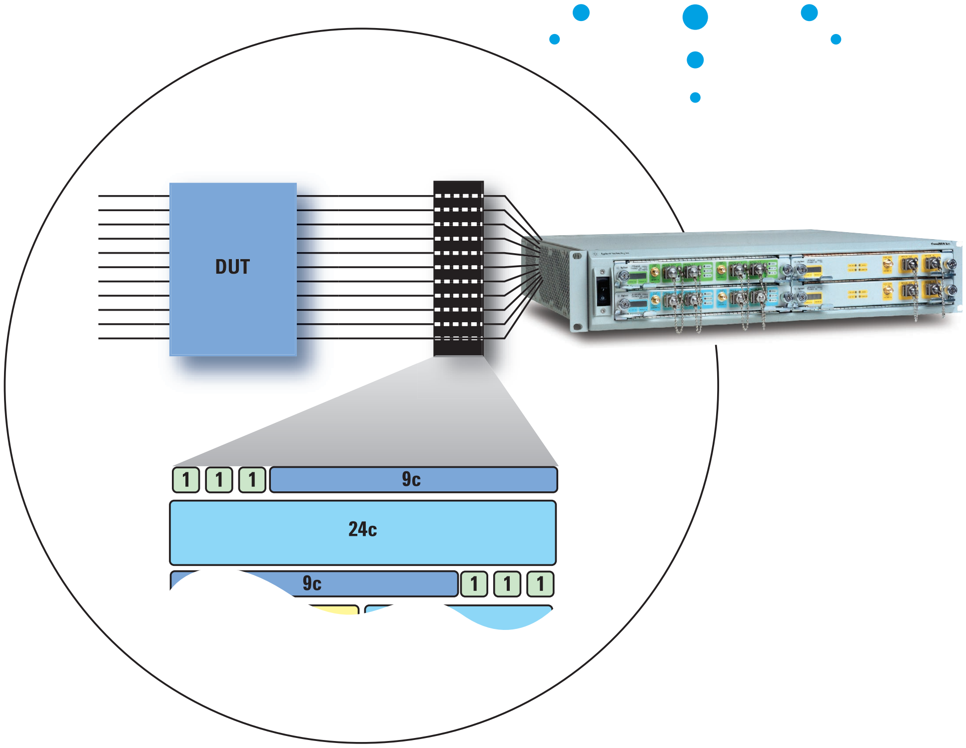
Next Generation SONET/SDH devices

– the driver for multi-port, multi-channel test

Application note



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Introduction

This application note describes next generation SONET/SDH telecomm network equipment and some of the new challenges faced in testing the behavior and characteristics of such equipment.

Next generation equipment is much more complex than legacy equipment due to the amalgamation of numerous functions into a single platform. This convergence of functions provides clear benefits, including lower purchase and operating costs. Service provisioning is also easier and faster, particularly in the metro area of the network. The metro network is located between the edge or access network (the customer interface) and the core network, which provides long distance transmission.

However, being in the metro area also means further complexity is necessary to access the large number and variety of interface types present at the edge of the network.

Next generation devices are capable of supporting multiple SONET/SDH rings, this in turn leads to the biggest challenges in testing and it soon becomes apparent that a new approach to testing is required.

This document deals only with issues raised by SONET/SDH testing and doesn't deal with GbE or any of the other interfaces.

Next generation SONET/SDH

Value delivered in the next generation network element

The values that NEMs are able to deliver to their customers with Next Generation SONET/SDH devices include cost reduction and improved ease of operation. This is the driver for the development of these devices.

Costs are reduced by combining the functions of several traditional network elements such as grooming, switching, wavelength division multiplexing (WDM) and add/drop multiplexing (ADM) into a single multi-function platform. This reduces capital costs simply through the fact that fewer elements are required in the network. Operating costs are also reduced through lower floor space requirements and reduced power consumption.

Ease of operation is delivered from the combination of telecom, data and multiple network functions in a single platform. This allows the network provisioning system to cater for both data and voice in a single network control environment, and permits “point and click” provisioning. Ease of operation is important because it provides operators with significant improvements in the ease and speed of service provisioning, enabling them to bring new services to market faster. There is also potential to improve market share by providing a greater variety of services, or more innovative services to end-users.

Next Generation SONET/SDH is particularly important in the Metro area, where multiple services from customer sites, including Ethernet, IP and voice need to be combined for transmission into the core network. To be effective in this area a typical next generation device must be able to accommodate interfaces for all of the varied technologies it may encounter in the Metro area. These devices are often referred to as Optical Edge Devices (OEDs) or multi-service provisioning platforms (MSPPs).

Some devices are focused on addressing the needs of the metro edge. These contain numerous interfaces catering for Ethernet, IP, voice, etc to accept the mix of services found at various customer sites. Their internal architecture will include adaptation layers to transform this mixture of traffic into the SONET/SDH frames, which are then multiplexed on to metro rings or towards the network core itself.

Other devices are more focused on the metro core, the link from the metro network into the core network. These may contain a lower variety and number of tributary interfaces but will have higher rate SONET /SDH line side interfaces possibly including DWDM capability.

By definition a next generation platform is an amalgamation of several network elements and as a consequence will feature many more ports than legacy equipment. Some next generation devices, such as the Cisco ONS15600, Ciena Core Director and Nortel Optera Metro are already capable of accommodating several hundred ports.

On the tributary side of the device, these ports would cover both voice and data technologies with a suitable variety of line rates. Where necessary the introduction of new, arbitrary concatenations such as STS-6c, STS-9c, STS-24c and their SDH equivalents, AU-4-2c, AU-4-3c and AU-4-8c are made accessible.

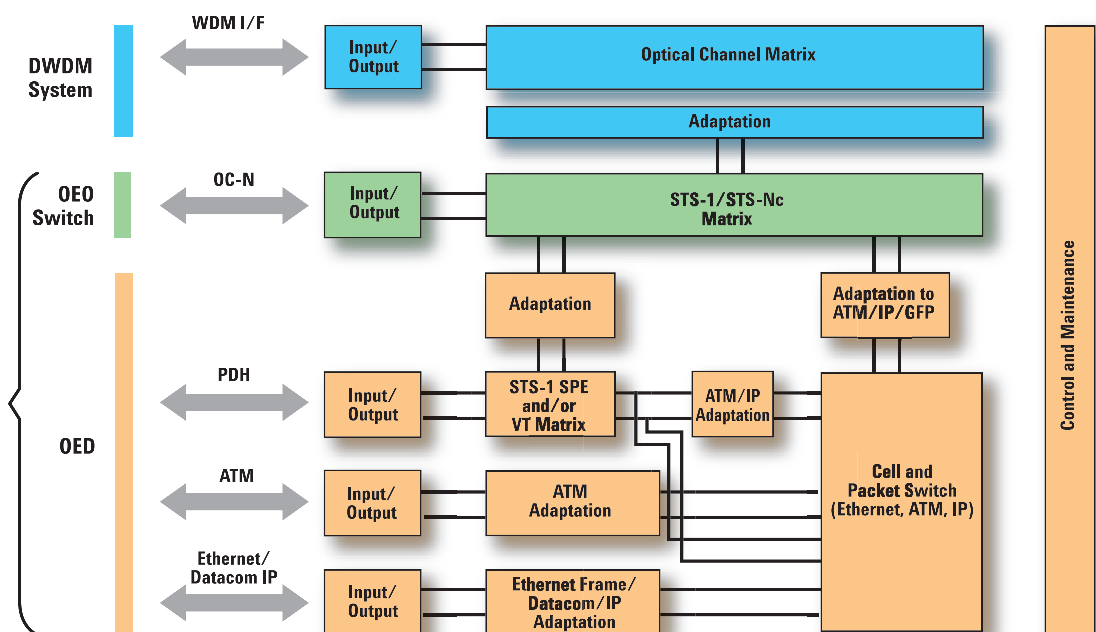
On the line or aggregate side of the device there is also a larger number of ports. With traditional devices, a single SONET/SDH ring would normally be supported. However, with next generation devices multiple rings may be supported. Already some devices accommodating 10 rings or even more are available.

Figure 1 shows how multiple functions are merged into a single device in NG SONET/SDH. The orange colored boxes provide the interfaces and infrastructure for receiving and transmitting a range of technologies including PDH, ATM, Ethernet and IP. The data and voice signals are connected through adaptation components to a SONET/SDH stratum. The stratum contains optical interfaces to handle SONET/SDH from STS-1 upwards and controls the switching functions. Note that SONET/SDH interfaces may serve both the tributary and the line side of the device. Finally, the blue colored boxes indicate the line side of the device, in this case a DWDM system.

Different NEMs devices will contain some or all of these sections with differing degrees of priority for each. For example, a device that is intended for use at the edge of the metro network will feature many of the orange and green colored boxes of Figure 1. A device that is intended for use nearer to the core area of the metro network would have more blue and green colored boxes.

Although there are advantages to the network operator using next generation devices, the internal complexity of these devices and the high number of ports introduce some significant design and test challenges for NEMs. Operators will also encounter new challenges in acceptance testing prior to deployment. The rest of this application note will describe some of these challenges.

Figure 1: Generic architecture of next generation SONET/SDH device



Behavior and test challenges of legacy devices

A traditional SONET/SDH device will perform one of several functions. For example, multiplexing/demultiplexing, cross connecting/switching, or grooming. Let's consider an add/drop multiplexer. If we regard the tributaries as the input side, and the line or aggregate side as the output, then there are generally fewer outputs than inputs. Normally only one ring is supported on the line side. Therefore a single port instrument is adequate for testing on the line (aggregate) side of the device. On the input side only SONET or SDH technology is involved with the possible addition of PDH interfaces. There is unlikely to be any other technology such as GbE present. This type of device is shown in Figure 2.

Behavior and test challenges of next generation devices

In contrast to the traditional device with a limited number of tributaries and supporting a single ring, the next generation device has many tributaries of varying rates and technologies and supports several rings. This is shown in Figure 3.

Figure 3:
Next generation device supporting multiple-rings

Next generation

- Support multiple rings
- Muxing of ADM with aggregation of multi-service data switch
- Integral DXC used to switch virtual tributaries (i.e. assign VT to rings)
- IP/Ethernet MAC switching
- Single NE covers DS-1 to OC-192 and also handles datacom interface
- Protection switching either performed at a card level or via integral DXC

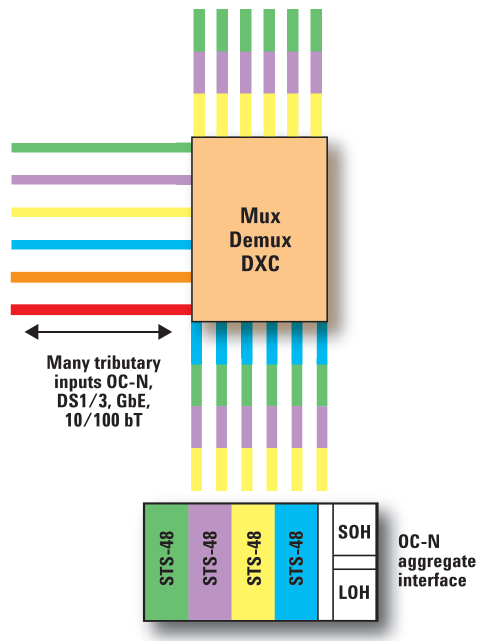
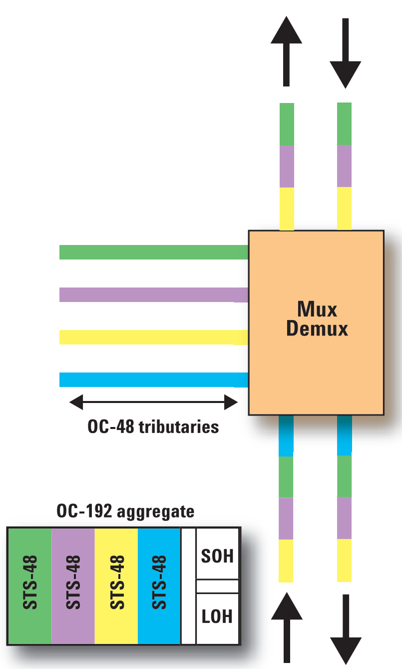


Figure 2:
Legacy SONET/SDH add/drop multiplexer

Normal operation

- Mixed payloads or tributaries
- Aggregate rings at higher rate (e.g. STS-192)
- Tributary traffic multiplexed into aggergate payloads
- Tributary traffic also demultiplexed from aggregate payloads



The support of multiple rings by next generation equipment is a fundamental change, and it is this aspect more than almost any other that presents significant and complex challenges for testing the device. Two typical challenges found in next generation devices are described as follows.

Multiple errors (errors on tributaries)

Let's see what happens when we inject an error onto one of the tributaries.

- The tributary interface registers B3 errors and as a result B1 and B2 errors will also appear on the tributary to reflect this state.
- The B3 errors are transported in the payload through the device and on to one or several of the rings on the line side to the far end. The B1s and B2s are terminated in the device.
- The transported B3 errors are detected by remote network elements which then respond by generating REI-P (or REI-RS in SDH)
- Now consider a worst-case scenario. The B3 error in the tributary is carried to all of the rings supported by our device. There is potential for flooding the network with errors and alarms as each network element within each ring responds by issuing REI-P until the signal is restored.
- Finally, protection switching is used to recover the tributary signal if the error rate exceeds the chosen error threshold, for example 10^{-3}. Alternatively, error suppression algorithms are used to contain the error rate below the threshold.

In the worst case, multiple paths on multiple rings are errored at the same time. It is no longer good enough to test one channel or even one port at a time. The only way that you can measure the true behavior of network elements in this type of environment is to use simultaneous multi-channel, multi-port testing. There is no other way to achieve a complete picture of the network elements characteristics. The only alternative is to test less and take chances. For example, use a single port tester and assume that what you see on one ring is representative of the others.

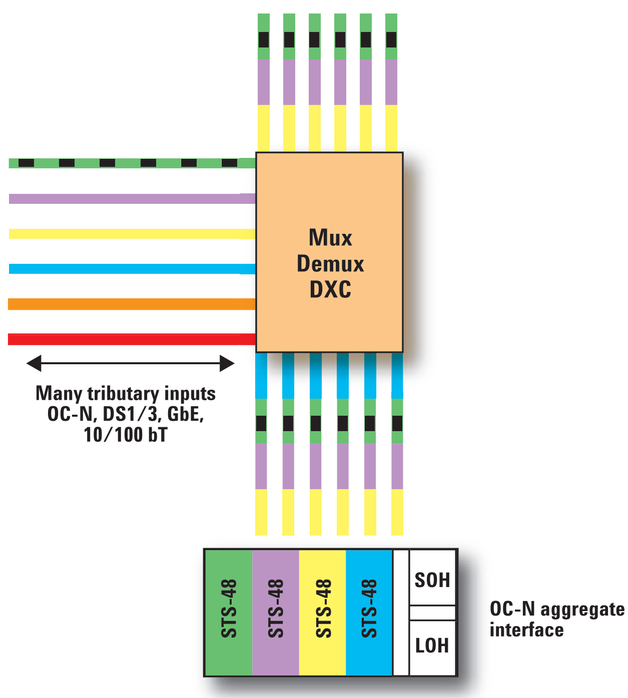


Figure 4:
The effect of tributary errors

Multiple alarms (failure of tributary)

Now let's see what happens if there's a cut in the tributary interface in a multi-service platform (MSPP).

- First, the tributary interface registers a LOS.
- This LOS then causes an AIS-P (or AIS-RS in SDH) to be generated in all impacted virtual containers on the line side of the device. Where multiple rings (multiple aggregate lines) are supported, this will occur across all affected rings at the same time.
- As the AIS-Ps are transported around the rings, the Network Elements associated with these rings then respond with an RDI-P (or RDI-RS in SDH).
- Finally, protection switching is used to recover the tributary signal.

If multiple rings are affected then once again there is potential for flooding the network with alarms until the signal is restored. As in the previous example, the only way that you can adequately test the behavior of a device in this scenario is to use simultaneous multi-channel, multi-port testing. There is simply no other option.

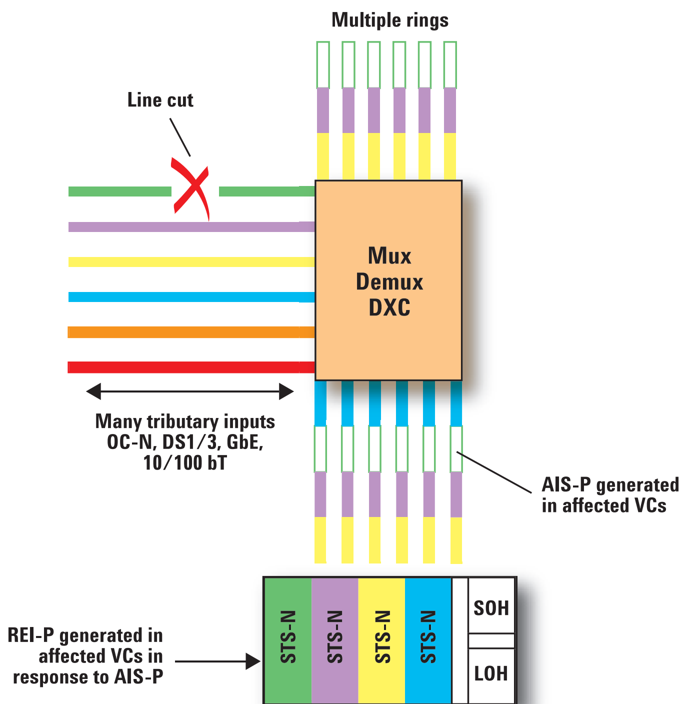


Figure 5:
The effect of a tributary failure

Error and alarm bursts

It is clearly useful to have a tester that can re-create the network conditions described previously. These conditions may be achieved with a suitable multi-port instrument capable of running in through mode.

Once installed in the network, devices will regularly be exposed to bursts of errors and alarms as a result of the scenarios described earlier. Performance monitoring involves generating errors and alarms to a device and then measuring the response to them. This is a vital part of both the operation and testing of a network element.

Performance monitoring is covered in Telcordia standard GR-253, ITU-T standards G.821, G.826 and G.828 and in the ITU-M2100 series standards. In essence, the standards define the number and frequency of errors or alarms that may be tolerated on a network connection before it is deemed to have failed, or before an associated device is deemed to have failed.

Manufacturers implement thresholds within the NE to ensure stability during error and alarm flooding conditions. An important test of these thresholds is to send bursts of errors and alarms in a controlled manner (e.g. a fixed number of errors just below and then just above the device threshold) and then observe the behavior of the DUT. Does it respond correctly? Is it stable? This can only be truly assessed by applying realistic inputs across all ports and channels simultaneously, and measuring the response of the device across all the ports and channels.

Protection switching

The previous examples referred to the use of automatic protection switching (APS) to restore the network to normal in the event of error rates exceeding set thresholds. In next generation devices with multiple rings APS becomes much more complex than before with a number of new protection schemes being apparent in these new devices. APS will be the subject of a separate application note.

Critical advantages of multi-port/multi-channel measurement

In conclusion, it is apparent that a new approach is required when testing next generation network elements (MSPPs). It is not so much the specific test functions that are a challenge, it is the number of ports and the need for simultaneous test that is important. Without simultaneous test across a number of ports it is easy to miss faults that occur intermittently and almost impossible to gauge the true behavior of a network element when multiple errors and alarms. This is summarized in the Figures 6a, 6b and 6c.

A fundamental requirement of the design of NG systems is their ability to remain stable during occurrences of error and alarm flooding. They must be able to respond correctly should the levels of errors and alarms exceed pre-set thresholds. Testing of this behavior is described in the “Error and Alarm Bursts” section. Workarounds for running such tests using splitters and amplifiers coupled to single port testers are possible for a few ports at a time. However, this method simply isn’t adequate to test the high port counts now being employed. In fact, it could even prove impossible to achieve the required error / alarm thresholds on enough ports for the test to have any validity. In this situation the first chance a manufacturer would have to discover a fault would be during the first customer installation. Not a risk that any manufacturer is likely to be comfortable with.

Similarly, when considering the switching and grooming capabilities of a next generation device it is important to have multi-channel measurements. This allows for the tracking of all payload containers through these devices and allows the containers to be tracked on the line side of the device. Again this is not possible on a single port, single channel device. You could test each port in turn, but you can’t see what’s happening on the other ports.

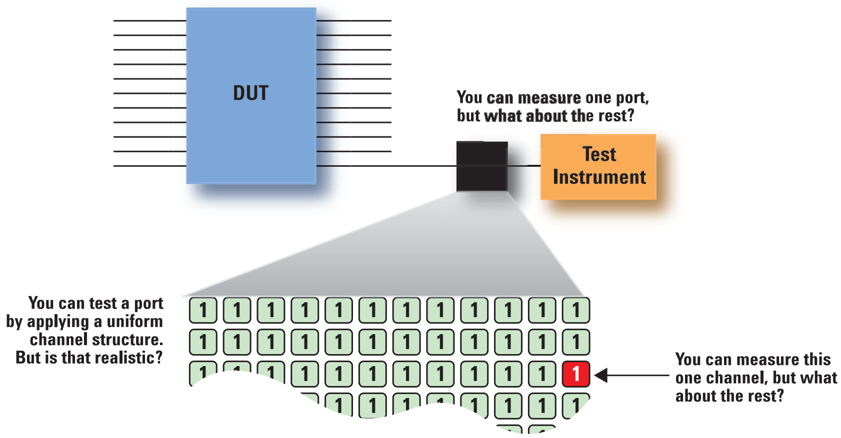


Figure 6a:
Conventional test equipment with next generation DUT

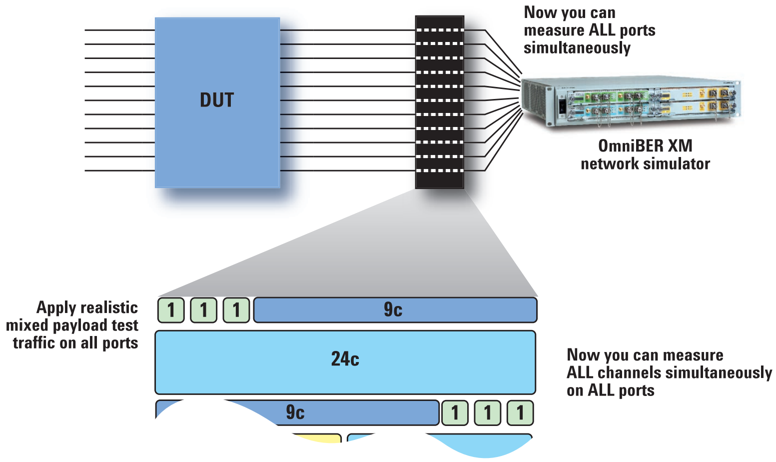


Figure 6b:
Next generation multi-port test equipment makes the difference

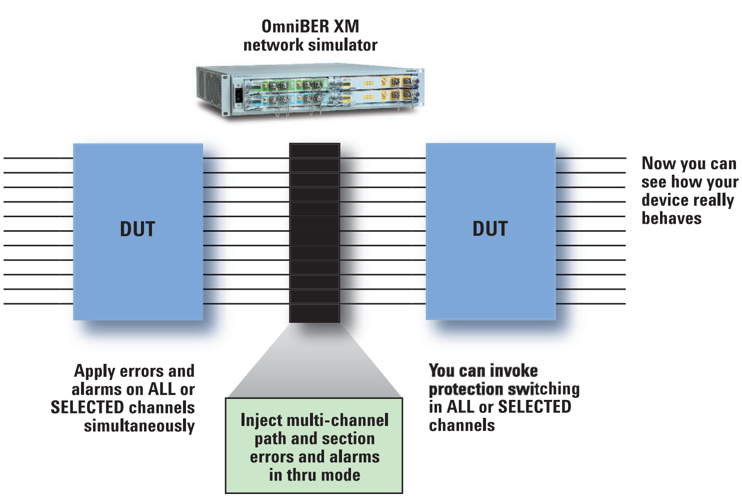


Figure 6c:
Thru-mode is essential for next generation testing

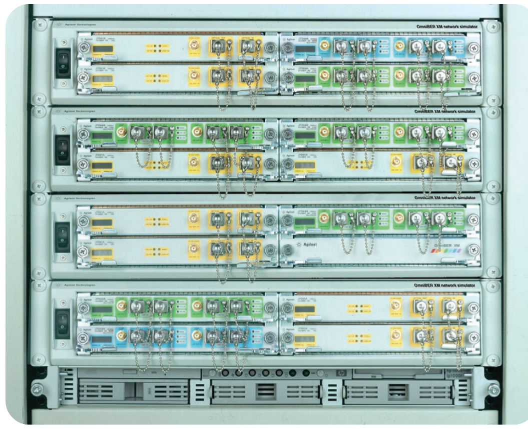
The key advantages with multi-port, multi-channel test equipment are:

- Visibility of the whole device under test
- Ability to stress the whole device under test
- Speed and productivity of testing numerous ports and channels in parallel

and

- Security that any potential faults will be discovered during testing and not by operators using the new equipment in their networks.

A new generation of network equipment has created a new set of challenges that are now being met only by the new breed of test equipment being introduced.



The OmnBER XM network simulator – modular and scalable

Related literature

For further information, please refer to the following publications:

- "OmniBER XM network simulator – redefining your strategy" brochure
  pub. no. 5988-6647EN

- J7241A/J7242A OC-192/STM-64 module data sheet
  pub no 5988-6665EN

- J7244A/J7245A OC-48/STM-16 dual-port multi-rate module data sheet
  pub. no. 5988-6785EN

- J7246A/J7247A OC-12/STM-4 dual-port multi-rate module data sheet
  pub. no. 5988-6786EN

- OmniBER XM configuration guide
  pub. no. 5988-6648EN

- OmniBER XM network simulator J7263A 4-slot chassis technical overview
  pub no. 5988-7996EN

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