Testing QoS, OAM, Policing, and Performance at 622 Mb/s and 2.4 Gb/s-High-Speed Test Solutions

Agilent Technologies Broadband Series Test System
Application Note

Introduction

One of the key benefits of ATM is that it operates over existing transport technologies such as the widely deployed PDH and SDH networks. Any test strategy should start with building confidence in the physical transmission medium. Once this requirement has been confidently completed, you can begin to test higher layers in the protocol stack until you have confidence in the end-to-end transmission of the services that generate the revenue for the carrier.

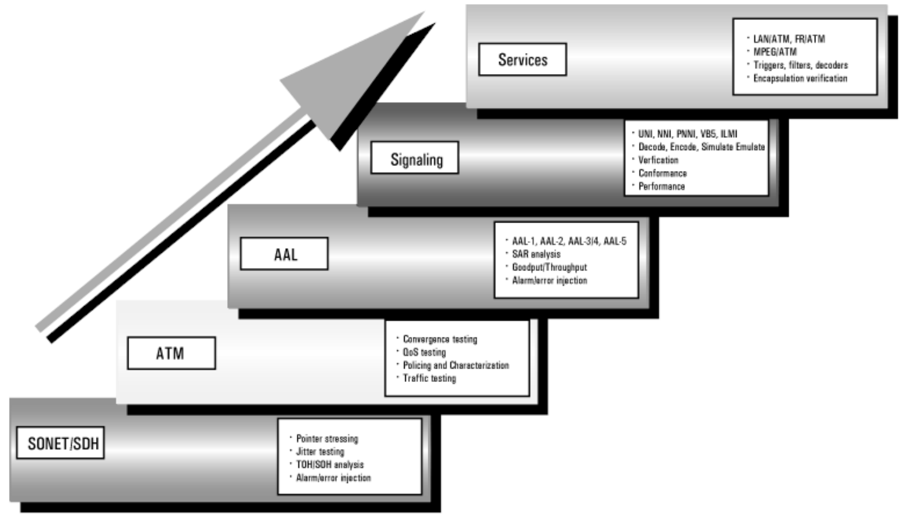
A typical broadband network might carry Internet TCP/IP data over Frame Relay links, aggregated through AAL-5 onto a high speed ATM backbone, carried on an underlying SONET/SDH transmission network. At each of these network layers, a distinct protocol operates to manage the flow of data from one end to the other.

However, these protocols operate independently from each other. Any one of them could stop the flow of data, although the cause will not be immediately apparent to an observer looking at only one or two of the protocol layers.

The limitation of many test tools is that they are optimised for looking at one specific protocol layer; for example ATM layer, service layer, or physical layer. A better approach is to correlate measurements across multiple layers in order to fully understand how they interact.

This application note will focus on the ATM Forum Traffic Management Specification Version 4.0 (TM4.0) which includes:

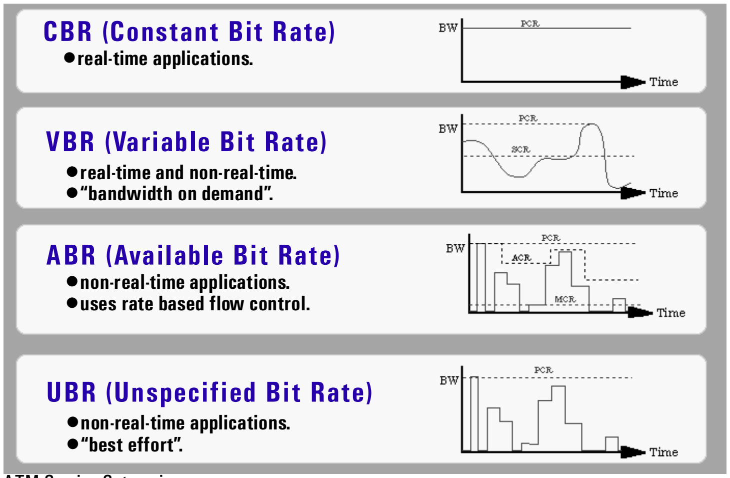
- Service Categories (Traffic Classes)
- ATM Quality of Service (QoS) parameters (I.356)
- Connection Admission control (CAC)
- Usage Parameter Control (UPC)
- Generic Cell Rate Algorithm (GCRA) for Policing and Shaping (I.371)



Correlating across the layers of ATM.

Other issues that will be examined are:

- TM4.0 Contract Verification
- OAM functional testing and in-service QoS measurements
- Adaptation Layer QoS testing
- Adaptation Layer performance testing
- Automated testing



ATM Service Categories.

Key aspects of ATM Forum TM4.0

The ATM Forum TM4.0 combines many aspects of QoS and traffic management in a single specification. Similar aspects are defined in ITU-T specifications, such as I.356 *ATM Layer Cell Transfer Performance* and I.371 *Traffic Control and Congestion Control*.

ATM service categories

The ATM Forum has defined five service categories. Each category has different traffic characteristics and QoS requirements:

- **Constant Bit Rate** (CBR) is defined for services such as uncompressed voice, uncompressed video, and leased line circuit emulation. These are often described as *real-time* applications, meaning that they are sensitive to delay and delay variation.
- **Variable Bit Rate**, *non-real-time* (VBR-nrt) is defined for services, such as TCP/IP file transfer, that generate bursty traffic. Non-real-time means that the service is not sensitive to delay. However, it may be sensitive to data errors or loss of data. For example, loss of data can cause TCP retransmissions which increases the load on the network.
- **Variable Bit Rate**, *real-time* (VBR-rt) is defined for services, such as MPEG-2 compressed video, that generate bursty traffic which is sensitive to delay and delay variation.
- **Available Bit Rate** (ABR) is defined for *non-real-time* applications that can adjust their transfer rate to suit the available network capacity. ABR improves network utilization by using feedback control loops to maximize traffic throughput. The ABR service category can therefore be offered at lower cost than VBR-nrt.
- **Unspecified Bit Rate** (UBR) is a *best effort* service category for non-real-time applications. UBR services can be offered at lower cost than ABR or VBR-nrt because there are no guaranteed traffic or QoS parameters.

ITU-T I.356 QoS parameters

The ITU-T I.356 standard specifies a number of cell transfer outcomes and the parameters that should be measured to determine ATM-layer Quality of Service (QoS). ATM Forum TM 4.0 provides similar definitions:

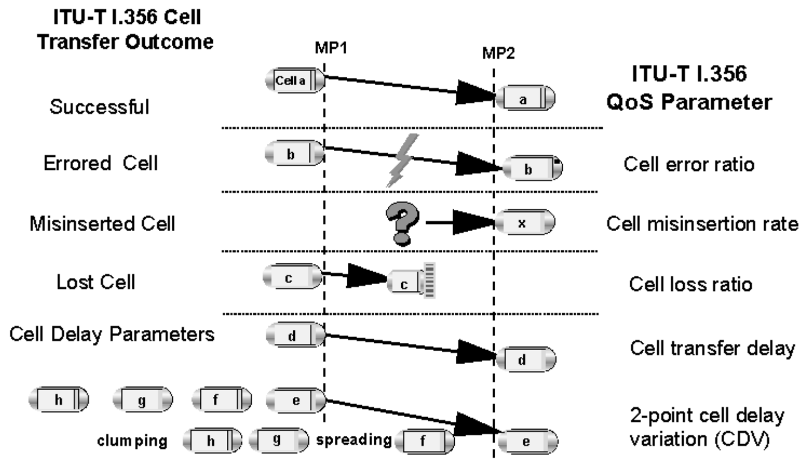
- **Cell error ratio:** A cell is errored if it arrives within the required time and has either different payload contents than when it was transmitted, or an invalid cell header. [Note: excludes cells in SECBs (Severely Errored Cell Blocks)]

  •cell error ratio = errored cells/ number of transmitted cells

- **Cell loss ratio:** A cell is lost if it does not arrive at a specified point within the required time after leaving a previous point. [Note: excludes cells in SECBs]
  •cell loss ratio = lost cells / number of transmitted cells
- **Cell misinsertion rate:** A cell is misinserted if it is received at the destination but was not part of the original transmission. [Note excludes cells in SECBs]
  •cell misinsertion rate = misinserted cells / time interval
- **Mean cell transfer delay** is the length of time it takes for a cell to travel between two measurement points (MPx). T1 is the arrival time at MP1, T2 is the arrival time at MP2.
  •cell transfer delay = T2 - T1
- **2-point cell delay variation** (CDV) is the variation in cell transfer delay (CTD) relative to the reference cell. The reference cell can be any cell in the stream.
  •peak-to-peak 2-point CDV = maximum CTD - minimum CTD
- **1-point cell delay variation** (CDV) is the variation in cell arrival time at a single measurement point relative to the expected arrival time. The expected arrival time is derived from the negotiated peak cell rate (PCR).
  •ΔT arrival = 1/PCR

2-point CDV measures only the delay variation added between the two measurement points. *1-point CDV* measures the total delay variation relative to an ideal CBR traffic stream.

- **Severely errored cell block (SECB) ratio:** A block of cells which exceeds pre-defined thresholds for either cell error count, cell loss count, or cell misinsertion count is counted as an SECB.
  [Note: SECB threshold values are not specified in the ITU-T standards. Bellcore makes some recommendations. Refer to GR-1248-CORE *Generic Requirements for Operations of ATM Network Elements*.]
  •SECBR = SECB count / total number of blocks



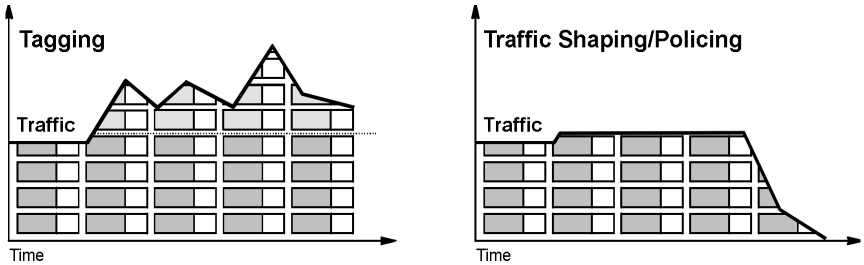
ITU-T I.356 QoS parameters.

I.356 Severely Errored Cell Block (SECB)

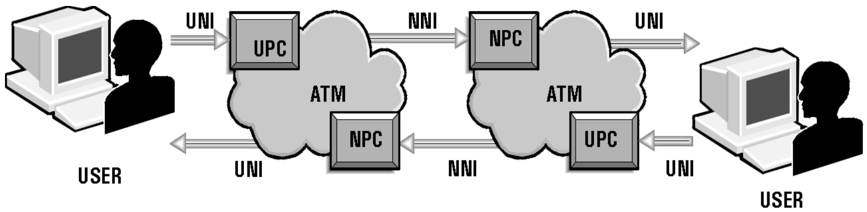
A cell block is a consecutive sequence of cells on a given virtual channel or virtual path connection. A cell block is classed as being severely errored when more than the specified number of cells in the cell block are errored, lost, or misinserted.

The Severely Errored Cell Block Ratio (SECBR) indicates the availability and reliability of the network or ATM equipment. It provides a measure of the amount of time the connection is unavailable due to excessive errors. The SECB measurement is also designed to prevent bursts of errors from inappropriately affecting the cell transfer measurements.

SECB events are not included in cell error ratio, cell loss ratio, or cell misinsertion rate.



Usage Parameter Control actions.



Usage Parameter Control (UPC) takes place between the user-equipment side and the network-equipment side of the UNI interface.

Connection Admission Control (CAC)

It is not possible for the network to guarantee QoS parameters for all users without placing some restrictions on the traffic characteristics. A negotiation process called Connection Admission Control (CAC) takes place between the user equipment and the ATM network via the UNI interface.

UNI signalling can be used to set up SVC connections. It is also be used to negotiate QoS and service category parameters. The user equipment appends QoS and service category Information Elements (IEs) to the UNI signalling *SETUP* message. The network can either accept or reject the requested parameters. If the connection is rejected, the user must modify the parameters (for example, reduce the requested peak cell rate) and repeat the negotiation process.

Usage Parameter Control (UPC)

Once the CAC negotiation process has completed and the connection has been accepted, the network will attempt to provide the requested QoS parameters. In order to achieve this, the network must verify that each user is conforming to their traffic contract. This function is called *Usage Parameter Control* (UPC) and takes place between the user-equipment side and the network-equipment side of the UNI interface. A similar function called *Network Parameter Control* (NPC) takes place between networks via the NNI interface.

The aim of UPC is to ensure that users who exceed their traffic contract do not degrade the QoS of users who are within their contract. The UPC function modifies non-conforming traffic by either shaping or policing:

- **Traffic Shaping**: Traffic which is too bursty (excessive cell delay variation) can be *smoothed out* by passing it through a buffer. This has the effect of increasing the average cell delay without causing cell loss. Shaping is suitable for non-real-time applications.
- **Traffic Policing:** The UPC function can discard or tag non-conforming cells as they enter the network, depending on the value of the Cell Loss Priority (CLP) bit in the cell header.

Non-conforming cells, with CLP=1, are *low priority* cells and are discarded. Non-conforming cells, with CLP=0, are *high priority* cells and are tagged.

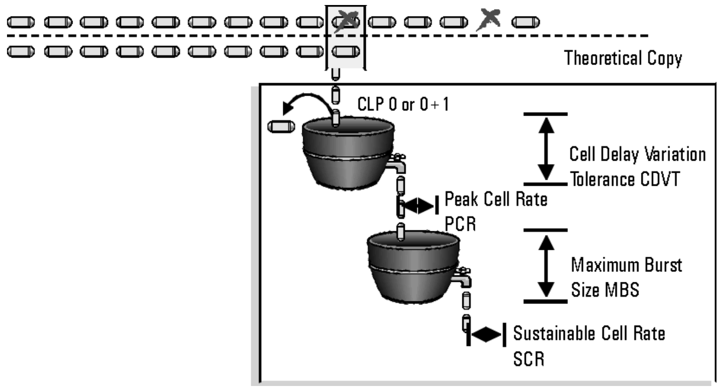
Tagging changes the CLP bit from 0 to 1 (high to low priority). The tagged cells are allowed to enter the network, but they will be discarded if congestion is encountered within the network.

GCRA Algorithm

The UPC function tests traffic for conformance by using the Generic Cell Rate Algorithm (GCRA), also known as the *leaky bucket* algorithm. A single GCRA with two parameters (PCR and CDVT) is used to characterize CBR traffic. Cell Delay Variation Tolerance (CDVT) is the amount of deviation allowed from the ideal inter-arrival time of cells arriving at the Peak Cell Rate (PCR).

An additional GCRA with two parameters (SCR and MBS) is required to characterize VBR traffic. Maximum Burst Size (MBS) determines the amount of burstiness that can be tolerated for a VBR stream of cells with an average throughput equal to the Sustainable Cell Rate (SCR).

The GCRA algorithm does not apply to ABR traffic because the ABR source continually shapes its traffic characteristics in response to flow-control feedback information contained in RM cells.



The Generic Cell Rate Algorithm (GCRA) is also called the *leaky bucket* algorithm.

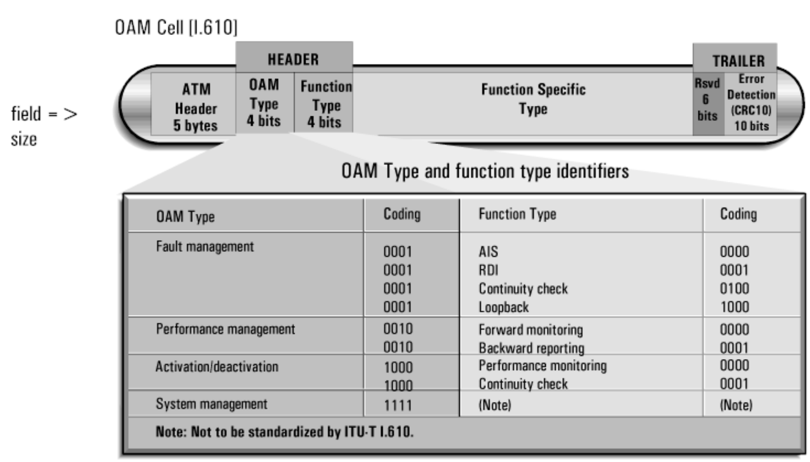
TM4.0 Summary

1 Service Category (Traffic Class)	1 Policing & Traffic Shaping Parameters			1 Guaranteed QoS Parameters	
	1 PCR, CDVT (GCRA)	1 SCR, MBS (GCRA)	1 RM Flow Control	1 CLR, CMR, CER	1 CTD, CDV
1 CBR	1 X	1	1	1 X	1 X
1 VBR-rt	1 X	1 X	1	1 X	1 X
1 VBR-nrt	1 X	1 X	1	1 X	1
1 ABR	1	1	1 X	1 X CLR Only	1
1 UBR	1	1	1	1	1

ATM OAM Testing

The Operations, Administration, and Maintenance (OAM) functions defined in I.610 include:

- **Fault management:** This function enables the ATM network equipment to report faults by sending AIS and RDI alarms. Once the network management center has been notified of a fault, it can determine the fault location by sending loopback and continuity check OAM cells.



OAM Type	Coding	Function Type	Coding
Fault management	0001	AIS	0000
	0001	RDI	0001
	0001	Continuity check	0100
	0001	Loopback	1000
Performance management	0010	Forward monitoring	0000
	0010	Backward reporting	0001
Activation/deactivation	1000	Performance monitoring	0000
	1000	Continuity check	0001
System management	1111	(Note)	(Note)

Note: Not to be standardized by ITU-T I.610.

Framework for implementing Operation, Administration and Maintenance (OAM) as defined in ITU-T I.610.

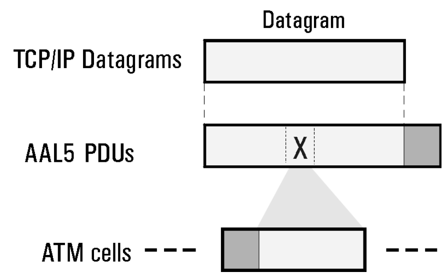
- **Performance management:** OAM PM (Performance Monitoring) cells can be inserted at regular intervals into a stream of user cells. This function enables the network to monitor QoS parameters (cell error, loss, misinsertion rate, cell delay, CDV, and SECB ratio) on blocks of user cells. This method is recommended by O.191 for performing *in-service* QoS measurements. In-service measurements are performed on live user traffic without the need to generate test traffic.
- **Activate/deactivate:** This function enables the network management center to remotely activate and deactivate OAM fault management and performance monitoring functions.

Functional testing of an OAM PM implementation

Before the OAM PM function is used to monitor in-service QoS, you should first verify that it has been implemented correctly. It is important to know that accurate information is reported to the management system.

When testing an OAM PM implementation, we have to ask the following questions:

- Is the Forward Monitoring PM cell generated correctly?
- Is the Backward Reporting PM cell generated correctly?
- Is the block size maintained?
- Does Forward Monitoring PM generation add any delay?
- Are the correct cells considered for PM cell content calculation? (F4 includes F5)
- Does a Forward Monitoring OAM-PM cell receiver calculate the I.356 QoS parameters correctly?
- Are these results reported to the management system accurately?
- Can the receiver handle multiple Forward Monitoring PM streams (load)?
- Does it handle corrupted OAM cells gracefully?



TCP/IP datagram encapsulation into ATM cells via AAL-5 PDUs.

Adaptation Layer QoS Testing

TCP/IP is the likely to become the most common higher-layer protocol carried by ATM networks. TCP/IP datagrams are encapsulated within AAL-5 PDUs. In order to evaluate the quality of service given to the higher-layer application, there is a need to correlate ATM layer QoS with AAL-5 layer QoS.

The Test and Traffic Management Working Groups within the ATM Forum have a draft specification that describes several higher-layer performance metrics. This will eventually be released as the TM5.0 specification. By using standard metrics and measurement techniques for packet-based applications, users can be sure that they are comparing switch and network performance in a realistic and fair manner.

Some of the QoS parameters that are relevant to AAL-5 are:

- **Frame Loss Ratio** (FLR) - the fraction of frames not fully delivered. This metric overcomes the limitations of the cell loss ratio and cell error ratio metrics
- **Frame Throughput -** the rate, given in bits per second, of frames successfully transmitted through the system under test

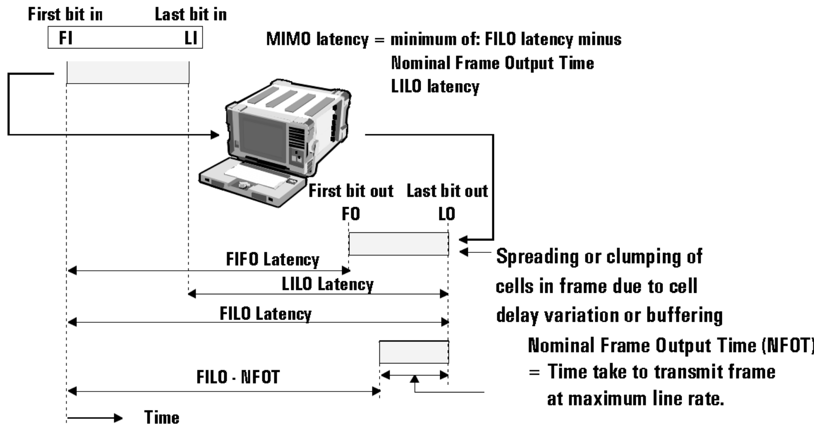
- **Maximum Frame Burst Size** (MFBS)- the maximum number of frames that can be sent at the peak rate without loss. To measure Maximum Frame Burst Size, send increasingly longer bursts of frames until loss occurs. Maximum Frame Burst Size helps to characterize the remaining useful buffer size of a switch and its ability to handle back-to-back frames.
- **Application Goodput** - the ratio of frames successfully received to frames transmitted during a measurement interval (the complement of FLR). This is a unitless measure, intended to characterize the proportion of data transferred that is useful to the application. Frame retransmission, for example, would reduce this ratio.
- **Throughput Fairness** - a measure of the fairness of resource allocation compared to the ideal allocation. An example would be the effect of congestion on two contending input streams
- **Frame Latency** - the delay of whole frames

Note that you can substitute the word *PDU*, *Packet*, or *Datagram* for *Frame* in any of the above parameters.

Frame Latency - FIFO, LILO, MIMO

There are several ways of measuring frame latency:

- **First-In, Last-Out** (FILO) - This method measures the time between the entry of the first bit to the exit of the last bit from the system under test.
- **Last-In, Last-Out** (LILO) - This method measures the time between the entry of the last bit to the exit of the last bit from the system under test.



AAL frame latency performance measurements: FILO, LILO, and MIMO.

- **Message In, Message Out** (MIMO) - This is defined as the minimum of (FILO latency minus Nominal Frame Output Time (NFOT)) and LILO latency. NFOT is the time taken to transmit the frame at the maximum line rate.

This MIMO metric is attracting a lot of discussion within the ATM Forum because it allows for different input and output link speeds. It also makes allowance for cells belonging to a frame which are not delivered continuously.

Automated QoS Testing

Many switch and network problems have already been solved at lower line interface rates during development, testing, validation, and installation. For example, switch functions such as cell tagging, and protocols such as LAN Emulation have been tested and debugged. At the newer, higher rates, the same challenges exist, but it is likely that a few *new* problems will also be encountered.

Unfortunately, all of the same tests must be executed again, at the higher line interface rates, to be confident that no new defects have been introduced. Equipment manufacturers and service providers are investing in automated testing for the regression testing of ATM switches and network services.

Many test instruments now offer an application programming interface (or API) and a development environment in which to develop test scripts and test suites. The preferred programming environment is UNIX with the C programming language, which enables greater re-use of existing code and developer skills.

However, many developers are standardizing on Tcl (pronounced *Tickle*), which stands for "Tool Command Language", as the preferred language for test scripts. Tcl programs are interpreted at run-time, so there is no need to compile and link programs, and small to medium-sized programs can be developed very quickly. Tcl is free, it runs on many platforms, it has been embedded in many test instruments and it is available with a graphical user interface development toolkit called Tk.

High-speed testing techniques

We will now look at some of the techniques used for testing QoS, OAM, policing, and performance in high-speed ATM networks.

We will examine five test scenarios to illustrate some of the issues that have been discussed in this application note.

- TM4.0 Contract Verification
- OAM functional testing and in-service QoS measurements
- ATM AdaptationLayer (AAL-5) QoS testing
- ATM AdaptationLayer (AAL-5) performance testing
- Automated testing

Test Scenario #1

ATM TM4.0 contract verification

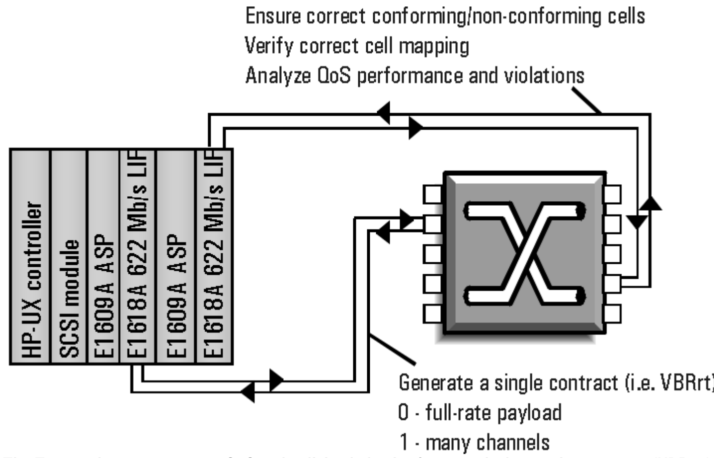
This test scenario focuses on verifying conformance with TM4.0.

To ensure that traffic policers (ingress) and traffic shapers (egress) are able to guarantee conformance to the negotiated user contract, the device should be tested to verify:

- correct traffic handling of conforming and non-conforming sources
- correct cell mapping from one port to another across the switch fabric
- CAC procedure: negotiation of QoS and traffic parameters

The stimulus of the analyzer should provide:

- a controlled traffic generator capable of specifying contracts as either CBR, VBR, UBR
- generation of a single VCC to many thousands for a single traffic class
- user-defined traffic payload editing
- PVC and SVC traffic generation



The Test equipment measures QoS and policing behavior for a particular service category (VBR-rt).

The analysis of the analyzer should include:

- QoS thresholding over the specified contract to identify QoS violations
- real-time, full-rate QoS statistics to correlate ATM and AAL performance
- traffic characterization according to the D-GCRA (dual leaky bucket algorithm)

Test Scenario #2

In-service QoS using I.610 OAM-PM cells

This test scenario involves verification of OAM PM functions, before using them to perform in-service QoS measurements.

The purpose of the functional tests is to ensure that the management system of the switch correctly reports PM information. The Forward PM cell is inserted at a nominal block-rate. A forward PM cell has a timestamp and a sequence number. These are used to calculate the QoS parameters at the far end. The Backward Monitoring PM cells are sent back to the source.

There are three main testing stages:

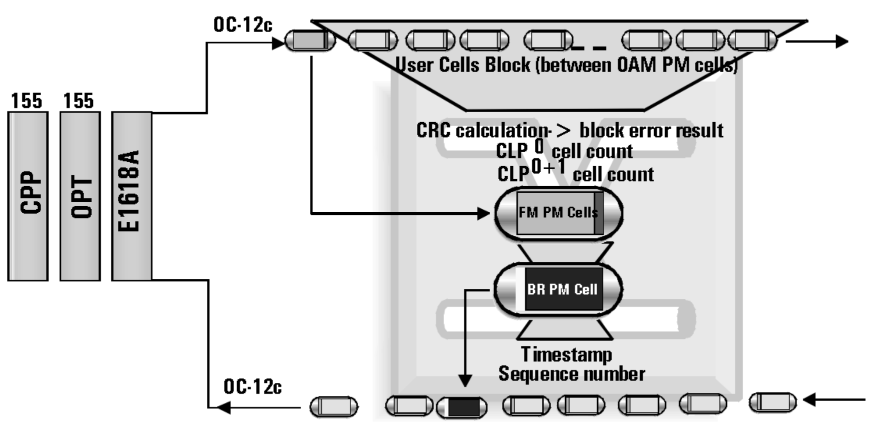
1. Send Backward Monitoring PM cells to the switch under test and verify that it reports the PM information correctly.
2. Configure the switch under test to generate Forward Monitoring PM cells and verify that the test instrument and switch management software report the same results.
3. Configure the switch under test to insert Forward Monitoring PM cells into blocks of live user traffic. Use the test instrument to measure QoS parameters in real-time such as cell error, cell loss, cell misinsertion, cell delay, CDV, and SECB ratio.

Limitations of using E1618A + E6270A for QoS measurements

- The E1618A 622 Mb/s line interface module works with the E6270A OAM Protocol Test Module. The maximum OAM and user cell rate is 149.76Mb/s.

Limitations of using OAM-PM cells for QoS measurements

- Cell Delay and Cell Delay Variation measurements are carried out on the OAM PM cells themselves and not the user cells. They only provide a sampled estimate of the user cell delay and CDV.



Functional OAM testing

Test Scenario #3

AAL-5 QoS

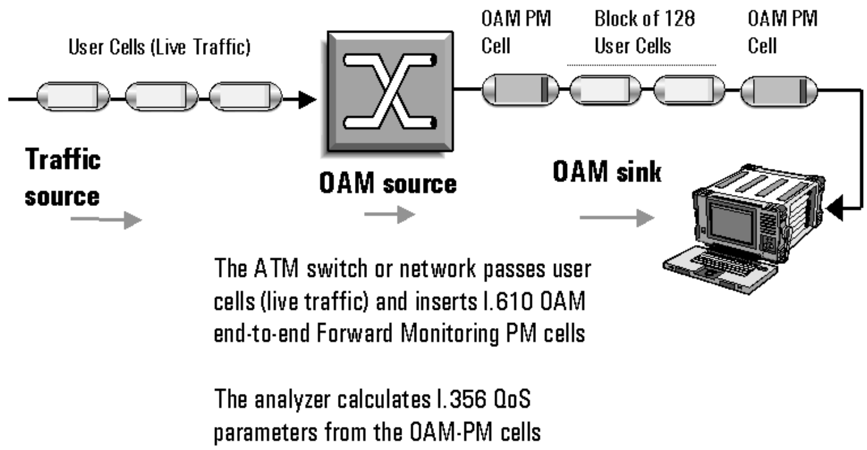
The purpose of this test is to determine the effect of ATM impairments on higher-layer QoS.

In this example, a single cell loss event causes a corrupt AAL-5 PDU, which might be carrying a TCP/IP datagram. The TCP/IP protocol retransmits the datagram. There might be a significant delay before this retransmission occurs -- especially on a long-distance, high-speed link. This may affect the performance of the application. For example, it might decrease application throughput or increase frame latency variation, causing synchronization to be lost in a multi-media application, or video buffers to overflow or underflow in a real-time video application. To measure AAL-5 performance of a switch or network:

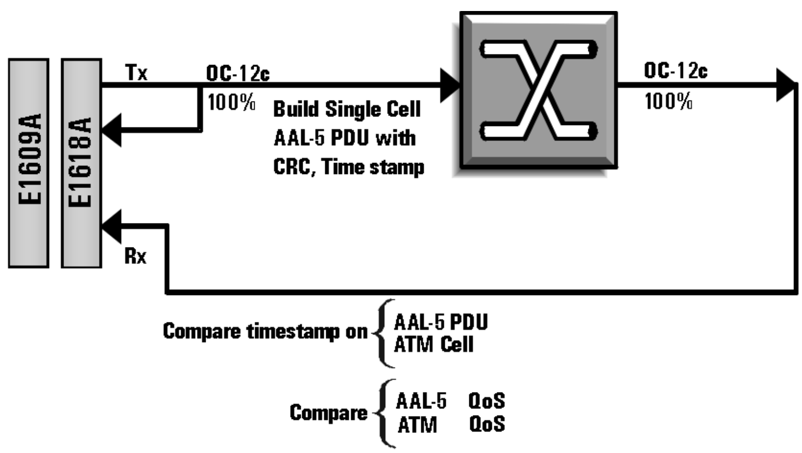
1. Inject a single-cell AAL-5 PDU with CRC and time-stamp into one port.
2. Inject a single ATM cell with CRC and time-stamp.

This technique allows ATM-layer Quality of Service measurements to be correlated with higher-layer performance measurements, such as:

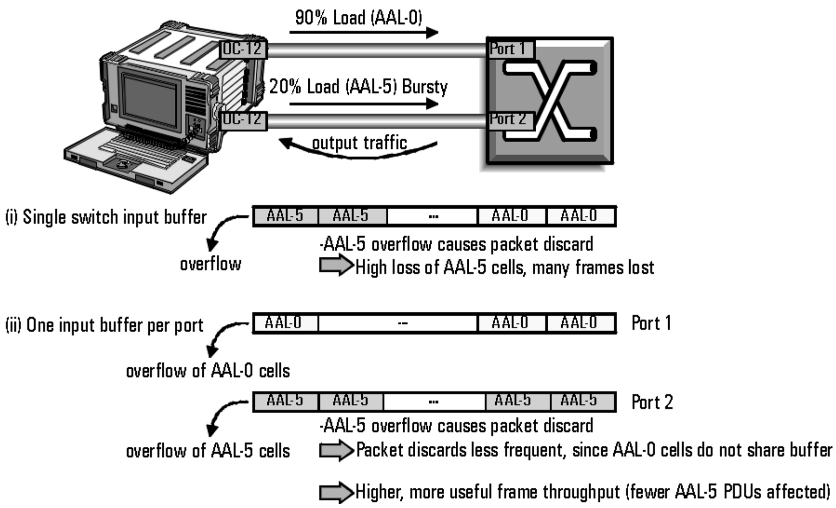
- Cell loss ratio vs. AAL-5 frame loss ratio
- Cell delay vs. AAL-5 frame latency



In-service QoS testing using OAM-PM cells.



Correlation of AAL-5 and ATM QoS measurements.



Evaluating AAL-5 performance for two different switch input buffer configurations.

Test Scenario #4

AAL-5 packet discard

The purpose of this test is to evaluate AAL-5 performance to fine-tune the network.

In this example, we want to determine which switch configuration offers the best AAL-5 performance under congested conditions. The switch could be configured with:

- a single input buffer for all ports or
- one input buffer per port.

Which is the best approach?

To answer this question, we use the following procedure:

1. Use the test equipment to send constant-rate AAL-0 traffic at 90% full load to input port 1
2. Send bursty AAL-5 traffic at only 20% load to input port 2
3. Configure the switch to route both traffic streams to output port 2. The switch is being asked to force a 110% traffic load to this single port, resulting in congestion!

In this example, the following results might be observed:

- When configured with a common, single input buffer, the (bursty) AAL-5 traffic suffers massive loss, while the AAL-0 traffic is affected much less because of the gaps in the AAL-5 traffic. Partial packet discard, when enabled, helps the AAL-0 traffic even more by discarding more AAL-5 traffic, thus increasing the inter-burst gap.
- When separate input buffers are used, the performance changes significantly. Cells from each port are treated equally, resulting in more AAL-5 traffic getting through and less AAL-0 traffic getting through. Partial packet discard helps the AAL-5 traffic throughput without affecting the AAL-0 traffic loss.

By analyzing the performance test results, we can conclude that using separate buffers is the best approach for this scenario.

Test Scenario #5

Automated QoS testing

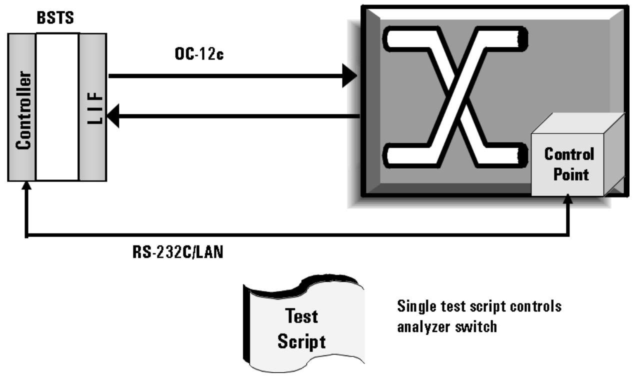
A complete test setup requires several elements to be controlled:

- During testing, the *switch or service under test* often needs to be configured for each test case. For example, to configure the timing mode of the ATM switch.
- Some test scenarios may also require data to be read from a *network management system*. For example, to monitor for OAM alarms.
- The *analyzer* is typically configured to generate test traffic and perform measurements and protocol decoding on the received data.

Ideally, a single test script should remotely control the whole of the system under test, including analyzer, network management system, and switches, as shown in the diagram. In this example, a UNIX workstation is running a Tcl test script to control all elements of the test setup.

The *QA group* of an equipment manufacturer could use an automated test setup for long term testing or production test.

A *service provider* could also use a similar test setup to remotely test the whole network or to benchmark equipment from several different manufacturers.



Conclusions

In this application note, we have discussed a number of management issues such as QoS, Policing, and OAM that are encountered in high-speed ATM networks.

A selection of test scenarios has been presented that illustrate some of the test techniques that can be used to verify both the functions and the performance of high-speed networks and equipment.

BSTS High-Speed Products

All of the previous test scenarios can be performed using the following high-speed products for the industry-standard Agilent Broadband Series Test System (BSTS):

- E1609A 0-622 Mb/s ATM Stream Processor (ASP)
- E1618A 622 Mb/s Optical Line Interface
- E4210B Option 005 2.5 Gb/s ATM Test Solution

E1609A 0-622 Mb/s ATM Stream Processor

The E1609A 0-622 Mb/s ATM Stream Processor (ASP) is a module that offers users of the BSTS a new paradigm to testing broadband devices and services. The E1609A ASP is a companion to the E4209B Cell Protocol Processor (CPP) and line interface that provides you with

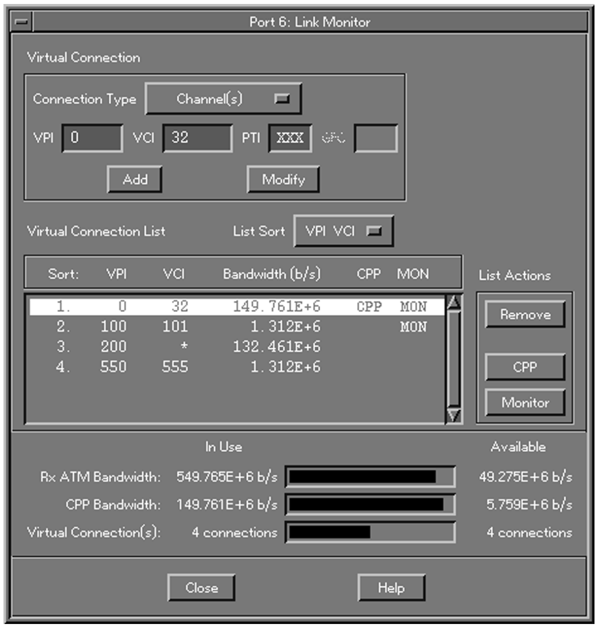
This page intentionally left blank.

High-Speed, QoS, and OAM Test Solutions

a new level of real-time traffic generation and analysis.

The E1609A ASP is a powerful tool for real-time Quality of Service and performance measurement that occupies only one slot of the Agilent Broadband Series Test System (BSTS). Combined with the E1618A 622 Mb/s Optical Line Interface and E4209B CPP, the E1609A ASP provides the most complete 622 Mb/s ATM test solution available.

ATM traffic generation and full-rate AAL-5 is available on over 16,000 VP/VCs for stress testing your system call tables and memory management.



E1609A ATM Stream Processor Link Monitor.

Real-time summary statistics on eight VP/VCs, enabling measurement of bandwidth utilization and address information, are displayed on the Link Monitor. Real-time AAL-5 statistics enable testing of early packet discard, and provide performance metrics – such as frame loss – for LAN Emulation and other higher-layer protocols.

From software release 1.1, the E1609A ASP offers extensive real-time multi-channel Quality of Service (QoS) performance measurements. It tests not only 622 Mb/s but also other line rates using existing line interfaces, adding value to your investment in the Agilent BSTS.

For customers who also require Operations and Maintenance (OAM), the E1609A ASP can be used in association with the E6270A OAM Protocol Tester for a comprehensive traffic management solution (release 1.1).

Key Features

- Full-rate 0-622 Mb/s ATM testing
- 2-slot 622 Mb/s SONET/SDH and ATM testing with E1618A
- Access to Cell Protocol Processor offers SVC call set-up, signalling, higher-layer and conformance testing
- Real-time AAL-5 and ATM statistics on two VP/VCs (release 1.0)
- AAL-5 and ATM traffic generation on over 16,000 VP/VCs
- PDU sequence builder
- Real-time ATM layer Quality of Service performance (release 1.1)
- Use with other lower speed line interfaces for Quality of Service measurement at all line rates (release 1.1)

E1618A 622 Mb/s Optical Line Interface

The E1618A 622 Mb/s Optical Line Interface provides OC-12c (SONET STS-12c and SDH STM-4c) access to the system under test via SC optical connectors. The LIF is a singe-mode device that can also be used with multi-mode systems when the appropriate attenuator is fitted.

Functionality includes alarm and error generation and detection, as well as extensive testing of line, section, and path overheads.

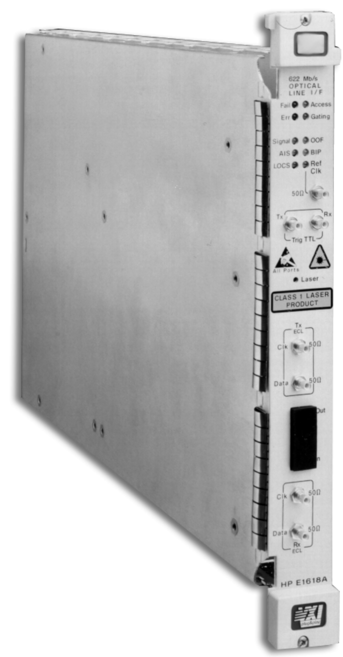
Payload pointer testing includes pointer stressing and measurement of both loss of pointer synchronization and pointer values. Section and path trace messages can be generated and captured in 16 and 64 byte formats.

External triggers can be used to synchronize transmitter or receiver events to other test equipment or network devices.

You can connect the E1618A LIF directly to the E4209B Cell Protocol Processor (CPP) for a cost effective signalling test solution at 622 Mb/s.

Key Features

- Full-rate 622 Mb/s SONET/SDH generation and analysis
- SONET/SDH transport overhead building, generation, error injection, capture, and save/load
- Alarm generation and detection
- BIP error injection and detection
- Payload pointer stressing
- Trace message generation & capture
- Automatic REI alarm generation
- Graphing and logging of real-time statistics for correlation of multiple measurements
- Tcl and C-scripting automated test environment (UPE)
- Optical and Electrical 622 Mb/s interfaces
- Works with the E1609A 0-622 Mb/s ATM Stream Processor for 2-slot full rate 622 Mb/s ATM traffic testing
- Access to the E4209B Cell Protocol Processor for signalling and higher layer test (directly or via the E1609A)



The E1618A 622 Mb/s Optical Line Interface (LIF) is a single slot, single port (1 Tx/ 1 Rx) VXI module for the BSTS that provides access to OC-12c/STM-4c devices.

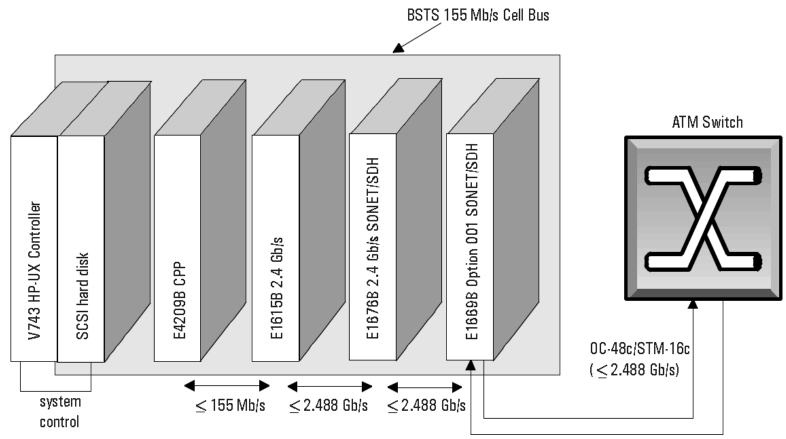
E4210B Option 005 2.5 Gb/s ATM Test Solution

The E4210B option 005 is a 2.4 Gb/s ATM analyzer bundle that provides access to the E4209A/B Cell Protocol Processor. You can perform tests at higher layers, including ATM, AAL (1,2,3/4,5), signalling and IP/ATM over an OC-48c/STM-16c interface.

This is a 7-slot VXI solution when fully configured and supports a 1310nm 2.4 Gb/s optical line interface (with optional 1550nm optics).

Key features

- Generate and analyze OC-48c/STM-16c frames for
- Test alarms, errors, and SONET/SDH pointer movements
- Generate and analyze ATM cell streams at full rate 2.4 Gb/s
- Perform OAM fault management tests
- Make ATM Quality of Service (QoS) measurements

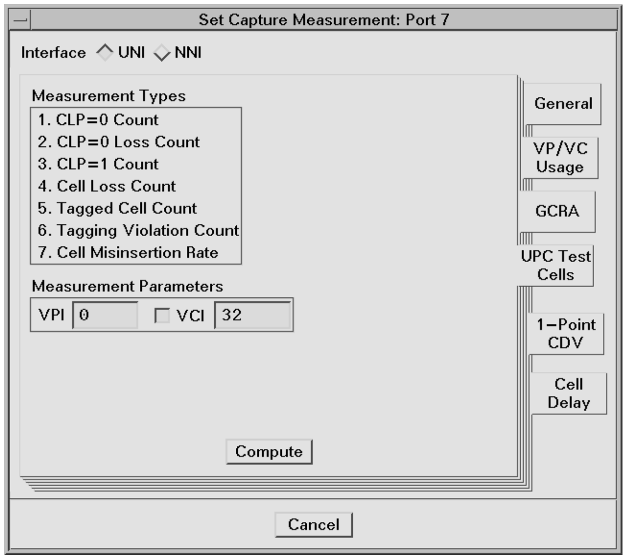


Analyze SONET/SDH ATM and higher layers at up to 2.4 Gb/s.

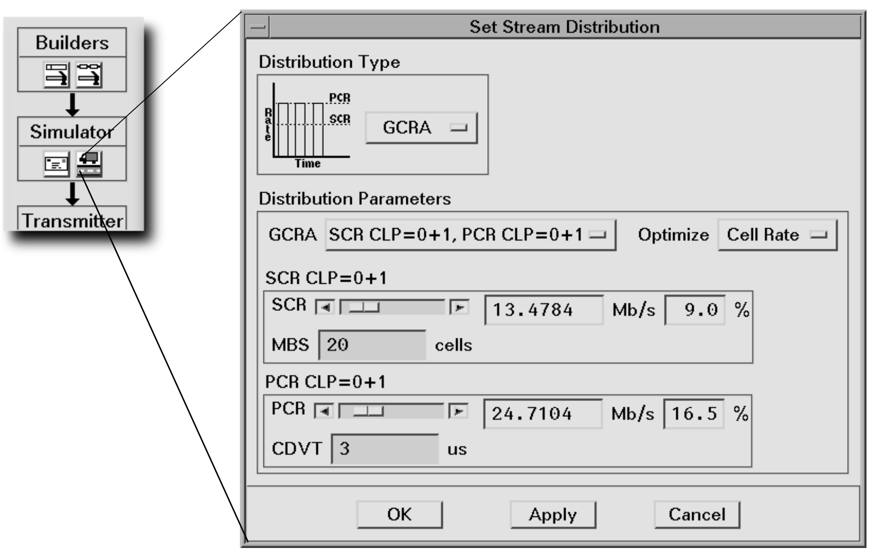
BSTS QoS and OAM Products

The previous test scenarios use the following QoS and OAM products for the industry-standard Agilent Broadband Series Test System (BSTS):

- E4223A ATM Policing & Traffic Characterization Test Software
- E6270A OAM Protocol Tester (OPT)



Working with the E4223A Policing & Traffic Characterization Test Application, the E4209B Cell Protocol Processor generates UPC test cell streams to provide in-depth QoS and policing analysis.



GCRA traffic shaping allows generation of precise traffic to stress the policing implementation.

P E4223A ATM Policing & Traffic Characterization Test Application

The E4223 A ATM Policing & Traffic Characterization Test Application is software which provides:

- traffic generation and analysis to verify policing algorithm implementations
- test features to characterize user traffic

Part of the modular Agilent BSTS, this test solution is ideal for R&D engineering, product development, quality assurance and active network application.

Key features:

- Generates pre-defined conforming (or non-conforming) traffic and then observes the reaction of the network equipment under test
- Uses a large sample of up to 131,072 cells to accurately characterize traffic
- Measures cell arrival time, cell interarrival time, cell delay, peak-to-peak cell delay variation and 1-point cell delay variation
- VP/VC utilization analysis

E6270A OAM Protocol Tester

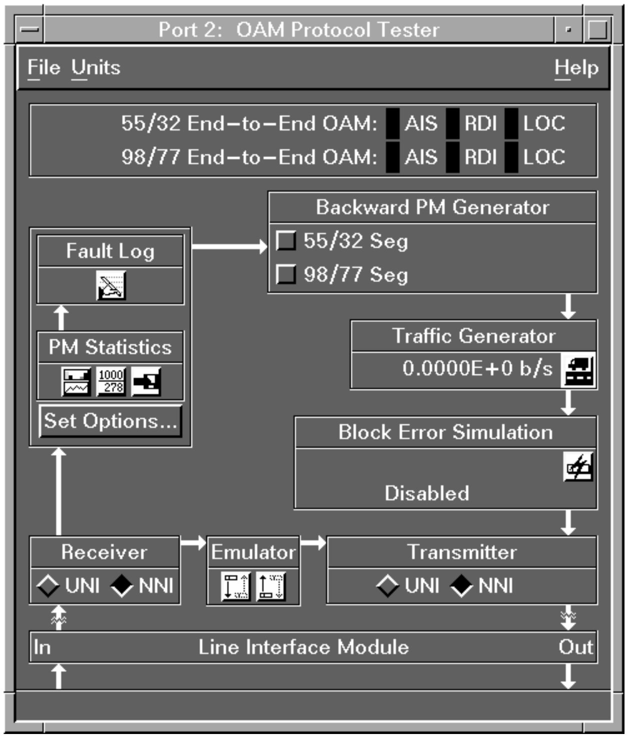
The E6270A OAM Protocol Tester (OPT) is a dedicated module for the verification of the ATM Operations and Maintenance (OAM) protocol.

Much more than a simple OAM cell decoder, the OPT fully leverages the features of OAM to offer a product which may be used for the verification of the fault-detection, fault-localization and performance monitoring features of OAM.

The large-scale deployment of ATM networks and services presents new network management challenges for both network equipment manufacturers and service providers. Delivery of time-sensitive payloads, such as voice and video, over ATM networks requires fault management and performance monitoring tools. Simple verification of connections is not enough to guarantee that Quality of Service (QoS) standards are being met and usable customer services delivered.

The ATM OAM protocol offers a standardized, in-service method for network monitoring. Its standardized data elements may be used to provide fault detection, fault localization and performance monitoring of ATM connections. From this information, key network management information such as QoS and network connectivity can be delivered.

OAM is a complicated protocol, requiring careful implementation and a dedicated test solution to ensure conformance with the relevant ITU-T and Bellcore specifications. With this module, Agilent has delivered the industry's first real-time test solution for ATM OAM.



Main control dialog for the E6270A OAM protocol tester.

The E6270A OAM Protocol Tester - a compact single-slot VXIbus module for the industry standard Broadband Series Test System.

Key Features

- Powerful 124 channel user-data generator
- Automatic generation of F4 and F5 OAM cells on all user-data channels
- Two channel receiver which allows simultaneous OAM F4 and F5 testing
- Generate OAM source requests and report request outcome
- Emulate OAM destination responses
- Monitor OAM cell flows
- Generate impaired OAM cells to stress test equipment

Acronyms

AAL	ATM Adaptation Layer
ABR	Available Bit Rate
AIS	Alarm Indication Signal
APS	Automatic Protection Switching
API	Application Programming Interface
ASP	E1609A ATM Stream Processor
ATM	Asynchronous Transfer Mode
BER	Bit Error Rate
BSTS	Broadband Series Test System
CAC	Connection Admission Control
CBR	Constant Bit Rate
CDV	Cell Delay Variation
CDVT	CDV Tolerance
CLP	Cell Loss Priority
CLR	Cell Loss Ratio
CPP	E4209B Cell Protocol Processor
CRC	Cyclic Redundancy Code
CTD	Cell Transfer Delay
FIFO	First In, First Out
FILO	First In, Last Out
FLR	Frame Loss Ratio
GCRA	Generic Cell Rate Algorithm
GUI	Graphical User Interface
IE	Information Element
IP	Internet Protocol
ITU	International Telecommunications Union
LAN	Local Area Network
LANE	LAN Emulation
LILO	Last In, Last Out
MBS	Maximum Burst Size
MFBS	Maximum Frame Burst Size
MIMO	Message In, Message Out
NFOT	Nominal Frame Output Time
NNI	Network to Network Interface
NPC	Network Parameter Control
OAM	Operations, Administration, and Maintenance
OC-3c	SONET Level 3 - 155 Mb/s (concatenated frame format)
OC-12c	SONET Level 12 - 622 Mb/s (concatenated frame format)
OC-48c	SONET Level 48 - 2.4 Gb/s (concatenated frame format)
OPT	E6270A OAM Protocol Tester
PCR	Peak Cell Rate
PDH	Plesiochronous Digital Hierarchy
PDU	Protocol Data Unit
PM	Performance Monitoring
PNNI	Private Network to Network Interface
PVC	Permanent Virtual Circuit
QoS	Quality of Service
RDI	Receive Defect Indicator
RM	Resource Management
SCR	Sustainable Cell Rate
SDH	Synchronous Digital Hierarchy
SECB	Severely Errored Cell Block
SECBR	SECB Ratio
SONET	Synchronous Optical Network
STM-1	SDH Level 1 - 155 Mb/s

STM-4c	SDH Level 4 - 622 Mb/s (concatenated frame format)
STM-16c	SDH Level 16 - 2.4 Gb/s (concatenated frame format)
SVC	Switched Virtual Circuit
Tcl	Tool Command Language
TCP	Transport Control Protocol
TM	Traffic Management
UBR	Unspecified Bit Rate
UNI	User Network Interface
UPC	Usage Parameter Control
UPE	User Programming Interface
VBR	Variable Bit Rate
VBR-nrt	VBR Non Real Time
VBR-rt	VBR Real Time
VC	Virtual Connection
VCI	Virtual Connection Indentifier
VP	Virtual Path
VPC	Virtual Path Connection
VPI	Virtual Path Identifier

Agilent Technologies Broadband Series Test System

The Agilent Technologies BSTS is the industry-standard ATM/BISDN test system for R&D engineering, product development, field trials and QA testing. The latest leading edge, innovative solutions help you lead the fast-packet revolution and reshape tomorrow's networks. It offers a wide range of applications:

- ATM traffic management and signalling
- Packet over SONET/SDH (POS)
- switch/router interworking and performance
- third generation wireless tesing
- complete, automated conformance testing

The BSTS is modular to grow with your testing needs. Because we build all BSTS products without shortcuts according to full specifications, you'll catch problems other test equipment may not detect.

www.Agilent.com/comms/BSTS

United States:

Agilent Technologies
Test and Measurement Call Center
P.O. Box 4026
Englewood, CO 80155-4026
1-800-452-4844

Canada:

Agilent Technologies Canada Inc.
5150 Spectrum Way
Mississauga, Ontario
L4W 5G1
1-877-894-4414

Europe:

Agilent Technologies
European Marketing Organisation
P.O. Box 999
1180 AZ Amstelveen
The Netherlands
(31 20) 547-9999

Japan:

Agilent Technologies Japan Ltd.
Measurement Assistance Center
9-1, Takakura-Cho, Hachioji-Shi,
Tokyo 192-8510, Japan
Tel: (81) 426-56-7832
Fax: (81) 426-56-7840

Latin America:

Agilent Technologies
Latin American Region Headquarters
5200 Blue Lagoon Drive, Suite #950
Miami, Florida 33126
U.S.A.
Tel: (305) 267-4245
Fax: (305) 267-4286

Asia Pacific:

Agilent Technologies
19/F, Cityplaza One, 1111 King's Road,
Taikoo Shing, Hong Kong, SAR
Tel: (852) 2599-7889
Fax: (852) 2506-9233

Australia/New Zealand:

Agilent Technologies Australia Pty Ltd
347 Burwood Highway
Forest Hill, Victoria 3131
Tel: 1-800-629-485 (Australia)
Fax: (61-3) 9272-0749
Tel: 0-800-738-378 (New Zealand)
Fax: (64-4) 802-6881

Specifications subject to change.

5968-1237E 04/00 Rev B

Agilent Technologies
Innovating the HP Way