Optimize Quality of Service in Fiber Optic Networks with Intelligent OTDRs

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How to use IntelliTrace Plus^{TM} technology to make accurate, automatic, one-button measurements to get the most out of your network

While optical time domain reflectometry is essential for the proper characterization of fiber optic networks, older OTDRs often lead you to misleading or inaccurate conclusions. Those instruments require a lot of time and patience from expert operators to get valid results, so their usefulness has been somewhat limited.

New Tektronix OTDRs use powerful IntelliTrace Plus^{TM} technology to analyze the fiber and then automatically perform a range of measurements with the push of a button. Even the novice OTDR operator can get complete, valid measurements in minutes and focus on optimizing the network itself. This technical brief describes the new OTDR software technology and demonstrates how to use it with confidence to maintain the best possible QoS in your fiber optic networks.

Measurement Challenges - One Size Does NOT Fit All

While the basic principles of OTDR operation are quite simple, specific measurements can be very challenging. Reflected optical power is a tiny fraction of transmitted pulse power (typically one-millionth) and it varies greatly with wavelength, cable length, backscatter coefficients, splice and connector characteristics. In order to optimize fiber measurements with an OTDR, it is necessary to select measurement parameters based on the type of testing being performed, length and attenuation of the fiber under test, and the time available for testing. For all but the shortest fibers, the optimal parameters vary in relation to the distance from the instrument.

Must choose between distance and resolution

As an example, have you ever tried to characterize a long fiber that has closely spaced fusion or mechanical splices close in as well as splices further out on the fiber? If you set up your OTDR using long pulses you'll see the end of the fiber, but fail to detect some of the close-in splices. If you switch to short pulses in order to have the resolution needed to measure those close-in and close-together splices, you won't be able to measure out very far along the fiber.

Tektronix

Trade off test time versus precision and accuracy

Most OTDRs require the tester to perform multiple measurements using different parameters to completely and accurately characterize properties along the entire fiber. These tests take time, and time can be a precious commodity during a network emergency or a lengthy commissioning process. In some situations, you may be willing to trade precision for time. When you are only looking for the end of the cable or to spot a major break, you don't need ultimate resolution – you just want a quick look. As you get closer to solving a problem, you are likely to spend more time in order to increase the accuracy.

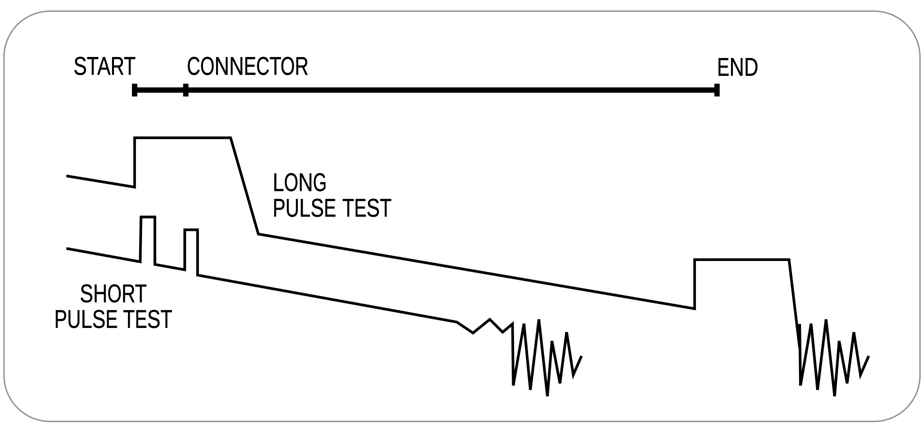
Careful tradeoffs must be made between all of the following parameters in order to get good data in a reasonable amount of time.

- Pulse width – The length of time that the OTDR laser is pulsed on for each acquisition. Using a long pulse width puts more power into a long fiber, but can overload the receiver which takes a long time to recover. (Pulse suppression techniques can be used to avoid this effect.)
- Averages – The number of individual acquisitions that are averaged together to reduce random noise in an OTDR trace. A lot of averaging reduces random noise to a very low level, but results in test times of several minutes or more.
- Range – The length of time that the OTDR waits between laser pulses to allow light to travel to the end of fiber and return to the detector. Long range is required to allow a laser pulse to reach the end of a long fiber and return, but this also increases the time to make a measurement.
- Setup time – The time it takes to complete a new test setup for the OTDR. More complex instruments take more time to adjust, but simpler devices may not give you the results you need. Time spent fussing with the instrument distracts from the primary mission of optimizing the network.

Forced to deal with multiple data sets

Any OTDR permits the adjustment of the parameters listed above, but most still require that you make many separate measurements on the same cable. For example, to address the problem of close-range resolution versus long-range visibility you must acquire several waveforms using different OTDR settings. After you complete the first scan with the short pulse; you would choose a longer pulse to test further along the fiber (possibly still not seeing the end of the fiber). When you're finally done — after two, three, or more acquisitions with successively longer pulses — you need to lay the traces out next to each other to try to get a complete picture of the fiber. If you have the time and patience, this old method will yield enough raw data (although piecing all of the data together is still a challenge).

Most OTDRs offer an "automatic test" mode that will select a single pulse width and range sufficient to measure the fiber end. While these models may test the fiber using multiple gain stages, they typically return traces for long fibers similar to the long pulse example in the figure below, completely missing the close-in events. These models still need to acquire multiple data sets to characterize the entire cable, and only one of those tests is "automatic."



► ***Figure 1:** The figure above illustrates some of the tradeoffs that must be made when selecting OTDR measurement parameters. The upper trace shows the results of testing a long fiber with a long pulse. The long pulse produced sufficient power in the fiber to detect the reflection from the fiber end, but the pulse was so long that that it obscured the reflection from a connector located close to the OTDR. The lower trace shows the results of testing a long fiber with a short pulse. In this case, both connectors close to the OTDR were detected, but there was insufficient power to detect the fiber end.*

Inconsistent, unreliable documentation

One of the most significant factors in maintaining the QoS of a fiber optic network is complete and reliable mapping and performance documentation for both commissioning and restoration after repairs. Manual documentation of multiple separate OTDR measurements is both time-consuming and prone to error. Ideally, you would like to have a way to return the OTDR to precisely the same settings and measurement parameters for restoration, but that is a substantial chore with manual processes.

Measurement Solutions - One Button, One Waveform, All of the Information

"IntelliTrace Plus" is the trade name for intelligent software that automates the fiber optic measurement process in the Tektronix NetTek OTDR. This patented approach selects different measurement parameters for up to four sections of a fiber and "splices" the data together into a single set of data and composite trace. It tests the fiber using multiple pulse widths, automatically doing what an expert OTDR operator would do. With the push of a button, IntelliTrace Plus technology automatically selects optimal acquisition parameters for best resolution near the front of the fiber, then changes the parameters to give optimal measurements in each range up to the end of the fiber.

IntelliTrace Plus technology also uses advanced waveshape analysis algorithms that dramatically improve the ability to locate and accurately characterize events in noisy environments. Additional software functions verify the integrity of the test connection, and allow the user to configure the instrument for three levels of time/precision balance.

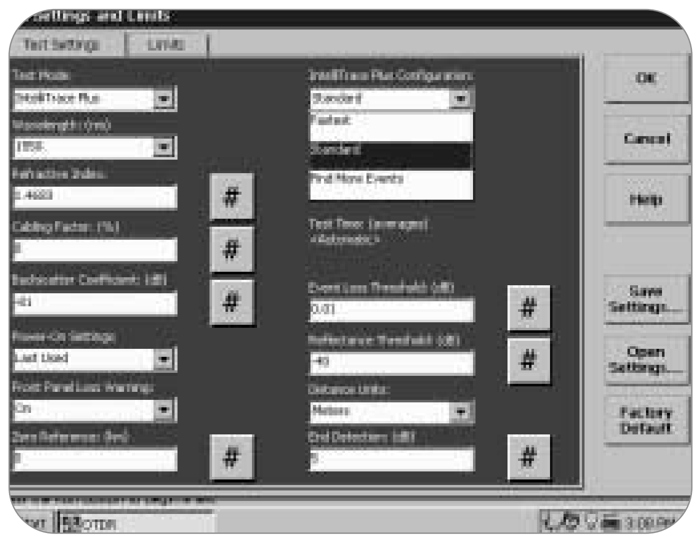
IntelliTrace Plus technology resides in the familiar Windows® environment and is controlled from the NetTek touch screen. Data is fully documented and easily transported to standard report and archiving programs.

The following sections describe IntelliTrace Plus measurement solutions in typical fiber optic network tests.

1. Choose the right balance of precision versus test time

There is no setup time penalty – IntelliTrace Plus technology automatically optimizes every test parameter with the touch of a single button. You can choose between three precision/time options:

- *Fastest* gives good test results in a minimal amount of time; useful to quickly locate the fiber end and any large events, such as mechanical splices, damaged or bent fiber, etc.
- *Standard* gives a more complete picture of the fiber under test and is sufficient to locate most small events, such as fusion splices, even in long fibers. Testing in the Standard mode typically takes 2-4 minutes depending on fiber length and attenuation.
- *Find More Events* offers the ultimate in detection and measurement of very small events, particularly on long fibers and when events are grouped closely together. Testing in this mode can require a large number of averages, particularly on the fiber segments furthest from the OTDR and may take up to ten minutes.



► ***Figure 2:*** *Screen shot of Settings window with IntelliTrace Plus options drop-down menu open.*

2. Verify the test connection

When you press the START button, IntelliTrace Plus technology first tests the connection between the fiber and the OTDR. If it finds that the backscatter level is low, it displays a status alert for a poor front-panel connection or fiber that is less than 50 meters in length. If the front-panel connection is poor, remove and inspect the connector for quality, then clean and reconnect. The NetTek continues to monitor the connection until it is corrected or you press "OK." As soon as the connection status bar indicates a good connection, the NetTek automatically initiates the fiber analysis — no operator intervention is required.

If the fiber is less than 50 meters in length, you simply push the "OK" soft key to begin testing. On the other hand, you should avoid overriding the alert caused by a poor connection. Dynamic range is reduced and you could get inaccurate test results.

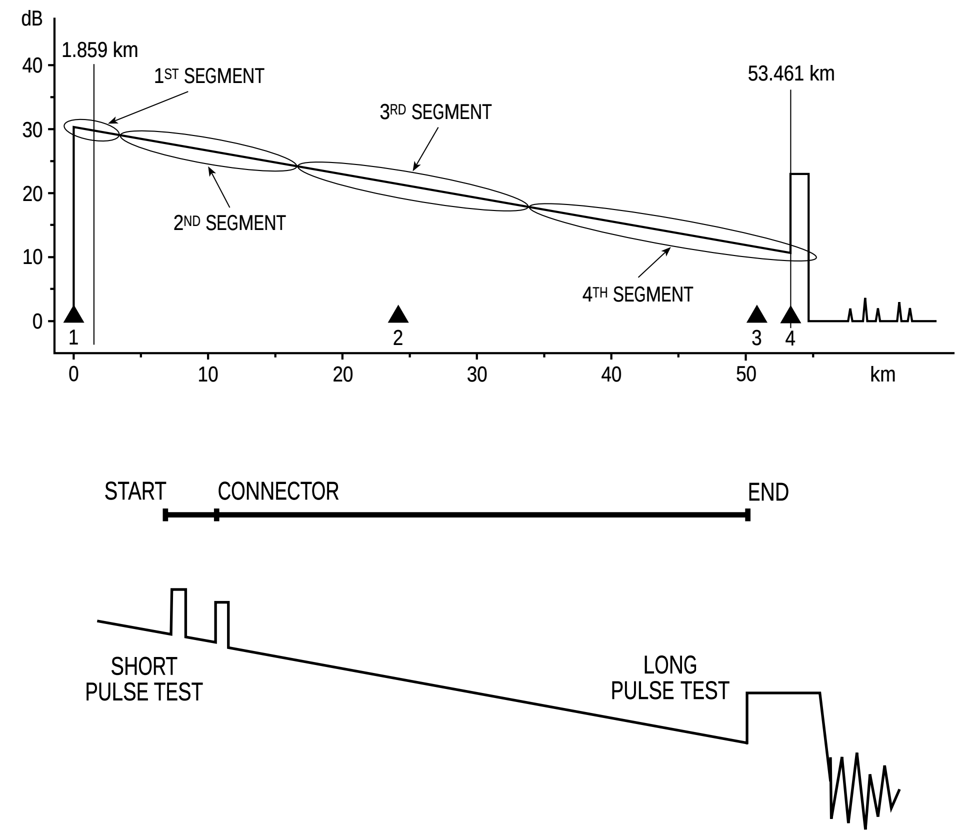
3. Get a single coherent trace from multiple measurements

IntelliTrace Plus technology analyzes the fiber in a sequential manner starting at the OTDR-to-fiber connection and working outward. It begins its analysis with a short pulse in order to provide the best possible resolution during the first part of the analysis that finds and measures the up-close and close-together splices.

As the IntelliTrace Plus software analyzes further along the fiber, it automatically adjusts the pulse width, gain, and other acquisition parameters until it has fully analyzed the entire length. There are many different types of fiber links, so the software is designed to change setups interactively by looking at each fiber's unique characteristics. The software monitors the trace dynamically and determines when acquisition changes need to be made. It keeps on going to over 150 km (if you have that much fiber).

IntelliTrace Plus technology uses more than just multiple pulse widths to analyze a fiber. It may increase the number of averages, change the filtering, or adjust the gain of the detection circuitry. The software automatically determines which parameters need to change based on criteria such as signal-to-noise ratio, length, total loss, and elapsed time.

As additional data is acquired, the display is updated. Although each trace segment is acquired with a different set of acquisition parameters, IntelliTrace Plus technology constructs a composite waveform to provide the best possible view corresponding to the best possible characterization of the fiber. At the conclusion of the analysis, the screen shows a composite waveform with markers indicating the locations of all the events and a table with measurements and other information about each event.



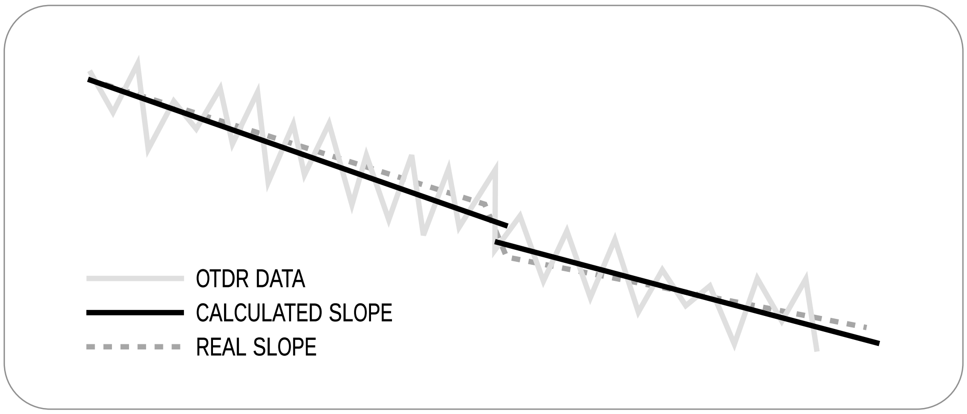
▶ ***Figure 3:*** *The figures above illustrate how IntelliTrace Plus technology separates the fiber into segments and the resulting improvement in the trace data. The software selects a short pulse width at the beginning, allowing the NetTek OTDR to locate and accurately measure the start and the nearby connector. As the acquisition continues, IntelliTrace Plus continually monitors the amount of noise on the trace. When the returned signal from the short pulse gets weaker due to fiber attenuation, the noise will increase. When the noise approaches a level that could result in impaired measurement accuracy, IntelliTrace Plus will designate a new fiber section and adjust the pulse width, OTDR amplifier gain and the number of averages to reduce noise to a level low enough to accurately locate and measure events.*

4. Cut through the noise with advanced waveshape analysis algorithms

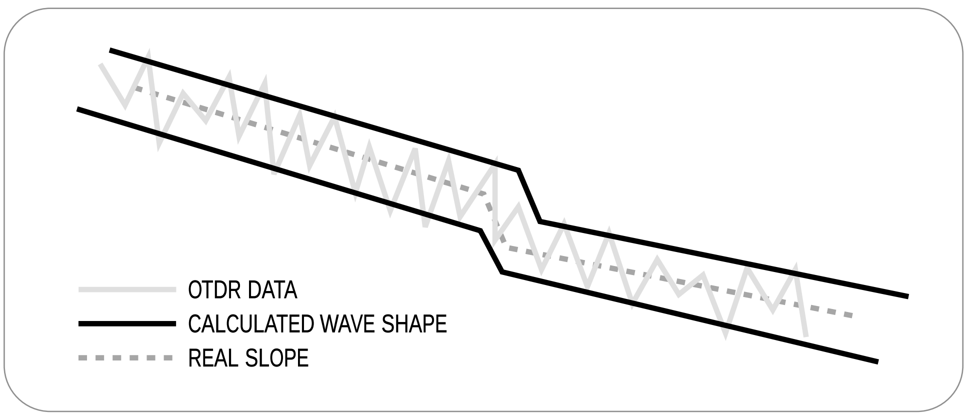
Once IntelliTrace Plus gathers the raw trace data, The NetTek OTDR employs proprietary “waveshape analysis” algorithms to detect events even when they are masked by noise. Waveshape analysis is a highly sophisticated method of data processing that accurately locates events based on inflection points in the data. Previous line-fit analysis algorithms can give inaccurate measurements, or even miss events. Waveshape analysis overcomes the shortcomings of line-fit algorithms and can even locate closely spaced events that are located in the “dead-zones” resulting from previous events.

As a “rule of thumb,” an event’s magnitude should be at least twice that of the noise in the data to be accurately located and measured by an OTDR that incorporates line-fit algorithms. With its waveshape analysis algorithms, the NetTek OTDR can accurately locate and measure events with magnitude of one half that of the noise in the data. This tremendous improvement in performance is achieved by analyzing the shape of the whole data and calculating the shape of the curve. Because noise is random, it generates an envelope after a minimal amount of averaging. This technique produces superior amplitude measurements of the events.

In addition, waveshape analysis improves the accuracy of location (distance) measurements over line-fit techniques by identifying the leading edge (distance to event) between sample points. For most OTDRs, best case distance accuracy is limited to the sample spacing.
The NetTek OTDR can actually locate events to within one tenth of the sample spacing!



▶ ***Figure 4:*** *OTDR splice measurement using line fit method. This figure illustrates the difficulty of accurately locating and measuring events when a line-fit algorithm is used on a noisy signal. Lines fitted to the noisy data may not accurately reflect the true slope and can result in inaccurate measurements.*



▶ ***Figure 5:*** *OTDR splice measurement using waveshape analysis. The figure above illustrates how the NetTek OTDR, using waveshape analysis, can accurately locate and measure events, even in noisy data.*

Conclusion

The NetTek OTDR with IntelliTrace Plus provides some of the highest resolution and most accurate OTDR measurements possible. The Windows user interface and touch-screen is simple and intuitive, allowing users with little or no knowledge of OTDR operation to achieve professional results.

Dynamic test optimization based on the noise level and selected operating mode and incorporating multiple pulse widths and acquisition settings for each section of fiber provides the best raw data of any OTDR. Waveshape analysis of the data finds more events than other OTDRs and locates and measures them with unparalleled accuracy.

With one tap on the touch screen, IntelliTrace Plus technology can find and measure a splice only a few meters from the front panel and in the same scan measure one that is more than 100 km away.

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