

Running 10.7G FEC Systems to ITU-T G.709 Standard with the ONT-503/506/512



Running 10.7G FEC systems to ITU-T G.709 standard

The optical transport network (OTN) is one of the major steps in moving towards deploying all optical networks (AON). This step allows network providers to leverage from available fiber infrastructure with Forward Error Correction (FEC) which minimizes the number of 3R regenerators needed in a network. The OTN system is transparent for various clients and accommodates extended tandem connection monitoring (TCM) processes for easy fault location in multi provider networks.

The ITU-T have published the following recommendations giving guidelines for OTN elements.


G.709: "Interfaces for the OTN"

G.798: "Characteristics of OTN hierarchy equipment functional blocks"

The OTN frame consists of: the mapped transparent client, the extensive overhead (OH) which is used for operations, administrations, monitoring and provisioning (OAM&P) and the FEC. As with SDH/SONET, the quality of transmission is monitored by multiple parity checks and the corresponding reactions of the OTN elements. These new systems are currently designed, produced and installed by several different vendors.

To check the designs and elements produced against ITU-T recommendations, various tests must be performed according to the following categories:

- Interface specification
- DUT response
- ITU-T conformance and interoperability
- Mapping/demapping of client signals
- Correct FEC behavior



The screenshot shows the 'Alarm Test' window for a Digital Wrapper G.709. It displays a table of alarms for both TX and RX directions, including their status (indicated by colored icons) and the time elapsed since they occurred. The 'Mode' is set to 'Continuously'. The 'Elapsed Time' is 00d 00h 05m 10s, and the test is set to run for 1 Hour.

TX Alarms	RX Alarms	Seconds [s]	RX Alarms	Seconds [s]
Mode: Continuously	<input type="checkbox"/> LOS	0	<input type="checkbox"/> SM-IAE	3
<input type="radio"/> LOS	<input type="checkbox"/> SM-BDI	0	<input type="checkbox"/> SM-BIAE	0
<input type="radio"/> LOF	<input type="checkbox"/> SM-IAE	0	<input type="checkbox"/> SM-TIM	***
<input type="radio"/> LOF	<input type="checkbox"/> SM-BIAE	3	<input type="checkbox"/> PM-BDI	8
<input type="radio"/> OOF	<input type="checkbox"/> SM-TIM	0	<input type="checkbox"/> PM-TIM	***
<input type="radio"/> OOF	<input type="checkbox"/> SM-BIAE	0	<input type="checkbox"/> FW-SF	4
<input type="radio"/> LOM	<input type="checkbox"/> SM-TIM	0	<input type="checkbox"/> FW-SD	0
<input type="radio"/> LOM	<input type="checkbox"/> PM-BDI	2	<input type="checkbox"/> BW-SF	0
<input type="radio"/> OOM	<input type="checkbox"/> PM-TIM	0	<input type="checkbox"/> BW-SD	0
<input type="radio"/> OOM	<input type="checkbox"/> FW-SF	0	<input type="checkbox"/> PT-LOSS	0
<input type="radio"/> OTU-AIS	<input type="checkbox"/> FW-SD	0	<input type="checkbox"/> TCM-Alarms	
<input type="radio"/> OTU-AIS	<input type="checkbox"/> BW-SF	0		
<input type="radio"/> ODU-AIS	<input type="checkbox"/> BW-SD	4		
<input type="radio"/> ODU-AIS	<input type="checkbox"/> PT-LOSS	9		
<input type="radio"/> ODU-OCI	<input type="checkbox"/> TCM-Alarms			
<input type="radio"/> ODU-OCI				
<input type="radio"/> ODU-LCK				
<input type="radio"/> ODU-LCK				
<input type="radio"/> BW-SF				
<input type="radio"/> BW-SD				
<input type="radio"/> BW-SD				

Menu ONT-5xx: DUT alarm responses

Are the line interfaces compliant with ITU-T recommendations?

One of the most important stress tests is the verification of the input parameters of all interfaces of the device under test (DUT). This test is essential in ensuring the proper interoperability of equipment from single and multi vendors. The **synchronization** to the incoming signal must first be checked before the more “physical” tests – such as **sensitivity** to optical power – can be carried out. Here, an optical attenuator (OLA) is used to reduce the optical power until the threshold of the input receiver is reached (BER on the test unit). The optical power meter (OLP) displays the minimum optical input power.

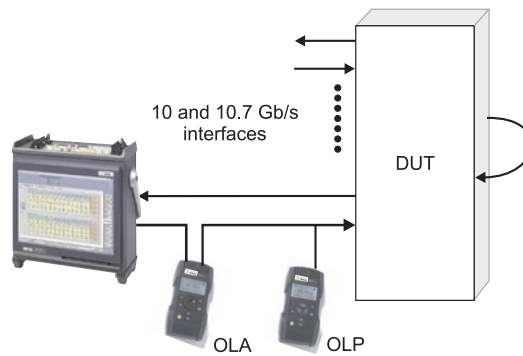


Figure 1: Check for line interface conformance with optical attenuator (OLA) and optical power meter (OLP)

With variation of the signal offset, the maximum allowed **clock deviation** has to be checked. For 10 and 10.7 Gb/s interfaces this is defined with ± 20 ppm.

During conformance testing, the maximum tolerable jitter (MTJ) of the input as well as the maximum allowed **intrinsic jitter** of the outputs must both be verified.

By performing these measurements the interface can be fully checked and detailed digital parameter tests can be initiated.

Does the DUT generate the correct response?

Depending on signal input failures and degradation, the DUT will generate alarm responses in the up and down-stream direction to deliver information on the line quality to neighbouring network elements.

The OTN maintenance interaction shown in figure 3 illustrates the coherence of alarm and error sources and sinks.

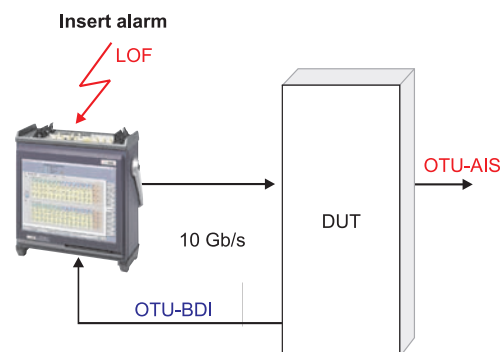


Figure 2: Verify alarm responses

During verification, the JDSU ONT-5xx optical network tester sends a stimulus to the DUT and checks for the responses in the up and downstream. For example, the detection of a LOF at the 10.7G interface will force an OTU-AIS in the 10.7G forward and an OTU-BDI in the 10.7G backward signal (figure 2).

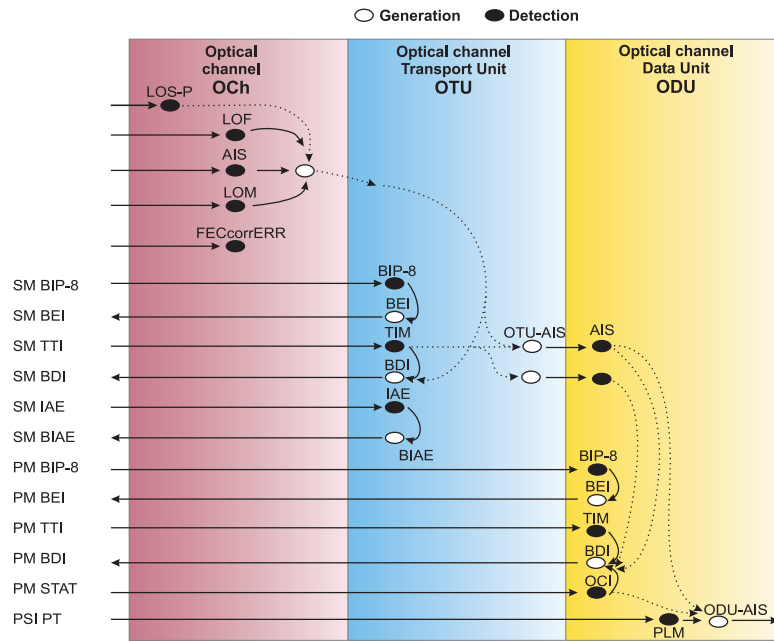


Figure 3: OTN maintenance integration

During system verification, the condition of the combination must be checked against the ITU-T recommendation G.798.

The ONT-5xx and the controller of the DUT show the alarm status simultaneously. Should the results of DUT and the ONT-5xx not match, the user receives information on the DUT allowing for further investigations to be carried out.

Verifying ITU-T conformance and interoperability

The ITU-T G.798 standard defines the generation and detection criteria of certain alarm events (figure 4).

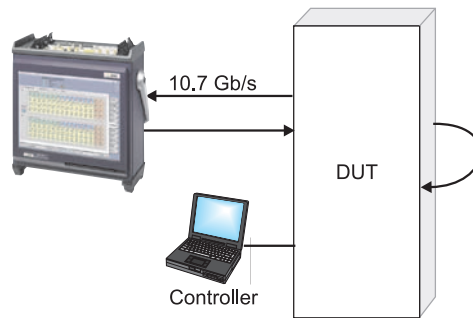


Figure 4: Verify ITU-T conformance

The thresholds are usually specified by a number of optical transport unit (OTU) frames such as the detection of section monitoring SM_BDI: SM_BDI bit = 1 in 5 consecutive OTU frames (table 1).

Abbreviation	Detection criteria according to G.709 and G.798
OOF	FAS (bytes 3, 4 and 5) are errored for ≥ 5 frames
LOF	If OOF persists ≥ 3 ms
OOM	MFAS numbers errored for ≥ 5 frames
LOM	If OOM persists ≥ 3 ms
OTU	
SM BEI	SM byte 3, bits 1 to 4: value 0 to 8: SM BIP-8 error count value 9 to 15: no SM BIP-8 errors value 11: see SM BIAE
OTU-AIS	PN-11 sequence (covers complete Och) $\geq 3 \times 8192$ bits
SM BDI	SM byte 3 bit 5 = 1 ≥ 5 frames
SM IAE	SM byte 3 bit 6 = 1 ≥ 5 frames
SM BIAE	SM byte 3 bits 1 to 4 = "1011" ≥ 3 frames
ODU – PM	
PM BEI	PM byte 3, bits 1 to 4: value 0 to 8: PM BIP-8 error count value 9 to 15: no PM BIP-8 errors
ODU-AIS	PM byte 3 bits 6 to 8 = "111" ≥ 3 frames
ODU-OCI	PM byte 3 bits 6 to 8 = "110" ≥ 3 frames
ODU-LCK	PM byte 3 bits 6 to 8 = "101" ≥ 3 frames
PM BDI	PM byte 3 bit 5 = 1 ≥ 5 frames
ODU – TCM	
TCMi BEI	TCM byte 3, bits 1 to 4: value 0 to 8: TCM BIP-8 error count value 9 to 15: no TCM BIP-8 errors value 11: see TCM BIAE
TCMi-BDI	TCM byte 3 bit 5 = 1 ≥ 5 frames
TCMi-BIAE	TCM byte 3 bits 1 to 4 = "1011" ≥ 3 frames

Table 1

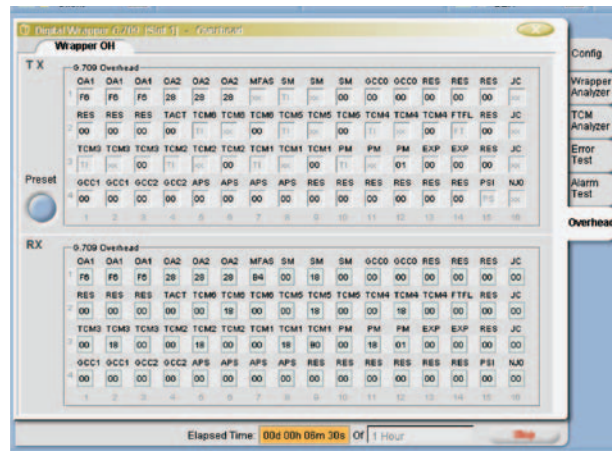
Test ONT-5xx simulates the alarms with a variable number of frames known as dynamic alarms which verify the detection criteria of the DUT. A practical measurement such as the activation of SM BDI bit for 4 frames would cause no SM BDI alarm whereas activation of 5 frames would.

Analysis of specific OH bytes is necessary to ensure interoperability of equipment from different vendor's. All major bytes need to be accessible to prove correct interpretation of the DUT.

For chip designers it is very helpful to have the capability to “stress” dedicated overhead bytes. This is useful for example, when proper synchronization of MFAS have to be proved with different conditions or the reaction of DUTs to different patterns in FTFI or PSI sequence fields need to be checked.

The ONT-5xx’s “**Sequencer**” provides the ideal tool for generating byte stress sequences up to 256 frames.

To identify the source and destination of a signal, the SM TTI is used with its SAPI and DAPI identification fields. Tandem connection monitoring (TCM) is used to check the cause of errors between different network providers. Interoperability is key to securing this. The ONT-5xx is able to generate fully ASCII editable bytes and generate **TTI mismatch** alarms to perform a quick check of accurate matches in received and expected values.



Menu ONT-5xx: OTU overhead

Correct mapping and demapping of client signals.

The OTNs framing structure allows for the mapping of a variety of traffic types into OPUs including: SONET/SDH, ATM cells and Generic Frame Procedure (GFP) frames.

The G.709 specifies guidelines for synchronous and asynchronous mapping.

With asynchronous mapping, rate differences between the client and the OPU are adjusted through “stuffing”.

To check the mapping capability of the DUT, an input client signal of 10 Gb/s with varying offset (allowed deviation ± 20 ppm) is transmitted then mapped into the OPU by the DUT. The ONT-5xx is then able to detect whether the client has been properly mapped into the OPU without alarm or error.

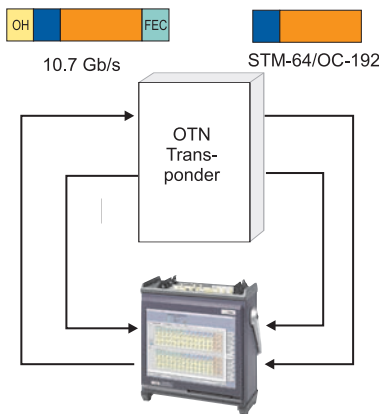


Figure 5: Duplex mapping/demapping test

In checking the demapping, the ONT-5xx sends a 10.7 Gb/s signal together with a mapped SDH/SONET client. The DUT demaps the client and sends the 10Gb/s signal to the ONT-5xx. The ONT can then detect, if the client has been correctly demapped.

To stress the DUT, the offset of the client can be varied above the specified limits.

The ONT-5xx has the unique functionality of checking for mapping and demapping simultaneously.

This “duplex testing”^{*} (figure 5) reduces time to revenue and improves efficiency as the ONT-5xx is optimized for such multi-port applications.

^{*}Duplex testing is the simultaneous testing of mapping and demapping at 10 Gb/s and 10.7 Gb/s.

Verification of correct FEC behavior

If errors occur on a 10.7Gb/s line in any area of the frame, the receiver of the DUT is able to correct up to 8 symbol errors per subrow or in other words, 512 errors per optical channel (OCh) frame. In order to verify correct FEC testing, a varying number of error patterns are inserted in subrows of the transmitted signal then transmitted through an OTN DUT. The ONT-5xx then generates correctable and uncorrectable FEC errors and as an additional stress test will generate “maximum” FEC errors for correction by the DUT.

At the receiving end, the optical channel (OCh) is checked to determine the error correcting capability of the DUT.

If the number of inserted errors exceeds the correction capability of the DUT, the ONT-5xx and DUT will reflect them as uncorrectable errors (figure 6).

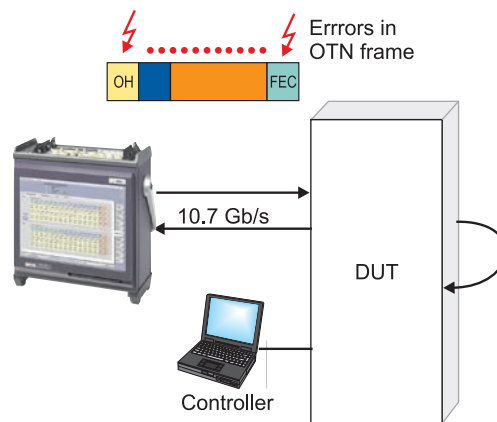
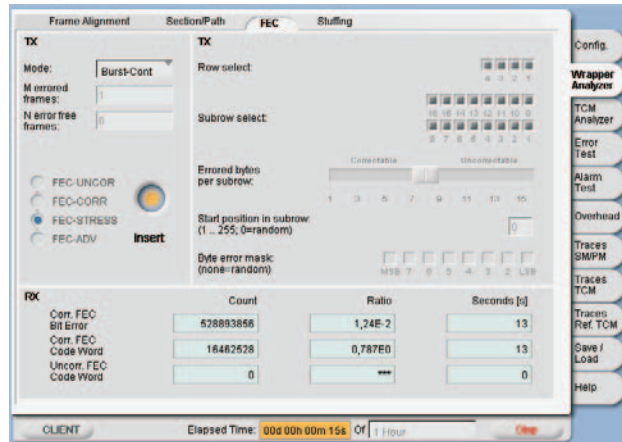


Figure 6: Check for FEC behavior

As G.709 systems are still in the design and manufacturing phases, engineers often want to stress the DUTs with different types of FEC errors. The ONT-5xx provides a set of advanced FEC error insertion possibilities offering the user the flexibility to select which and how many rows and subrows should be affected. The number of errored bytes and their start positions in the subrow can also be selected. An editable byte error mask points to the bits to be errored in the byte thus allowing for the testing of almost any FEC error condition.



Menu ONT-5xx: Advanced FEC error insertion

Summary

To verify 10.7Gb/s network elements to ITU-T recommendations, the following should be performed:

1. Interface specification
 - Synchronization to incoming signal (FAS)
 - Optical power sensitivity
 - Clock deviation
 - Maximum tolerable jitter
 - Intrinsic jitter (outputs)
2. Alarm/error response
3. ITU-T conformance and interoperability
 - Dynamic alarms
 - OH bytes
 - Sequencer
 - TTI mismatch
4. Mapping/demapping
 - Client signal offset
 - Duplex testing
5. FEC verification
 - Correctable, uncorrectable, maximum
 - Advanced

Abbreviations

DAPI	Destination Access Point Identifier	OTN	Optical transport channel network
DUT	Device under test	OTU	Optical transport channel unit
FEC	Forward error correction	OTU-AIS	OTU alarm indication signal
FTFL	Fault Type Fault Location	OTU-BDI	OTU backwards defect indication
LOF	Loss of frame	PSI	Payload Structure Identifier
MFAS	Multiframe alignment signal	SAPI	Source Access Point Identifier
OCh	Optical channel	SM	Section monitoring
OH	Overhead	SM TTI	SM trail trace identifier
OLA	Optical attenuator	SM-BDI	SM backwards defect indication
OLP	Optical power meter	TCM	Tandem connection monitoring
OPU	Optical channel Payload Unit	TTI	Trail trace identifier

JDSU ONT-503/506/512 Optical Network Tester –the right solution for G.709 testing

The ONT-5xx combines optical and digital testing in a single unit, making it a complete solution for both optical layer and performance testing. Featuring a modular design, the ONT-5xx allows easy upgrades, powerful software and remote web-based monitoring. The ONT-5xx measures all optical bit rates up to 10 Gb/s, making it the most complete digital and optical DWDM solution. When these capabilities are combined with the ONT-5xx's powerful optical spectrum analyzer (OSA) and Q-factor analysis functions, engineers and network operators can perform all tests required during optical system verification and maintenance and optical component verification.

ONT-5xx Highlights:

- User defined combination of **optical** (optical spectrum analyzer, Q-factor) and **digital** (up to 10.7 Gb/s) modules
- **Multi-port capability** for simultaneous and independent use of different modules
- **Multi-user** functionality for remote operation.
- Common, intuitive graphical **browser** user interface

For further information on the ONT-5xx solution, go to: www.jdsu.com

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