Discover What's Possible™

Understanding OTDRs

www.anritsu.com

Table of Contents

Introduction

Fiber Optic Communications

Fiber optic communications is simple: an electrical signal is converted to light, which is transmitted through an optical fiber to a distant receiver, where it is converted back into the original electrical signal. Fiber optic communications has many advantages over other transmission methods. A signal can be sent over longer distances without being boosted; there are no interference problems from nearby electrical fields; its capacity is far greater than for copper or coax cable systems; and the fiber itself is much lighter and smaller than copper systems.

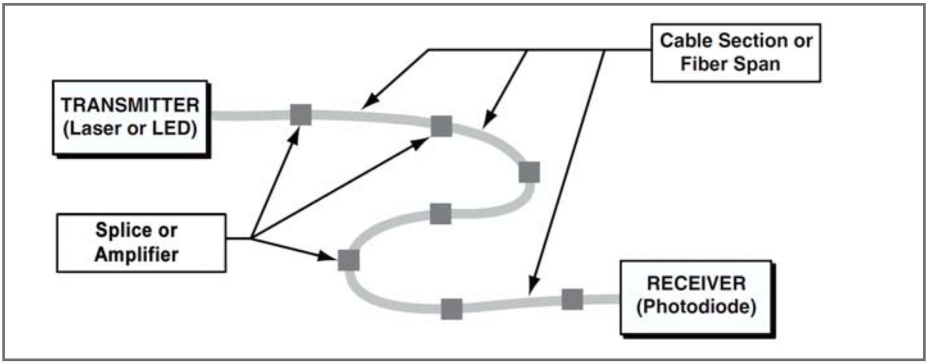


Figure 1 - Typical Fiber Optic Transmission System

The major limiting characteristic in an optical communications system is the attenuation of the optical signal as it goes through the fiber. The important thing is that the information contained in the light sent down the fiber is received and converted back to its original form. Light is attenuated in a fiber as it travels along due to Rayleigh scattering (explained later). Some light is also absorbed into the glass, and some leaks out of the fiber due to **imperfections** in the glass or due to excessive **bending** of the fiber. If too much light is lost (or attenuated) then the signal may be too weak at the far end for the receiver to distinguish between pulses in the signal. If the signal is too weak at the receiver then we must boost the transmitter output power, increase the receiver sensitivity, or decrease the distance between the transmitter and receiver to compensate for the excessive **attenuation**. It is important to know how much light is lost in a length of fiber before it is put into use in a communications system. If the overall attenuation is too high, then corrective action must be taken.

Testing Optical Fiber For Loss

The best way to measure overall attenuation in a fiber is to inject a known level of light in one end and measure the level when it comes out the other end. The difference in the two levels —measured in decibels, or dB — is the **end-to-end attenuation** (sometimes called "insertion loss"). The most accurate way to make this measurement is with a calibrated **light source** and **optical power meter**. But a light source and power meter measurement does not indicate if the attenuation is high along the entire fiber or is localized in one trouble-spot. It does not indicate where a problem may be in a fiber.

On the other hand, an OTDR provides a plot of distance versus signal level in a fiber, and this information is extremely useful in knowing where to find a problem in the fiber.

Other Fiber Tests

The most important test for most fibers is an accurate measurement of the attenuation characteristics. But other tests may be needed for high-speed or very long fiber systems. A **dispersion** test measures how the information carrying capacity of a fiber may be affected due to the differential speed of light in the fiber. That is, some parts of the light that represents the information being transmitted can travel faster than other parts. In multimode fiber this is called a **bandwidth** measurement. Dispersion and bandwidth tests are not done with an OTDR.

The OTDR

An Optical Time Domain Reflectometer — "OTDR" for short — is an electronic-optical instrument that is used to characterize optical fibers. It locates defects and faults, and determines the amount of signal loss at any point in an optical fiber. The OTDR only needs to have access to one end of a fiber to make its measurements. An OTDR takes thousands of measurements along a fiber. The measurement data point spacing is as low as 5 cm (2 inch). The data points are displayed on the screen as a line sloping down from left to right, with distance along the horizontal scale and signal level on the vertical scale. By selecting any two data points with movable cursors, you can read the distance and relative signal levels between them.

OTDR Applications

OTDRs are widely used in all phases of a fiber system's life, from construction to maintenance to fault locating and restoration. An OTDR is used to:

- Measure overall (end-to-end) loss for system acceptance and commissioning; and for incoming inspection and verification of specifications on fiber reels

- Measure splice loss — both fusion and mechanical splices — during installation, construction, and restoration operations
- Measure reflectance or Optical Return Loss (ORL) of connectors and mechanical splices for CATV, SONET, and other analog or high-speed digital systems where reflections must be kept down
- Locate fiber breaks and defects Indicate optimum optical alignment of fibers in splicing operations
- Detect the gradual or sudden degradation of fiber by making comparisons to previously-documented fiber tests

How an OTDR Works

The Optical Time Domain Reflectometer (OTDR) uses the effects of **Rayleigh scattering** and **Fresnel reflection** to measure the characteristics of an optical fiber. By sending a pulse of light (the "optical" in OTDR) into a fiber and measuring the travel time ("time domain") and strength of its reflections ("reflectometer") from points inside the fiber, it produces a characteristic **trace**, or profile, of the length vs. returned signal level on a display screen.

The trace can be analyzed on the spot, printed out immediately for documentation of the system, or saved to a computer disk for later analysis and comparisons. A trained operator can accurately locate the end of the fiber, the location and loss of splices, and the overall loss of the fiber. Most newer OTDRs provide for automatic analysis of the raw trace data, thereby eliminating the need for extensive operator training.

RAYLEIGH SCATTERING

When a pulse of light is sent down a fiber, part of the pulse runs into microscopic particles (called **dopants**) in the glass and gets scattered in all directions. This is called **Rayleigh** (pronounced RAY-lay) **scattering**. Some of the light — about 0.0001% — is scattered back in the opposite direction of the pulse and is called the **backscatter**. Since **dopants** in optical fiber are uniformly distributed throughout the fiber due to the manufacturing process, this scattering effect occurs along its entire length.

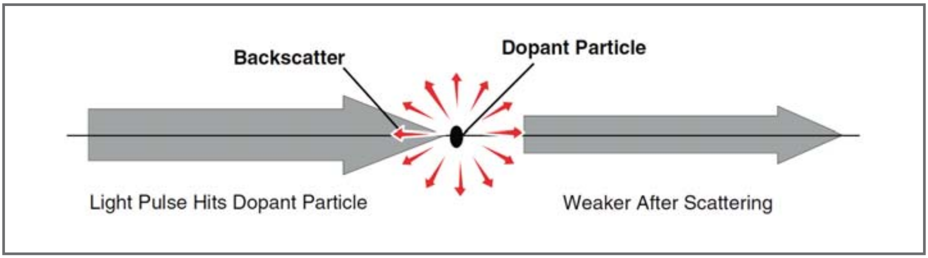


Figure 2 - Rayleigh Scattering

Rayleigh scattering is the major loss factor in fiber. Longer wavelengths of light exhibit less scattering than shorter wavelengths. For example, light at 1550nm loses 0.2 to 0.3 dB per kilometer (dB/Km) of fiber length due to Rayleigh scattering, whereas light at 850nm loses 4.0 to 6.0 dB/Km from scattering. A higher density of dopants in a fiber will also create more scattering and thus higher levels of attenuation per kilometer. An OTDR can measure the levels of backscattering very accurately, and uses it to detect small variations in the characteristics of fiber at any point along its length.

The Rayleigh scattering effect is like shining a flashlight in a fog at night: the light beam gets diffused — or scattered — by the particles of moisture. A thick fog will scatter more of the light because there are more particles to obstruct it. You see the fog because the particles of moisture scatter small amounts of the light back at you. The light beam may travel a long way if the fog is not very thick, but in a dense fog, the light gets attenuated quickly due to this scattering effect. The dopant particles in fiber act like the moisture particles of the fog, returning small amounts of light back towards the source as the light hits them.

FRESNEL REFLECTION

Whenever light traveling in a material (such as an optical fiber) encounters a different density material (such as air), some of the light — up to 4% — is reflected back towards the light source while the rest continues out of the material. These sudden changes in density occur at **ends of fibers**, at **fiber breaks**, and sometimes at **splice points**. The amount of the reflection depends on the magnitude of change in material density (described by the **Index of Refraction (IOR)** — larger IORs mean higher densities) and the angle that the light strikes the interface between the two materials. This type of returned light is called a **Fresnel** (pronounced freh-NELL) **Reflection**. It is used by the OTDR to precisely determine the location of fiber breaks.

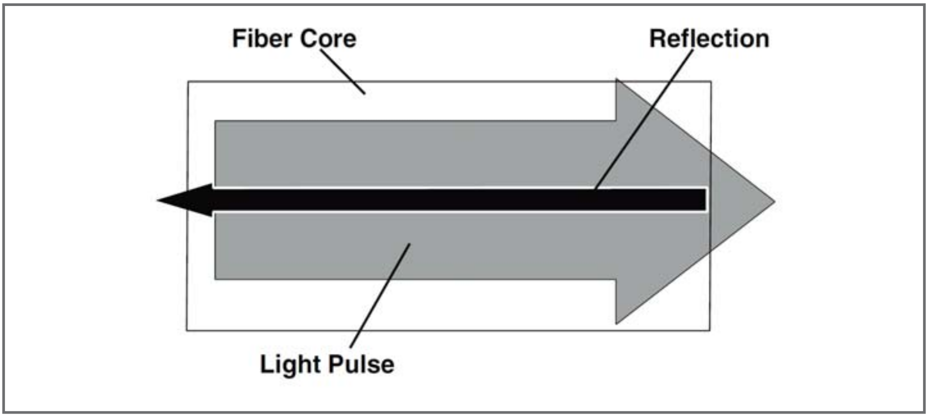


Figure 3 - Fresnel Reflection

A Fresnel reflection is like shining a flashlight at a window. Most of the light passes through the window, but some of it reflects back at you. The angle that the light beam hits the window determines whether or not the reflection will bounce back into the flashlight, your eyes, or the ceiling.

BACKSCATTER LEVEL VS. TRANSMISSION LOSS

Although the OTDR measures only the backscatter level and NOT the level of the transmitted light, there is a very close correlation between the backscatter level and the transmitted pulse level: the backscatter is a fixed percentage of the transmitted light. The ratio of backscattered light to transmitted light is also known as the "**backscatter coefficient.**" If the amount of transmitted light drops suddenly from Point A to Point B (caused by a tight bend, a splice between two fibers, or by a defect), then the corresponding backscatter from Point A to Point B will drop by the same amount. The same loss factors that reduce the levels of a transmitted pulse will show up as a reduced backscatter level from the pulse.

OTDR Block Diagram

The OTDR consists of a laser light source, an optical sensor, a coupler/splitter, a display section, and a controller section.

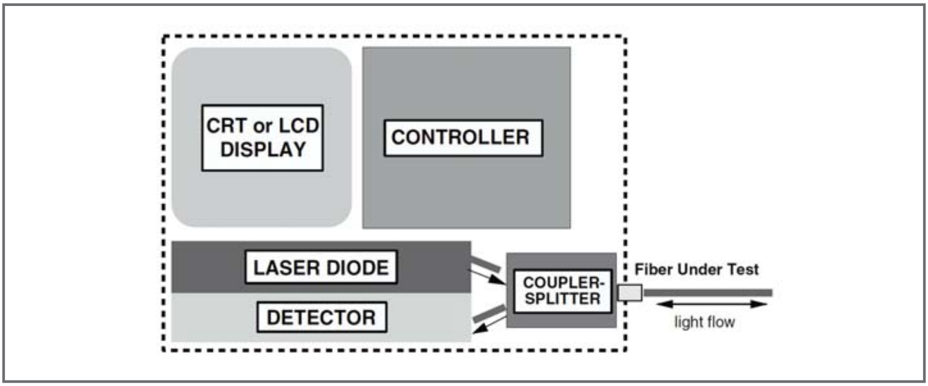


Figure 4 - OTDR Block Diagram

LASER LIGHT SOURCE

The **laser diode** sends out pulses of light on command from the controller. You can select the duration of the pulse (the **Pulse Width**) for different measuring conditions. The light goes through the coupler-splitter and into the fiber under test (FUT). Some OTDRs have two lasers to allow for testing fibers at two different wavelengths. Only one laser is used at a time. You can easily switch between the two with the press of a button.

COUPLER/SPLITTER

The **coupler/splitter** has three ports — one each for the source, the fiber under test, and the sensor. It is a device that allows light to travel only in specific directions: FROM the laser source TO the fiber under test, and FROM the fiber under test TO the sensor. Light is NOT allowed to go directly from the source to the sensor. Thus, pulses from the source go out into the fiber under test, and the returning **backscatter** and **Fresnel reflections** are routed to the sensor.

OPTICAL SENSOR SECTION

The **sensor** is a photodetector that measures the power level of the light coming in from the fiber under test. It converts the optical power in the light to a corresponding electrical level — the higher the optical power, the higher the electrical level put out. OTDR sensors are specially designed to measure the extremely low levels of **backscatter**ed light. The sensor section includes an electrical amplifier to further boost the electrical signal level.

The power of a **Fresnel reflection** can be up to 40,000 times higher than that of **backscatter**, and may be more than the sensor can measure — thus overloading the sensor, driving it into **saturation**. The electrical output level is subsequently "clipped" at the sensor's maximum output level. Therefore, whenever a test pulse encounters an end of a fiber — whether at a mechanical splice or at the end of the fiber — it causes the sensor to be "blinded" for as long as the pulse occurs. This blind period is known as the "dead zone." (See **Dead Zone**, page 10)

CONTROLLER SECTION

The **controller** is the brains of the OTDR. It tells the laser when to pulse; it gets the power levels from the sensor; it calculates the distance to scattering and reflecting points in the fiber; it stores the individual data points; and it sends the information to the display section.

A major component of the controller section is a very accurate clock circuit which is used to precisely measure the time difference between when the laser pulses and when the sensor detects returning light. By multiplying this round-trip pulse travel time by the speed of light in fiber (which is the speed of light in free space corrected by the **Index of Refraction**), the round-trip distance is calculated. The distance from the OTDR to the point (one-way distance) is simply half of the round-trip distance.

Since backscattering occurs all along a fiber, there is a continuous flow of light back into the OTDR. The controller samples the level measured by the sensor at regular time intervals to get its data points. Each data point is described by its sequence time (which relates to distance from the OTDR) and power level. Because the original pulse gets weaker as it travels down the fiber (due to **Rayleigh scattering** induced loss), the corresponding returned backscatter level gets weaker further down the fiber. Therefore, the data points generally have decreasing power levels from start to end. But when a Fresnel reflection occurs, the power level of the corresponding data point for that location suddenly goes up to its maximum level — way above the level of the backscatter just prior to it.

When the controller has gathered all its data points it plots the information on the display screen. The first data point is displayed at the left edge of the graph as the starting point of the fiber. Its vertical position is based on its returned signal power level: a higher power is plotted higher up on the graph. Subsequent data points are placed to the right, one data point every resolution setting. The resultant trace is a sloping line that runs from the upper left towards the lower right. The slope of the line indicates its lossper-unit-distance (dB/km) value. Steep slopes mean larger dB/km values. Data points corresponding to backscatter level make up the line. Fresnel reflections look like spikes coming up from the backscatter level. A sudden shift of the backscatter level indicates a "point loss," that may indicate either a fusion splice or a stress point in the fiber where light is escaping.

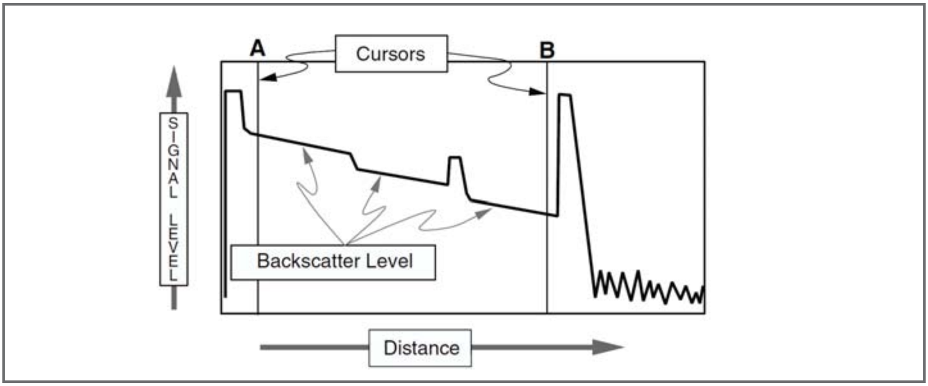
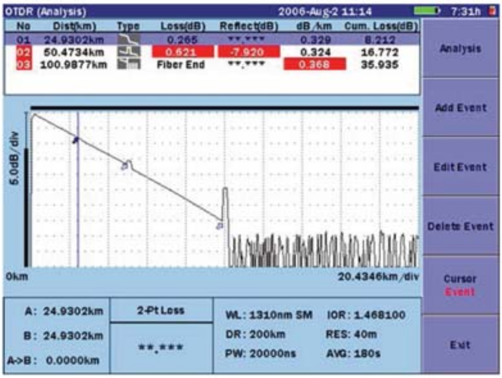


Figure 5 - Components of OTDR Trace Display

DISPLAY SECTION

The **display section** is a **CRT or LCD screen** that shows the data points that make up the fiber trace, and displays the OTDR set-up conditions and measurements. Most OTDR displays connect the data points with a line to provide a clearer look at the overall trace. You can manipulate **cursors** on the screen to select any point on the fiber trace. The distance to the cursor is displayed on the screen. An OTDR with two cursors will display the distances to each cursor and the difference in backscatter levels between them. You can choose the type of measurement being made with the cursors, such as 2-Point Loss, dB/Km, Splice Loss, and Reflectance. The measurement results are shown on the display.



OTDR Display (MT9083)

OTDR Specifications

DYNAMIC RANGE

The **dynamic range** of an OTDR determines how long of a fiber can be measured. It is listed as a dB value — larger values generally mean longer distance measurement capability. A test pulse needs to be strong enough to get to the end of the fiber to be tested, and the sensor has to be good enough to measure the weakest backscatter signals which come from the end of a long fiber. The combination of the **total pulse power** of the laser source and the **sensitivity** of the sensor determines the dynamic range: a very powerful source and a sensitive sensor will give a large dynamic range, while a weaker source and an average sensor will yield a low dynamic range. Dynamic range for an OTDR is determined by taking the difference between the backscatter level at the near end of the fiber and the upper level of the average **noise** floor at or after the fiber end. A sufficient dynamic range will produce a clear and smooth indication of the backscatter level at the far end of the fiber. An insufficient dynamic range will produce a "noisy" trace at the far end — the data points that make up the trace backscatter level will not form a smooth line, but will vary up and down from one to the next. It is difficult to distinguish details in a noisy trace — the data point variation can be more than the value of a splice loss.

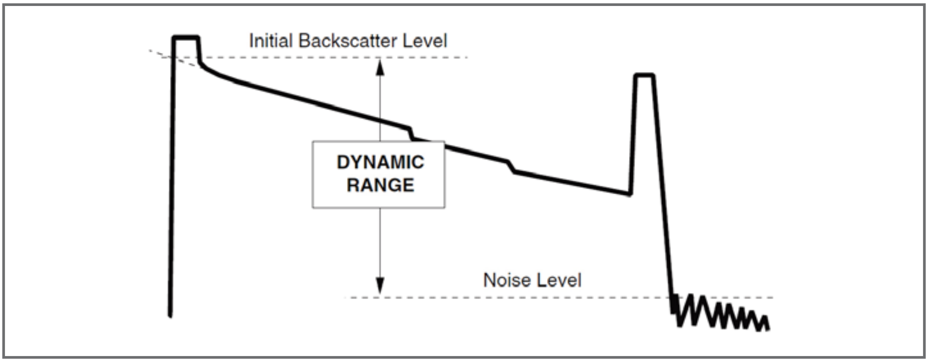


Figure 6 - Dynamic Range

Increasing the total pulse output power of a laser source can be accomplished in two ways: increase the absolute amount of light emitted, or increase the pulse duration (**pulse width**). There are limits to each of these procedures:

A laser diode has a natural maximum output level that cannot be exceeded. Also, a higher output level means a shorter component life — the laser might burn out faster.

When the pulse width is increased other performance characteristics, such as the **dead zone**, are affected: longer pulse widths produce longer dead zones.

Sensors also have natural limitations to their ability to measure low light levels. At some point, the electrical level sent out by the sensor (which corresponds to the optical power level detected) becomes lost in the **electrical noise** of the circuitry and the controller cannot distinguish between the noise and sensor measurements. Electrical **shielding** within an OTDR is critical in order to decrease the adverse effects of ambient electrical noise in the instrument. Additionally, when a sensor is operating at its peak sensitivity, its level **accuracy** is decreased. To improve accuracy at lower light levels an OTDR will use **averaging** techniques to combine the measurements from thousands of pulses. The use of averaging will improve the **sensitivity** of a sensor and can therefore improve an OTDR's dynamic range.

There are several different methods to calculate Dynamic Range. The method above describes the "98% Noise Level" method recommended by many standards organizations. It describes the point at which the backscatter level just starts to get mixed up with the noise level of the instrument. Another common method is called "SNR=1" (Signal-To-Noise Ratio), which is similar to the 98% method, but produces a Dynamic Range value of about 2 dB more. The SNR=1 method indicates the point at which the backscatter level of the trace is lower down into the instrument's internal noise level. This means you might not be able to clearly distinguish details in the trace at the end of the fiber. A third method is the "Fresnel Detection," which can add 10 or more dB to the Dynamic Range value. Fresnel Detection measures the point at which the peak of a Fresnel reflection at the end of the fiber can be detected just above the noise level. While this method produces the highest value, it is misleading because it does not relate to how the OTDR is employed for normal use.

DEAD ZONE

Dead zone refers to the space on a fiber trace following a Fresnel reflection in which the high return level of the reflection covers up the lower level of backscatter.

An OTDR's sensor is designed to measure the low backscatter levels from a fiber, and becomes "blinded" when a larger Fresnel reflection hits it. At a minimum this blind period lasts as long as the pulse duration. When the sensor receives the high level from the reflection it becomes saturated and unable to measure the lower levels of backscatter that may follow immediately after a reflective event. The dead zone includes the duration of the reflection PLUS the recovery time for the sensor to readjust to its maximum sensitivity. High quality sensors recover quicker than cheaper ones and thus achieve shorter dead zones.

The dead zone effect can be illustrated by considering what would happen while you are looking at a starlit sky: with no other lights around, your eyes become sensitive and you are able to see the very dim light from the stars (like backscatter). If someone then shines a flashlight in your eyes, the overpowering light (like a Fresnel reflection) blinds you and you are no longer able to see the stars. You will not be able to see anything but the bright light for as long as it is in your eyes (pulse duration). After the light is removed, your eyes slowly readjust to the darkness, becoming more sensitive, and you are able to see the low light level of the stars again. The OTDR sensor acts very much like our eyes in this example. The period of blindness and recovery to backscatter sensitivity is the dead zone.

Since the dead zone is directly related to the pulse width, it can be reduced by decreasing the pulse width. But decreasing the pulse width lowers the **dynamic range**. An OTDR design must make a compromise between these two characteristics. Likewise, the OTDR user must choose a pulse width depending on whether it is more important to see closely spaced events or see farther out in a fiber. The best design gives you a large dynamic range at a short pulse width. This **dynamic range per pulse width** will determine how far out in the fiber you will be able to resolve two closely-spaced events (splices). You can make a good judgement between two OTDRs by comparing the traces of each taken at the same pulse width and averaging time (or in real time). The unit with the "cleaner" looking trace (not as much noise) indicates a better design.

Importance Of Dead Zones. Dead zones occur in a fiber trace wherever there is a fiber connector, and at some defects (such as cracks) in the fiber. There is always at least one dead zone in every fiber: where it is connected to the OTDR. This means that there is a space starting at the beginning of the fiber under test in which NO MEASUREMENT CAN BE MADE. This space is directly related to the pulse width of the laser source. Typical pulse widths in OTDRs range from 3 ns (nanoseconds — billionths of a second) to 20,000 ns. In distances, this works out to be from 2 feet (0.6 meters) to over a mile long. If you need to characterize the part of the fiber that is close to the near end, or if you need to measure two splices that are close together (less than 100' apart), you will need to select the shortest pulse width possible that will reach out to the point you want to measure.

Dead zones are characterized as an **event dead zone** or an **attenuation dead zone**. An event dead zone is the distance after a Fresnel reflection before another Fresnel reflection can be detected. It tells you how soon after a reflection (usually the reflection from the connector at the OTDR) you can detect a reflection from a break or from another splice. This is important if you are trying to isolate two different splices that are spaced at a close proximity to each other, such as in a restoration situation. A short event dead zone means you will be able to see a second splice after the first one.

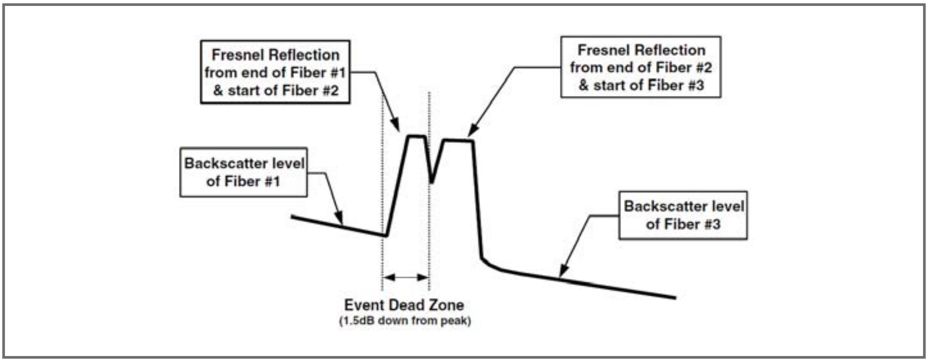


Figure 7 - Event Dead Zone

An attenuation dead zone is the distance after a Fresnel reflection until the backscatter level can be detected. This specification tells you how soon after a reflection you can measure a second event, such as a fusion splice or a defect in the fiber. To make any loss measurements in fiber you must be able to see backscatter on both sides of the splice. This means the trace has to have come all the way down from its peak at the reflection to the backscatter level. Attenuation dead zones are always longer than event dead zones, since the detector must make a full recovery down to the backscatter level.

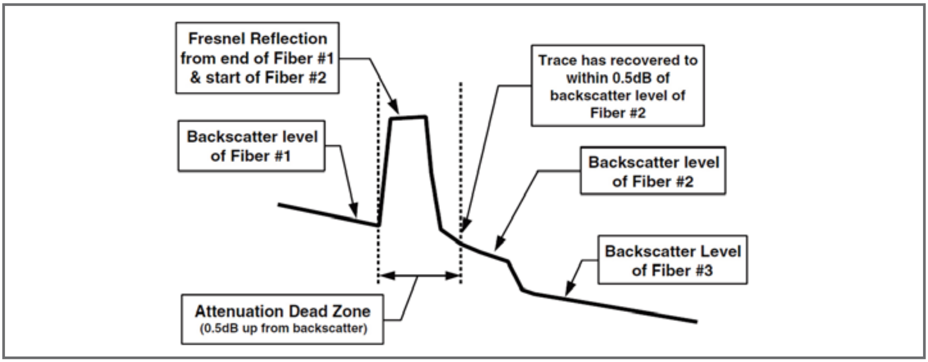


Figure 8 - Attenuation Dead Zone

RESOLUTION

There are two resolution specifications: loss (level), and spatial (distance).

Loss resolution is the ability of the sensor to distinguish between levels of power it receives. Most OTDR sensors can display down to 1/100th (0.01) or 1/1000th (0.001) of a decibel differences in backscatter level. This specification must not be confused with level accuracy, which is discussed later. When the laser pulse gets farther out in the fiber, the corresponding backscatter signal gets weaker and the difference between backscatter levels from two adjacent measurement points — or from two measurements of the same point — becomes larger. Thus, the data points that make up a trace develop relatively more vertical separation farther out along the fiber than they do close in to the OTDR. This produces a noisy trace towards the end and requires some averaging over many measurement pulses to smooth it out. Noise in the trace may prevent you from detecting or measuring low-loss splices and low-loss defects.

Spatial resolution is how close the individual data points that make up a trace are spaced in time (and corresponding distance). It is measured in terms of distance— high resolution being 0.5 cm (less than 2 in.) The OTDR controller samples the sensor at regular time intervals to get the data points. If it takes readings from the sensor very frequently, then the data points will be spaced close together and the OTDR can detect events in the fiber that are closely spaced. The ability of the OTDR to locate the end of the fiber is affected by the spatial resolution: if it only takes data points every 8 meters, then it can only locate a fiber end within +/- 8 meters. See the section on distance accuracy.

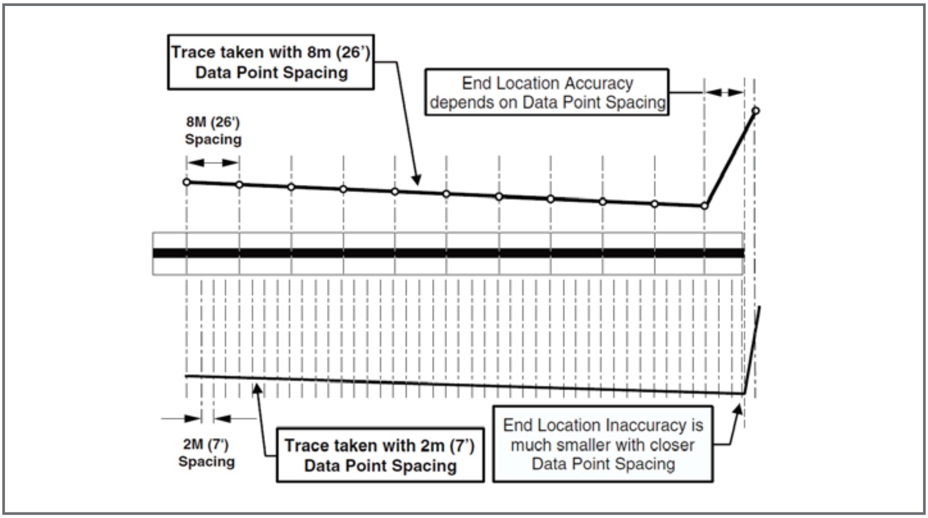


Figure 9 - Data Point Resolution

You are able to select and measure the distance (and loss) between any two data points on a fiber trace. Those that are spaced closer will provide more detail about the fiber. An OTDR displays the fiber trace as a line that connects the data points, and allows you to place a cursor between points as well as on points. This interpolation of the information produces a better **display resolution** than the actual spatial (or data point) resolution. It is easy to achieve "centimeter resolution" on the display screen simply by spreading out the space between two measurement points on the screen so that the cursor moves only a very small distance. This does not mean the OTDR is making high resolution measurements. Its just a high resolution display.

Spatial resolution is reduced in certain areas by a dead zone. Valid measurements of fiber attenuation are only made from backscatter level to backscatter level. Data points that were taken while the sensor was in saturation due to a Fresnel reflection cannot be used to make loss measurements, since the sensor was not able to make an accurate level measurement at that time. Therefore, the spatial resolution around a Fresnel reflection is worse (lower resolution) because the only usable points occur before and after the **dead zone** area around a splice.

LOSS ACCURACY

The **loss accuracy** of the OTDR sensor is measured in the same way as optical power meters and photodetectors of any kind. The accuracy of any optical sensor depends on how closely the electrical current output corresponds to the input optical power. Most optical sensors convert incoming optical power to a corresponding electrical current level evenly across its operating range, but the electrical output is extremely low. All sensors use **electrical amplifiers** to boost the very low electrical output level, and all amplifiers introduce some amount of **distortion** to the signal. High quality amplifiers are able to boost both high and low levels by the same amount. In other words, they have a very "linear" response to an input over most of the operating range. Lower quality amplifiers introduce significant distortion into the amplified signal at either high or low input levels — they become non-linear at the extremes of operation. The **linearity** inherent in an optical sensor and its amplifier will determine how accurately the incoming optical power is converted to an amplified electrical level.

Loss accuracy for many optical sensors is stated as either as a flat plus-or-minus (+/-) dB amount (if its measurement range is small), such as "+/-0.10 dB", or a percentage of the power level, such as "2%". For OTDRs, a better representation of the accuracy is the **linearity**, stated as a +/- dB amount per dB of power measured over certain ranges of measurement, such as "+/- 0.10 dB/dB in the 10 to 20 dB range." OTDRs are expected to maintain a reasonable accuracy over very wide ranges of measurements — some spanning over 40dB of backscatter levels — and thus require good linearity over the entire optical input range of the sensor. Linearity problems in an OTDR often show up as a rolling off, curving up ("ski-sloping") or bumpy appearance of the displayed fiber trace. Linearity specifications are usually not listed for OTDRs in marketing brochures.

Fresnel reflections are generally outside of the measurement range of the sensor and are not considered in the linearity specifications. However, the trace display during the recovery period after a reflection often exhibit characteristics of non-linearity as the incoming power level transitions from extremely high (reflection) to very low (backscatter).

DISTANCE ACCURACY

There are three components to **distance accuracy** in an OTDR:

1. Clock stability

2. Data point spacing

3. Index of Refraction (IOR) uncertainty

The accuracy of distance measurements depends on the stability and accuracy of the **clock circuit** which times the pulses going out and the interval between sampling of the sensor readings. Clock accuracy is stated as a percentage, which relates to percentage of distance measured. For instance, an accuracy of 0.01% of distance means that if the distance to the end of the fiber is measured as 20,000 feet, then the accuracy of this measurement is +/-2 feet (20,000 x 0.0001). If the clock runs too fast or too slow, then the time measurements — and corresponding distance measurements — will be shorter or longer than the actual value.

Spatial resolution also affects accuracy. An OTDR can only make accurate distance measurements based on the actual data points it takes. The closer the data points are spaced, the more likely one of them will fall close to, or on, a fault in the fiber.

Distance in an OTDR is calculated from the speed of light in the fiber, and the speed of light in fiber is calculated from the speed of light in free space (a constant value) divided by the **Index of Refraction** (IOR). This means that the user-settable IOR is critical in accurate measurement of distance. If the IOR is wrong, then the distance will be wrong. However, the characteristics of a fiber can change along its length, producing slight variations in its IOR, and therefore causing additional distance inaccuracies. This "**fiber uncertainty**" is due to the variance of IOR within the same fiber and between two or more fibers spliced together. The worst case for IOR variation is when two different manufacturers' fibers are spliced together.

INDEX OF REFRACTION

The index of refraction is the ratio of the speed of light in a vacuum to the speed of light in a particular fiber. Since light is fastest in a vacuum (like outer space), and slower in denser materials — like the atmosphere or glass — this ratio is always more than one (1). It is approximately 1.5 in glass. Light can change speed depending on the density of the material it is travelling in. The density in a fiber is determined by the amount and type of dopants used in the manufacturing process, and the distribution of the dopants may not be exactly the same throughout the entire fiber nor between any two fibers. Thus there are index of refraction variations between fibers and within each fiber. The index of refraction is the "calibration" factor which tells the OTDR how fast the light is travelling so it can make accurate distance measurements.

In most cases you should use the fiber manufacturer's recommended IOR setting for the fiber type and wavelength to be tested. Table 1 is a listing of IOR values for various fibers. Check with the fiber manufacturer if you have questions about the IOR. Changes in the fiber manufacturing processes will change the IOR values.

Manufacturer	Singlemode Fiber Type	IOR			Multimode Core Size	IOR	
		1300nm	1550nm	1625nm		850nm	1300nm
Alcatel	ESF	1.4640	1.4645		50	1.4820	1.4800
	SF	1.4640	1.4645		62.5	1.4970	1.4920
	Teralight		1.4645				
	TL Metro	1.4690	1.4692				
	TL Ultra		1.4692				
AT&T	TrueWave	1.4738	1.4732				
Corning	LEAF	1.4640	1.4690	1.4690	50	1.4900	1.4860
	SMF-28/e	1.4677	1.4682	1.4685	62.5	1.4960	1.4910
	SUB SMF-ls		1.4700				
Lucent	AllWave	1.4660	1.4670				
	TW 97	1.4710	1.4700				
	TW RS 98	1.4710	1.4700	1.4700			
Pirelli			1.4700				
SIECOR/Corning	SMF-28e	1.4677	1.4682				
Sumitomo	PureGuide		1.4700				
	SM OF SE-3	1.4660	1.4670				

Table 1 - Index of Refraction
(not guaranteed to be accurate; check with the fiber manufacturer for more details)

WAVELENGTH

Optical fiber is normally used and tested in only three wavelength bands: 850 nm, 1300 nm, and 1550 nm. Multimode fibers work in the 850 nm and 1300 nm bands. Singlemode fibers work only in the 1300 nm and 1550 nm bands.

The measuring wavelength of an OTDR is listed as its **central wavelength** with a certain linewidth. **Linewidth** is the spread of wavelengths around the central wavelength of the laser source. For example, a laser with a central wavelength of 1300 nm and a linewidth of 20 nm will include wavelengths from 1290 nm (1300 - 10) to 1310 nm (1300 + 10). Lasers with narrow linewidths are more expensive than those with wide linewidths. Central wavelengths are also normally specified as being within a certain tolerance, such as +/- 30 nm. For a specification that reads "1310 nm +/- 30 nm, Linewidth 20 nm", the central wavelength could be anywhere between 1280 nm and 1340 nm, and the wavelengths covered could be anywhere from 1270 nm to 1350 nm.

Loss in fiber is wavelength-dependent. It is important to test fiber at about the same wavelength as it will be operated. Optical transmitters (lasers and LEDs) are generally specified as to their wavelength band, i.e., 850, 1300, or 1550. Their specific central wavelength and linewidth is not always clearly listed. In some cases, if a test for attenuation is made at one end of a wavelength band — at 1320 nm for instance — and the system will be operated at the other end of the band — 1280 nm for instance — then the test signal will be attenuated at a slightly different amount than the operating signal. In long fiber runs (over 50 miles) this could lead to unexpected problems at the receive end of the system.

The clearest wavelength-dependent loss can be seen when comparing two traces of the same fiber taken at the two different wavelengths. The longer of the two wavelengths will indicate less overall loss than the shorter wavelength since it exhibits lower scattering loss. This shows up as a shallower slope of the trace (lower loss per unit of length — dB/Km). However, the longer wavelength tends to leak out of a fiber easier due to bending. By comparing traces taken at the two wavelengths, you can easily determine if a fiber is being stressed due to bending. Excessive bending frequently occurs in splice storage trays, within splice closures, at cable bends along its route, and at the end connectors. The following figure shows the difference you can see in the two wavelengths.

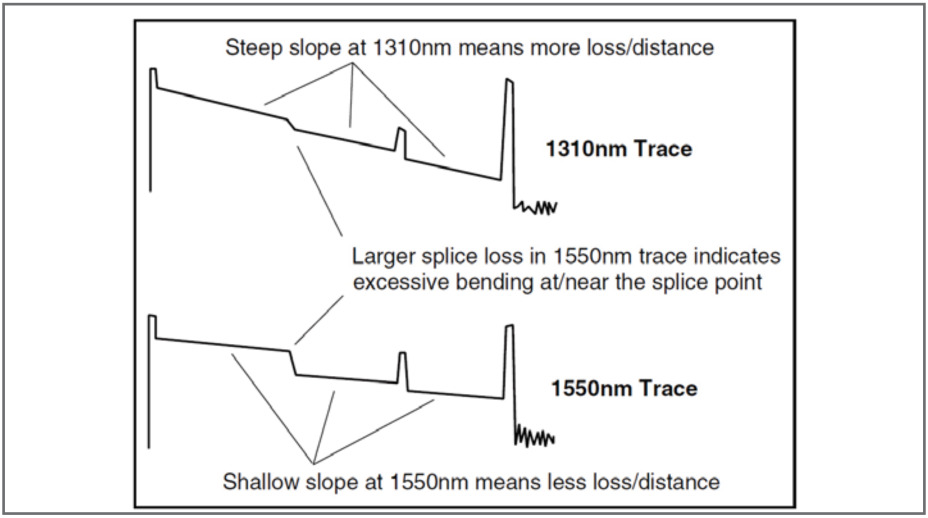


Figure 10 - Wavelength Differences

CONNECTOR TYPE

In order to hook up a fiber to a source or sensor, a **connector** must be attached to the fiber. There are many connector types available on the market, but the most common types are: Biconic™, SMA, and D4 with LC. Fibers always have male connectors attached. Test equipment and transmission equipment always have female connectors (or female-female "bulkhead" connectors that allow two male connectors to be coupled).

Some of the connector characteristics that must be considered are **reflectance** of the connector, repeatability, stability of connection, physical size (length is usually important), and material composition. Connectors that are designed to make contact with each other will have lower reflectance values. Keyed connectors (with tab & slot configurations) can only be connected one way and are therefore more repeatable than nonkeyed connectors. When a connector is properly mated, it should not be able to be easily rotated or moved enough to change the amount of light passing through it. The length of a connector will determine how far it may stick out from patch panels and the transmission equipment. Metallic connectors will probably last longer and be more stable than plastic connectors. The FC/PC-style family of connectors has very good characteristics and is one of the best for singlemode and multimode use. The ST-style connector is also very good and is now becoming one of the standard connectors in many systems. The SC style is a push-pull type that is commonly used in high fiber density applications.

The actual connector on the OTDR should be a good one, even if the connectors on your fibers are not the same type. You will nearly always be making the connection between the OTDR and your fiber with a **patchcord** or "**jumper**"— a short length of single-fiber cable with a connector on each end. (See the following section on Configuring an OTDR).

EXTERNAL INTERFACES

Most OTDRs provide a means to connect external devices such as USB thumb drives and personal computers to transfer the test setup files and result data.

Using An OTDR

CONFIGURATION

Choosing the configuration of an OTDR depends on the fiber to be tested. OTDRs can measure only one fiber type at a time — singlemode or multimode. Either a single- or dual-wavelength measuring capability for each type of fiber can be selected. Thus, OTDRs are available to test 850nm and/or 1300nm Multimode; or 1300nm and/or 1550nm Singlemode. Most traditional large OTDRs are modular in design so that the laser section can be changed to suit the type of fiber to be tested. "Mini" OTDRs usually are not modular.

Mainframe and Module.

In the modular design, the OTDR Mainframe contains the controller, display, operator controls, and optional equipment (such as printer/plotter, external interfaces, MODEM, disk drive, etc.). The optical module, consisting of the laser source and optical sensor sections, is plugged into the mainframe, and can be changed to allow testing at various wavelength and fiber type combinations. Some Mini-OTDRs are modular, so you can change the configuration in the field.

Fiber Type.

An optical module is typically limited to working with either singlemode or multimode fiber. The primary difference between these two fiber types is the diameter of the light-carrying fiber core: multimode cores are at least five times larger than singlemode. Since an OTDR must both send and receive light, it cannot efficiently connect with both fiber types. For example, a module designed for singlemode fiber will couple light INTO both singlemode and multimode fibers easily, but when the light returns, most of the backscatter from the multimode fiber will be lost as it tries to couple into the smaller core of the singlemode fiber going to the detector.

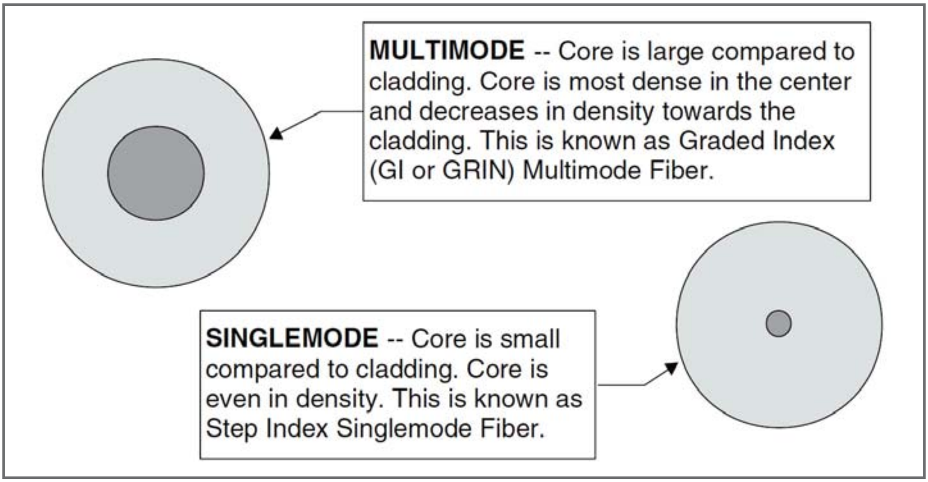


Figure 11 - Optical Fiber Types

Singlemode fiber cores are all about the same size: between 8- and 10- microns in diameter. A singlemode optical module is optimized for best light coupling in this diameter range.

Multimode fiber cores come in diameters of 50-microns, 62.5-microns, and 100-microns. A multimode optical module is optimized at only one of these core sizes internally, although it will be able to measure the other two size cores without difficulty.

TRICKS OF THE TRADE

You can test multimode fiber with a singlemode OTDR, but you can't test a singlemode fiber with a multimode OTDR. When testing multimode with a singlemode unit, the distance measurements will be accurate as long as you are using the correct index of refraction—but the loss measurements will appear to be slightly better than they actually are. That is, a splice loss may read as lower in value than it really is because the light from the singlemode OTDR travels mostly in the center of the core, whereas loss occurs at the core edge.

Wavelength

The test wavelength is one of the important specifications of an OTDR. It is critical to test a fiber system at the wavelength it will operate. But it may also be useful to test the system at the other wavelength as well. Although you can configure an OTDR that will operate at just one wavelength, it is best to include the capability of testing at both wavelengths for the fiber type (850 nm and 1300 nm for multimode; 1310 nm and 1550 nm for singlemode fibers). A complete test of a fiber should be done at both wavelengths so that you will know its complete characteristics in case the system will be upgraded to work at the other wavelength later.

In some cases you may want to test at other wavelengths not in the operating bands. These are known as "**out of band**" wavelengths, and include **1625 nm** and **1650 nm**. The 1244 nm wavelength is used for measuring the "water peak" region of high attenuation in a fiber's spectral attenuation curve. If the water peak attenuation grows due to unusual chemical activity within the fiber, then the 1310 nm operating band may soon become effected. The 1625 nm band is usually used for fiber monitoring purposes when a long-haul fiber is being operated in the 1550 nm band. The loss at 1625 is similar to that at 1550, so you can still measure the entire fiber length. It is also more sensitive to bending losses so you can detect problems before they effect system operations. The 1625 wavelength test is usually done on a "live" fiber by coupling the light in and out of the fiber with a wavelength division multiplex (WDM) device.

Shorter wavelengths of light exhibit greater amounts of attenuation in the same fiber due to their higher sensitivity to Rayleigh scattering. But longer wavelengths are more sensitive to bending loss, and will "leak out" of fiber more than shorter wavelengths. This means that a fiber that has been **stressed** by **bending** will show a greater loss at the point of bending when tested at 1550 nm than it will at 1300 nm; even though the overall **end-to end attenuation** will be lower at 1550 nm than at 1300 nm. The sensitivity of different wavelengths of light to different loss mechanisms in fiber can be a very important tool in **troubleshooting** a fiber cable.

Connector

Fiber systems are always connectorized before they are put into use. Either a connector is field-installed on the fiber, or a pre-connectorized fiber "**pigtail**" cable is spliced onto the fiber end. The connector on the OTDR should match the connector of the fiber system for best results. Some OTDRs offer "Universal" type connectors that allow you to change them in the field. Other OTDRs have only fixed, non-changeable connectors.

When an OTDR is used to test many different fiber systems with different connector types installed, a fiber "**jumper**" cable (or "**patchcord**") must be used. A jumper cable has a connector on both ends, one of which is connected to the OTDR, and the other is connected to the fiber system. The jumper may have different connectors on each end to make the match between the system and the OTDR. Even when an OTDR connector type matches the system, a jumper cable is often used to eliminate wear and tear on the system fiber. You may have more than one connector type in your fiber system, so you will need as many patchcords as you have connector types. Each patchcord will have the OTDR type connector on one end and the system type connector type on the other end.

When making a connection to a non-connectorized, **"bare" fiber**, you will need to use a pigtail. This is the same as a jumper, but with only one end connectorized. The other end is bare fiber so that you can make a temporary splice to the bare fiber end to be tested.

MEASUREMENT PARAMETERS

Once an OTDR has been properly configured for the fiber system to be measured, you are ready to make the test. There are a few decisions that must be made in determining the instrument **set-up** conditions to get the best results. Many of these measurement parameters only need to be set once, and will remain in the instrument's memory. If trace data can be stored in the OTDR's memory or on a diskette, then when the trace is recalled back to the screen, the setup information may also be recalled.

Distance Range

Distance range is also known as **display range**. It limits the amount of fiber that will be displayed on the screen. The distance range must be approximately 25% longer than the fiber to be tested. The distance range affects test accuracy and the time required to complete a test.

Since an OTDR must send out one test pulse at a time, and allow all returns from the pulse to get back to the detector before sending out another pulse, the distance range determines the rate at which test pulses are sent out. This is known as the **Pulse Repetition Rate** (PRR). The faster the rate, the quicker the averaging time for a given number of averages. Since a longer fiber requires longer pulse transit times, the overall averaging is slower with longer distance ranges because the PRR is slower. If a long fiber is tested using a shorter distance range, then there is a possibility that a new test pulse will be sent into the fiber before all the return signals from the previous pulse are received by the OTDR detector. The resultant multiple received signal levels could produce unpredictable results on the OTDR display and could affect level measurements. It could also produce "ghosts" in the fiber trace.

Resolution

Measurement resolution — the spacing between data points — can be selected on some OTDR configurations. Higher resolutions (closer data points) will provide more detail about a fiber, but a test will usually take longer than one made at a lower resolution. The best resolution offered by most OTDRs will be 5 cm (about 2 inch) between data points. Normally the resolution will be 8 meters (about 25 feet).

Higher resolution can provide more accurate location of an event. For example, if an OTDR takes measurements every 8 meters along a fiber, it is possible that a break could occur 7 meters after a data point. The resulting Fresnel reflection would appear to begin at the data point 7 meters before the break since the following data point (1 meter past the break) would be in the Fresnel reflection level. The break would be measured as being 7 meters prior to the actual break, since distance to a break is always located at the last backscatter point before a Fresnel reflection. The actual location of the break (reflection) would be off by 7 meters, or 23 feet. If the data point resolution were shortened to 0.5 meters, then the reflection location would be more accurately located — to within about 1 foot (See Figure 9 - "Data Point Resolution" on page 14.)

Resolution should not be confused with the horizontal display scale. Also, the cursor resolution — how short of a distance the cursor can be moved on the screen — has nothing to do with data point spacing. Most cursors can be placed between data points and thus appear to offer a better resolution.

Pulse Width

You can change the duration of the laser pulse. By selecting a longer or shorter **Pulse Width**, you can control the amount of backscatter level coming back, and the **dead zone** size. A long pulse width will inject the highest amount of optical power into the fiber and therefore will travel farther down the fiber and produce stronger backscatter levels. But it will also produce the longest dead zones. Conversely, a short pulse width will give the shortest dead zones, but will send back weaker backscatter.

Long pulse widths give the maximum dynamic range for an OTDR and are used to quickly find defects and breaks in a fiber. Because the backscatter levels are higher with longer pulse widths, shorter averaging times are required to get a "clean" trace.

Short pulse widths are used to look at the part of the fiber that is closest to the OTDR, and to resolve two or more events that are closely spaced within the fiber. Because of the shorter dead zone it can detect details in the fiber backscatter just past a Fresnel reflection. But because of the lower levels of backscatter, longer averaging times are needed.

The rule of thumb for setting the pulse width is:

"Long Pulse to look long: Short Pulse to look short."

Averaging

The data points obtained from a single measurement pulse may vary in level from one to the next even though there is little change in the pulse they came from. The resulting trace looks noisy or fuzzy. To get a more reliable and smoother-looking trace, OTDRs send out thousands of measurement pulses every second. Every pulse provides a set of data points that are then averaged together with subsequent sets of points in order to improve the **signal-to-noise ratio (SNR)** of the trace. Averaging takes time. Usually, a lot of averaging is required when a long fiber is being tested and when a short pulse width is being used. You can pre-set the amount of averaging that takes place so that test results will be consistent.

When a test is made in "**real-time**" there is little or no averaging done. With a real-time display you can see changes occurring in the fiber as they happen. Real-time is normally used during splicing operations to identify a fiber and measure the splice as it is being made. It is also used to make rapid measurements of fiber cable on a reel for acceptance testing.

INTERPRETING THE FIBER TRACE

After a fiber has been scanned and the resulting trace is displayed on the screen, you must interpret the trace. Cursors are used to select the end points of measurements, and the numerical results are displayed on the screen.

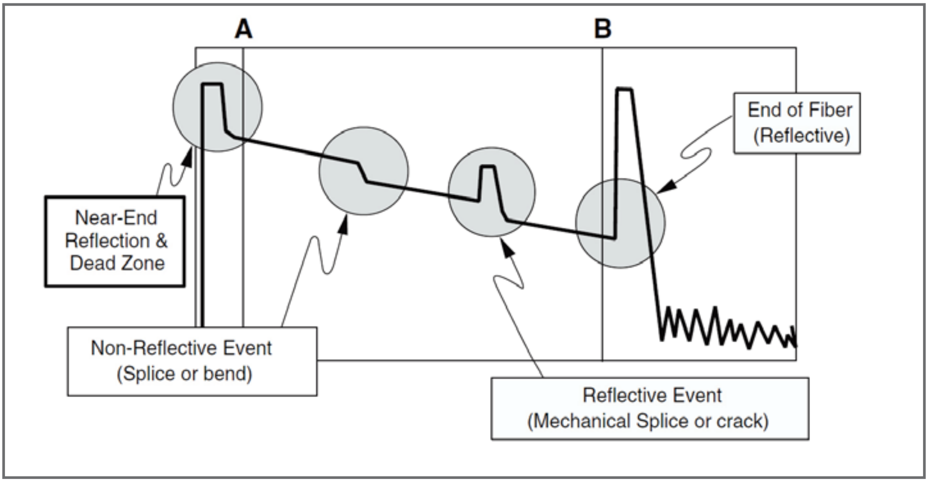


Figure 12 - Elements of an OTDR Trace

FAULT LOCATION

The most critical measurement that is made with an OTDR is the location of a defect or break in the fiber. In order to repair a fault, the precise location must be located.

A Fresnel Reflection occurs at most fiber faults. This appears as a sudden **spike up** on the fiber trace, indicating that the OTDR pulse has encountered a sudden change in the density of the glass — that is, it encountered air at the end of the fiber. The distance to this reflection on an OTDR trace is the point at which the trace spikes up. If the trace returns to the backscatter level after the reflection, then the fiber is not completely broken. The amount of shift in the backscatter level from before the reflection to after the reflection indicates how much light is lost at the fault or defect.

Many mechanical splices produce a Fresnel reflection. It is important to know where mechanical splices are in a fiber in order to keep from confusing them with faults. If there is backscatter after a reflective event, then the event is probably a mechanical splice. If there is only noise after a reflection, then it is probably the end of the fiber.

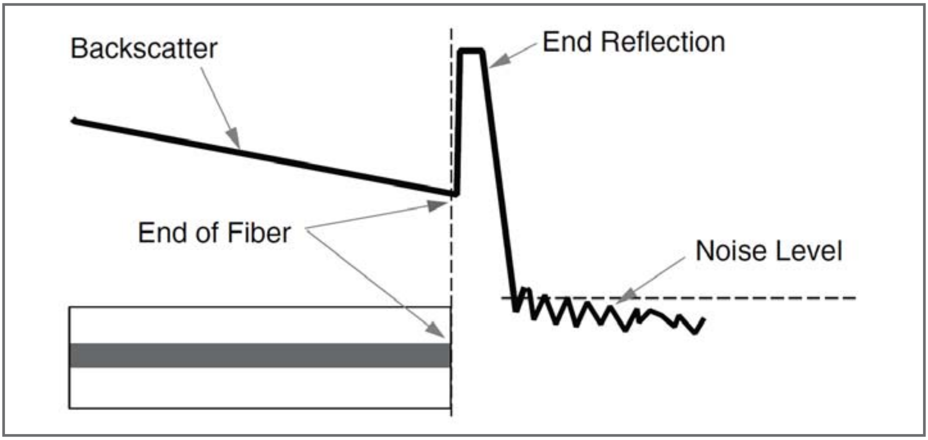


Figure 13 - Fiber End Location

Distance Measurements

The distance to a cursor is displayed on the screen. By simply moving a cursor to any point on the trace, you can read the distance to that point from the OTDR. Units of measurement can usually be selected to display distance in meters, feet, or miles. Keep in mind that you are measuring the length of the fiber itself (known as the **optical distance**), not the sheath length nor the ground distance along the cable run. There can be 2% to 6% more fiber length than sheath length since the fiber is given slack within the cable to allow for flexing of the cable. Also remember that there are usually coils of cable at splices and sometimes at other points along the cable route. Figure 14 illustrates how the fiber length, which is what the OTDR measures, is longer than either the ground distance or the sheath distance.

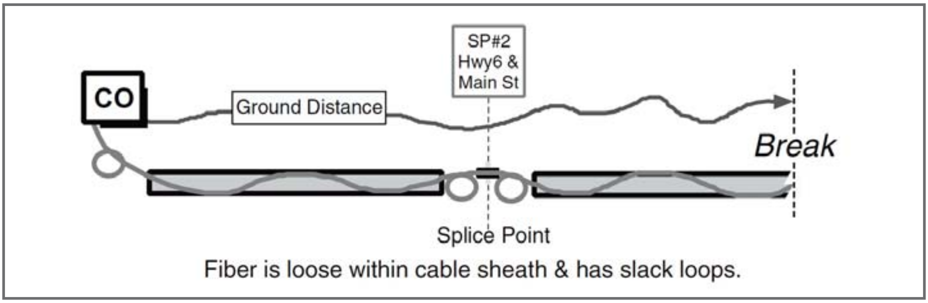


Figure 14 - Fiber Distance Measurements

The measured distance to an event in a fiber, such as a mechanical splice, fusion splice, or fiber end, depends on where the cursor is placed. To get the most accurate distance measurements, you should always place the cursor on the **last point of backscatter** just prior to an event.

The following diagrams indicate where you place a cursor to accurately measure distances to an event in the fiber.

For a reflective event (such as a mechanical splice), place the cursor just before a reflection so the cursor does not ride up on the spike.

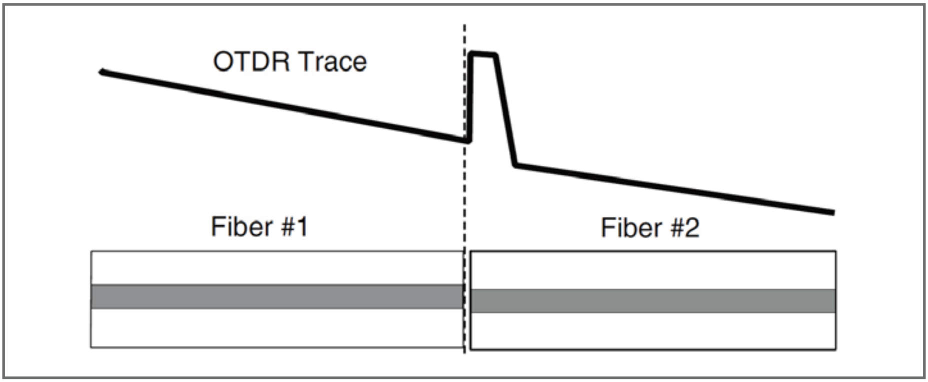


Figure 15 - Reflective Event Location

For a non-reflective event (such as a fusion splice or fiber kink), place the cursor at the point just before the trace drops (or rises).

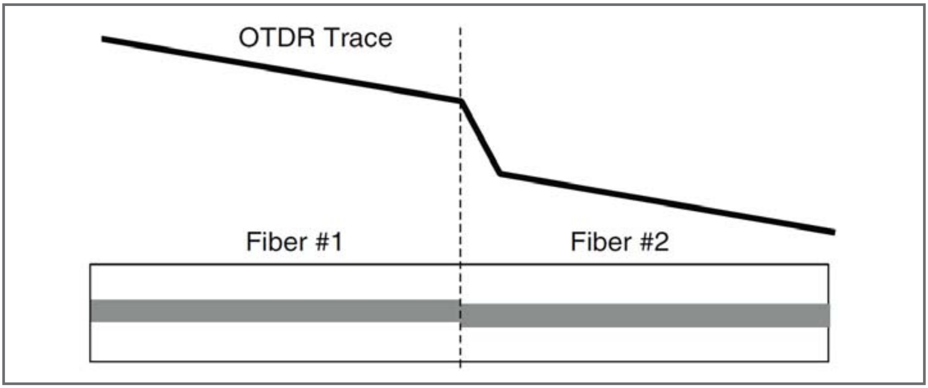


Figure 16 - Non-Reflective Event Location

When two cursors are used, the OTDR will display the distance to each cursor from the OTDR as well as the distance between the two cursors. This feature is used to isolate sections of a fiber.

Loss Measurements

Loss is measured between two or more cursors. Loss can only be accurately measured from backscatter level to backscatter level. This means that both cursors must be on backscatter. Neither can be on a Fresnel reflection or in a dead zone.

Overall Loss

The end-to-end attenuation of a fiber can be measured by placing one cursor just to the right of the near-end dead zone, and another cursor just to the left of the far-end Fresnel reflection. The loss from cursor to cursor is read on the screen. (Note: This measurement is not as complete as an end-to-end attenuation measurement made with a light source and power meter combination because it does not include the part of the fiber hidden in the initial dead zone, and it does not characterize the loss in the two end connectors.)

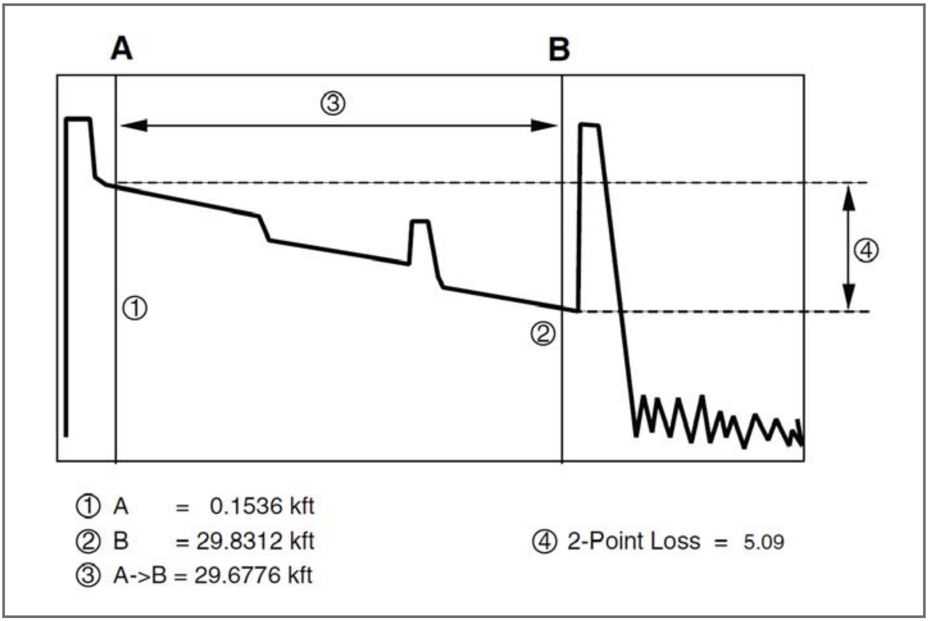


Figure 17 - OTDR Measurements Display

Section Loss

The loss in a section of fiber is measured by simply placing two cursors on the ends of the section to be measured and reading the level difference between the two.

Splice Loss

A splice is identified as a sudden shift in the backscatter level. There may also be a Fresnel reflection if it is a mechanical splice. A splice loss occurs at a single point in the fiber. A bend or point of stress may also show up as a point loss. The loss at a single point can be measured in two ways: by the 2-Point method or by the LSA Splice Loss method.

The **2-Point method** is identical to the way section loss is measured, except that the two cursors are placed as close together as possible, with the left cursor set just at the point to be measured, and the right cursor set as close as possible to it, but still on the backscatter. The backscatter level at a point loss does not shift directly down, but rather has a slight roll-off to it. The length of the roll-off region is related to the pulse width (just like the distance taken up by a Fresnel reflection). Since valid loss measurements can only be taken from backscatter to backscatter, the right cursor cannot use any part of this roll-off portion. This forces the right cursor to be placed farther out on the fiber than the next data point after the loss occurs. Consequently, the level measurement between the two points includes the loss occurring at the point plus an amount of loss (usually very small) that would normally occur over such a distance.

The **LSA Splice Loss method** uses a mathematical technique called **Least Squares Approximation** to eliminate the excessive distance-induced loss found in the 2-Point method. You simply place a cursor on the point to be measured and select "LSA Splice Loss," or simply "Splice," from the control panel loss mode section. The OTDR then determines what the loss would be if the drop in backscatter level display was straight down instead of rolling off.

In making an LSA splice loss measurement, the OTDR will highlight part of the trace before the splice location (wherever you place the main cursor — usually the "A" cursor) and part of the trace after the splice. The highlight may be an actual brighter part of the line, or a set of markers (tick marks on the trace showing the limits of each of the highlight areas). The OTDR looks at the highlighted areas and mathematically determines the slope of the trace lines on each side of the splice (by the "Least Squares Approximation" — or "LSA" — method). It then determines the vertical interval between these two lines at the cursor location. This is the best measurement of the shift between the two lines, which represents the change in signal level from one fiber to the next. And that is what defines splice loss — the change in signal level where one fiber is joined to the next. It is important that the highlight areas on both sides of the splice location do not include another splice or a non-linear part of the trace. If part of the highlight area is not straight, then the slope calculated by the OTDR will not be correct and the subsequent splice loss reading will be wrong. Most OTDRs allow you to adjust the highlight area so that you can make sure there is only linear backscatter included.

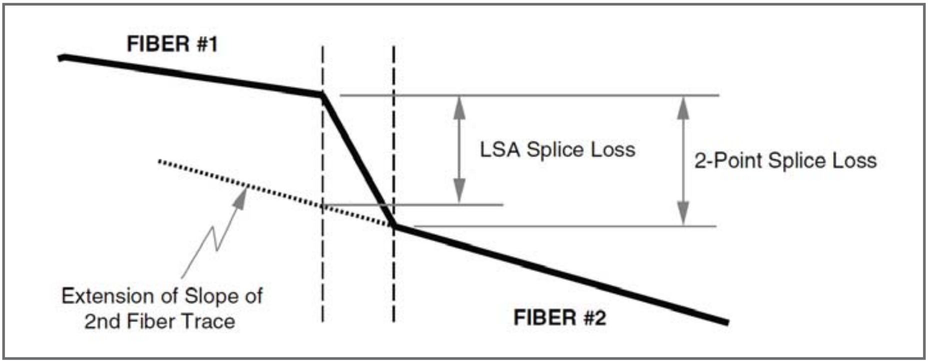


Figure 18 - LSA vs. 2-Point Splice Loss

Quality Factor (dB/Km)

The Measurement of loss per unit distance is a common method for determining a fiber's quality. Less loss per unit length means you will have a stronger signal at the receiver. The distance unit of measurement is usually kilometers (Km). Fiber and fiber cable is ordered based on its type (SM or MM) and its loss per Km at a specified wavelength. Typical values for singlemode fiber at 1300 nm is 0.4 to 0.6 dB/Km. At 1550 nm this drops to 0.2 to 0.35 dB/Km. For multimode fibers, the values range from 1.0 to 6.0 dB/Km.

The quality factor is automatically calculated for a fiber when two cursors are set on the trace and the "dB/Km" measurement is selected from the control panel. The OTDR simply displays the distance and loss between the two cursors, and calculates the dB/Km value by dividing the distance into the loss. In most OTDRs, if the distance units are set to display in feet, then the loss/distance unit will usually be dB/KFt (kilo-feet, or thousands of feet) instead of dB/Km.

Reflectance

The amount of **reflection** at a connector, break or **mechanical splice** depends on how clean the break is, and how much the index of refraction changes when the light leaves the fiber. Most mechanical splices use an **index-matching** gel or fluid to reduce the amount of change. Smaller changes in the index of refraction produce smaller reflections. Some OTDRs can measure the amount of reflecting light automatically by placing one cursor just in front of the reflection and pressing the appropriate button on the control panel. Reflectance is measured in -dB (negative decibels), with a small negative value indicating a larger reflection than a large negative value. That is, a reflectance of -33 dB is larger than a reflectance of -60 dB. The larger reflectance will show up as a higher spike on the trace.

By measuring and comparing reflectance levels in mechanical splices over time, you can determine if there are changes occurring in the splices. Sometimes the reflectance level will increase even if the splice loss does not get worse. This could indicate the beginning stages of the failure of the mechanical splice. Increasing reflectance could mean that the fiber ends are starting to come apart (the splice is losing its grip), or the index matching fluid is starting to dry up or leak out.

By knowing the level of reflectance at a connector, you can determine if a problem is occurring very close to the connector — perhaps at the pigtail splice or in the connector strain-relief part. If the OTDR measures the distance to the far connector to be the correct length, but the reflectance is much lower than it was previously, the fiber might be fractured just inches short of the connector end-face — thus causing a lower reflection due to the ragged edges of the shattered glass. Since the connectors are the most handled part of the fiber, it is easy to damage the fiber right next to the connector and not realize it. An OTDR can be used to isolate this type of problem by using its reflectance measuring capabilities.

Optical Return Loss (ORL)

Similar to Reflectance, ORL is the total amount of light coming back towards the transmitter from the entire fiber. This includes all backscatter and all reflections. Some newer OTDRs can calculate ORL from the fiber trace.

AUTOMATIC MEASUREMENTS

The latest-model OTDRs have the additional capability to automatically configure themselves and to automatically perform the standard measurements normally made. These "**auto-ranging**" and "**auto-analysis**" features take the guesswork out of testing fiber and allow anyone to make precise, consistent measurements on any fiber. These two features can be used independently of each other so that you can set up your OTDR the way you want to, but still be able to use the automatic analysis capability.

Auto-Range Feature

Auto-ranging, also known as "Automode" or "Auto-Setup," sets the variable distance range (**display range**) of the OTDR, as well as the **pulse width** and **resolution**, to the best settings for the fiber under test. It does this by first sampling the fiber for several seconds to determine its approximate length, and then by selecting a display distance that will allow the entire fiber to be seen on screen. It will also choose a **pulse width** and **resolution** setting that will produce the quickest and most reliable test.

Fiber Analysis Software (FAS)

One of the most important tasks in using an OTDR is being able to interpret the fiber trace correctly. The fiber analysis feature can perform this task for you by using the computer part of the OTDR to scan and analyze the digital test results obtained from the fiber. It will look for shifts in the **backscatter** level which indicate splice losses or defects; it will look for sudden spikes up from the backscatter, which indicate **Fresnel reflections** (usually mechanical splices, breaks or fiber terminations); and it will measure the loss in each of these "**events**" that it finds. The results you see are summarized in an "**event table**," which lists each event, its location, loss and reflectance (if any). A typical event table will look like this:

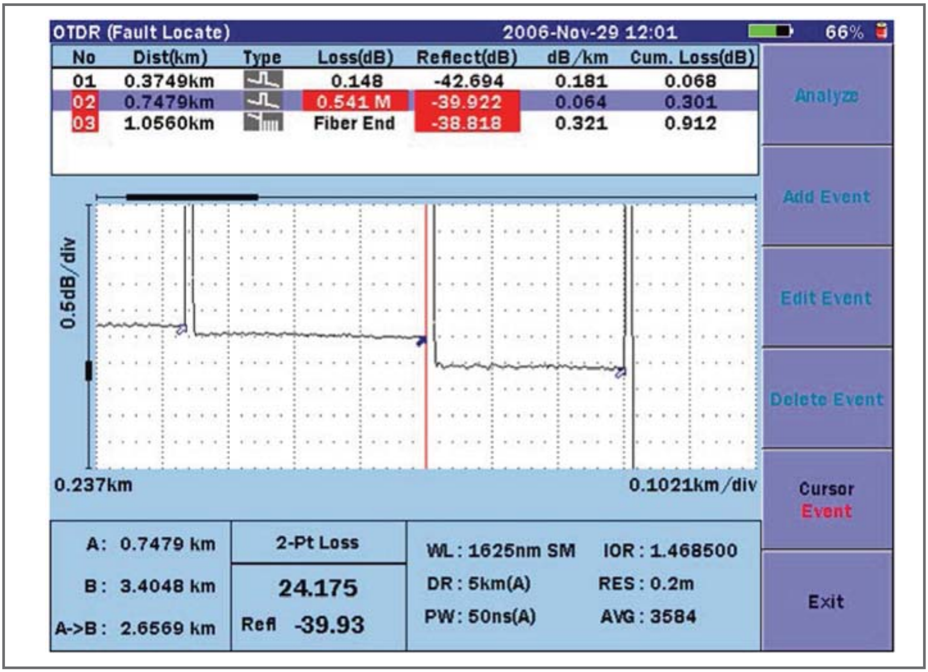


Figure 19 - Event Table Example

The table shows five events (including the cable end), and gives all the important information about the cable at one look. The first column shows you if the event is **N**on-reflective (a fusion splice or tight bend), **R**eflective (a mechanical splice), or the **E**nd of the cable. In some cases the Type of event will be indicated by a letter rather than a symbol. By looking down the various columns you can see if the splices meet your loss criteria. By looking at the dB/km column you can see if the fiber between splices is within its normal loss range. The reflectance values in the last column for the last event depends on whether the fiber end has been connectorized (will show -20 to -40 dB if it has), or if it has been broken (usually a value of lower than -45 dB).

Some OTDRs will link the event table to the actual trace so you can see where each event is situated in relation to the others. You may also be able to delete and add events, or add text comments for each event. This capability will let you build complete documentation for each fiber for use in maintenance or for providing detailed records to customers. This "**landmarking**" capability is valuable for determining the ground location of cable cuts or other problems. You just need to add the physical ground location in the comments section for each event found on a trace. Most OTDR manufacturers who use the auto-analysis feature also have a similar stand-alone program available for use on a desktop or laptop computer. If your OTDR has a floppy disk drive for storing test data, you can either load a previous test into your OTDR or into your computer and run the analysis software. This stand-alone software is a good choice if you are using an older OTDR that doesn't have built-in analysis, but does have trace data storage.

Automatic fiber analysis routines don't always find all the events in a fiber, and sometimes will find events that are not there. If your splices are very good and you have trouble finding them on the trace, then the software will probably also have trouble finding and measuring them. The ability of the software to locate an event depends on the thresholds you set up, the length of the fiber, and the amount of averaging you have done on the trace. You have the option of setting the sensitivity of the analysis routine so that it will only find events that meet or exceed a certain threshold. If the threshold is set to 0.20 dB, then the software will not mark splices with lower losses. On the other hand, when measuring very long fibers, the far end of the trace may be very noisy, with the individual data points fluctuating up and down from one to the next. This fluctuation may cause the software to find a "false" event that is not there. You can decrease the noise in the trace by increasing the averaging time (scan time). You can reduce the number of false events by keeping the loss threshold above 10 dB.

Some fiber analysis software will let you pre-set the location of your splice points into a "template" or master trace file. You can then run all the other fibers in the cable against this master to only get the measurements on the splices you know are there. By only measuring specific, known points you can then create an overall cable loss table by exporting the analysis results to a spreadsheet or database. This is an excellent way to manage your fibers and to determine if your splices or other sections of the fiber are getting worse over time.

Measurement Problems

Even a trained and experienced OTDR operator may have difficulty interpreting a fiber trace at times. There are a few cases where it is almost impossible to get an exact distance or loss determination based on one measurement. In some extraordinary circumstances it may be necessary to test a fiber with different set-up conditions or from both ends in order to get meaningful results.

NON-REFLECTIVE BREAK

When a fiber gets cut or broken the end may shatter so that the light hitting the end may not reflect at all. Also, the end of the fiber may become immersed in oil or grease, which may also eliminate the Fresnel reflection. When this happens, the trace will suddenly fall off into the noise level. There may be a rounding-off of the backscatter where it falls off so that it may be difficult to judge where the fall-off point is. The best method to determine the break point is to use a **2-Point loss method** to determine at which point the backscatter level drops off by 0.5dB. Place the left cursor as near to the end as possible but still on the backscatter. Then move the right cursor in towards the left cursor until the loss between the two reads 0.5dB. The actual end of the fiber should be very close to the point measured by the right cursor. To increase your confidence in this location, take the OTDR to the other end of the fiber and test back to the break from the other side. It is possible that the other side of the break will reflect some light. (Keep in mind that the fiber could be broken at more than one point.)

"GAIN" SPLICE

Sometimes when two fibers are spliced together, the backscatter level at the splice point shifts UP instead of DOWN. At first glance this would appear to be a GAIN in power at the splice. The OTDR may even indicate a **negative splice loss**. What has happened is that the two fibers were **mismatched**: the second fiber has a higher **backscattering coefficient** than the first, and more light gets scattered back by it. The OTDR sensor reads this as a higher level than the end of the first fiber and plots the corresponding data points higher up on the screen. If the same splice is tested from the opposite direction, the OTDR would indicate a higher "normal" loss than the amount of the "negative" loss. In this case, the true splice loss value is the average of the two readings. That is, if the "gainer" reads -0.25 dB, and the opposite direction reads 0.45 dB, then the actual splice loss is 0.1 dB.

The following figure shows what a "gain" splice looks like on an OTDR display in comparison to what a "normal" splice looks like. Note that the slopes of the two fiber traces are different. The second fiber has a steeper slope than the first fiber, which indicates a higher backscatter level throughout the fiber. It would normally appear higher on the screen than the first fiber because it returns more light to the OTDR. A difference in **Index of Refraction** can produce different backscatter levels, and thus different slopes of the trace. The other possible cause of a gain is that the "mode field diameter" (which is related to the fiber's core size) is different in the two fibers, which causes more backscattering to come back from the second fiber. When a gain splice occurs, it is because the two fibers being spliced together are mismatched in some way. This phenomena is most apparent when you splice fibers made by two different fiber manufacturers. Because of the inherent difference in optical characteristics between any two fiber manufacturers (see the section on Index of Refraction) you can expect the two fibers to be mismatched, thereby producing "gainers."

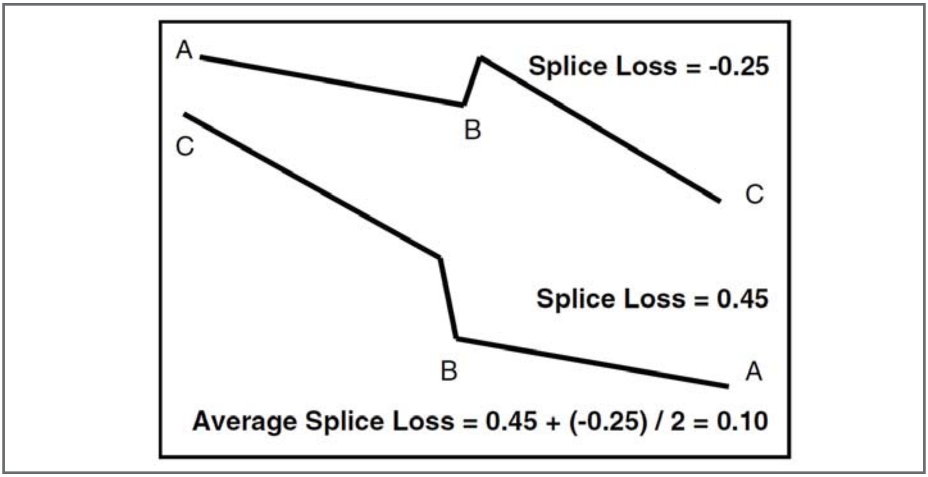


Figure 20 - Treatment of Gain Splices

The average of all splices in a fiber span [a span is one or more fibers spliced together to make a continuous fiber link from one connector end to the other] is usually the benchmark used in constructing a system. If the average is equal to or better than the goal, then the overall loss budget planned for will be met. Gain splices can be confusing in determining splice loss averages since they usually are displayed as a negative loss on the OTDR. In order to determine the average splice loss value for a string of splices in a fiber span, you need to include the gain splice values along with the normal loss values. That is, use BOTH the positive and negative values as displayed by the OTDR in summing the total of all splice loss values. Then divide by the number of splices summed.

The most accurate method of determining the average splice loss values in a fiber span is to make a bi-directional measurement of each splice — that is, measure the splice of Fiber AB to Fiber BC first from the Fiber A end, then from the Fiber C end — individually average each splice loss, then take the average of the entire span. This method is time consuming and can usually only be done after the entire system has been spliced. The next best method is to take the one-directional average of all splices in a span using the splice values measured from the same direction only. Normally, when a gain occurs, the next splice will be a higher-than-normal loss. This is because the fiber with the higher backscatter level causing the gain will also cause a higher measured loss going to the next fiber, and the effects of the two splice measurements will cancel out. Avoid calculating splice loss averages using one-directional splice loss values when the individual splice values along the span were measured from different directions.

GHOST REFLECTIONS

Sometimes you will see a Fresnel reflection where you don't expect one — usually after the end of a fiber. This usually happens when a large reflection occurs in a short fiber. The reflected light actually bounces back and forth within the fiber, causing one or more **false reflections** to show up at multiple distances from the initial large (true) reflection. That is, if a large reflection occurs at 1,325 feet, and there is an unexpected reflection at 2,650 feet (twice the distance to the first) and another at 3,975 feet (three times the distance to the first), then it is likely the 2nd and 3rd reflections are "ghosts."

Another type of ghosting happens when you set the range shorter than the actual length of the fiber (in order to see details up close in a very long fiber). This allows the OTDR to send additional pulses of light into the fiber before all of the backscatter and reflections from the first pulse have cleared the whole fiber. When you get more than one pulse in the fiber at one time, you set up a condition where returned light from different pulses arrive at the OTDR at the same time, producing "unpredictable results." Often this will take the form of a series of reflections, or excessive noise, occurring in one area of the fiber.

Here are a few "ghost-busting" techniques you can use to determine if ghosts are occurring and then possibly eliminate them:

1. Measure the distance to the suspect reflection. Then place a cursor half this distance on the fiber. If an expected reflection is at the half-way mark, then the suspect is probably a ghost.

2. Suppress or reduce the known (true) reflection. By making the amount of returned power smaller, the ghost will also be reduced (or eliminated). To reduce the reflection, you can use **index matching gel** at the reflection, or reduce the amount of power going to the

reflective point by selecting a shorter pulse width or by adding attenuation in the fiber before the reflection.

3. Change the Distance Range (Display Range) of the OTDR. In some OTDRs, a ghost is caused when the Distance Range is too short. Increase the Range setting and the ghost may disappear.

4. If a ghost seems to occur in the fiber, then measure the loss across the suspected reflection. A ghost will show no loss across it when you do a splice loss measurement.

Choosing an OTDR

In selecting an OTDR, you should take several factors into consideration. Ask for recommendations from other people who already use OTDRs. Ask yourself these questions:

- **What fiber type(s) and wavelength(s) will you be testing? —** Singlemode, Multimode, or both. Consider your short-term and long-term needs. If you might need to test different types and/or wavelengths later on, then look for modular systems where you can reconfigure the OTDR. However, if you might have to work on a singlemode and multimode project at the same time it might make more sense to get a separate OTDR for each type of fiber. That would let you work two jobs at once instead of having to wait on the OTDR mainframe to finish on one job before going on to the next.

- **What kind of measurements will you be making —** loss, distance, reflectance, splice alignment? Make sure the OTDR you select can do all of these easily, quickly, and accurately. If you need to make "live" tests (like during a "hot cut" — splicing of fibers in a working cable) you will need an OTDR that can do an active splice loss measurement in "real time." Surprisingly, few OTDRs can make this active measurement. Also look for a simple front panel control layout which lets you take control of your testing parameters, as well as a display that is easy to interpret.

- **How often will you use the OTDR?** If you will be using the instrument only when a problem occurs in the fiber, or for semi-annual maintenance evaluations, then you will need a simple unit with few front-panel controls, and which has a built-in HELP feature to refresh you on the basics. If you will be using the unit frequently, then you will want more easily accessible controls for detail functions such as horizontal and vertical scale changes, pulse width changes, cursor movement, loss mode switching, wavelength switching, and display orientation. These controls should be easily accessible without going through layers of menus.

- **How many different operators will be using the OTDR, and what will their training level be?** If several people will be expected to use it, the OTDR must be user-friendly and must be able to produce consistent results. For example, if one group uses the OTDR to build a fiber system, and another group will use the OTDR to maintain the system, each fiber should be tested with the same setup conditions each time to compare with the initial data. A built-in **trace storage** capability, with a **trace overlay** feature (to allow a current trace to be overlaid on a trace of the same fiber taken at the time of acceptance) will allow quick and accurate "before and after" comparison of the fiber's characteristics.

- **What documentation will be required?** If you need to keep permanent records of fiber tests, then choose an OTDR with a printer, plotter, and/or disk storage capability. Also consider the range and type of external printers and plotters supported by the unit. An OTDR should give you the ability to store trace information on a disk, print it out on an internal printer/plotter, and/or print/plot it from a computer program using the computer's printer.

- **Will you use a computer to store or analyze data?** A very efficient means of keeping trace data on file is to store the information in a computer. This will allow you to recall the traces at any time for comparison and analysis. Some OTDR manufacturers have programs that **emulate an OTDR** on a computer, so you can make the same loss and distance measurements on a laptop computer or office computer just like you can on an OTDR. The software should also be able to analyze the trace data to produce fiber event tables and cable loss tables for complete documentation. If this option seems beneficial to your operations, then make sure the program will run on the type of computer you use. Some programs run under MS-DOS®, some under Windows®, some in both.

- **How much support do you want from the vendor?** Fiber optics testing can get confusing at times and you may need some fast answers from someone who has seen the problem before. Check to see if the OTDR supplier has a "help line" or some way to provide technical information. Is the local representative technically qualified and experienced enough to talk you through problems? Check the warranty repair turnaround policy — how long will you be without an OTDR if you have to send it in for repairs? What is the manufacturer's reputation in the industry? In your area?

- **Will you ever get other OTDRs?** If compatibility between models is important, then determine if the data from a manufacturer's previous models are compatible with the current (and future) models. Is it easy to compare traces with data taken years ago on a different model? Some OTDR manufacturers completely change their models when they come out with a new one, and don't provide backward compatibility in features, operation, or trace data. If you change models, will you have to completely re-train your OTDR operators?

- **Can your OTDR be upgraded to add new features or improve operations?** While some OTDRs must be taken out of service and sent to the factory for upgrades, most OTDRs can be upgraded in the field simply by placing a disk with the new operating software in the unit. **Software upgrades** can provide completely new features and improved performance without losing the use of the OTDR. Most current OTDRs are modular in design, so you can easily change the optics to improve the measuring range, add other measuring wavelengths, or add peripherals (such as a power meter and light source). Ask before you buy.

Mini-OTDRs

The latest developments in OTDRs in the widespread availability of small, battery-operated units that offer similar capabilities (and sometimes MORE) which previously could only be found in full sized models. The only limitation of a Mini is the lack of a built-in printer. This is offset by the good long-range and high-resolution performance of the better units.

These mini-OTDRs are typically single OR multi-wavelength units which include automatic trace analysis. Some units allow you to test at BOTH singlemode AND multimode wavelengths without changing modules. The most complete "mini's" include built-in data storage, a built-in optical power meter, a stable light source, and a visual fault locator (red laser light source).

In choosing a mini-OTDR, look for a large, well-lit, easy to read screen (color is easier to read than monochrome); an automatic ranging and analysis feature for "one-button testing"; an internal data storage device so you can store test results and setup information; and the ability to measure both long fibers PLUS perform high-resolution tests. If inexperienced users will use the Mini you should look for a model which has an up-front one-button test feature that is available as soon as you turn the unit on. That is, you should only have to turn the unit on, connect the fiber, and press a single clearly marked button to get a fiber test—whether a fault location, or a complete analysis. It also makes sense to consider the company behind the equipment: Is it experienced in making OTDRs? Can you read and compare traces taken with other OTDRs in the Mini? What kind of support can you expect from the factory? Although Mini-OTDRs are basically smaller versions of their larger cousins, and cost around half as much, you still need to make sure you are getting equipment and a manufacturer you can trust.

Appendix A - Fiber Testing Tasks

This section describes the most common tests performed on telecommunications optical fiber. You may need or want to do only some of these tests.

1. Determine Continuity to Fiber End

The fiber must be able to pass light from the transmitter to the receiver. This test determines if light is making the trip from one end to the other. It is the most basic and simple test. You can use a simple Optical Power Meter to check for light at the receive end (assuming there is light going into the fiber at the other end), or you can check the overall length of the fiber with an OTDR. A Visible Laser will let you visually check continuity.

2. Locate Break in Fiber Cable

Finding where a fiber is broken is the first step to getting a system repaired and working again. Since the fiber cable is typically hidden from view, a break usually must be detected with test equipment. A Visible Laser source is good for detecting breaks in the fiber close to the ends. Use an OTDR/Fault Locator to detect breaks that are outside of the end equipment site.

3. Identify Fiber to Be Spliced

It is often difficult to distinguish which single fiber out of many in a cable is to be spliced next. Since the system's light is invisible to the human eye, and often the fiber colors at a splice point don't match with the colors or numbers at the office ends of the cable, the task of simply determining which fiber should be spliced can be very hard to accomplish without some type of test equipment. Both the person doing the splicing AND the person doing the testing must be working on the same fiber in order to reduce the time it takes to complete and test a splice. Light from a Visible Laser can be seen coming out of a fiber end by the human eye several miles down a fiber. Or, at the splice point, you can connect a fiber to an Optical Power Meter (using a raw fiber adapter or a clamp-on Fiber Identifier attached to the Power Meter) and test for the presence of light injected into the fiber from the equipment end. The person at the equipment end can determine if the person at the splice point is working on a particular fiber by putting an OTDR on the fiber and observing the trace in real-time for changes in the end reflection while the fiber is being cleaned, cleaved, and spliced.

4. Determine Continuity Through Splice

In building or restoring a fiber system, you have to know that the splice just made is of sufficient quality to allow light to pass between the two fibers. It's not enough to know that light injected just before the splice makes it to a point just after the splice (such as in Light

Injection & Detection — LID — splicing systems). You also must be assured that the light is making it all the way to the next splice point or the end of the fiber cable. Continuity through a splice is checked by looking through the splice to the next open point in the fiber with an OTDR or with a light source and detector. You can also clamp on to a point beyond the splice with a Fiber Identifier (AM- 450) and Optical Power Meter to check for the presence of light. If the splice point is only a few miles from the equipment end, then a Visible Laser could indicate visually if light is passing through the splice.

5. Measure Splice Loss

The quality of a splice is measured in dB. Splice losses must be kept low in order to allow enough light to get through to the system detector. Typical permanent splice losses are under 0.5 dB. Temporary splices for restorations must only be good enough to pass light through to the receiver. True measurement of splice loss can only be done by comparing the amount of light just before the splice to just after the splice. OTDR-type test equipment is the only test equipment which is designed to make a true splice loss measurement. A Visible Laser can be used as a rough GO/NOGO indication by seeing how much light leaks out at the splice.

6. Measure Fiber Loss (End-to-End Attenuation)

The "bottom line" in a fiber system is whether the detector can read the light that reaches it. Fiber systems are designed with a specific "loss budget" that must be met for the system to work properly. For a given amount of light injected into the fiber by the transmitter, there is a maximum amount of light loss that can be tolerated before the signal is too weak at the receive side for the detector to detect. End-to-End loss takes into account the normal loss in the fiber, the loss at each of the splices, and any loss due to defects or tight bends in the fiber cable. Overall loss is measured most accurately with a stable light source of known power and an Optical Power Meter. An OTDR will also measure overall loss, but not as completely (it leaves out connector losses).

7. Measure Fiber Quality (dB/km)

The quality of a fiber is measured in the amount of loss (in dB) it has per thousand meters — kilometers or km. The lower this dB/km value, the longer the system can be with the same loss budget, because the fiber attenuates the light less. Fiber cable is usually ordered from the manufacturer with a specified dB/km value at a specific operating wavelength. Singlemode fiber has about 0.20 to 0.5dB/km loss, and multimode fiber typically measures from 1 to 6 dB/km loss (these values depend on the wavelength of the light, the fiber diameter, and other factors). A dB/km measurement is made by testing for overall (end-to-end) loss, and dividing the result by the length (in kilometers) of the fiber. It is done most efficiently and easily with an OTDR.

8. Measure Reflectance of Splice & Connector

Reflectance is the amount of light that bounces off a fiber end at a mechanical splice or connector. If enough light is reflected back into the transmitter, the system performance can be affected — particularly for SONET (high-speed digital systems) and for analog video systems. Reflectance is measured in -dB and should be -40dB or lower (-50dB is lower than -40dB) in order to ensure trouble free operations. Reflectance of splices and connectors in mid-span can only be made with an OTDR.

9. Overall Return Loss (ORL)

Overall Return Loss, also called Optical Return Loss, or ORL, is the total amount of light returned from a fiber for a given amount of light injected into it. This includes all reflections and backscatter in a fiber. It describes how much light comes back to the transmitter (light source). Too much optical return can cause problems in CATV and high-speed digital systems (like SONET). ORL can be measured in two ways: 1) By using a calibrated light source and power meter along with other specialized components — these may all be combined into one ORL Meter, or 2) By using an OTDR with ORL capability. The ORL Meter directly measures the return signal amount, whereas the OTDR calculates ORL from the backscatter and reflection levels it normally measures in a fiber.

10. Document Results (Print or Record to Disk)

In order to properly maintain a fiber system, you should know what it was like when it was at its best condition — when it was first built and turned up. By comparing routine maintenance results to the original records of end-to-end loss, splice loss, reflectance, etc., you can tell if any part of the system is degrading. Documentation ranges from writing the results on a slip of paper to getting a printout from the test set, to storing the test results for later viewing or analysis on the computer. An OTDR with a built-in data storage is the most efficient and cost-effective way to archive test data. It also allows you to recall the original data back to the instrument for comparison with current test data.

Stand-alone programs that emulate the OTDR on desktop and laptop computers will make documentation much more effective. You can take just the stored fiber test data from the OTDR (or other test equipment) and work with it in the office while the equipment is being used out in the field. With this type of program you can overlay an original and current trace to see any degradation. You can have the program analyze your test data to tell you the location and loss of your splices. And you can print out the details or summaries from your computer printer to make clean, readable reports every time.

LANDMARKING is another important task you can do with trace data saved to a disk. Using the fiber analysis program you can associate physical ground locations with optical distances along a cable. Landmarks are usually put in the comments section of an event listing for a fiber trace. You can enter the nearest street intersection, the manhole number, or the geographical coordinates (for use with a GPS system). This lets you determine where to go on the ground when you discover problems in a fiber.

Appendix B - English-Metric Measurements

Units of Measurement

The meter (m) is the standard unit of measurement for distance. The second (s) is the standard unit of measurement for time. By multiplying and dividing the unit by increments of 10, 100, 1000, etc., different magnitudes are expressed in a standard format. For example, when applied to the meter, the standard shorthand notations and the corresponding magnitudes are:

1 **kilo**-meter (km) = 1,000 m = 10^{+3}m

1 **centi**-meter (cm) = 0.01 m = 10^{-2}m

1 **milli**-meter (mm) = 0.001 m = 10^{-3}m

1 **micro**-meter (µm) = 0.000001 m = 10^{-6}m

1 **nano**-meter (nm) = 0.000000001 m = 10^{-9}m

1 **pico**-meter (pm) = 0.000000000001 m = 10^{-12}m

The same shorthand is used for any other unit of measurement. Thus, time measurements are described in milli-seconds (**ms**), micro-seconds (**µs**), nano-seconds (**ns**) and pico-seconds (**ps**).

English-Metric & Metric-English Conversions (approximate)

1 foot (ft) = 12 in = 0.305 m

1 inch (in) = 0.083 ft = 2.54 cm

1 mile (mi) = 5280 ft = 1.61 Km

1 meter (m) = 39.4 in = 3.28 ft

1 kilometer (km) = 0.621 mi = 3,279 ft or 3.28 Kft

Standard and Typical Values in Fiber Optics

Operating Wavelengths:	850 nm, 1300 nm, and 1550 nm; = 0.85 µm, 1.3 µm, and 1.55 µm (1000 nm = 1 µm)
Bare Fiber outer Diameter:	125 µm
Fiber Core Diameter:	8-10 µm (Singlemode) 50-100 µm (Multimode)
Speed of Light (c):	300,000 km/s = 186,000 mi/s = 0.3×10^9 m/s = 0.3 m/ns
Speed of Light in Fiber (v):	= c/n =200,000 km/s = 124,000 mi/s = 0.2 m/ns = 8in/ns (for n = 1.5)

Relationships in Fiber Optics

Distance covered by a 1 ns light pulse in fiber:	1 ns x 0.2 m/ns = 0.2 m = 8 in
Time for light to travel 1 mile in fiber:	1 mi / 124,000 mi/s = 8 µs
Time for light to travel 1 kilometer in fiber:	1 km / 200,000 km/s =

Anritsu OTDRs

Anritsu offers a complete range of test equipment for the optical communications industry including R&D, production, installation, monitoring, and manufacturing. Anritsu is a recognized leader in high-speed optical technology and field test solutions including evaluating a wide range of optical devices and fiber systems.

Model	OTDR Standard	OTDR Construction	OTDR Fault locate	OTDR Submarine	Loss Test Set	Light Source		Optical Power		Optical Return Loss	Visual Fault Locator	Video Inspection Probe	Optical Spectrum Analysis	Channel Drop	Polarisation Mode Dispersion	Chromatic Dispersion	Optical Component Test	Eye Pattern Analysis	Optical Channel Analysis
						Spectrum	Wavelength	Low Level	Med/High Level										
MT9083 ACCESS Master	●	●	●		●		●	●	●	●	●	●							
MT9090A/MU909011A Drop Cable Fault Locator			●						●	●	●	●							
MT9090A/MU909014/15 uOTDR	●	●	●				●	●		●	●	●							
MT9090A/MU909020A Optical Channel Analyzer							●		●										●
MW90010A Coherent OTDR				●															
CMA5000a* Multi-Layer Test Platform	●	●	●		●		●	●	●	●	●	●	●	●	●	●			
CMA50 Power Meter/Loss Test					●			●	●	●	●								
CMA5 Light Sources and Power Meters								●	●										
MS9740A Optical Spectrum Analyzer						●	●	●	●				●		●		●		

*See Transport/Datacoms page 17 for more details.

MT9090 Network Master

With its four independent modules the MT9090 finally addresses the need of providing all the features and performance required for installation and maintenance of FTTx access networks. The very compact battery-powered Network Master is a comprehensive solution for OTDR, 10Mb/100Mb & Gigabit Ethernet, Drop Cable Fault locator and Optical Channel Analyzer.

Modules Available include :

MU909011A Drop Cable Fault Locator
MU909014x/15x µOTDRModule
MU909020A Optical Channel Analyzer
MU909060A Gigabit Ethernet Module

MT9090A/MU909011A Network Master µOTDR

- High-end OTDR performance in a pocket-size package with unique battery operation
- Full AUTO mode simplifies operation, no OTDR knowledge needed
- Complete PON testing through splitters up to 1 × 64

Introducing the first handheld OTDR that does not compromise performance – the new µOTDR from Anritsu. With performance that rivals traditional OTDRs that are four times the size and more than double the price, the Network Master MT9090A µOTDR has created a new class of test instruments. It features 5 cm resolution for accurate mapping of events, deadzones of less than 1 meter (3 feet) and a dynamic range of up to 37 dB – enough to test over 150 km (90+ miles) or PON-based FTTX networks featuring up to a 1x64 split. The MT9090A µOTDR also takes portability to a new level by being the first handheld OTDR that truly fits in the palm of your hand.

The MT9090A with MU909014x/15x module represents a new era in optical fiber testing!

MT9090A/MU909011A Network Master Drop Cable Fault Locator

- Integrated launch fibre provides accurate initial connector measurement without external devices.
- High resolution, widescreen color display that is easy to read indoors or out.
- Fixed parameters simplify operation and ensure proper set-up – just press "START".

Until now, the right tool just didn't exist for cost effectively testing short fibres. Handheld OTDRs and Fault Locators lacked the resolution and specifications to find issues in such short spans while mini-OTDRs were too large, too expensive and too complicated.

The MT9090A from Anritsu finally addresses this need by providing all of the features and performance required for installation and maintenance of short fibres in a compact, modular test set. The MT9090A represents an unmatched level of value and ease of use, while not compromising performance. Data sampling of five centimeters and deadzones of less than one meter, ensure accurate and complete fibre evaluation while a simple testing sequence requires only one key press to initiate – allowing anyone to make error-free measurements.

The MT9090A represents a new era in drop cable and premise testing. Its ease of use, low price, high-resolution and size make this the perfect product for "last mile" testing.

MT9083A/B/C ACCESS Master™ OTDR

- Test ultra-long fibers spans (>200 km).
- Rapid testing of PON based networks up to 128 splits.
- Up to 150,000 data points for superior fiber detail.
- Significantly reduced test times.
- SCPI remote command support.

The MT9083C test sets are designed to make your measurement experience simple and error-free with true one-button fault location, pass/fail classification, automated file saving and naming and even a macrobend detection feature for identifying installation issues. They feature multiple wavelengths and options to satisfy any network testing requirement: access or metro, FTTx or LAN...all without straining your budget. For customers installing and maintaining metro area or core networks, the ACCESS Master offers an automated fiber construction application and multiple wavelengths including speciality applications such as 1383 nm for certifying legacy fibers for CWDM upgrades.

MW90010A Coherent OTDR (C-OTDR)

- Measure submarine cables up to 12,000 km long with 10 m resolution.
- Unique solution for submarine links fault detection.
- Compact & lightweight for easy transportation.

The MW90010A is designed for detecting faults in ultra-long optical submarine cables of up to 12,000 km including multiple repeaters (EDFAs). It is the ideal solution for evaluating new cables at service deployment as well as for troubleshooting in-service faults.

Ultra-long optical submarine cables use optical amplifiers to boost signals. The C-OTDR can measure the backscatter light through all repeaters by using coherent detection. As a result, it can display every fault condition, such as optical loss between repeaters, bending loss, distances, breaks, etc., on-screen for waveform data analysis.

CMA5000a OTDR Module Series

- Never obsolete - expandable modular design.
- Dedicated testing modes simplify common tasks.
- Easy to use testing from fault location to advanced analysis.

The CMA5000a series OTDR modules simplify installation, commissioning and trouble-shooting of core, metro, CWDM and PON based FTTx optical networks. They feature a multitude of available wavelengths for single mode, multimode and hybrid applications including 850 nm, 1300 nm, 1310 nm, 1383 nm, 1490 nm, 1550 nm, 1625 nm and 1650 nm. Up to four of these wavelengths can be combined into a single optical port providing full spectrum fibre characterisation at the press of a button and dedicated testing modes simplify operation for any user profile - novice to expert.

Index

Anritsu

Specifications are subject to change without notice.

Anritsu Corporation
5-1-1 Onna, Atsugi-shi, Kanagawa, 243-8555 Japan
Phone: +81-46-223-1111
Fax: +81-46-296-1238

● U.S.A.
Anritsu Company
1155 East Collins Blvd., Suite 100, Richardson,
TX 75081, U.S.A.
Toll Free: 1-800-267-4878
Phone: +1-972-644-1777
Fax: +1-972-671-1877

● Canada
Anritsu Electronics Ltd.
700 Silver Seven Road, Suite 120, Kanata,
Ontario K2V 1C3, Canada
Phone: +1-613-591-2003
Fax: +1-613-591-1006

● Brazil
Anritsu Eletrônica Ltda.
Praça Amadeu Amaral, 27 - 1 Andar
01327-010 - Bela Vista - São Paulo - SP - Brasil
Phone: +55-11-3283-2511
Fax: +55-11-3288-6940

● Mexico
Anritsu Company, S.A. de C.V.
Av. Ejército Nacional No. 579 Piso 9, Col. Granada
11520 México, D.F., México
Phone: +52-55-1101-2370
Fax: +52-55-5254-3147

● U.K.
Anritsu EMEA Ltd.
200 Capability Green, Luton, Bedfordshire, LU1 3LU, U.K.
Phone: +44-1582-433200
Fax: +44-1582-731303

● France
Anritsu S.A.
12 avenue du Québec, Bâtiment Iris 1- Silic 638,
91140 VILLEBON SUR YVETTE, France
Phone: +33-1-60-92-15-50
Fax: +33-1-64-46-10-65

● Germany
Anritsu GmbH
Nemetschek Haus, Konrad-Zuse-Platz 1
81829 München, Germany
Phone: +49-89-442308-0
Fax: +49-89-442308-55

● Italy
Anritsu S.p.A.
Via Elio Vittorini 129, 00144 Roma, Italy
Phone: +39-6-509-9711
Fax: +39-6-502-2425

● Sweden
Anritsu AB
Borgarfjordsgatan 13A, 164 40 KISTA, Sweden
Phone: +46-8-534-707-00
Fax: +46-8-534-707-30

● Finland
Anritsu AB
Teknobulevardi 3-5, FI-01530 VANTAA, Finland
Phone: +358-20-741-8100
Fax: +358-20-741-8111

● Denmark
Anritsu A/S (Service Assurance)
Anritsu AB (Test & Measurement)
Kay Fiskers Plads 9, 2300 Copenhagen S, Denmark
Phone: +45-7211-2200
Fax: +45-7211-2210

● Russia
Anritsu EMEA Ltd.
Representation Office in Russia
Tverskaya str. 16/2, bld. 1, 7th floor.
Russia, 125009, Moscow
Phone: +7-495-363-1694
Fax: +7-495-935-8962

● United Arab E mirates
Anritsu EMEA Ltd.
Dubai Liaison Office
P O Box 500413 - Dubai Internet City
Al Thuraya Building, Tower 1, Suit 701, 7th Floor
Dubai, United Arab Emirates
Phone: +971-4-3670352
Fax: +971-4-3688460

● Singapore
Anritsu Pte. Ltd.
60 Alexandra Terrace, #02-08, The Comtech (Lobby A)
Singapore 118502
Phone: +65-6282-2400
Fax: +65-6282-2533

● India
Anritsu Pte. Ltd.
India Branch Office
3rd Floor, Shri Lakshminarayan Niwas, #2726, 80 ft Road,
HAL 3rd Stage, Bangalore - 560 075, India
Phone: +91-80-4058-1300
Fax: +91-80-4058-1301

● P.R. China (Hong Kong)
Anritsu Company Ltd.
Units 4 & 5, 28th Floor, Greenfield Tower, Concordia Plaza,
No. 1 Science Museum Road, Tsim Sha Tsui East,
Kowloon, Hong Kong
Phone: +852-2301-4980
Fax: +852-2301-3545

● P.R. China (Beijing)
Anritsu Company Ltd.
Beijing Representative Office
Room 2008, Beijing Fortune Building,
No. 5, Dong-San-Huan Bei Road,
Chao-Yang District, Beijing 100004, P.R. China
Phone: +86-10-6590-9230
Fax: +86-10-6590-9235

● Korea
Anritsu Corporation, Ltd.
8F Hyunjuk Building, 832-41, Yeoksam Dong,
Kangnam-ku, Seoul, 135-080, Korea
Phone: +82-2-553-6603
Fax: +82-2-553-6604

● Australia
Anritsu Pty. Ltd.
Unit 21/270 Ferntree Gully Road, Notting Hill,
Victoria 3168, Australia
Phone: +61-3-9558-8177
Fax: +61-3-9558-8255

● Taiwan
Anritsu Company Inc.
7F, No. 316, Sec. 1, Neihu Rd., Taipei 114, Taiwan
Phone: +886-2-8751-1816
Fax: +886-2-8751-1817

Phone: +49-89-442308-0
Fax: +49-89-442308-55

1005

Please contact: