Fiber Optic Test Methodology and Equipment

In this article we will digress slightly from the discussion of fiber optic technology and focus on a very important aspect of fiber optic equipment and systems – ***TESTING***. I can't begin to count how many times either myself or my colleagues have been on the other end of phone conversations trying to assist someone with setting up and troubleshooting their fiber optic system only to find that the integrators had neither optical test equipment nor the proper knowledge to use what they did have. In order to make the installation and integration of fiber optic systems as enjoyable and painless as possible, it's important to have at least the minimum of fiber optic test equipment to help facilitate a smooth and pleasurable experience!

There is a plethora of test equipment available for fiber optic equipment & system testing. The most common and useful are the following: Optical power meter, Optical light source, Optical loss test set, Fiber fault locator, Optical connector inspection scopes and the Optical Time Domain Reflectometer (OTDR). This article will provide a brief overview of each of these and explain their purpose. However, before we begin, it is important to stress safety when working with fiber optics. All of the light sources used in fiber optic transmission in the AV, broadcast, telecom, etc. applications emit infrared light. That is, light that is invisible to the eye. While invisible, it can still be dangerous, depending on the power. Therefore, care must be taken, especially when using inspection scopes to ensure that any light source is turned off before looking at the end of any fiber.

Optical Power Meter (OPM) - The most basic and useful (and essential) of the test equipment is the optical power meter. This is equivalent to an electrician having a volt meter. The OPM allows you to measure optical transmitter output power, power at various junction (connector or patch panel) points, and receiver input power. In many cases, the optical power meter will be all that you need to properly diagnose a system problem and get the system up and running quickly. The optical power meter can provide an absolute measure of power in either micro or milliwatts (µW, mW) or dBm (power referenced to 1 mW). An absolute reading of 1mW is equivalent to 0dBm. Since most equipment uses dBm to indicate its optical power characteristics, the dBm scale on the power meter is the most convenient to use. Optical power meters will also have buttons to select the wavelength of the light they are measuring. There are selections for 850, 1300/1310 and 1550nm. It's important to match the meter's wavelength setting to that of the light you are measuring to ensure accurate readings.

Optical Power Meter

Using the fiber transmitter's own light source, the OPM can be used to measure the transmitter's output power, the light exiting the fiber at the receiver as well as the light from the fiber at various interim points such as patch panels, etc. In this way, you can compare the readings on the meter to the specifications of the fiber transmitter, fiber loss, and overall optical loss budget. The OPM can also be used to measure the difference between two readings thus providing an optical loss figure that may represent the overall loss of the fiber span. The transmit (Tx) power minus the received (Rx) power (dBm - dBm = dB) gives you the value of the fiber system link loss. A good, basic power meter can be purchased for about $400-500 – a very wise investment!

Another power meter is available for measuring the optical powers of up to 16 individual CWDM (Coarse Wavelength Division Multiplex) lasers. This power meter will provide both a digital display of the wavelength's absolute power and a bar graph of all the selected wavelengths on one display. This allows the user to monitor the optical characteristics of each optical transmitter in the CWDM system simultaneously – saving time and money when troubleshooting the system. These photos show various displays from this CWDM power meter.

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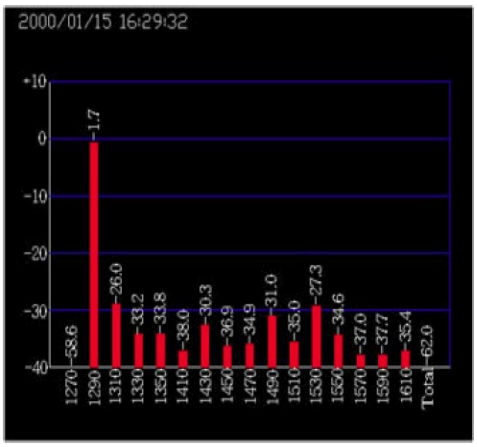
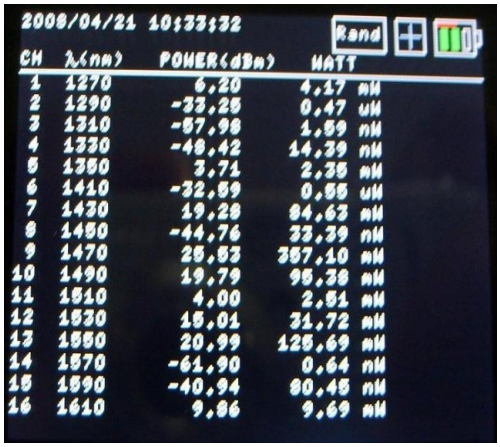
CWDM Power Meter



Graphical display of optical power



Tabular display of optical power

Optical Light Source (OLS) – The OLS is generally a handheld or portable device that has different types of optical emitters that correspond to the type of fiber used in the system. Multimode OLS devices will have emitters of both 850nm and 1300nm while singlemode OLS units will emit light at 1310nm and 1550nm. More flexible OLS units will have light sources applicable to both multimode and singlemode fiber. When used in conjunction with an OPM, the entire fiber infrastructure including fiber, splices and connectors can be tested at different wavelengths to verify the fiber installation's integrity, without the need for any transmitter/receiver equipment. Since an OPM and OLS are used at different ends of the fiber, two persons are required to properly test the fiber. Obviously, this can be difficult if adequate, trained personnel are not readily available. OLS prices range from $1K - $5K depending on type of source(s), LEDs and/or lasers and wavelengths.

Optical Light Source

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Optical Loss Test Set (OLTS) – There are different versions of the OLTS some of which are basically a package containing a separate OPM and OLS while others combine both the functions of the OPM and OLS in a single, portable unit. While the basic units still require two persons to properly test a system (one at each end), there are automated OLTS units that communicate with each other and allow one user to change the operating parameters of both units from one end to test the fiber at different wavelengths. Prices for the OLTS range from $1K to $10K, depending on how feature-rich the units are.

Optical Loss Test Set

Fiber Fault Locater – As the name implies, these devices are used to locate fiber breaks and consist of a visible (red) laser and a connector adapter for launching the light into the fiber under test. They are basically a red laser pointer designed specifically for coupling the light into a fiber connector. They can be used with either multimode or singlemode fiber and can identify fiber breaks, bad connectors and splices, sharp bends (microbends) and can also be used as a fiber identifier. In the presence of a broken fiber, the visible laser will shine through the break and leak out through the cladding and through the jacket of a standard fiber jumper or pigtail giving a visual indication of where the break or bend is located. Distances in excess of 2km can be checked for continuity. A fault locator can be obtained for a few hundred dollars. Fiber fault locators are quite affordable and range in price from $200 to $500, depending on features.

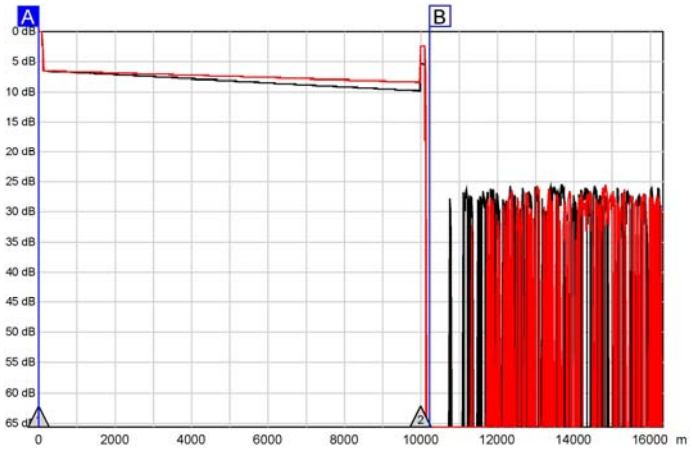
Optical Connector Inspection Scopes – One of the problems working with fiber in the AV and broadcast world is that cables are continuously being run in environments that are less than pristine in terms of cleanliness. Unprotected, the connector end faces can become very dirty causing high losses and potentially compromising the loss budget and performance of the optical link. In addition, if dirt is present on a fiber connector that is then inserted into a fiber transmitter, receiver or another mating connector, the dirt can be transferred to the other device making it difficult to clean and, in some cases, damaging the units. Obviously it's important to ensure that the fiber connector end faces are kept clean to ensure proper performance each and every time the fiber is connected to equipment. There are recommended cleaning material & devices for properly cleaning the end face of optical connectors ensuring that the surface is clean and dry.


Optical Inspection Scope

The optical inspection scope is used to visually check the end surface of the connector and can identify contamination or damage to the connector end face. The most common and portable one is basically a microscope with an optical connector port and internal light source to illuminate the connector front surface. They typically have 200X magnification so that you can easily see the optical core of both singlemode and multimode fibers. Even though these generally have filters to protect the eye against laser light, it is important to ensure that the fiber does not have any active light source attached to the other end. $500-$2K is the typical price range for these inspection scopes, again depending on some of the features. The more expensive digital scopes can store images of the connector ports for future comparison.

Optical Time Domain Reflectometer (OTDR) – The OTDR is a versatile, one person instrument that identifies and quantifies events such as fiber distance & attenuation, connector and splice losses and fiber breaks. In addition, it will measure the distance to these events as well as the total length of the fiber. Some of these events are characterized as expected (such as connector loss) while some are unexpected, such as fiber breaks, sharp fiber 'kinks' or tight bends, etc.

Optical Time Domain Reflectometer (OTDR)



OTDR Trace

The OTDR works by sending very short, high intensity pulses of light down the fiber and measures the reflection or backscatter of this light as it propagates down the fiber. By measuring the time it takes for the pulse of light to return as well as its amplitude, the OTDR will calculate the distance to these events as well as the magnitude of each. It is a very versatile and effective way to perform single-ended testing and troubleshooting of a fiber link. While an optical loss test or OPM can only measure total loss of a fiber span including connectors, splices, etc, the OTDR can not only measure total loss but is the only instrument that can identify the location and size of any anomaly within the fiber span to better aid in quickly finding and repairing the problem. However, this versatility comes at a price. The cost of a basic, portable OTDR is in the range of $5-8K while the cost of a basic optical power meter is in the range of a few hundred dollars. While not for everyone, the OTDR can save time and money in diagnosing a fiber problem to ensure that system downtime is held to a minimum. While the OTDR is straightforward to use, it does require a higher set of skills and some initial training to help better understand its functions, capabilities and limitations. It is generally not a piece of equipment that most installers would have access to.

All of these pieces of test equipment have different adapters to allow them to mate with various optical connectors including ST, FC, LC & SC types.

Documentation – Using all of this test equipment is only as good as the supporting documentation you keep. When measuring optical powers or fiber attenuation and loss budget it is important to document the data you gather. In this way you can easily track any changes in the system that may lead to some failure over time. For example, it is always a good idea to measure the output power of the optical transmitter and mark it down right on the unit itself along with its wavelength of the light as well as the power coming into the receiver. If, over time, the system starts to act erratically and exhibits performance issues, you can easily measure these points again and compare to the original data obtained. In this way you can quickly determine if something in the optical environment has changed to cause performance issues.

Fiber optic test equipment is an important part of system installation & integration. In some applications such as rental & staging, these fiber systems are subjected to extreme abuse. Cables & connectors are dragged through mud, run over and stepped on and are, in general, in a rather hostile environment. In addition, quick set up is extremely important. Having the proper test equipment and documentation for that, 'just in case', situation can significantly help reduce the setup time.

This article was intended to introduce you to some of the more common pieces of fiber optic test equipment and their uses. They are generally quite easy to use. You can receive additional information on these and other fiber optic test equipment by contacting The Light Brigade (www.lightbrigade.com). They are a fiber optic training company and can provide you with additional information on fiber optic test equipment, test methodology and training.

Our next topic in the March '09 issue will focus on the courtroom environment and discuss how fiber optics plays an important part in bringing high quality, real-time video, audio and data to the courtrooms. These services include remote arraignment & witness testimony, evidence presentation, media feeds, remote court reporting, etc. If you have any questions or if you have any particular fiber topic you would like to know more about, please send an email to me at emiskovic@meridian-tech.com.

(Photos courtesy of The Light Brigade)
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