Advanced OTDR Analysis – *Has technology made it a Lost Art?*

Is the ability to manually set up tests and interpret Optical Time Domain Reflectometer (OTDR) traces becoming a lost art, due to embedded processors and sophisticated software? This article discusses some of the advanced OTDR techniques that expert technicians use to perform during testing. Similar to a digital photographer's film camera experience, an understanding of the knowledge and skills used for manual OTDR testing can enhance a technician's fiber testing when using the latest OTDR with automatic capabilities.

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Has technology made it a lost art?

An Optical Time Domain Reflectometer (OTDR) is the only tool that can give detailed visibility of loss and reflective instances, which are often called "events." An OTDR's ability to detect events such as connectors, splices, and faults in an optical fiber run depends mainly on its dead zone, dynamic range, maximum range, distance accuracy, loss threshold, linearity, and sampling resolution specifications. In order to accurately acquire and assess these events, the instrument must be set to the most appropriate pulse widths, averaging time, wavelengths, loss threshold and distance range. And once a trace is acquired, the determination must be made whether the result is acceptable or not.

The knowledge and skills to manually set up tests, interpret and understand OTDR traces is rapidly going the way that film photographers have gone with the advent of digital photography. The latest OTDRs utilize embedded processors running sophisticated software to help users acquire traces and interpret the results. Like the best digital cameras, these instruments can usually take a better picture than legacy OTDRs that relied on expert users to set them up and subjectively "process" the results.

Seasoned professionals along with new fiber technicians are choosing OTDRs that automatically select most testing parameters and test against pre-assigned limits based on industry or job-specific requirements. And they're relying on their OTDR to compare event characteristics and pass or fail the trace based on these results. This saves both novices as well as experts an inordinate amount of time and eliminates subjectivity from the testing process. But is it making advanced OTDR analysis a lost art? This article discusses some of the advanced OTDR techniques that expert technicians use to perform during testing. Similar to a digital photographer's film camera experience, an understanding of the knowledge and skills used for manual OTDR testing can enhance a technician's fiber testing when using the latest OTDR with automatic capabilities.

Shooting a trace

OTDRs are used to find and analyze instances of disturbance to a fiber optic signal. These instances are often called "events." Some events are expected and others are unexpected in a fiber link. These events are categorized into reflective and non-reflective in fiber optic links. To do this, OTDRs send a series of very short, high-power light pulses into a fiber and record the light reflected back to the OTDR as each pulse travels down the fiber. This enables an OTDR to determine the location, loss and reflectivity of events such as connectors, splices, tight bends and breaks in fiber optic cabling. It can be a very effective single-ended testing and troubleshooting tool, requiring equipment and an operator at only one end. OTDRs have an advantage over loss/length meters in that an OTDR can pinpoint the locations of faults, reflective events, and loss events on the fiber cabling.

Running an OTDR test is often referred to as "shooting a trace." A "trace" is the graphical plot of the fiber being tested where power is on the Y axis and distance is on the X axis ***as shown in Figure 1***.

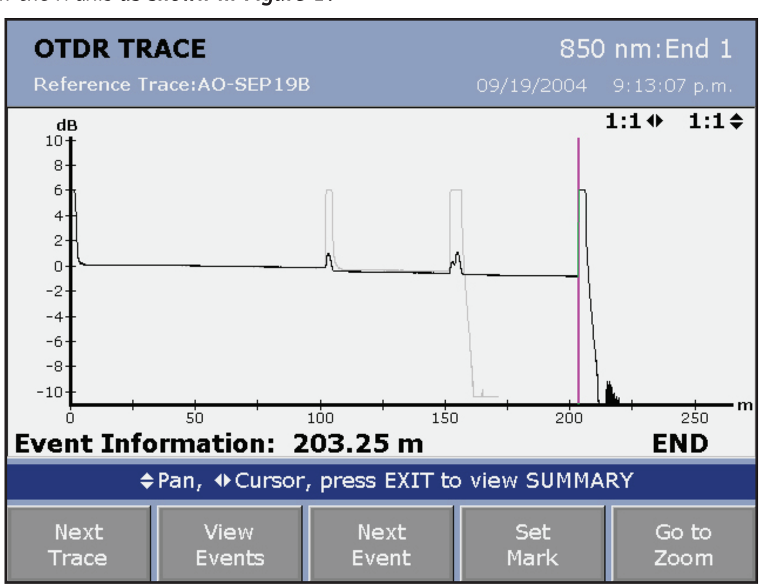

Figure 1 – An OTDR trace showing light power, measured in dB, on the Y axis and distance, measured in meters, on the X axis.

The fiber acts as a waveguide for the light pulse. As the source pulse travels down the fiber, most of the light travels in the direction of the fiber. A small fraction of the light is scattered in a different direction, due to the normal structure of (and small defects in) the glass that makes up the fiber. "Backscatter" is the tiny portion of the scattered light that is directed back toward the OTDR and can be detected. The OTDR uses backscatter changes to detect events in the fiber that reduce or reflect the power in the source pulse. Thus the portion of an OTDR trace between events is called the "backscatter line."

As the light pulse travels down the fiber, its power decreases because of loss from scattering, or at events such as connections and splices. At the same time, reflections are caused by connections, breaks, cracks, splices, sharp bends, and the end of the fiber. An OTDR is able to determine both the loss and "reflectance" of individual events as well as total loss and total reflectance or "optical return loss" for a section of fiber.

Identifying events

In addition to expected events such as connectors and splices, OTDRs also locate and characterize unplanned events on fibers. These events include ghosts, gainers, hidden, and unplanned loss events. Figure 2 shows examples of events on an OTDR trace. An expert fiber technician can usually identify these types of events on a trace without the help of an automatic event analyzer and event table that many OTDRs now possess.

Unplanned events often appear due to the way that OTDRs work, and usually show something occurring in the fiber link that is not optimal. Dirty connectors, sharp bends and mismatched fiber core sizes are examples of unplanned events. So an expert technician often has a deep understanding of how OTDRs work as well as extensive experience with fiber cabling infrastructure.

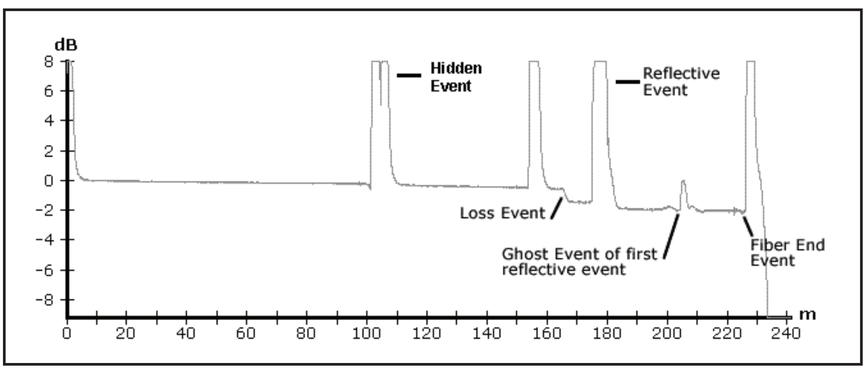

Figure 2 – A complex OTDR trace can show a number of different events. These can be caused by such things as dirty connectors, sharp bends, and mismatched fiber core sizes.

Using manual settings

Set up is a critical step of OTDR testing. An expert technician can set up an OTDR in manual mode or choose a combination of manual and automatic settings to achieve the most accurate and illustrative OTDR traces. Settings important for this are fiber type and specifications, wavelengths, averaging time, distance range, and pulse widths. Some other settings only available on the most advanced OTDRs are launch fiber compensation, test limits, and the ability to name and identify which end of the fiber the testing originated from.

The most basic setting is the fiber type and the specifications for index of refraction and backscatter coefficient. Some OTDRs allow the user to choose from a menu of optical fibers commonly available today. In this case, the index of refraction (n) and backscatter coefficient are already loaded into the tester. Otherwise, it is necessary to enter the fiber specifications from the manufacturers catalog or website. With the right fiber specs plugged into the OTDR, the user is assured that the location and reflectance results are accurate.

Pulse width is the most important OTDR setting for advanced OTDR analysis. It determines the dead zone and affects the dynamic range of the instrument. Narrow pulse widths allow a technician to see more detail on the trace and identify events that are close together. Longer pulses allow for maximum distance range. It is important to consider that these short pulse widths often limit distance range and produce noise on the trace.

Another important setting is selecting the wavelengths at which tests will be performed. Most OTDRs allow tests at multiple wavelengths, and some allow simultaneous tests at two wavelengths. Since light behaves differently at different wavelengths, expert technicians like to compare OTDR traces acquired at more than one wavelength. For instance, a dirty connector will often look OK on a trace acquired at 850 nm but show dramatic “tailing” at a longer 1300 nm wavelength.

Averaging time sets the number of measurements averaged together to create a trace. This can range from a few seconds to more than three minutes. A short averaging time decreases testing time but results in “noisy” traces, while choosing longer averaging time increases dynamic range and accuracy. An expert technician will use a longer averaging time to make cleaner traces and make it possible to detect small events on the trace.

Distance range is a setting that helps frame the trace on the OTDR. Maximum distance range does not actually change with this setting, but rather is tied to the dynamic range of the instrument and the fiber that is being tested. A technician performing advanced OTDR testing will usually choose a distance range that is double the distance of the event that he is looking for.

The loss threshold setting can help identify events that have very low loss or ignore small loss events that the user doesn’t need to see. A low loss threshold setting reduces noise on the trace, which makes small events visible, but tends to increase test time and makes dead zones longer.

Tips and tricks of the trade

Keep connectors and the OTDR port clean. The RFC 2544 and advanced Ethernet performance measurements described are end-to-end tests. They require a main test instrumentat the near-end of the link under test and a remote test instrument at the opposite end. The main instrument initiates the measurement test plan, gathers and processes the results, and provides a user-interface for review and saving of test results. Depending upon the test instrument supplier, there may be a choice of far-end remote instrument type.

Start with Automatic OTDR Settings and use Pass/Fail limits. This may seem contradictory to all the discussion about the power of manual settings. But in most cases, the OTDR will still acquire and analyze traces better and faster than the best technician. The trick is to use stringent pass/fail limits, then use manual to enhance the troubleshooting experience when a failure is identified.

Test at multiple wavelengths. Always test at both the shorter and longer wavelengths, even if the job or design specification doesn’t require it. This allows comparison of traces for the same fiber at different wavelengths and faster identification of problems such as dirty connectors.

Use bidirectional averaging for increased accuracy. It is common to see a gainer or negative loss value due to a mismatch in backscatter coefficient between the launch fiber and the fiber that is being tested. The solution and most accurate OTDR testing procedure is to test in both directions on the same fiber, then use software to average the losses recorded in opposing directions.

Use qualified launch and receive fibers and utilize launch-fiber compensation. To accurately measure the first and last connector on a fiber a launch and receive fiber must be used. The launch fiber must be longer than the attenuation dead zone for the maximum pulse width. Keeping the end faces of launch and receive fibers clean and protected from damage is key.

Choose a results management software package that is easy to use for reporting and analyzing after testing is long over. Test results should be quickly and easily downloaded to a software program on a computer. Customized professional reports should be easy to create, and analysis of tests should be possible. The ability to email trouble traces is also useful. A program such as Fluke Networks LinkWare results management also allows a user to easily send test results to colleagues, engineers, or industry experts at the Fluke Networks Technical Assistance Center.

Advanced OTDR analysis – not a lost art

OTDRs are an important documentation and troubleshooting instrument used by organizations to install and maintain optical fiber. In addition to troubleshooting, OTDRs can examine the performance of each connection, as opposed to an optical loss test set which only shows the sum of all losses. In this way it can improve the quality of an installation and ensure that poor connections are detected and not masked by other very good connections in the fiber link.

New technology has enabled a wide range of automatic capability in todays OTDRs. But advanced OTDR Analysis is not a lost art. Understanding OTDR traces and how to use manual settings is still beneficial for all testing and required in rare cases where an OTDRs can misinterpret events, or miss them altogether, due to improper test parameter set up or improper choice of an OTDR for the application. In many cases, technicians are limited by their inability to correctly interpret OTDR traces without the aid of the instrument's software. Understanding how the OTDR and its analyzer work and how an OTDR's specifications affect its performance and how to properly set it up can help users get maximum performance from their OTDR.

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