PDH tributary bits mapped in a higher-order C-3 container. See Figure C.6.

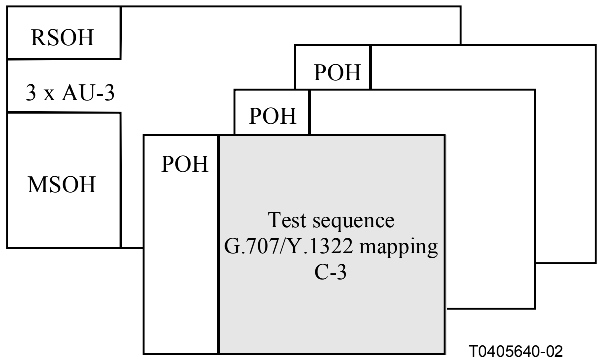


Figure C.6/O.181 – TSS6 test signal structure

C.7 Test signal structure TSS7 applied to all PDH tributary bits mapped in a lower-order C-3 container

For testing NEs providing LPA-3 functions only and using an AU-4 structure, the test signal structure TSS7 is a PRBS test sequence with a length of $2^{23} - 1$ bits according to 5.6/O.150 [12] which is applied to all PDH tributary bits mapped in a lower-order C-3 container. See Figure C.7.

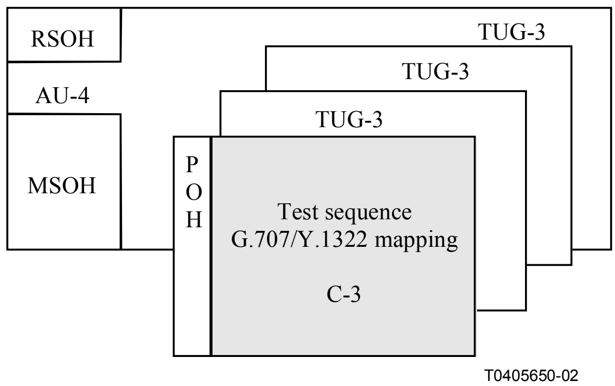


Figure C.7/O.181 – TSS7 test signal structure

C.8 Test signal structure TSS8 applied to all PDH tributary bits mapped in a lower-order (C-2, C-11, C-12) container

For testing NEs providing LPA-m (m = 11, 12, 2), the test signal structure TSS8 is a PRBS test sequence with a length of $2^{15} - 1$ bits according to 5.3/O.150 [12] which is applied to all PDH tributary bits mapped in a lower-order container (C-2, C-11 or C-12). See Figure C.8.

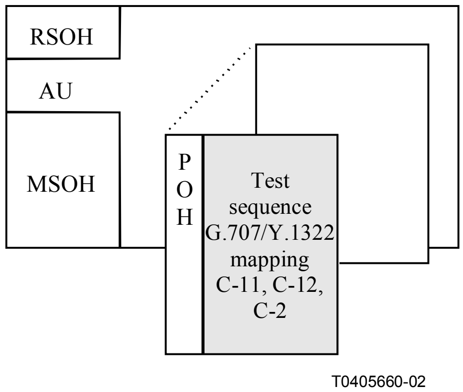


Figure C.8/O.181 – TSS8 test signal structure

C.9 Test signal structure applied to VC-4-Xc contiguous concatenated structures

The STM-N test signal structure illustrated in Figure C.9 is a PRBS test sequence of length $2^{23} – 1$ bits or $2^{31} – 1$ bits according to ITU-T Rec. O.150 [12], which is applied to all payload bytes of the C-4-Xc concatenated container.

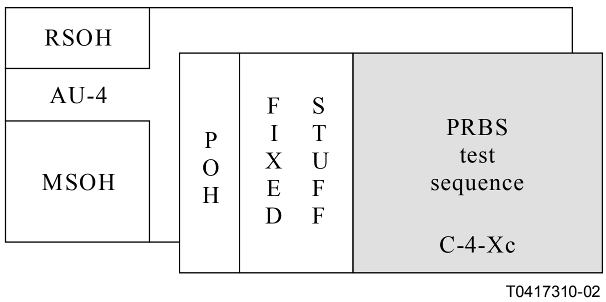


Figure C.9/O.181 – TSS9 test signal structure

C.10 Test signal structure applied to VC-2-Xc contiguous concatenated structures

The STM-N test signal structure illustrated in Figure C.10 is a PRBS test sequence of length $2^{15} – 1$ bits according to ITU-T Rec. O.150 [12], which is applied to all payload bytes of the C-2-Xc concatenated container.

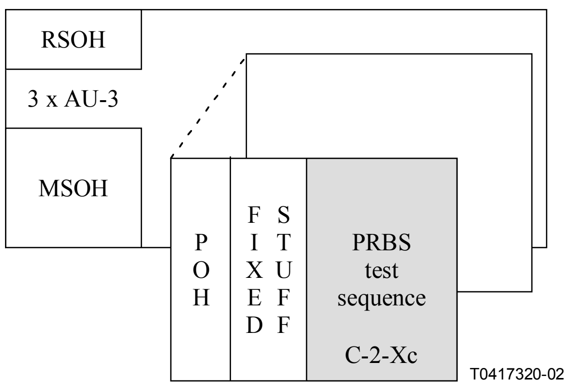


Figure C.10 – TSS10 test signal structure

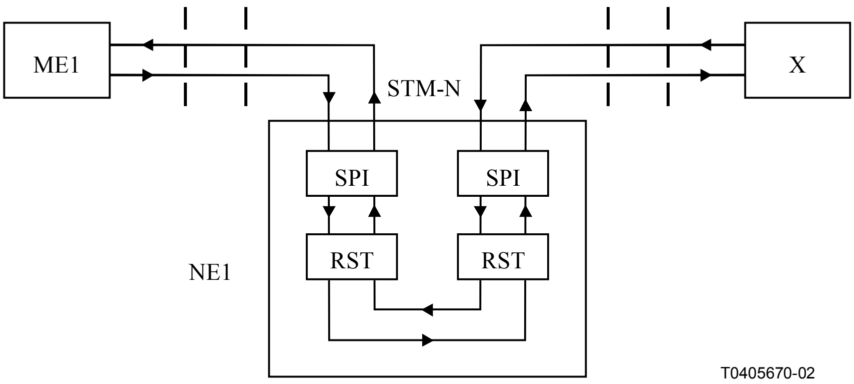
Appendix I

Examples of measuring equipment connections to network elements illustrating different out-of-service measurement modes

In Figures I.1 to I.6, network elements are described according to the generalized block diagram of ITU-T Rec. G.783 (see Figure 1-1/G.783 [6] that shows basic and compound functions which may be combined in SDH equipment.

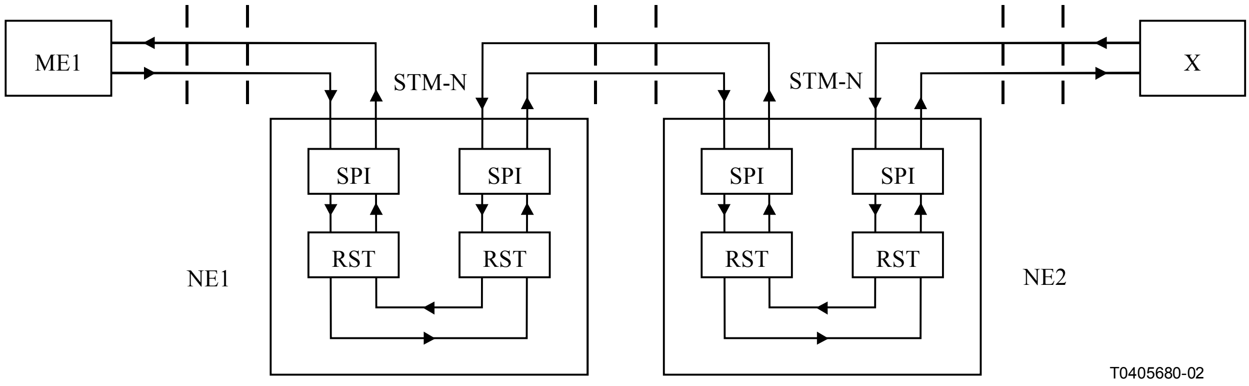
In these figures, the following abbreviations are used:

- NE Network Element.
- ME Measuring Equipment working in independent reception and transmission mode.
- X This can represent either a loop-back at the physical layer level (via an attenuator, for example), or a loop-back at a Network Element level, or a Measuring Equipment working in transparent mode or else a Measuring Equipment working in independent reception and transmission mode.



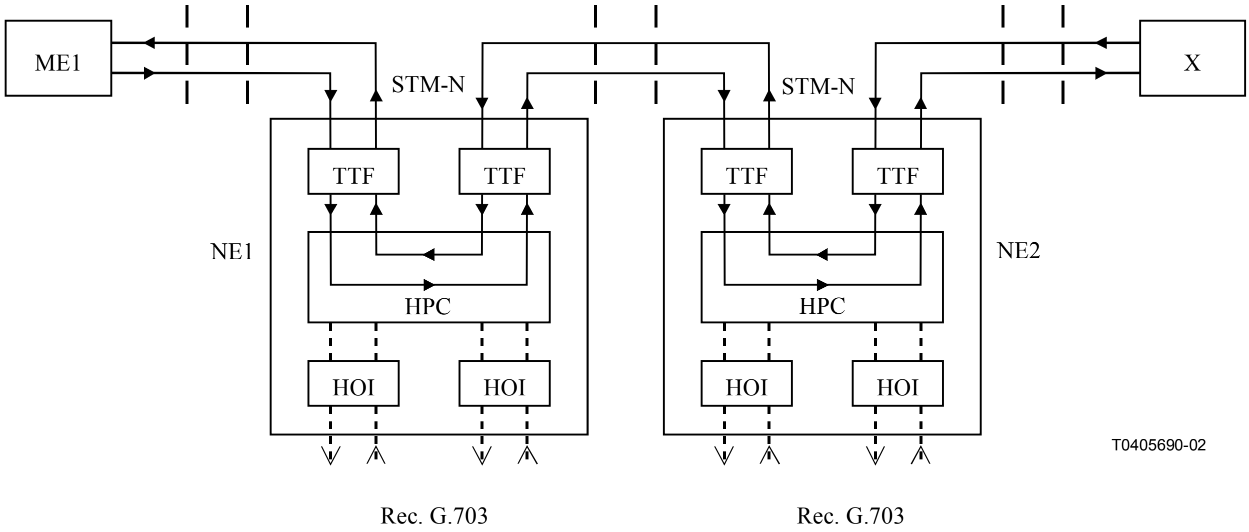
NOTE – In this configuration, any error activity in the sections ME1 NE1 or NE1X is likely to cause a change in the B1 value calculated at the end of the corresponding section. NE1 is a regenerator. Multiplex section end-to-end transparency is performed as shown by the arrows.

Figure I.1/O.181 – Example of out-of-service error performance measurement on a regenerator section



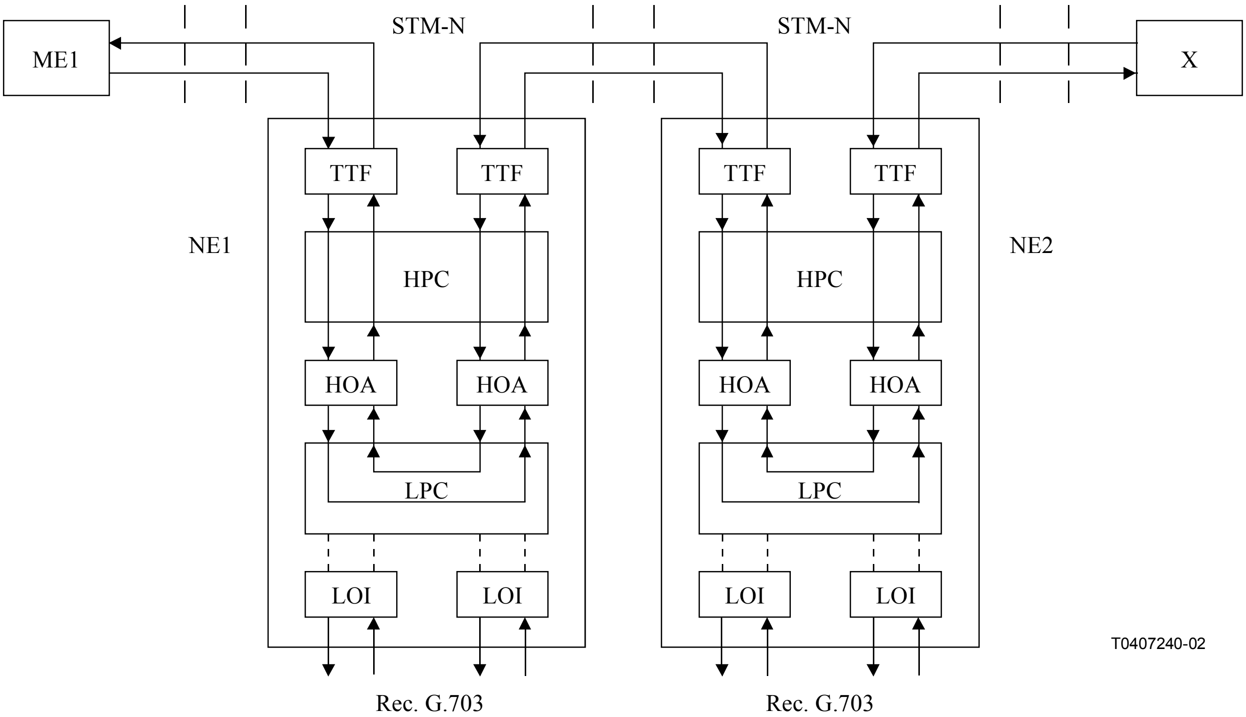
NOTE – NE1 and NE2 are regenerators. VC-3/VC-4 end-to-end transparency is performed as shown by the arrows.

Figure I.2/O.181 –Example of out-of-service error performance measurement on a multiplex section



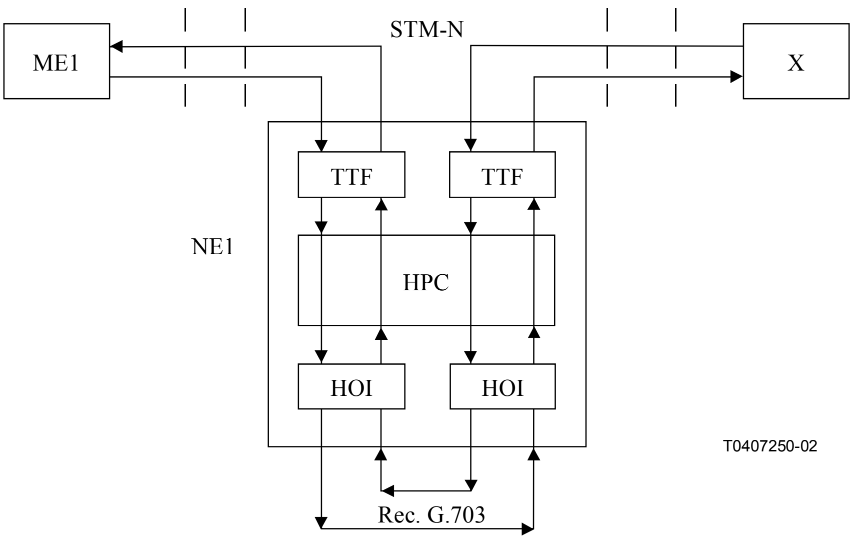
NOTE – NE1 and NE2 are cross-connects type I. The HCS function is omitted. C-3/C-4 end-to-end transparency is performed as shown by the arrows.

Figure I.3/O.181 –Example of out-of-service error performance measurement with higher-order container (C-3/C-4) end-to-end transparency



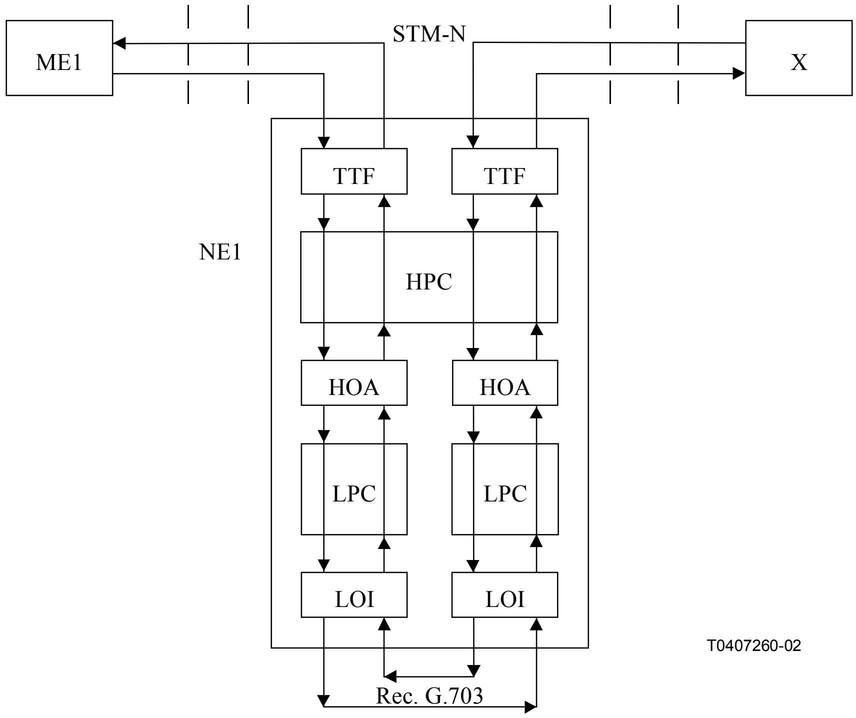
NOTE – NE1 and NE2 are multiplexers type III.1. C-11/C-12/C-2/C-3 end-to-end transparency is performed as shown by the arrows.

Figure I.4/O.181 –Example of out-of-service error performance measurement with lower-order container (C-11/C-12/C-2/C-3) end-to-end transparency



NOTE – In this configuration, any error activity in the sections ME1 NE1 or NE1X is likely to produce a change in the B3 value calculated at the end of the corresponding path. NE1 is a cross-connect type I. The HCS function is omitted. ME1 performs the plesiochronous tributary mapping in a higher-order container. PDH tributary end-to-end transparency is performed as shown by the arrows.

Figure I.5/O.181 –Example of out-of-service error performance measurement with plesiochronous tributary mapping in a higher-order container (C-3/C-4)



NOTE – In this configuration, any error activity in the sections ME1 NE1 or NE1X is likely to produce a change in the B3/BIP-2 value calculated at the end of the corresponding path. NE1 is a multiplexer type III-1. ME1 performs the plesiochronous tributary mapping in a lower-order container. PDH tributary end-to-end transparency is performed as shown by the arrows.

Figure I.6/O.181 –Example of out-of-service error performance measurement with plesiochronous tributary mapping in a lower-order container (C-11/C-12/C-2/C-3)

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