VanGuard Data

Optic Network and Advanced OTDR Operators Training

OTDR Operation for High Quality Traces

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Agenda

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5. Returned / Measured Optical Power
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    b) Reflection From Connectors
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    d) Reflection From the End Event
6. OTDR Parameter Selection
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    b) Wave Length
    c) Trace Acquisition Time
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OTDR Operation for High Quality Traces

Introduction

Through this lesson we cover the fundamentals of What is an OTDR, how an OTDR operates and the basic building blocks and operation of an OTDR.

In this lesson a basic understanding of optical attenuation, dB, fibre join types and other fundamental knowledge is required. If your not familiar with these concepts try our prerequisite lesson ‘Introduction To Fiber Optics’ available from our web site.

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OTDR Operation for High Quality Traces

What is the VanGuard Data OTDR Emulator?

The Vanguard Data OTDR Emulator is a software package specifically designed for OTDR training. It allows the user gain practical hand on experience using an OTDR by setting all common parameters such as Wavelength, Pulse Width, Trace Duration and IOR then taking a virtual trace in real time all from the computer desktop.

The trace is calculated to provide realistic OTDR simulation without the need for expensive hardware.

The practical components of this training will be performed in the OTDR Emulator which can be downloaded from our web site:

www.vanguarddata.com.au/otdrem/otdrem_download.html

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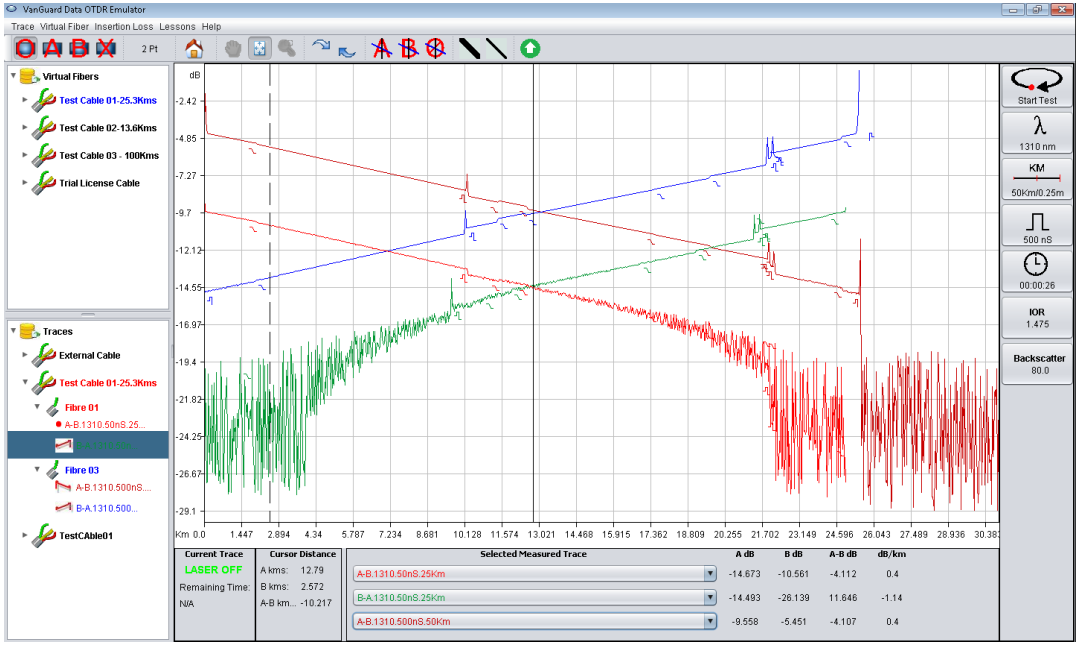
OTDR Operation for High Quality Traces

The VanGuard Data OTDR Emulator



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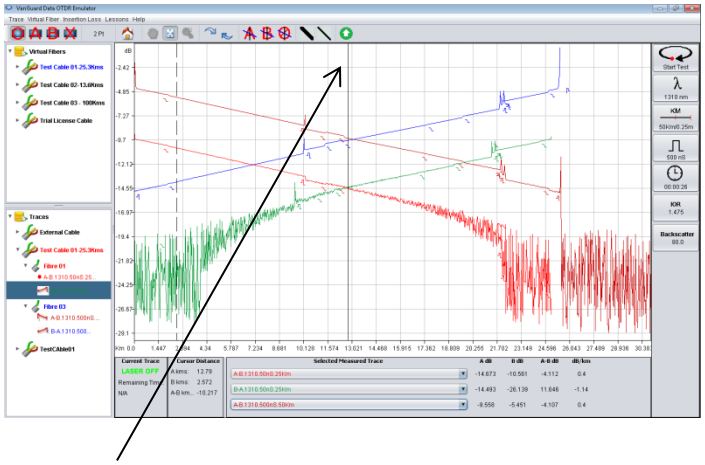
OTDR Operation for High Quality Traces

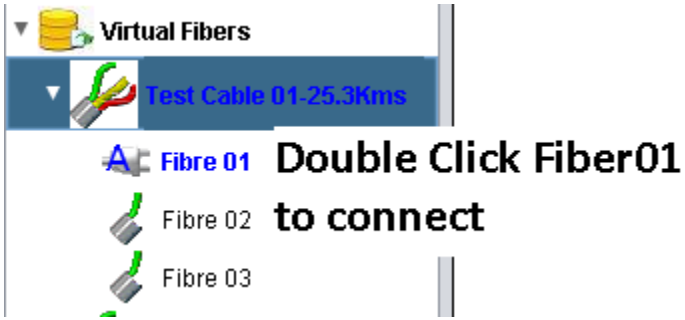
Practical 01 – Getting Stated

Just to get stated – Lets take our first trace using the OTDR Emulator.

1) Open the OTDR Emulator



2) Connect to the Virtual Fiber



3) Click Auto Select Trace Parameters from the tool bar

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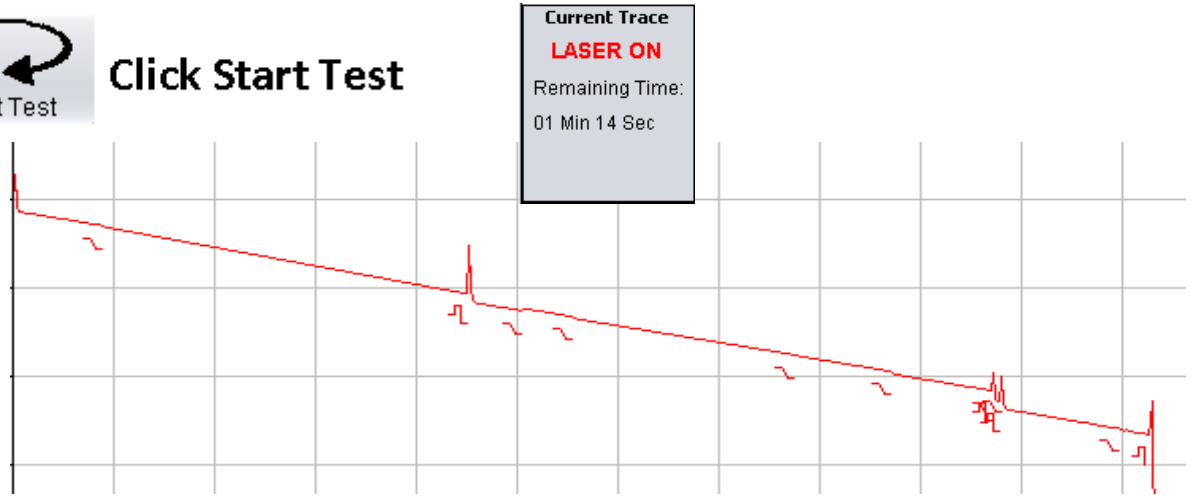
OTDR Operation for High Quality Traces

Practical 01 – Getting Stated

4) Click Start Test.

Click Start Test

5) Wait for the trace to complete.



Congratulations. You just took your first OTDR Trace, easy wasn't it!
Try taking a trace on a different fibre and with different parameters.

Keep this trace as we will use it as a reference throughout the lesson.

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OTDR Operation for High Quality Traces

What is an OTDR?

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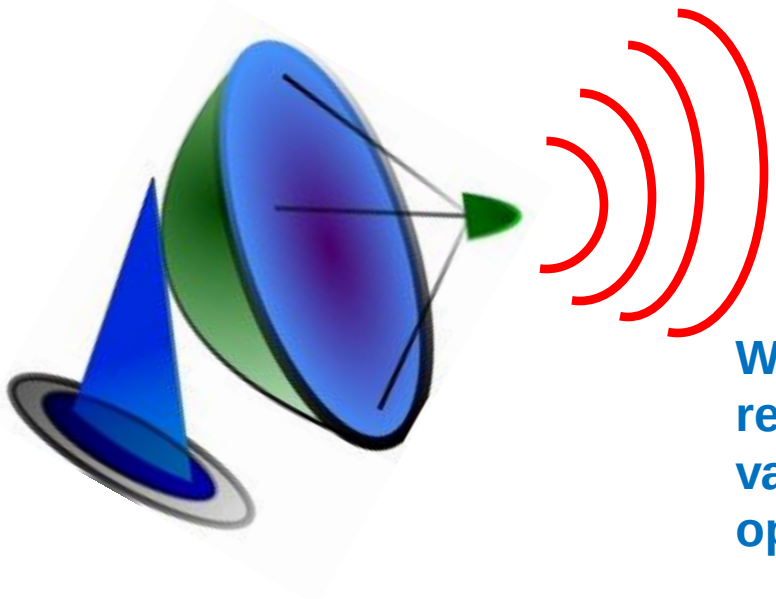
OTDR Operation for High Quality Traces

What is an OTDR?

Put simply, an OTDR (or Optical Time Domain Reflectometer) is just like a RADAR for optic fiber. It sends pulses of optical energy into an optic fiber then measures and graphs the reflected signal.



When analyzed correctly the returned optical power indicates various characteristics of the optic fiber being tested.

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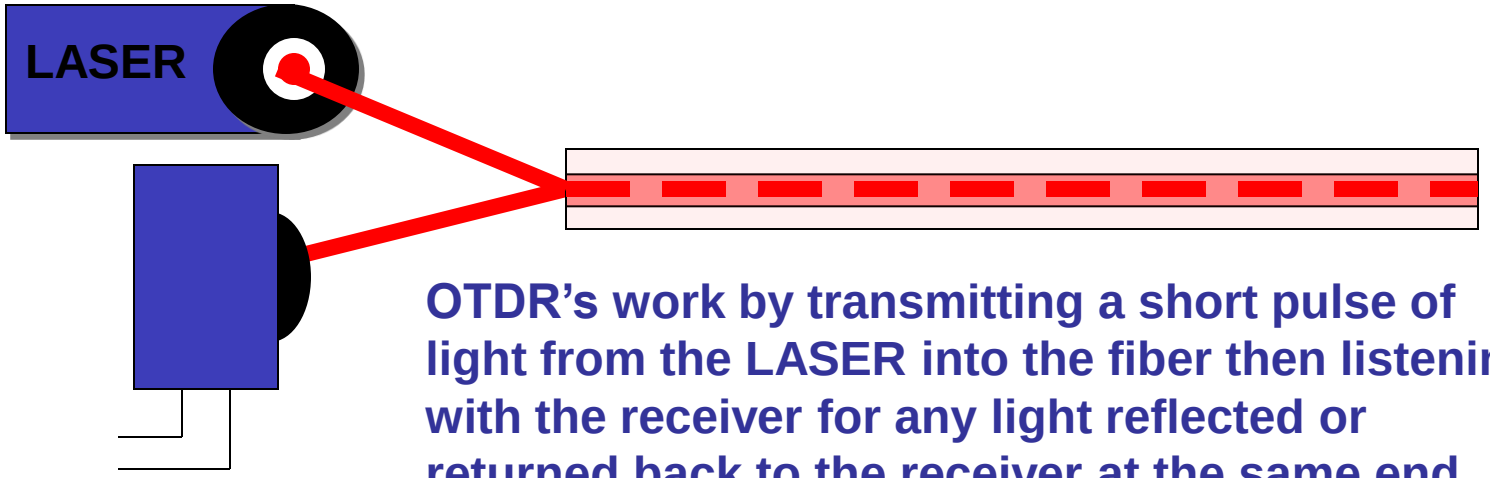
OTDR Operation for High Quality Traces

What is an OTDR?

An optic fiber transmission system has a light source (LASER or LED) and an optical receiver (Photo Diode) at separate ends of the fiber. Because the OTDR transmits and receives optical power from the same end these components are both coupled into one output test port on the OTDR.



OTDR's work by transmitting a short pulse of light from the LASER into the fiber then listening with the receiver for any light reflected or returned back to the receiver at the same end.

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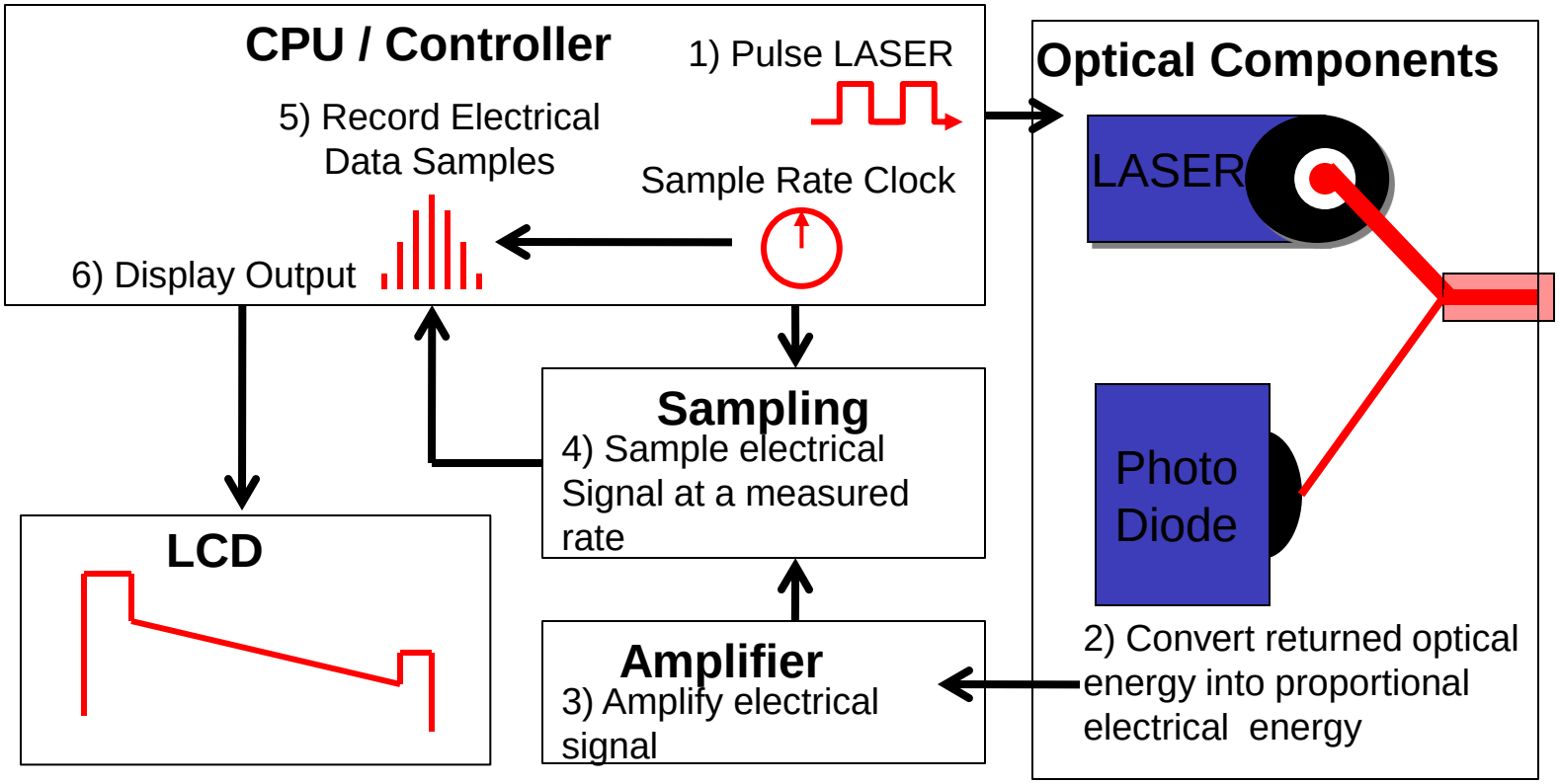
OTDR Operation for High Quality Traces

OTDR Functional Block Diagram



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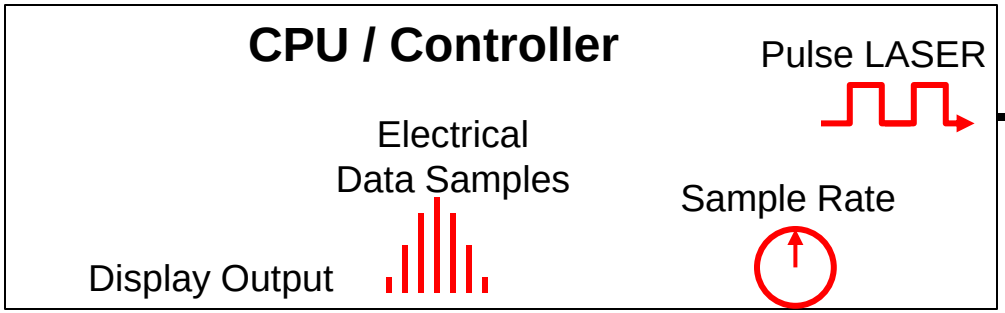
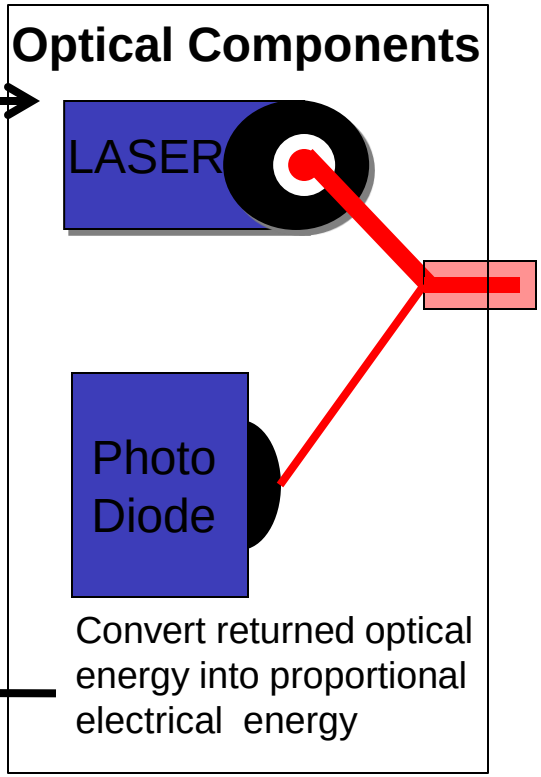
OTDR Operation for High Quality Traces

OTDR Functional Block Diagram





1) Under control of the CPU, the LASER is pulsed on for a short duration.

2) Optical power interacts with events on the fiber being tested and some is returned to the photo diode due to backscatter or reflection.

3) The Photo Diode converts the returned optical power into a proportional amount of electrical power

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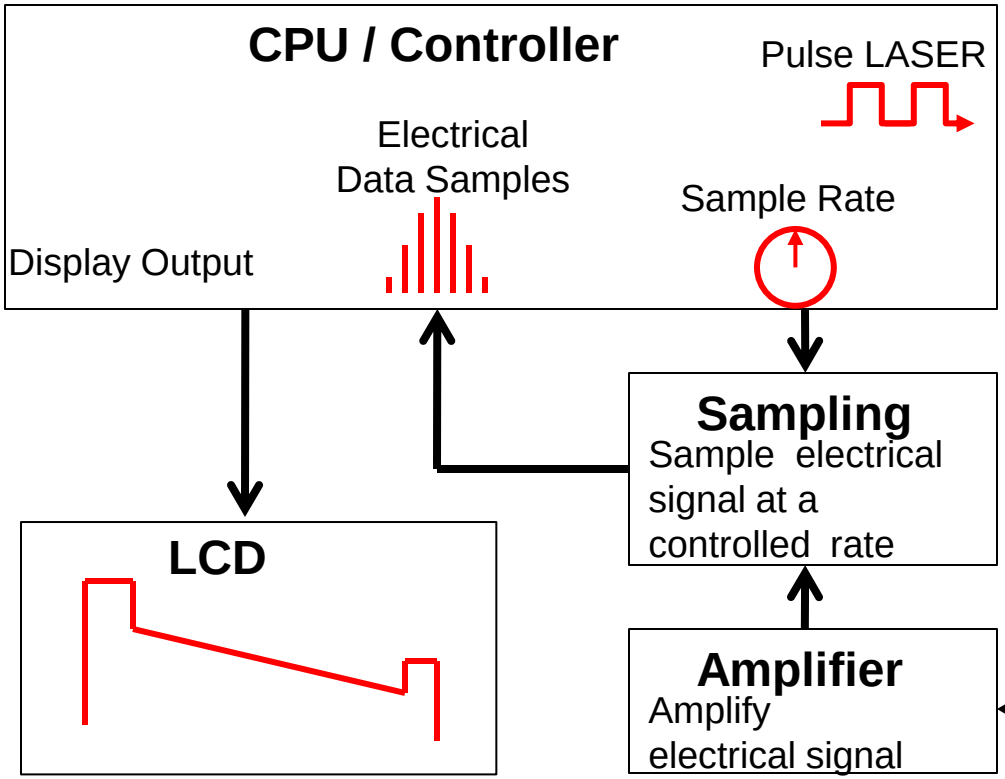
OTDR Functional Block Diagram



4) **The proportional electrical signal is amplified.**

5) **The CPU samples and records the electrical level at evenly spaced periods.**

6) **The sampled data indicates the level of returned optical power. Time of sample X the speed of light allows distance to be calculated.**

7) **Data samples are graphed as optical power (dB) against distance and displayed on the LCD. This is a trace that the operator can analyse.**

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OTDR Operation for High Quality Traces

Returned Optical Power

What causes light to be Returned to the OTDR?

Optical power is returned to the OTDR from:

1) Backscatter
2) Reflection from connectors.
3) Reflection from the start connector (The Launch)
4) Reflection from the end event (The Fresnel Reflection)

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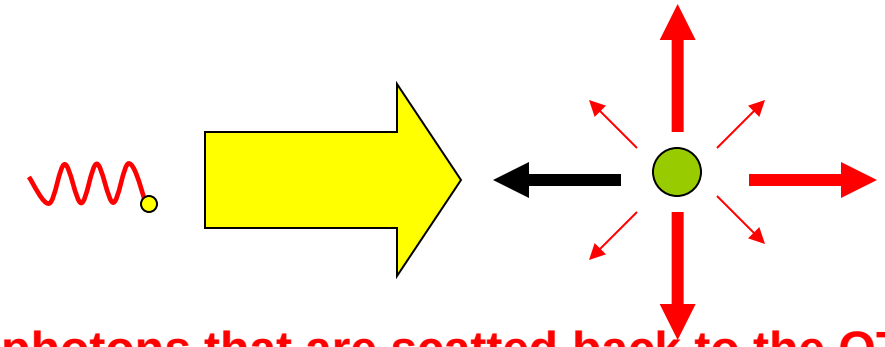
OTDR Operation for High Quality Traces

Causes of Returned Optical Power

Returned Power Due to Backscatter:
Backscatter is a phenomenon where photons are scattered in all directions as they interact with the larger particles of the optic fiber itself. Some of these are naturally scattered back to the OTDR to be measured as returned optical power.



The photons that are scatted back to the OTDR cause Backscatter. The OTDR measures Backscatter and plots the amplitude of the backscatter to data points on the trace. This indicates the quality of the fiber itself opposed to a joining point

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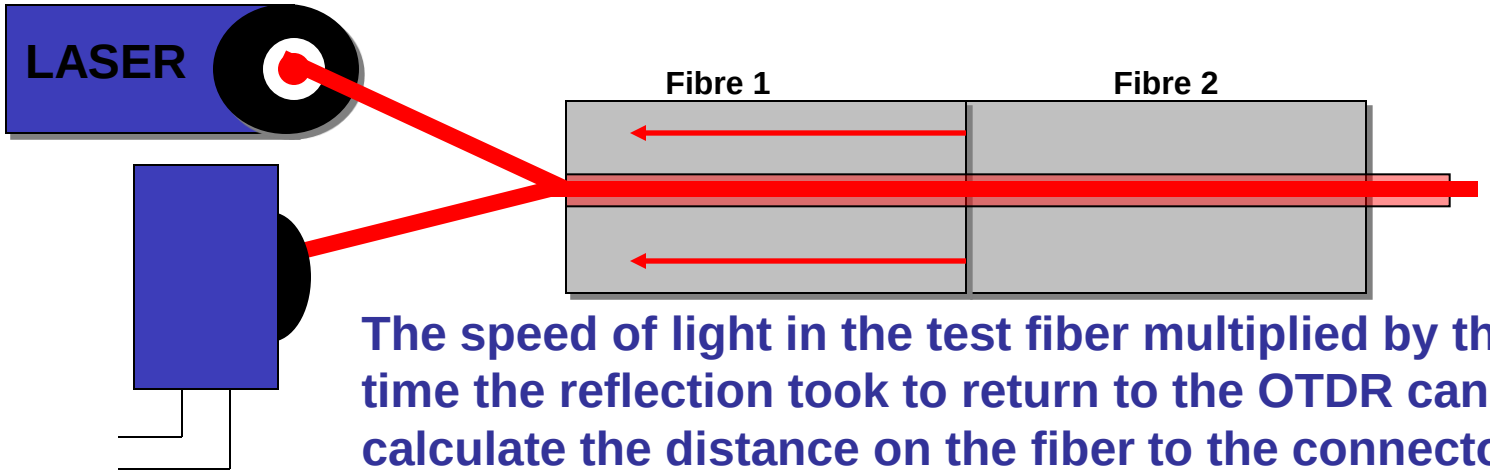
Causes of Returned Optical Power

Remember that an optical connector is reflective?
Reflective Events (connectors) return a fraction of the available optical energy back to the source. The reflected light will have a specific amplitude and will take a measureable duration from the time the LASER sent the light until the reflection was received.



The speed of light in the test fiber multiplied by the time the reflection took to return to the OTDR can calculate the distance on the fiber to the connector.

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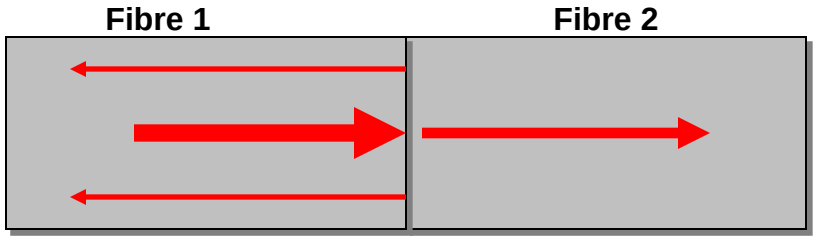
OTDR Operation for High Quality Traces

Returned Optical Power

Reflection From Connectors.
Optical connectors present a polished glass surface to the LASER source that causes a slight reflection.



This reflection is picked up by the OTDR which translates the additional returned optical power to a change in the dB level on the trace. The trained eye will identify this as a connector.

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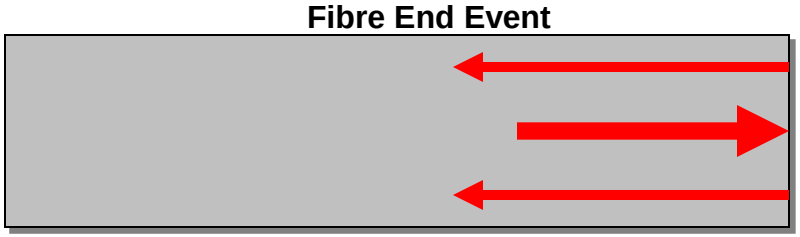
OTDR Operation for High Quality Traces

Returned Optical Power

Reflection From the End connector.

The last connector in an optic fiber causes what is known as the End Event on the trace. Exactly like any other connector the End connector is reflective and will return optical power to the OTDR.



The end event gets special attenuation as it is commonly much larger than terminated connectors and can represent up to 4% of the total optical power at that point. It is know as the Fresnel Reflection. The End event reflection is also used to identify the fiber length.

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OTDR Trace Parameters

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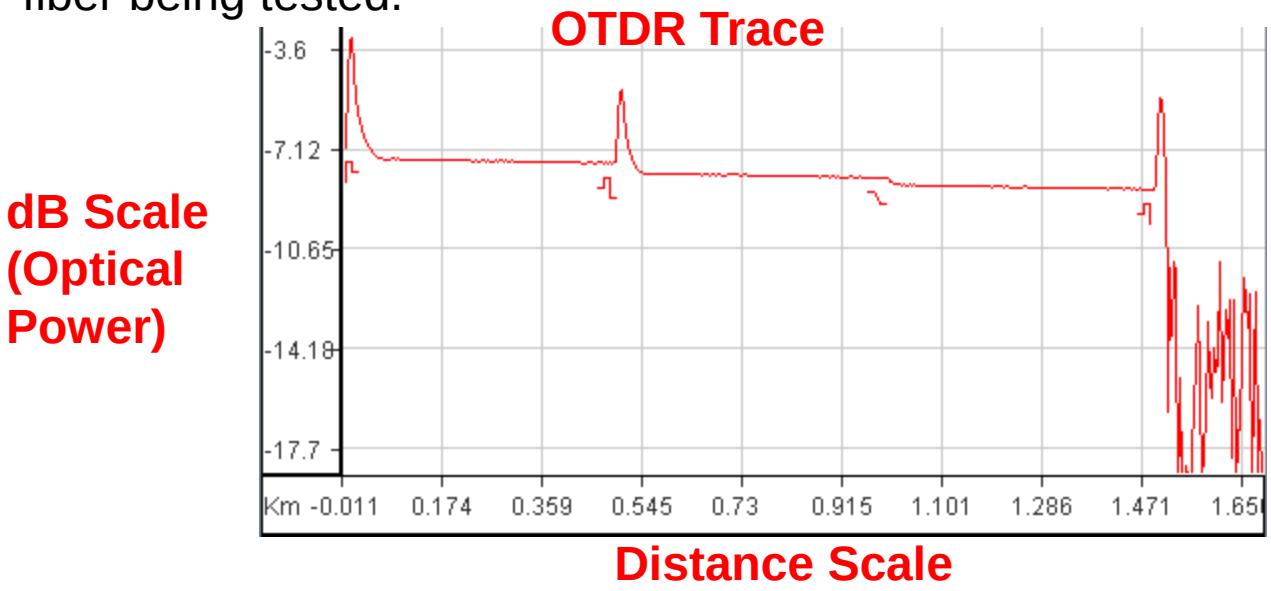
The OTDR Trace

Before covering OTDR parameters lets have a quick look at our first trace. An OTDR Trace is a graph of the returned optical power measured against distance. With practice, you will be able to read the trace and understand the various characteristics of the fiber being tested.



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The OTDR Trace.

Different OTDR parameters can change the usability and accuracy of the trace which we will now discuss.

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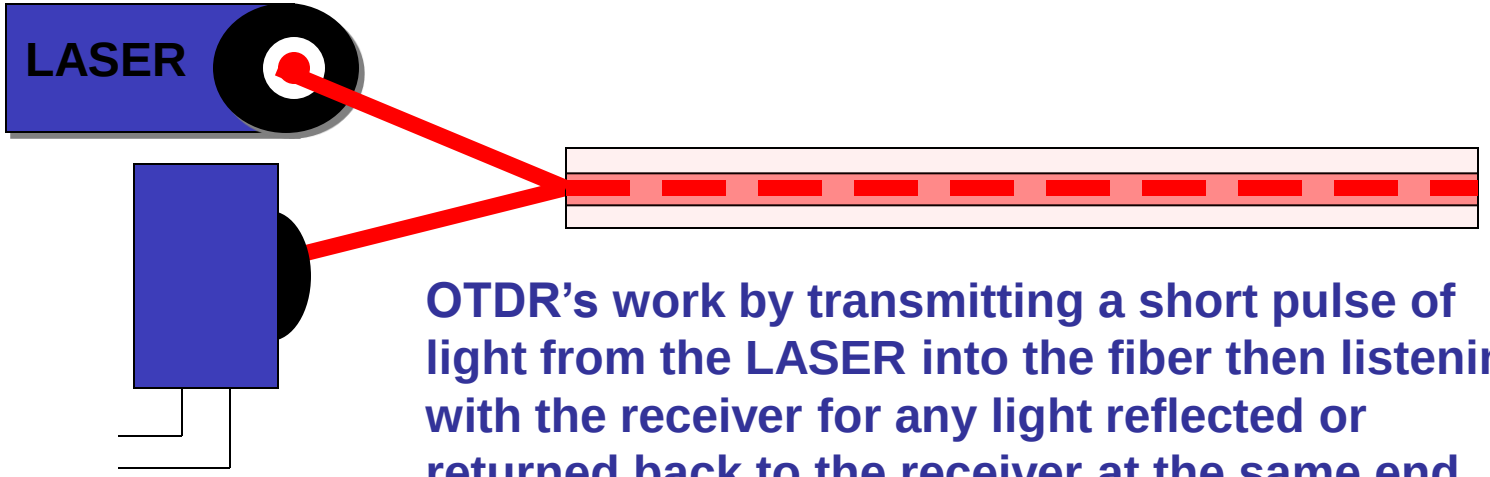
Pulse Width.

Remember from earlier this lesson that an OTDR sends short pulses of light down the fiber and waits for reflected light. The length of this pulse is know as the pulse width.



OTDR's work by transmitting a short pulse of light from the LASER into the fiber then listening with the receiver for any light reflected or returned back to the receiver at the same end.

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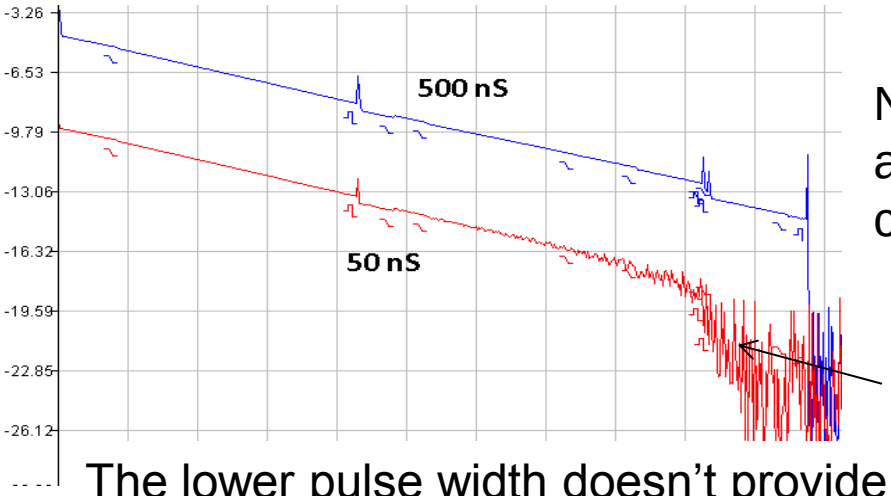
Pulse Width.

The pulse width is measured in nanoseconds or microseconds which is the time the OTDR LAZER is cycled on for. A longer pulse width puts more optical power into the fiber which allows the OTDR see further distances.



Notice that the blue trace is not able to see the end of the fiber clearly.

Trace Noise

The lower pulse width doesn't provide enough power to see the end of the fibre so what is called a 'Noisy Trace' is the result

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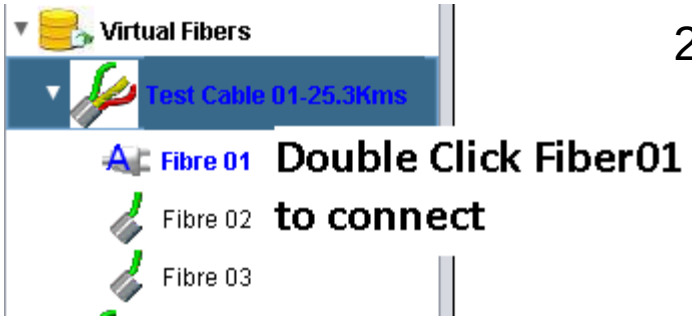
Practical 02 – Pulse Width.

On the VanGuard Data OTDR Emulator, Connect to Test Cable 01 – 25.3 Kms / Fibre 01.

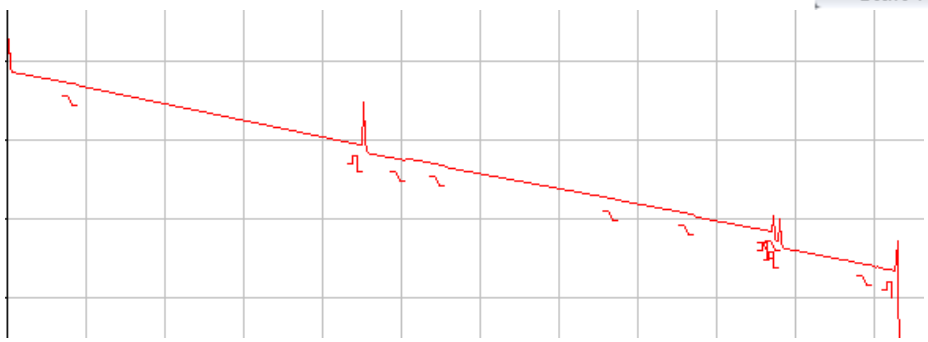
1)



2)

3)

Click Start Test



You will get a good quality trace with a suitable pulse width selected

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OTDR Operation for High Quality Traces

Practical 02 – Pulse Width.

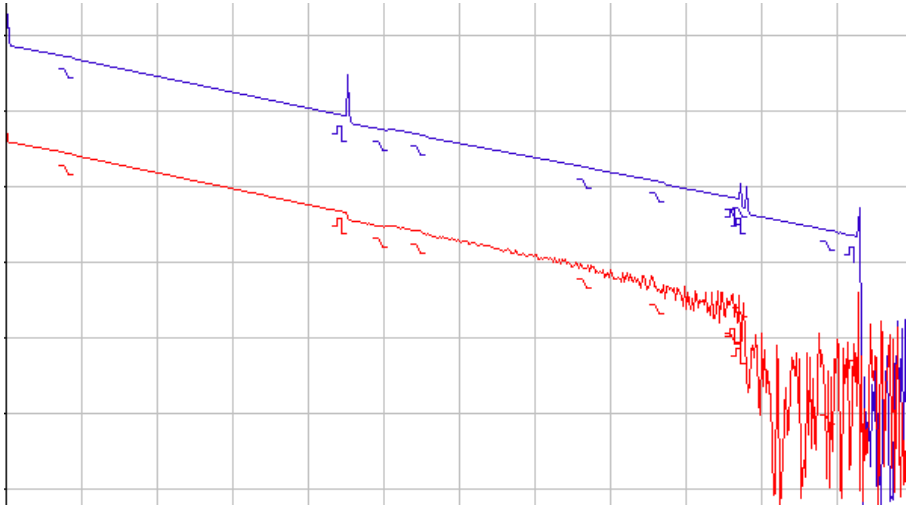
Change the pulse width to 50nS and take the trace again.

4) 

Change Pulse Width to 50nS

5) 

Click Start Test



The second trace with a lower pulse width is very noisy as it doesn't have enough optical power to see the end of the fibre.

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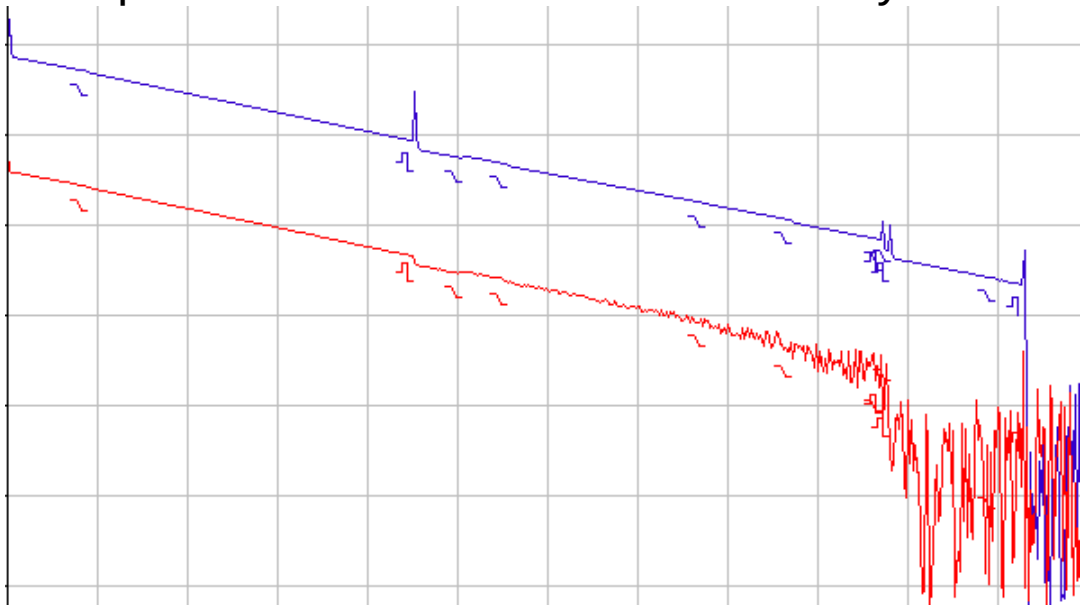
OTDR Operation for High Quality Traces

Practical 02 – Pulse Width.

From this practical you have seen how a the pulse width setting can impact the quality of the trace. Try a few other pulse width settings and see why a very high pulse width is also not a good selection. The answer will be provided in the advanced trace analysis lesson.



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OTDR Operation for High Quality Traces

Optical Wave Lengths

Optical Power generated by a LASER or LED for data transmission is invisible to the human eye but is still considered to be light. Like visible light, it can be generated in a variety of colors which are caused by the frequency of the optical power.

If you consider light as a wave, the different colors can be considered as different frequencies. The frequencies are incredibly high but they can still be described in exactly the same way.

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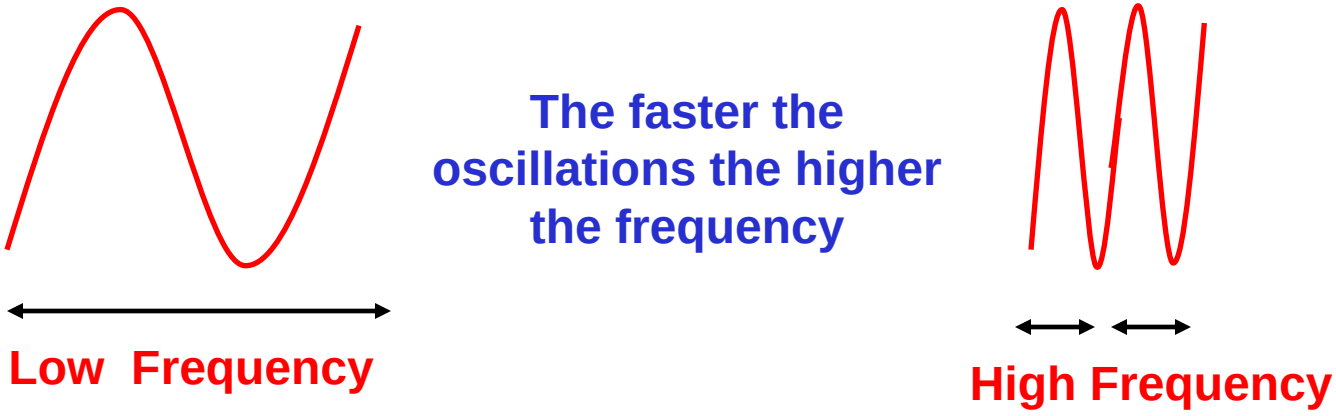
Optical Wave Lengths

Frequency: Measured in Hertz is the number of oscillations per second of a wave. You might be more familiar with describing a wave by its frequency with more every day objects such as 50 – 120 Hz for mains power (depending on where you live)



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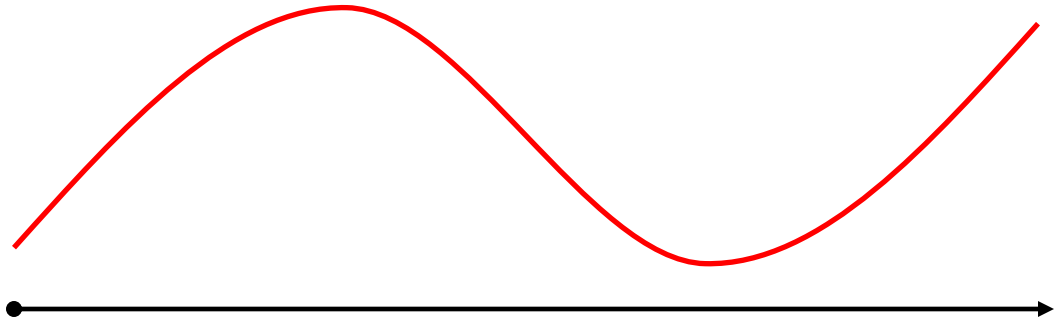
Optical Wave Lengths

Wavelength: A wave oscillating at a know rate and leaving the source at the speed of light will have a measurable physical distance. The faster the oscillation (or the higher the frequency) the faster the wave will complete one full cycle and therefore the shorter the wavelength.

The Greek character lambda (λ) is commonly used to indicate wavelength.



The lower the frequency is, the longer the wavelength.

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OTDR Operation for High Quality Traces

Optical Wave Lengths

For waves such as mains power we characterize it by the frequency.
i.e: 50Hz, 120Hz etc

Because light has such high frequencies that are hard to communicate we refer to the wave by its wavelength instead.

Example:
1550nM is a commonly used wavelength in data communications, the same value represented in Hertz would be:

193548387096774 Hz

As you can see, in the case of optical frequencies it is much easier to describe them using wavelengths instead of in Hertz.

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OTDR Operation for High Quality Traces

Optical Wave Lengths

There are a number of common wavelengths selected for use in data transmission equipment.
They are:

Single Mode	
Wavelength	**dB / km**
1310nM	0.33
1550nM	0.21
1625nM	0.25

Multi-Mode	
Wavelength	**dB / km**
850nM	3.00
1300nM	1.00

Different wavelengths attenuate (loose) optical power at different rates. 1550nM is the most efficient wavelength and is commonly used for single wavelength transmission systems.

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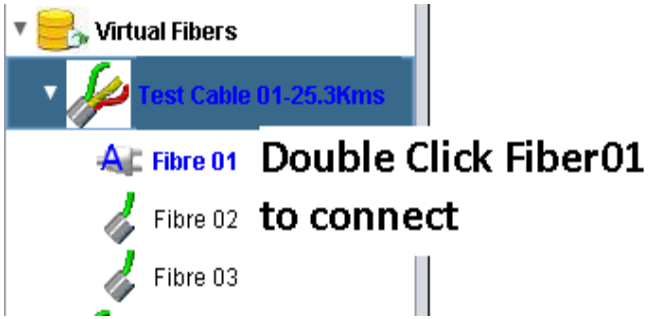
OTDR Operation for High Quality Traces

Practical 03 - Wavelength.

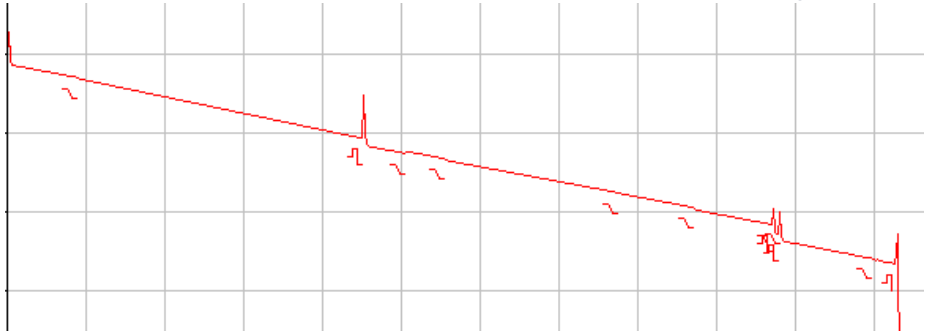
On the VanGuard Data OTDR Emulator, Connect to Test Cable 01 – 25.3 Kms / Fibre 01.

1) 

2) 

3) 

4) 



You will get a trace taken at 1310nM

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OTDR Operation for High Quality Traces

Practical 03 - Wavelength.

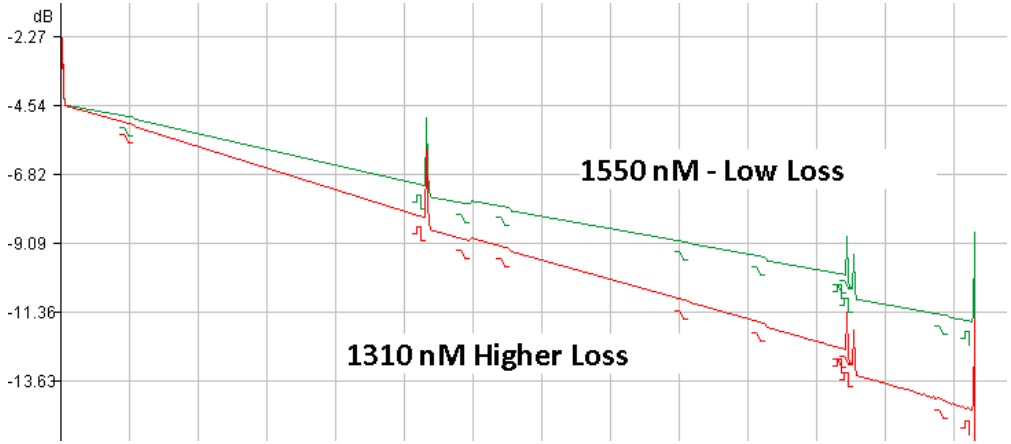
Change the wavelength to 1550nM and take the trace again.

5) 

Select 1550nM

6) 

Click Start Test



If you consider the left had scale is attenuation in dB you can see that the 1550nM trace looses less optical power for the same distance of fibre. The slope of the trace is know as the ‘Attenuation Slope’ and indicates the dB per km that the fibre is attenuating optical power.

OTDR Operation for High Quality Traces

Trace Acquisition Time.

When an OTDR takes a trace it rapidly sends light pulses and measures the response repeatedly for what is known as the Trace Acquisition Time, this is the length of time the trace is active for.

By sending multiple pulses, an OTDR can average the result which removes some of the noise on the trace so a lower pulse width can be used. The advantages of a lower pulse with will be discussed soon.

One of the most important characteristics of a trace is to have a low level of noise while using the lowest possible pulse width.

One of the most challenging skill of OTDR operation to master is to make a suitable balance between Pulse Width and Acquisition Time

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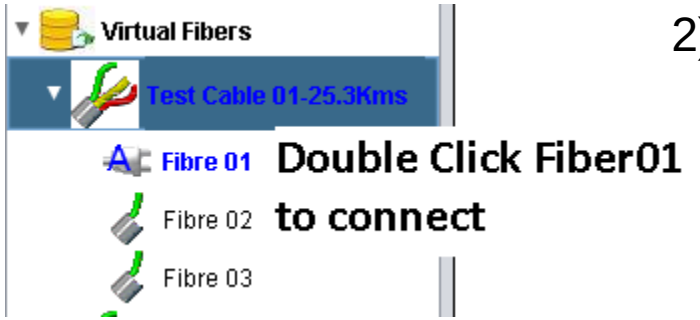
OTDR Operation for High Quality Traces

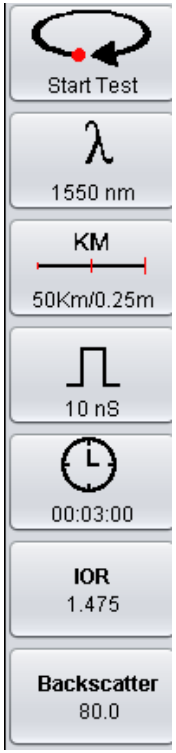
Practical 04 – Acquisition Time.

On the VanGuard Data OTDR Emulator, Connect to Test Cable 01 – 25.3 Kms / Fibre 01.

1)



2)



Configure:

1550 nM

50Km

10 nS

3 Min Acquisition

3)

Click Start Test

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Practical 04 – Acquisition Time.

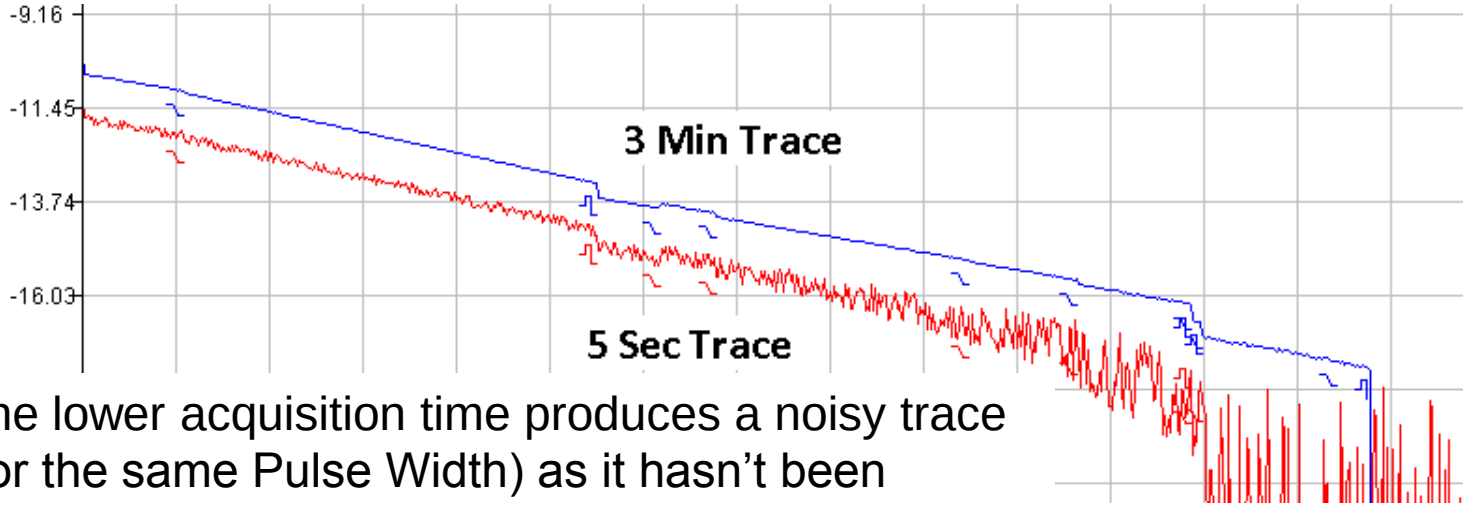
Change the trace acquisition time and take the trace again.

4) 

Change Acquisition Time to 5 Sec

5) 

Click Start Test



The lower acquisition time produces a noisy trace (for the same Pulse Width) as it hasn't been averaged as long.

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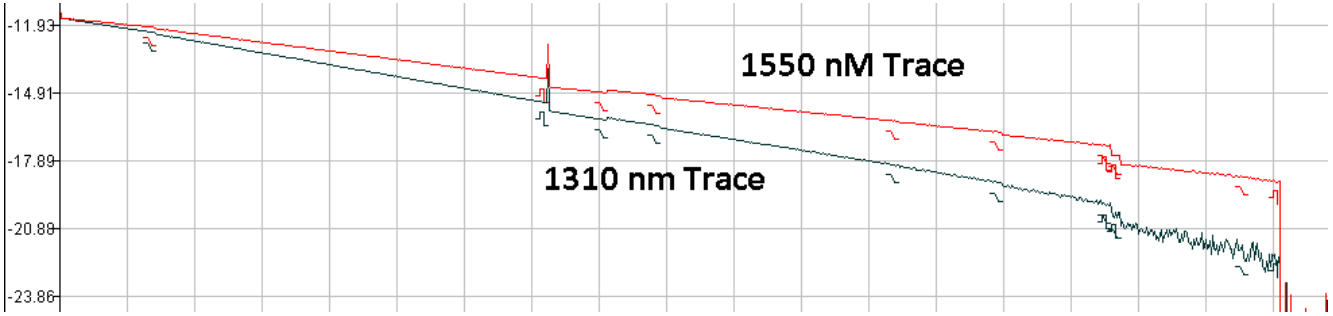
OTDR Operation for High Quality Traces

Practical 04 – Acquisition Time.

Return the trace acquisition time to 3 min and set the wavelength to 1310 nM and take the trace again.



Notice that even when all other settings are equal that the 1310nM trace has much more noise than the 1550nM trace.

Why do you think that is the case??????

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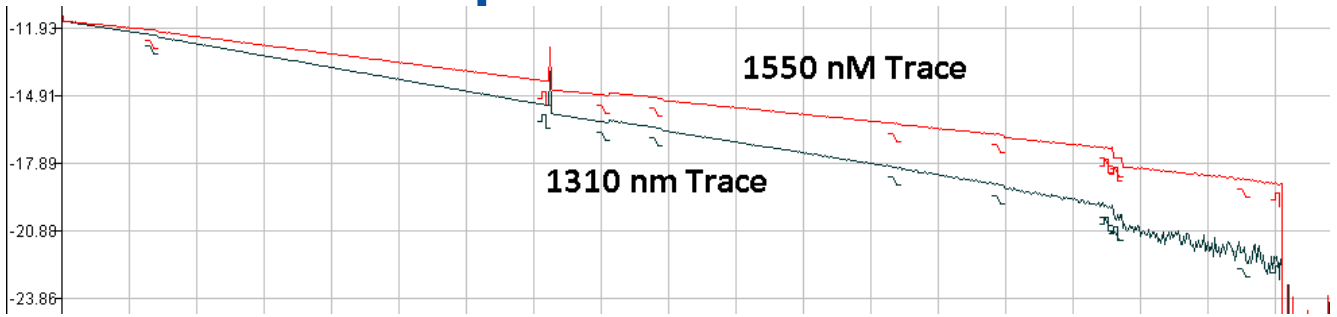
OTDR Operation for High Quality Traces

Practical 04 – Acquisition Time.



Remember this statement form earlier in the lesson:

"One of the most challenging skill of OTDR operation to master is to make a suitable balance between Pulse Width and Acquisition Time"

The reason the 1310nM trace has more noise is because 1310nM has a higher attenuation rate and therefore needs either more power (higher pulse width) or longer acquisition time to average out the noise for the same length of fiber.

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OTDR Operation for High Quality Traces

Index Of Refraction (IOR)

•The Index Of Refraction (IOR) is a means of describing the speed of light in an optic fiber by comparing it to the speed of light in a vacuum.

The IOR of an optic fiber is calculated by:

$$\text{IOR} = \frac{\text{Speed Light in Vacuum}}{\text{Speed Light in Fiber}}$$

•You won't have to measure the speed of light or manually calculate the IOR. The IOR is generally printed on the cable being tested. You will have to understand what the IOR is and how to enter it into the OTDR being used and why it is important.

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OTDR Operation for High Quality Traces

Index Of Refraction (IOR)

•The reason an OTDR needs to have an accurate value for the speed of light in the fibre is because different fiber types have different speeds due to the materials they are made from and the OTDR uses the speed of light in the fibre to calculate distance measurements.

•Therefore, if you have an incorrect IOR all of the distance measurements will be inaccurate.

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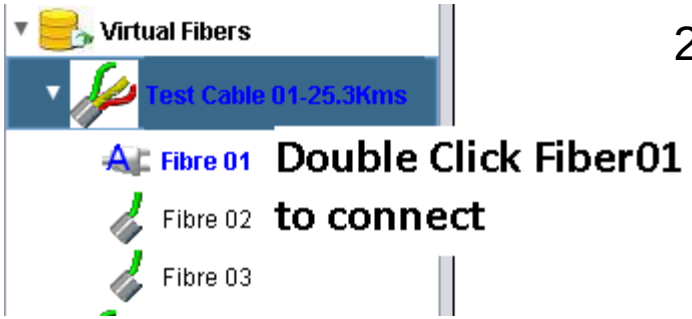
OTDR Operation for High Quality Traces

Practical 05 - IOR.

On the VanGuard Data OTDR Emulator, Connect to Test Cable 01 – 25.3 Kms / Fibre 01.

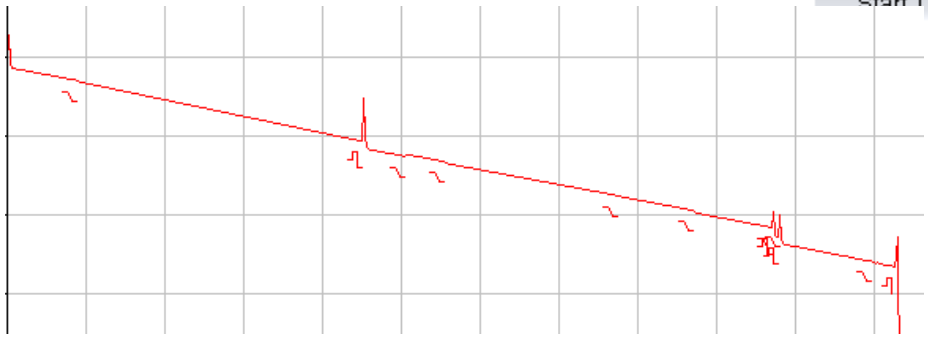
1)



2)

3)

Click Start Test



You will get a good quality trace with suitable parameters.

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OTDR Operation for High Quality Traces

Practical 05 - IOR.

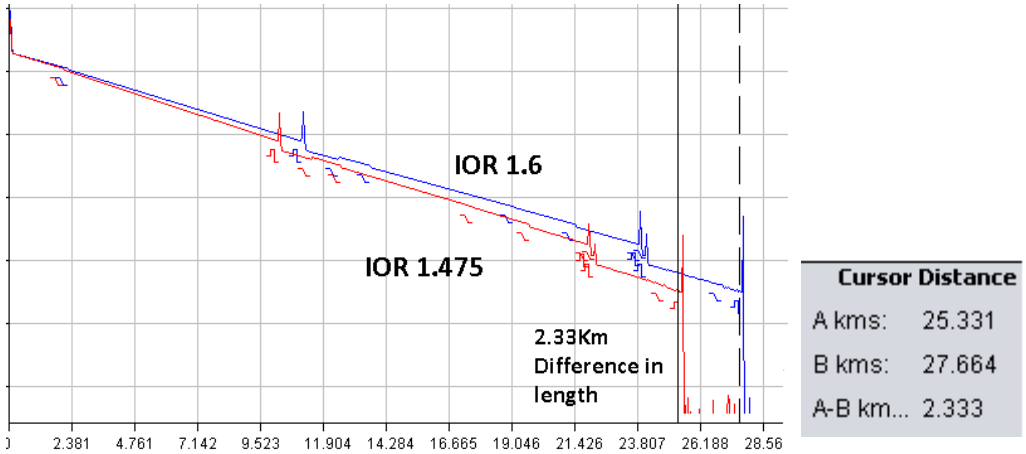
Change the IOR to 1.6 and take the trace again.

5) 

Change IOR to 1.6

6) 

Click Start Test



Because the IOR has been changed the trace shows different distances for the same fiber. If trying to find a fault at a measured distance this can be a serious problem so always make sure the IOR is correctly set.

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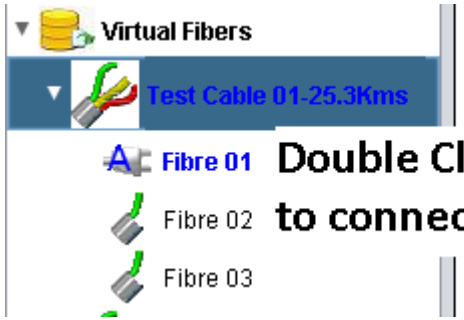
OTDR Operation for High Quality Traces

Practical 06 – Adjust Trace Settings.

The OTDR Emulator has a unique feature not possible with a real OTDR. That is; to adjust trace settings AFTER the trace has been taken to show how a trace could be improved from its initial result.

On the VanGuard Data OTDR Emulator, Connect to Test Cable 01 – 25.3 Kms / Fibre 01.

1)



2)

3) Change the PW to a low value

4)

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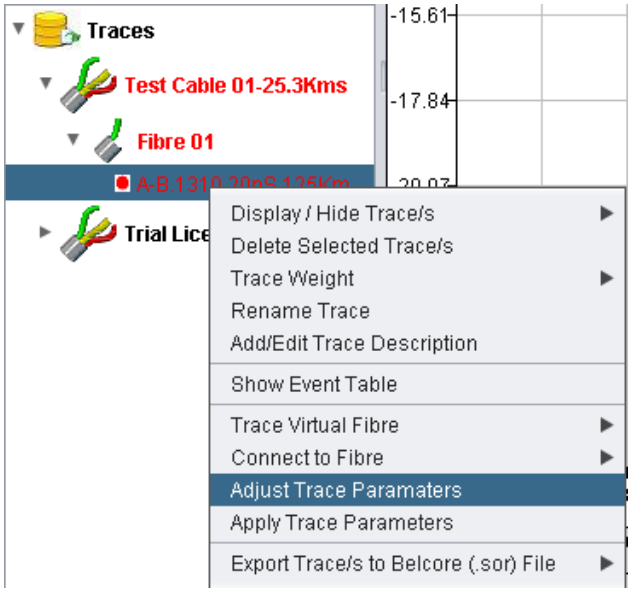
OTDR Operation for High Quality Traces

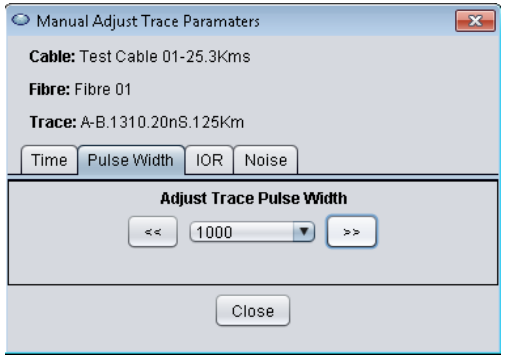
Practical 06 – Adjust Trace Settings.

Because the pulse width is too low the trace is noisy.

5) Right Click the Trace in the trace list and select Adjust Trace Parameters



6) The Adjust Trace Dialog will be displayed. From here you can reset the trace parameters and the trace will be re-calculated with the new values in real time.



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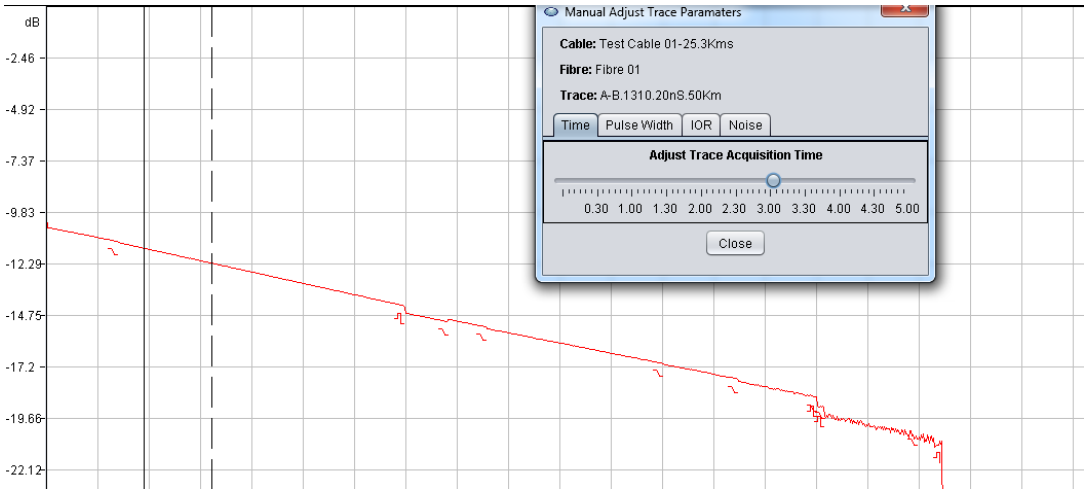
OTDR Operation for High Quality Traces

Practical 06 – Adjust Trace Settings.

The pulse width and acquisition time are too low so the trace is noisy.

7) Slide the time scale slowly over to 3 Minutes and see how the trace improves over longer acquisition times. (Return it to 30 Sec when complete



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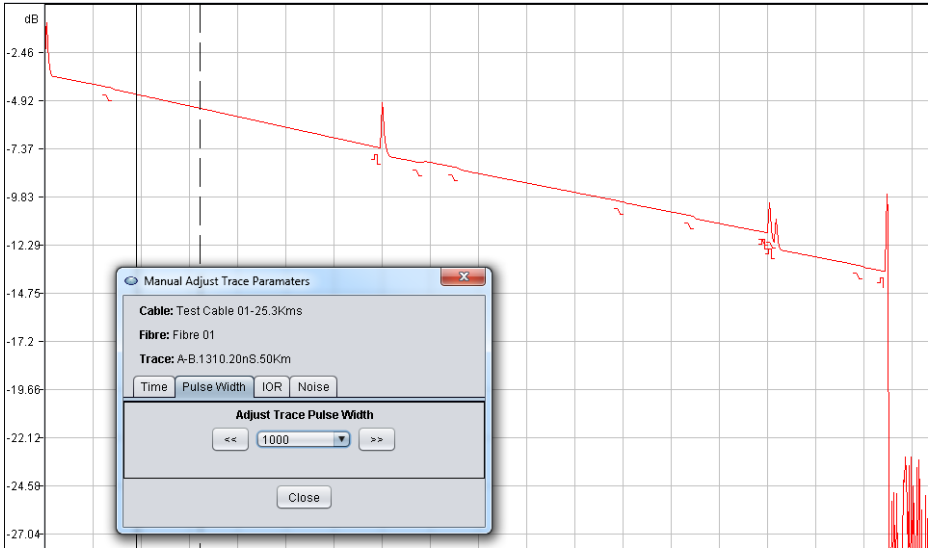
OTDR Operation for High Quality Traces

Practical 06 – Adjust Trace Settings.

The pulse width and acquisition time are too low so the trace is noisy.

8) On the Pulse Width tab, adjust the pulse width up for each option between 10nS and 1000nS and see how the change in pulse width changes the trace.



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OTDR Operation for High Quality Traces

OTDR Settings - Summary.

When configuring an OTDR you need to consider:

1) Pulse Width
2) Wavelength
3) Range and Resolution
4) Acquisition Time and
5) IOR.

At this stage that best measure of a good quality trace is a low level of noise. To achieve a clean trace it is a balance of acquisition time and pulse width but the values can change per wavelength.

Before moving on, test the other fibres in the OTDR Emulator. Adjust the acquisition time and pulse width across different wavelengths and consider how you would do this in the field with time constraints to finish the job.

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OTDR Operation for High Quality Traces

Conclusion.

Congratulations on completing:

OTDR Operation for High Quality Traces

In this lesson you have covered:

1) What is an OTDR and how they work
2) How to set up an OTDR for a high quality trace

Now complete the last session in this series:

OTDR Trace Analysis

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