MN9320A

Optical Channel Drop Unit

Application Note

"Analyzing Data Errors in those 'inaccessible' DWDM Wavelengths"
Using the Anritsu MN9320A Optical Channel Drop Unit

MN9320A

Functional and Simple to Use

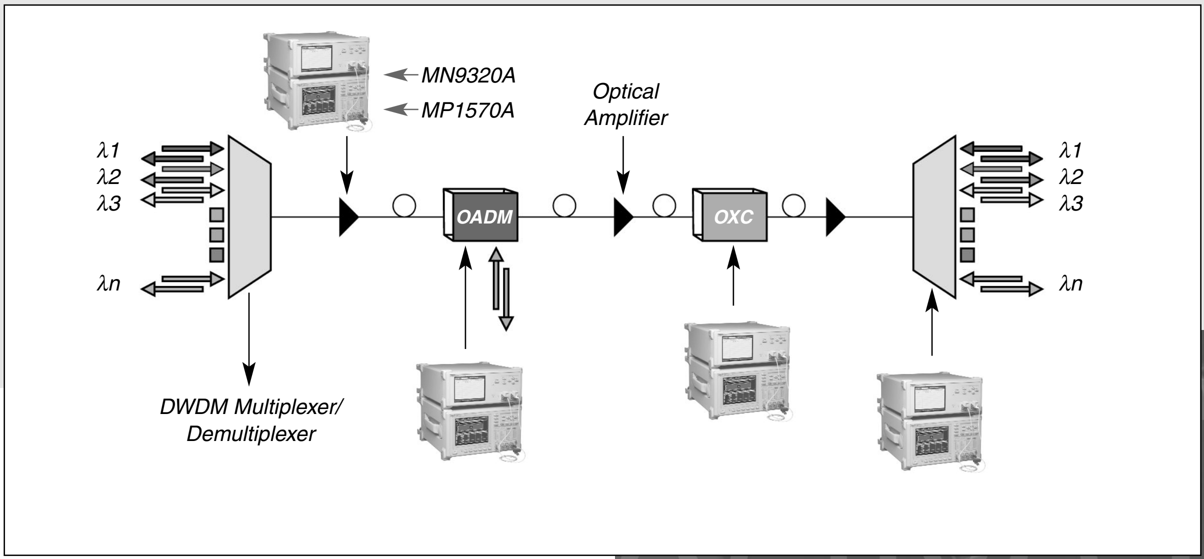
- Single-button operation
- Channel table shows wavelength and optical power
- Any channel can be dropped
- Filter design prevents data corruption at 10-Gbps

The testing of DWDM systems can be complex and there is often a need to analyze data quality within individual channels during both the commissioning and maintenance processes. Access to this specific channel data at discrete points throughout the network requires both Bit Error Rate testers and a means of extracting that data without corrupting it. The following application note describes the difficulties in configuring a DWDM system, and how access to individual channel data using the Anritsu MN9320A, can help resolve commissioning and maintenance problems.

Dense Wavelength Division Multiplexing (DWDM), is a technique used in fiber optic transmission to expand the traffic carrying capacity of a single fiber. It has been widely adopted by network operators globally as a means of increasing the capacity of their existing networks without the need for additional and very costly re-cabling. DWDM expands the design possibilities for an All Optical Network (AON), based on its channel add and drop functionality.

Compared to the traditional single channel network design, the components used in DWDM systems must have tighter tolerance, and more importantly, must function correctly when integrated in an overall system construction to avoid the multiplication of individual component errors. Drift in characteristics of one component can have a detrimental 'cascade' effect on others related to it. So correct system commissioning combined with routine maintenance or fault finding is critical if all is to remain in balance.

The simplest way to envisage a DWDM transmission system is as a series of parallel wavelengths or colors of light all being transmitted in tandem along the same fiber. In particular, each channel of light must be considered separately from the others, as its particular route to the final destination may present different obstacles to getting there.



When we consider that these adjacent channels may only be 0.4 nm or 50-GHz apart from one another, the slightest change in a neighboring characteristic may lead to significant data transmission errors in another channel.

Components used in any DWDM system undoubtedly are of very high performance, but it’s only when the 'system' is constructed and commissioned that all the parts are pulled together. At this time, tools for measuring and verifying consistent performance are required.

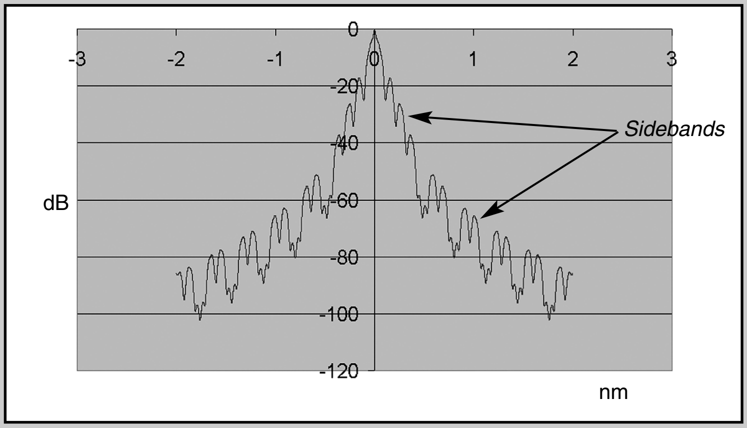
The Integrated System

A DWDM system consists of many components, all of which play a part in its overall performance. The components increase the possibility that the system may not perform correctly, with each representing a potential point of failure.

As mentioned previously, channel spacing of 50-GHz is not uncommon in today's DWDM networks. In order to get this close spacing, lasers with very narrow line-widths must be used and their output wavelength must remain very stable to avoid interference with adjacent channels. We must also remember that the transmitted signal for each channel not only consists of the main data envelope, but that it also has 'sidebands' on either side of it which can potentially interfere with adjacent channels (called cross-talk). These sidebands increase in size and number as the data rate of the traffic increases. So if we are considering a system with channels spaced at 50-GHz, carrying traffic at rates of 10-Gbps, then the risk of cross-talk between channels is significantly increased.

Optical multiplexer or demultiplexer are components that enable individual channels to be inserted into a transmission path or removed from it without affecting the other transmitted traffic. These devices must have high optical rejection ratios to prevent adjacent channels or their sidebands from interfering with one another. Their design will be based on the maximum data rate they are to carry and the minimum channel spacing that may be utilized.

The optical amplifier or EDFA is a device that amplifies the optical signals presented to it, no matter what modulation rate or protocol is used. However, their gain characteristics are wavelength dependent and this dependence must be equalized (or balanced) during system set up. Adding new channels or changing the channel power of just one single channel, may result in the system performance being 'skewed' by the amplifier and result in other channels on that fiber failing to perform correctly.



Transmitted Signal

The traditional single channel transmission system historically required minimal consideration of the fiber performance, other than the fiber attenuation figure, and optical power budget. A DWDM system on the other hand is dependent upon other fiber characteristics being known and more importantly, remaining stable over time. Chromatic dispersion of a fiber can be considered as an effect that results in light of different wavelengths or frequencies travelling at different speeds along its length, resulting in pulse spreading of the data it carries when it is finally seen by the receiver. It becomes very critical as a system characteristic as soon as data rates reach 10-Gbps.

In a DWDM system, a small amount of dispersion is usually desirable to avoid cross-channel interference effects like 'four wave mixing'. However, once compensation is optimized, this characteristic tends to remain stable.

Polarization Mode Dispersion (PMD) on the other hand, is determined by the polarization states of the signal path within the fiber. Although its effects can be reduced, it cannot be totally eliminated, and must be measured during commissioning and regular maintenance. A cable that has acceptable PMD one day may change over time. For example, the weight of laying a new cable on top of another may stress the older cable. The greater the speed of the data being transmitted, the more the dispersion effects become critical to the overall system performance. A system that functions efficiently at 2.5-Gbps, may not do so at 10-Gbps.

It can be seen that a fully functional DWDM transmission system is very dependent upon correctly operating and aligned components, minimal cross-talk between channels and dispersion of small, manageable, and consistent values. A change in any one of these characteristics can result in a system failure, which will be seen as degradation in Bit Error Rate (BER), by the end user and operator.

Diagnosis and isolation of the root cause therefore becomes very complex. The interrelationship between components clouds the original point of failure. The analogy may be made to the human body. When we are healthy, all our component parts work in harmony, but when we feel sick, a doctor will need to study all the symptoms before making a diagnosis as the outward signs may conceal the true reason for the illness.

System Quality of Service (QoS)

In terms of customer expectations, the measure of the overall QoS provided to them by a Service Level Agreement (SLA) is usually stated in terms of the number of Errored Seconds, or Severely Errored Seconds over a given time period. This is typically measured with a Bit Error Rate Tester (BERT), which looks at specific data test patterns and compares them to what was sent from a transmitter at some other location in the network. The ability of a network to meet its specified SLA performance, will be determined by all the components mentioned above, assuming the data sent from the transmitter is sent out correctly. It is then potentially subject to many optical effects as it travels to its final destination, where under correct conditions, it should terminate error free.

The All Optical Network (AON)

Having focused on the DWDM network, let us just consider the technology close to being implemented in the near future.

As we move closer to the AON, we can expect to see light being filtered, routed, switched and even translated or converted from one wavelength to another. The optical path of a 10-Gbps signal may pass through many optical elements on its way to its designated receiver. In doing so, it may leave the transmitter at one wavelength and arrive at another.

This will possibly change wavelengths a few more times en route. Now multiply this scenario for 40 or even 100 channels and consider all the components used in a DWDM system. It is now possible to envisage how critical the commissioning and in the longer term, the faultfinding process can be, for just that one system.

The MN9320A, a DWDM Channel Access Tool

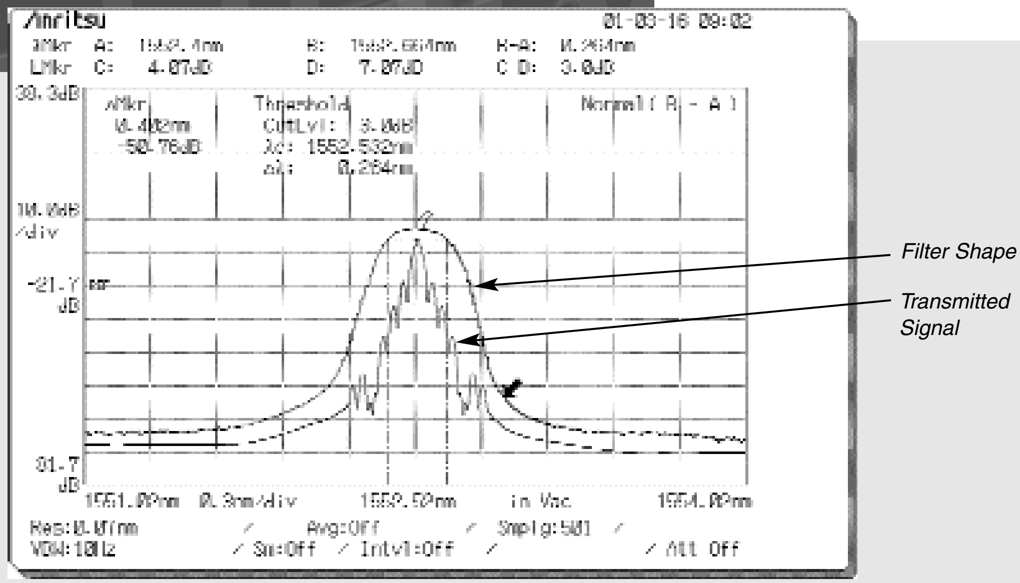
It must be stated that the MN9320A is not an Optical Spectrum Analyzer (OSA), but a DWDM access tool, designed to complement the Anritsu range of BER testers such as the MP1570A (or any other BERT). However, the MN9320A does have some DWDM measurement capability similar to an OSA. Combined with its excellent channel drop capability, the MN9320A is often all that is needed.

Having said this, there are a number of OSAs on the market that claim to offer a channel drop capability. The following section aims to explain why technology used for good to high performance OSAs is not suitable for high data rate channel dropping. The critical issue is that dropping a 10-Gbps DWDM channel at 50-GHz spacing requires some very high performance filter technology, without which, the channel drop function will degrade the dropped signal and possibly introduce more bit errors than originally existed.

Channel Drop Technology

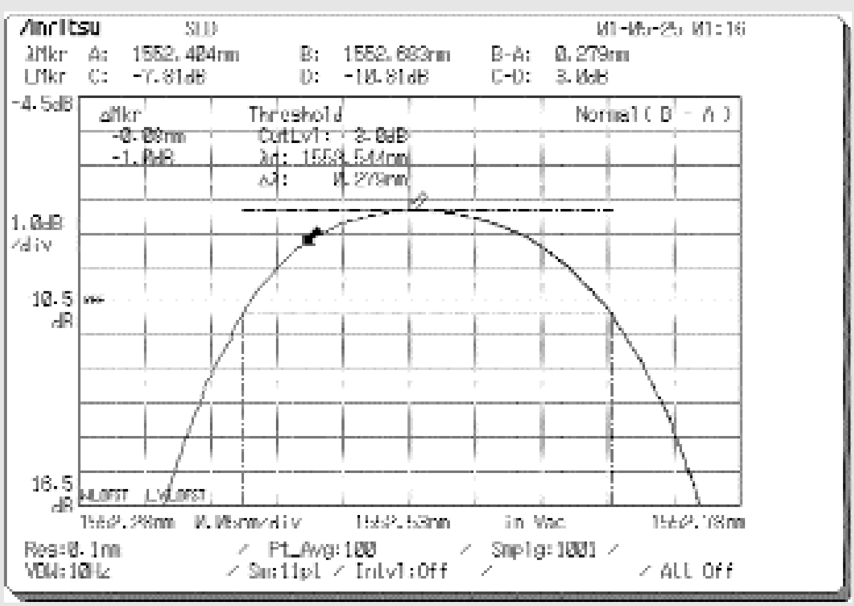
Previously mentioned in this document is the need for closely spaced channels to have sufficient isolation between them, in order to avoid data in one affecting data in the other. The technology to do this has been developed for the transmission equipment manufacturers by component vendors, in order to meet these stringent demands. Anritsu has been able to benefit from this technology and integrate it into a portable DWDM access tool to assist network installers and operators to more effectively manage their networks. In order to provide excellent channel drop functionality at 50-GHz spacing and to ensure that the filter shape does not distort a signal of 10-Gbps, it must have a 'square' shape with a flat top and steep sides. It has to be wide enough to capture all the data within the transmission envelope and not corrupt the sidebands as previously discussed. Having said this, the skirt of the filter must be narrow enough to include only the data in the selected channel and not effect channel data on either side of it. The filter must also allow for the small wavelength variation for each channel as it will not always comply perfectly to the ITU-T wavelength specification.

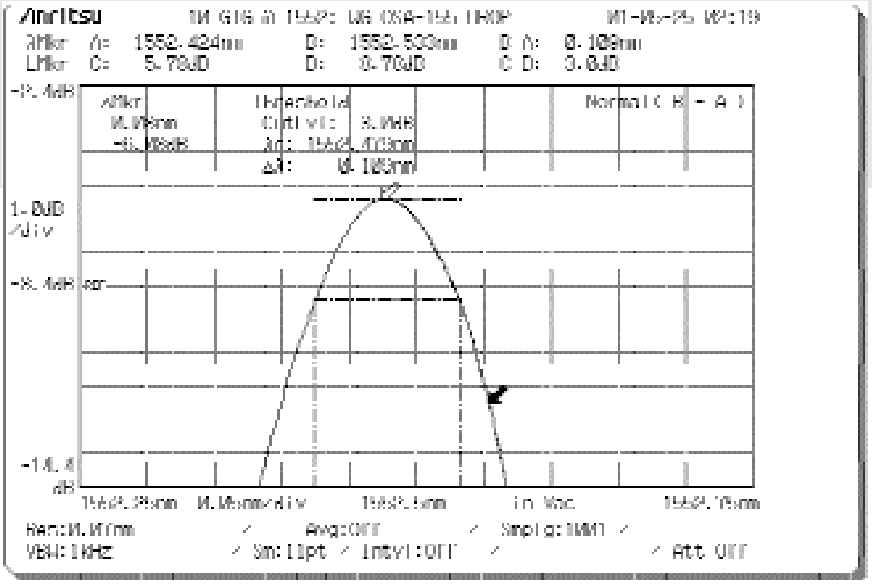
As would be expected in a transmission system, this filter must be very accurate in terms of its wavelength position and repeatability. If these specifications are poor, the filter will start to corrupt the transmitted data because it doesn't capture it all correctly. The following diagram shows the MN9320A filter shape superimposed onto a DWDM signal.



It can be seen from the diagram above that as the channel spacing gets closer, the shape of the filter becomes more critical. *Extracting a 10-Gbps signal when channels are spaced at 50-GHz, is technically difficult.*

The two following plots, show the difference between a filter designed to drop data at 10-Gbps on a 50-GHz grid and that of a product primarily used as an OSA (but with limited drop capability). The two markers are set at the 3 dB points on the curve in each case. You can see that the level difference for the MN9320A is just 1 dB, while the OSA filter is 6 dB, indicating how flat the OCDU filter is.





DWDM Network Data Analysis

Now that we have a means to access one of many DWDM channels, we can also verify the number and position of channels present and their respective channel powers, which traditionally has involved an OSA. The benefits when doing this are that the user of the BERT does not have to understand an OSA, which can be quite complex, especially when it is not a task performed daily. And, the wavelength accuracy and repeatability of the MN9320A guarantees that any user can identify and select to drop any 10-Gbps channel without fear of reading false errors.

There should also be some consideration given to the calibration requirements of a field portable access tool like the MN9320A. Typical OSAs require some form of internal or external reference source against which the unit is “aligned” routinely in order for it to achieve its specification. Sometimes this is impractical in the field as it is time consuming and requires operator intervention. To avoid this issue, the MN9320A uses a closed loop filter design which requires no calibration, yet still achieves a typical wavelength accuracy of 10 pm. The user can just walk in, turn the unit on, make a measurement and access a channel, simply and easily.

In a typical DWDM network, each element or access point within it has a monitor port providing a tap into the main transmission path, from which all the channels can be seen. The level of this port is lower than the main signal, but can provide maintenance staff a means of viewing the traffic present. Typically network operations center staff will not normally redirect traffic at the request of maintenance staff as this requires authority at a very high level and potentially may disrupt traffic, hence the use of the monitor port. By connecting the MN9320A to the monitor port, the user can identify channel compliance to the ITU grid and measure all the traffic within that channel by presenting it to a BERT such as the Anritsu MP1570A. A feature of the MN9320A is its over power protection mode. Individual channel powers in a DWDM system can be very high and if that channel were to be fed directly into the receiver of a BERT, it might damage it.

Since the MN9320A is totally transparent to the data signal at 10-Gbps and below, what appears at the output is only the chosen channel data, which when connected to the MP1570A allows parameters such as BER to be measured directly and compared with expected values for that location. Should this figure be inadequate, the service provider can make corrections elsewhere and the changes can be seen on the MP1570A. Typically, a BER test is 'out-of-service' as it requires a predefined test pattern to be transmitted from elsewhere in the network which can only be done on 'dark' fibers. If we bear in mind the transparency of the MN9320A, any other test may be performed in or out of service depending upon the tester chosen. When real 10-Gbps testing at 50-GHz channel spacing is called for, the MN9320A OCDU is the only product available to handle the challenge.

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February 2002
P/N : 80402-00176
Printed in USA

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ISO 9001
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