Conformance testing

– an essential part of
SONET deployment

Introduction

Testing SONET network elements for compliance with the relevant standards is a complex and time-consuming application. It is, however, an essential part of building SONET-compliant networks.

Glossary

ADM	Add-drop multiplexer
AIS	Alarm indication signal
ANSI	American national standards institute
BIP	Bit interleaved parity
FEBE	Far end block error
FERF	Far end receive failure
LOF	Loss of frame
LOP	Loss of pointer
LOS	Loss of signal
NE(s)	Network element(s)
NDF	New data flag
OC-n	Optical carrier level 'n' (n = 1, 3, 12 or 48)
OOF	Out of frame
SONET	Synchronous optical network
STS	Synchronous transport signal
VT	Virtual tributary

SONET compliance testing
– the need for a standard

Since the mid 1980s, thousands of engineering-years of effort have been applied to the creation of today's SONET standards. The prize which justifies this staggering investment in the standardization process is "a telecommunications transmission network for the 21st century" – a system, based on SONET-compliant network elements (NEs), which is flexible, reliable, and efficient to operate and maintain.

From a network operator's point of view, the benefits promised by SONET technology are four-fold:

- Efficient management of network bandwidth.
- Extensive in-service performance monitoring.
- Dynamic network protection.
- Inter-operability of NEs from different vendors.

Realizing these benefits relies on the uniform implementation of a wide range of inter-linked functions within SONET equipment. Together, these functions fully describe the NE's functional operating characteristics. Verifying correct operation of these basic functions is therefore the first vital step in ensuring that new (or upgraded) SONET equipment delivers the promised operational benefits.

Current SONET standards (Bellcore GR-253 and ANSI T1.105) restrict themselves to describing, in detail, the required operating characteristics for compliant network elements. What they do not cover is an industry accepted method for verifying compliance. This lack of a 'conformance test' dimension to the standards leaves a fundamental question unanswered, namely: What constitutes SONET compliance?

Allowing each organization involved in SONET compliance testing to formulate its own answer will, without doubt, carry a significant cost. At best, the cost will be delays in deploying new generations of SONET NEs (or upgrades to those already deployed) due to test duplication. At worst, it will result in equipment which deviates from the standards being deployed, thereby risking network integrity.

To ensure that there is only one answer to the SONET compliance question will require the creation of a conformance test standard – a document which clearly defines 'what to test' and 'the method to use'.

Get it right first time!

What is compliance testing?

The term 'compliance test' refers to the in-depth testing necessary to verify an NE's agreement with Bellcore and ANSI SONET standards. This design verification application can be segmented into three broad categories:

- Functional testing (signal structure, operating characteristics).
- Network management protocol testing.
- Parametric testing (physical line signal characteristics).

Of these categories, 'functional testing' is the area which should be given priority when considering test standardization. This view is arrived at after evaluating each category against factors such as:

- Stability of standards.
- Scope for differing interpretations of current standards.
- How often testing is necessary.

Compliance testing is a costly undertaking, both in terms of time and capital investment necessary to perform the task. It is also a recurring application. These two facts emphasize the importance of adopting a test approach which is effective and efficient.

Successful compliance testing requires a solution which enables you to execute hundreds of complex tests, and obtain repeatable results in which you have full confidence. The size and recurring nature of the application requires that this is achieved in a way which minimizes test time. A solution which meets these requirements will consist of:

- Tests designed to rigorously verify all specified operating characteristics of an NE.
- High performance measurement hardware providing the real-time controls necessary to reliably generate complex test signals (eg, alarm and error sequences for threshold tests).
- A well defined and documented test procedure.
- An efficient method for executing sequences of tests (typically achieved through automation).

SONET functional tests

Testing an SONET NE for compliance with the standards entails detailed verification of its operation in the areas of:

● Alarm handling.
● Pointer processing.
● Protection switching.
● Overhead channels.
● Performance monitoring.
● Payload handling.
● Jitter and wander.

Many of these functional tests require the application of a single input stimulus and the monitoring of multiple output responses.
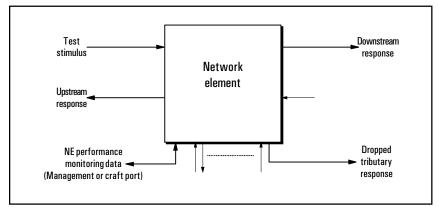

Figure 1. Connecting to network element under test

An example of this is testing an ADM's response to a received Line-AIS defect. On detecting this defect the ADM must:

● Transmit STS-AIS in all unterminated downstream paths.
● Transmit STS-Yellow upstream in all terminated paths.
● Transmit AIS in all dropped tributaries.
● Transmit Line-FERF upstream.
● Record the Line-AIS defect in it's internal performance monitoring.

When designing an SONET conformance test station and its associated test procedure, you must therefore make a decision on whether all responses are tested simultaneously or separately. The trade-off you will make is cost, in terms of measurement hardware, versus test time.

SONET alarm testing

SONET standards define a hierarchy of alarm conditions, covering defects detected at the:

- Physical transmission layer (LOS).
- Regenerator section termination (OOF, LOF).
- Multiplexer section termination (Line-AIS/FERF).
- High-order path access level (STS-LOP).
- High-order path termination (STS-AIS/Yellow).
- Low-order path access level (STS-LOP).
- Low-order path termination (VT-AIS/Yellow).

Full compliance testing of an NE's alarm handling entails verifying the alarm detection and de-activation thresholds, plus the appropriate responses (including internal performance monitoring). This must be done for each alarm supported by the NE.

To rigorously test an alarm detection/de-activation threshold, measurement hardware capable of generating a precise three-stage alarm on/off sequence is required. This sequence consists of:
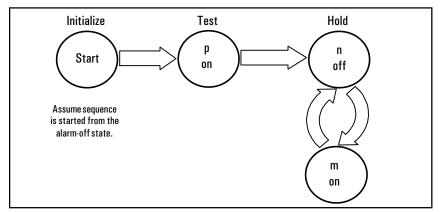

Figure 2. Testing alarm detection and de-activation thresholds

- A user-definable starting state (alarm on or off).
- The test condition – a single burst of the alarm on or off (opposite polarity to starting state). The duration of this burst is programmed to be equal to or just below the threshold level under test.
- A repeating on/off sequence designed to hold the NE in the alarm state it enters as a result of the test condition. On and off durations are separately programmed to be below the expected alarm detection and de-activation thresholds.

This three-stage sequence supports rigorous alarm threshold testing by ensuring the NE has only one opportunity to detect the test condition.

As a practical illustration, consider how the above sequence is used to test Line-AIS. Bellcore GR-253 specifies that an NE must enter the Line-AIS state on receiving three to five consecutive frames containing the Line-AIS signal. Exiting the Line-AIS state must occur on receiving three to five consecutive frames which do not contain the Line-AIS signal.
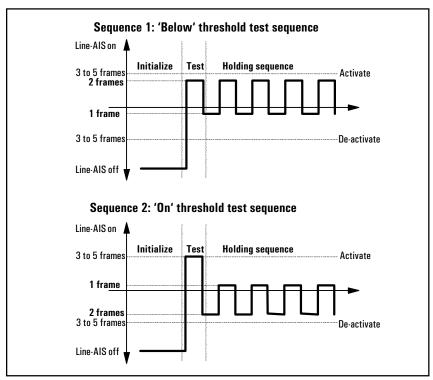
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Figure 3. Line-AIS detection threshold test

First check that the NE does not enter the Line-AIS state when the alarm signal is received for only two consecutive frames.

Sequence 1 (figure 3): From Line-AIS normally off, transmit a single burst of Line-AIS on for two frames, immediately followed by a repeating one-frame off, two frames on holding sequence. This holding sequence maximizes the time during which the alarm is on, but without exceeding the expected detection threshold.

Next, check the Line-AIS state is entered when the alarm signal is received for five consecutive frames.

Sequence 2 (figure 3): From Line-AIS normally off, transmit a single burst of Line-AIS on for five frames, immediately followed by a repeating two frames off, one frame on holding sequence. In this case the holding sequence maximizes the 'alarm-off' duration, but without exceeding the expected de-activation threshold.

Testing the de-activation threshold is achieved in a similar manner – the main difference being that the sequence is started from the normally on state.

Testing pointer generators and interpreters

Pointers perform a critical role in the error-free transmission of pay-load data (subscriber data) through an SONET network. They also enable individual payload channels to be simply inserted or extracted from a high-speed OC-n line signal (an example of this being the functionality provided by ADMs).

Thorough testing of an NE's compliance with the complex pointer generation and interpretation rules is an essential part of the SONET conformance test application. The pointer functions which require verification are:

● NE generates valid pointer structure (NDF, SS-bits, offset address).
● Error-free handling of pointer justifications
  (increment and decrement from all possible offsets).
● I and D bit majority voting.
● NDF operation.
● NDF majority voting.
● LOP entry and exit criteria.

The ability to perform this type of detailed testing requires measurement hardware capable of dynamically erroring the pointer associated with a mapped payload test pattern. With the exception of LOP tests, correct operation is verified by monitoring the payload test pattern for errors.
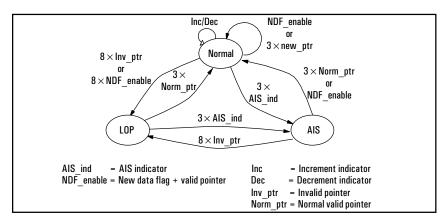

Figure 4. Pointer operation: ANSI T1.105

The above clearly illustrates the complexity of the SONET pointer interpreter rules. Testing an NE for correct implementation of these rules requires measurement hardware capable of generating sequences of errored and valid pointers similar to that described for alarm threshold testing.

Testing an NE's performance monitoring functions

Another significant area for SONET compliance testing is verifying an NE's in-service performance monitoring functions, namely:

● Valid BIP generation.
● Correct BIP error detection.
● Upstream FEBE generation on detection of received B3/BIP-2 errors.
● FEBE detection.
● Internal logging of errored seconds and severely error seconds information.

Performing this type of test requires measurement hardware capable of generating controlled errors in a selected BIP or FEBE channel. On the receive side the measurement hardware must provide BIP and FEBE error measurements.

Access to the NE's internal performance monitoring data is also necessary. This can be achieved via the NE's management system or, alternatively, using a local control terminal connected to the NE's craft port.

Conclusion

Testing SONET network elements for compliance with the standards is a costly and recurring application. It is, however, an essential part of building an SONET compliant network.

The costs associated with this application can be minimized through 'test standardization' coupled with 'test automation'. Adopting a solution based on these two principles will ensure your SONET compliance testing is both effective and efficient by providing:

● Repeatable testing.
● Simpler result interpretation.
● Improved ability to share result data with other conformance test groups.

For information on SONET test solutions, contact your local Hewlett-Packard sales office.

Related HP literature

HP 75000 Series 90 modular telecom analyzer	Technical specifications	5964-9881E

For more information on Hewlett-Packard Test & Measurement products, applications or services please call your local Hewlett-Packard sales offices. A current listing is available via Web through AccessHP at http://www.hp.com. If you do not have access to the internet please contact one of the HP centers listed below and they will direct you to your nearest HP representative.

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