

International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

O.182

(07/2007)

**SERIES O: SPECIFICATIONS OF MEASURING
EQUIPMENT**

Equipment for the measurement of digital and
analogue/digital parameters

**Equipment to assess error performance on
Optical Transport Network interfaces**

ITU-T Recommendation O.182

ITU-T O-SERIES RECOMMENDATIONS
SPECIFICATIONS OF MEASURING EQUIPMENT

General	O.1–O.9
Maintenance access	O.10–O.19
Automatic and semi-automatic measuring systems	O.20–O.39
Equipment for the measurement of analogue parameters	O.40–O.129
Equipment for the measurement of digital and analogue/digital parameters	O.130–O.199
Equipment for the measurement of optical channel parameters	O.200–O.209
Equipment to perform measurements on IP networks	O.210–O.219

For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation O.182

Equipment to assess error performance on Optical Transport Network interfaces

Summary

ITU-T Recommendation O.182 specifies measuring equipment for monitoring defects and anomalies and for measuring error performance and forward error correction (FEC) efficiency at the OCh layer of the optical transport network (OTN).

Source

ITU-T Recommendation O.182 was approved on 22 July 2007 by ITU-T Study Group 4 (2005-2008) under the ITU-T Recommendation A.8 procedure.

Keywords

Error performance, Forward Error Correction, In-service, Measuring equipment, Measurement mode, Optical Transport Network, Out-of-service, Test Signal Structure.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. 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 Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

© ITU 2008

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

CONTENTS

Page

1	Scope	1
2	References.....	1
3	Definitions	2
3.1	Terms defined elsewhere.....	2
3.2	Terms defined in this Recommendation.....	2
4	Abbreviations and acronyms	3
5	Conventions and background	5
5.1	Conventions.....	5
5.2	Background.....	5
6	Measurement modes	6
7	Events to be monitored	6
7.1	Network events.....	7
7.2	Test signal structure events	8
7.3	Forward error correction (FEC) events	8
7.4	Events to be monitored at the OCh layer.....	8
7.5	Test signal structure to be used at OPuk layer.....	9
8	Generator	10
8.1	Synchronization.....	10
8.2	Bit rates.....	10
8.3	Test signal structures	10
8.4	Digital signal outputs.....	10
8.5	Anomaly and defect addition on the output signal.....	10
9	Receiver.....	10
9.1	Digital signal inputs.....	10
9.2	Test signal structures	11
9.3	Error performance measurement	11
9.4	Defects and anomalies indication.....	13
9.5	Events time stamping	13
10	Forward error correction (FEC) performance verification functions	13
10.1	Parameters and results	13
10.2	Error generation.....	14
10.3	Measurement of the error correction and detection.....	14
11	Miscellaneous functions	16
11.1	FEC activation.....	16
11.2	Display.....	16
11.3	Access to overhead bytes.....	16

	Page
11.4 Output to external recording devices.....	16
11.5 Remote control port.....	16
12 Operating conditions.....	16
12.1 Environmental conditions.....	16
12.2 Behaviour in case of power failure.....	16
Annex A – Criteria for detecting anomalies and defects	17
A.1 Anomalies.....	17
A.2 Defects.....	18
A.3 Other information	19
Annex B – List of test signal structures	21
B.1 Test signal structure TSS1 applied to all bytes of a CBR2G5	21
B.2 Test signal structure TSS2 applied to all bytes of a CBR10G	21
B.3 Test signal structure TSS3 applied to all bytes of a CBR40G	22
B.4 Test signal structure TSS4 applied to NULL/PRBS	22
Annex C – Procedure of goodness of fit for Poisson distribution by χ^2 test.....	24
C.1 Introduction	24
C.2 Fundamental properties	24
C.3 Other properties	24
Appendix I – Test of goodness of fit for Poisson distribution by χ^2 test	27
I.1 Introduction	27
I.2 Test of goodness of fit by χ^2 test	27
I.3 Theory of χ^2 test.....	28
I.4 Application of test of goodness of fit to Poisson distribution	30
Bibliography.....	38

Copyright International Telecommunication Union/ITU Telecommunication Sector
 Provided by IHS Markit under license with ITU-T
 No reproduction or networking permitted without license from IHS
 Full document details: ITU-T O.182 2007

ITU-T Recommendation O.182

Equipment to assess error performance on Optical Transport Network interfaces

1 Scope

This Recommendation specifies the functions of measuring equipment which has the capability of assessing OCh layer (OTUk, ODUk, OPUk) frame-error performance at OTN interfaces.

[ITU-T G.959.1] defines the OTN physical interface characteristics. [ITU-T G.709] defines the OTN signals applicable to these measurements.

Depending on the network entity under test, this Recommendation specifies the use of either in-service or out-of-service measurement modes.

Annex A of [ITU-T G.709] specifies FEC for OTUk frame. This Recommendation defines the functions of Forward Error Correction (FEC) performance verification.

Furthermore, this Recommendation defines the required functions of the generator and receiver part of the error performance measuring equipment.

This Recommendation does not cover OTUkV framing.

2 References

The following ITU-T Recommendations and other references contain provisions 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; 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. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T G.707] ITU-T Recommendation G.707/Y.1322 (2007), *Network node interface for the synchronous digital hierarchy (SDH)*.
- [ITU-T G.709] ITU-T Recommendation G.709/Y.1331 (2003), *Interfaces for the Optical Transport Network (OTN)*.
- [ITU-T G.798] ITU-T Recommendation G.798 (2006), *Characteristics of optical transport network hierarchy equipment functional blocks*.
- [ITU-T G.806] ITU-T Recommendation G.806 (2006), *Characteristics of transport equipment – Description methodology and generic functionality*.
- [ITU-T G.870] ITU-T Recommendation G.870/Y.1352 (2004), *Terms and definitions for optical transport networks (OTN)*.
- [ITU-T G.872] ITU-T Recommendation G.872 (2001), *Architecture of optical transport networks*.
- [ITU-T G.959.1] ITU-T Recommendation G.959.1 (2006), *Optical transport network physical layer interfaces*.
- [ITU-T G.972] ITU-T Recommendation G.972 (2004), *Definition of terms relevant to optical fibre submarine cable systems*.
- [ITU-T G.975.1] ITU-T Recommendation G.975.1 (2004), *Forward error correction for high bit-rate DWDM submarine systems*.

- [ITU-T G.8201] ITU-T Recommendation G.8201 (2003), *Error performance parameters and objectives for multi-operator international paths within the Optical Transport Network (OTN)*.
- [ITU-T G.8251] ITU-T Recommendation G.8251 (2001), *The control of jitter and wander within the optical transport network (OTN)*.
- [ITU-T M.2401] ITU-T Recommendation M.2401 (2003), *Error performance limits and procedures for bringing-into-service and maintenance of multi-operator international paths and sections within an optical transport network*.
- [ITU-T O.3] ITU-T Recommendation O.3 (1992), *Climatic conditions and relevant tests for measuring equipment*.
- [ITU-T O.150] ITU-T Recommendation O.150 (1996), *General requirements for instrumentation for performance measurements on digital transmission equipment*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 optical transport network (OTN): See [ITU-T G.872]

3.1.2 forward error correction (FEC): See [ITU-T G.972]

3.1.3 CBR2G5, CBR10G, CBR40G: See [ITU-T G.709]

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 black box testing: Black box testing does not explicitly use the knowledge of the internal implementation.

3.2.2 in-service measurement modes: The digital signal transported by the entity under test (EUT) is analysed at a given access point of the EUT.

3.2.3 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 analysed at an access point at the other side of the EUT.

3.2.4 test signal structure (TSS): A test signal structure specifies the mapping of a defined test pattern onto an OPUk.

3.2.5 white box testing: White box testing allows one to peek inside the "box" (the actual EUT) and to use the knowledge of the internal implementation of the EUT.

Out-of-service measurement is performed in absence of user traffic. Consequently, the test signal to be used in case of out-of-service mode must be defined. Annex B defines the test signal structure named TSS_x (x being a number) to be used.

Table 3-1 presents the four test signal structures. They are detailed in Annex B.

Table 3-1 – Test signal structures

TSS1	Test signal structure TSS1 applied to all bytes of a CBR2G5
TSS2	Test signal structure TSS2 applied to all bytes of a CBR10G
TSS3	Test signal structure TSS3 applied to all bytes of a CBR40G
TSS4	Test signal structure TSS4 applied to NULL/PRBS

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AIS	Alarm Indication Signal
BBE	Background Block Error
BBER	Background Block Error Ratio
BDI	Backward Defect Indicator
BEI	Backward Error Indicator
BIAE	Backward Incoming Alignment Error
BIP-8	Bit Interleaved Parity
CBR	Constant Bit Rate
CBR2G5	Constant Bit Rate of 2.5 Gigabits
CBR10G	Constant Bit Rate of 10 Gigabits
CBR40G	Constant Bit Rate of 40 Gigabits
EB	Errored Block
EDC	Error Detection Code
EUT	Entity Under Test
FA	Frame Alignment
FEC	Forward Error Correction
FUEB	FEC Uncorrected Error Blocks
GCC	General Communication Channel
IAE	Incoming Alignment Error
JC	Justification Control
LCK	Locked Defect
LOF	Loss of Frame
LOM	Loss of Multiframe
LOS	Loss Of Signal
LSS	Loss of Sequence Synchronization
LTC	Loss of Tandem Connection
ME	Measuring Equipment
NJO	Negative Justification Opportunity

OCh	Optical Channel with full functionality
OCI	Open Connection Indication
ODTUjk	Optical channel Data Tributary Unit j into k
ODU	Optical channel Data Unit
ODUk	Optical channel Data Unit-k
OH	OverHead
ONNI	Optical Network Node Interface
OOF	Out Of Frame
OOM	Out of Multiframe
OPU	Optical channel Payload Unit
OPUk	Optical channel Payload Unit-k
OTN	Optical Transport Network
OTUk	Optical channel Transport Unit -k
PJO	Positive Justification Opportunity
PLM	Payload Mismatch
PM	Path Monitoring
PRBS	Pseudo Random Binary Sequence
PSI	Payload Structure Identifier
PT	Payload Type
RES	Reserved for future international standardization
RS	Reed-Solomon
SES	Severely Errored Second
SESR	Severely Errored Second Ratio
SM	Section Monitoring
STM(-N)	Synchronous Transport Module (-N)
TC	Tandem Connection
TCM	Tandem Connection Monitoring
TCMi	Tandem Connection Monitoring i (i = 1,2,...,6)
TIM	Tail trace Identifier Mismatch
TSE	Test Sequence Error
TSS	Test Signal Structure
VC-n	Virtual Container-n

Copyright International Telecommunication Union/ITU-T

5 Conventions and background

5.1 Conventions

The following conventions are directly taken from [ITU-T G.709]:

Transmission order: The order of transmission of information in all the diagrams in this Recommendation is first from left to right and then from top to bottom. Within each byte the most significant bit is transmitted first. The most significant bit (bit 1) is illustrated at the left in all the diagrams.

Value of reserved bit(s): The value of an overhead bit, which is reserved or reserved for future international standardization, shall be set to "0".

Value of non-sourced bit(s): Unless stated otherwise, any non-sourced bits shall be set to "0".

5.2 Background

The following figures illustrate OTN framing. They are directly taken from [ITU-T G.709]:

OTUk, ODUk and OPUk overhead assignment: The assignment of overhead in the optical channel transport/data/payload unit signal to each part is defined in Figure 5-1.

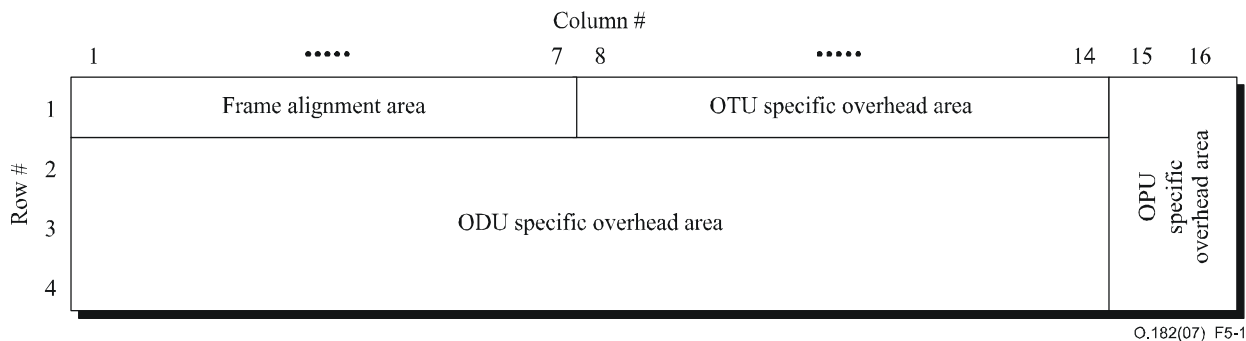


Figure 5-1 – OTUk, ODUk and OPUk overhead (taken from ITU-T G.709)

OTUk, ODUk and OPUk frame structure: The frame structures in the optical channel transport/data/payload unit signal are defined in Figures 5-2, 5-3 and 5-4.

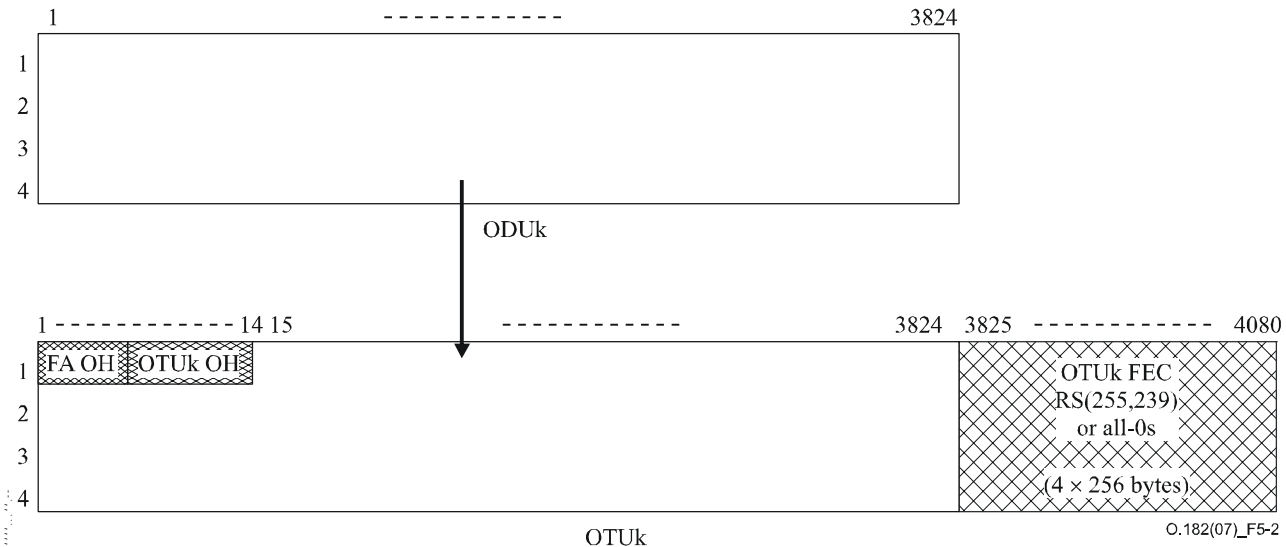


Figure 5-2 – OTUk frame structure (taken from ITU-T G.709)

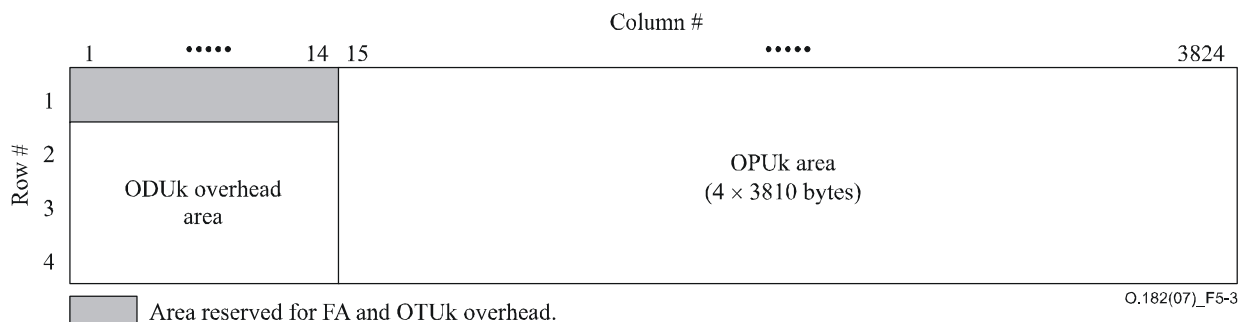


Figure 5-3 – ODUk frame structure (taken from ITU-T G.709)

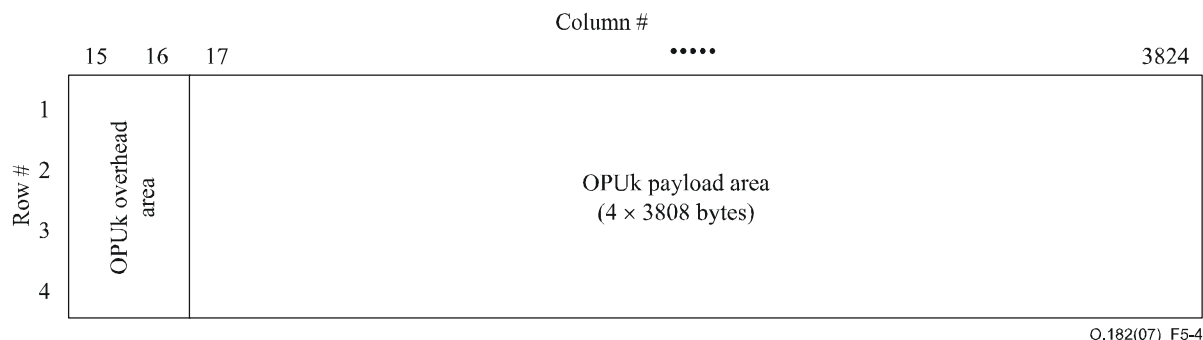


Figure 5-4 – OPUk frame structure (taken from ITU-T G.709)

6 Measurement modes

Two measurement modes shall be supported by OTN measurement equipment:

1) *Out-of-service measurement mode (OSM)*

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 analysed at an access point at the other side of the EUT. Annex B defines the test signal structures (TSSx) to be used.

2) *In-service measurement mode (ISM)*

The digital signal transported by the EUT is analysed at a given access point of the EUT by observing the overhead and, optionally, the FEC.

The advantage of ISM is that customer traffic is not affected by the measurement, i.e., ISM is non service affecting. However, because of the way the overhead, i.e., the BIP or FEC, is computed, there is a non-zero probability that not all bit errors are detected.

With OSM, the possibility to do a bit-by-bit comparison of the signal applied to the EUT and the signal extracted at the other side of the EUT, allows detection of all individual bit errors. However, because the test sequence replaces the customer signal, this measurement mode is service affecting.

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.

7 Events to be monitored

This clause defines the network events that shall be monitored in order to specify the error performance measurement procedures.

Measurement equipment defined in this Recommendation shall be able to test OTUk signals without FEC.

Measurement equipment defined in this Recommendation shall be able to test OTUk signals with FEC defined in [ITU-T G.709].

The following subclauses list defects, anomalies and other events related to error performance which shall be detected by the measuring equipment on OCh layer signals. Criteria for detecting anomalies and defects are given in Annex A.

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

7.1 Network events

A measurement equipment shall monitor the anomalies and the defects recommended in the latest agreed version of [ITU-T G.709] and [ITU-T G.798].

Tables 7-1 and 7-2 summarize the anomalies and the defects monitored. They are explained in Annex A.

Table 7-1 – Network anomalies

Name	Meaning
OOF	Out Of Frame
OOM	Out of multiframe
SM-BIP-8	Section monitoring – Bit interleaved parity error
PM-BIP-8	Path monitoring – Bit interleaved parity error
SM-BEI	Section monitoring – Backward error indicator
TCMi-BIP-8	Tandem connection monitoring i – Bit interleaved parity error (i = 1,2,...,6)
TCMi-BEI	Tandem connection monitoring i – Backward error indication (i = 1,2,...,6)

Table 7-2 – Network defects

Name	Meaning
LOS	Loss of signal
LOF	Loss of frame
LOM	Loss of multiframe
OTU-AIS	Optical channel transport unit – Alarm indication signal
SM-BDI	Section monitoring – Backward defect indicator
SM-IAE	Section monitoring – Incoming alignment error
SM-TIM	Section monitoring – Tail trace identifier mismatch
SM-BIAE	Section monitoring – Backward incoming alignment error
ODU-AIS	Optical channel data unit – Alarm indication signal
ODU-OCI	Optical channel data unit – Open connection indication
ODU-LCK	Optical channel data unit – Locked defect
PM-BDI	Path monitoring – Backward defect indicator
PM-TIM	Path monitoring – Trail trace identifier mismatch
ODU-PLM	Optical channel data unit – Payload mismatch

Table 7-2 – Network defects

Name	Meaning
TCMi-BDI	Tandem connection monitoring i – Backward defect indicator
TCMi-IAE	Tandem connection monitoring i – Incoming alignment error
TCMi-TIM	Tandem connection monitoring i – Tail trace identifier mismatch
TCMi-BIAE	Tandem connection monitoring i – Backward incoming alignment error
TCMi-LTC	Tandem connection monitoring i – Loss of tandem connection (i = 1,2,...,6)

7.2 Test signal structure events

Monitoring of network events shall be complemented by the following events which are detected in Out-of-service mode using defined test signal structures:

- Loss of sequence synchronization (LSS): see A.2.20;
- Test sequence error (TSE): see A.1.11.

7.3 Forward error correction (FEC) events

The measuring equipment shall monitor the following events generated by the FEC:

- FEC corrected errors (FCE): see A.1.6;
- FEC uncorrected error blocks (FUEB): see A.1.7.

7.4 Events to be monitored at the OCh layer

The OCh transports a digital client signal between 3R regeneration points. OCh client signals defined in this Recommendation are the OTUk signals.

Measuring equipment shall be able to receive OCh layer signals as defined in [ITU-T G.709].

The following subclauses give the events monitored for OTUk, ODUk, OPUk signals.

7.4.1 OTUk layer

Measuring equipment shall support the capability to disable the FEC decoding process.

Table 7-3 – Events to be monitored at the OTUk layer

Type of event	List of monitored events for this layer
Anomalies	OOF, OOM, SM-BIP-8, SM-BEI, FCE (Note), FUEB (Note)
Defects	LOS, LOF, LOM, OTU-AIS, SM-BDI, SM-IAE, SM-TIM, SM-BIAE
NOTE – In the case of using the FEC code that is defined in ITU-T Rec. G.709.	

7.4.2 ODUk layer

Measuring equipment shall support monitoring for tandem connection monitoring events.