



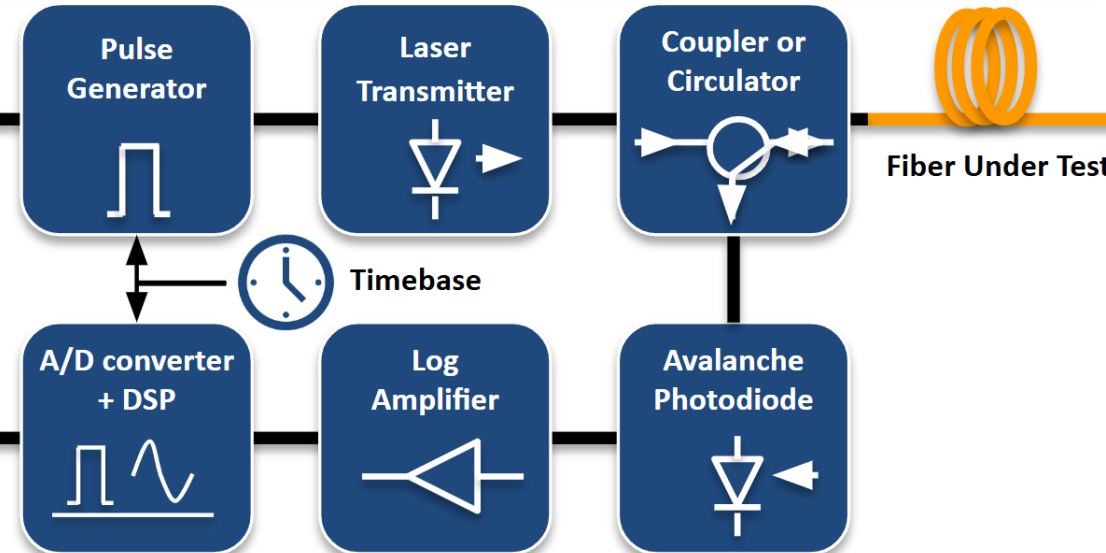
Principle of Operation

Works like an “optical radar” - pulses of light are injected into a fiber and the travel time of reflected light comprising Rayleigh scattering and Fresnel reflections is measured

Micro-Processor and Display

- Primary OTDR Settings
- Wavelength/s (nm)
 - Distance Range (km, miles, ...)
 - Pulse Width (ns)
 - Acquisition Time (sec)
 - Index of Refraction (IOR)

- Signal Processing | Trace Analysis
- Fiber Length (km, miles, ...)
 - Event Loss (dB)
 - Reflectance (-dB) | ORL (+dB)



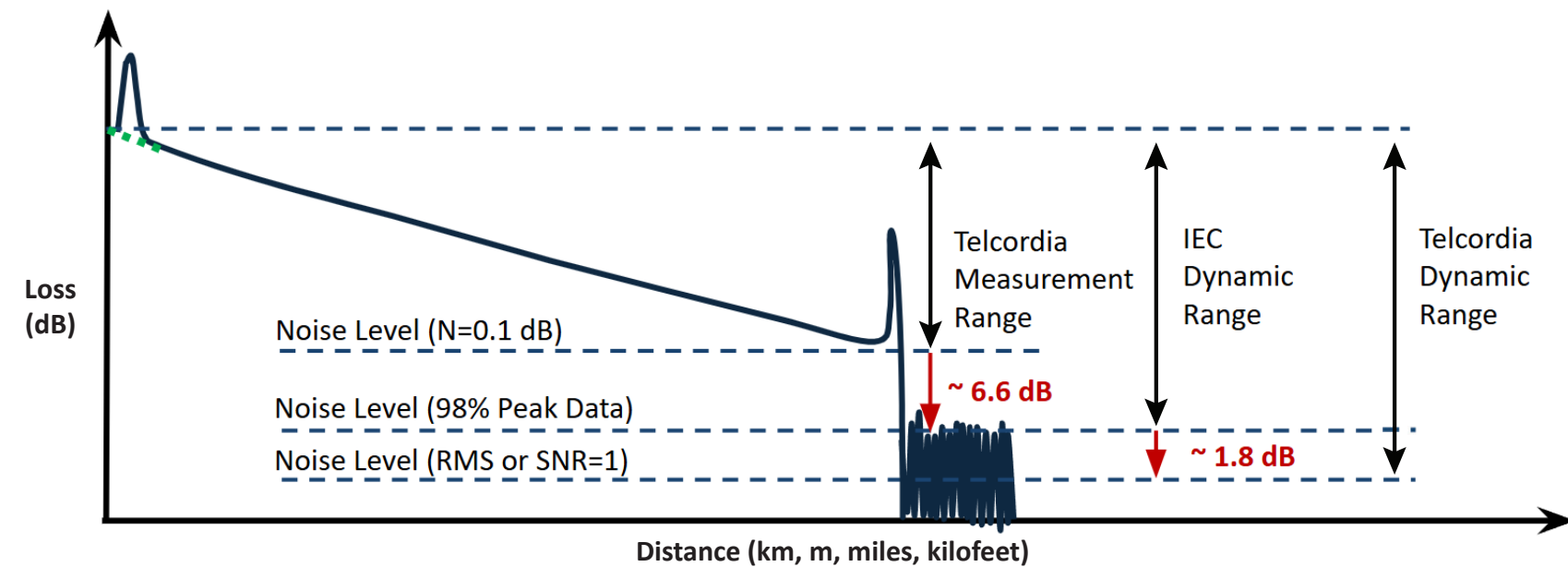
Rayleigh Scattering:
Occurs when a light pulse encounters small variations in the glass material (dopants, impurities, ...) causing small amounts of light to be scattered in all directions including back towards the OTDR's receiver circuitry (backscatter).

Fresnel Reflections:
Occur when the light pulse encounters abrupt changes in material density such as connections, breaks or wherever an air gap exists.

Key Performance Parameters

Dynamic Range

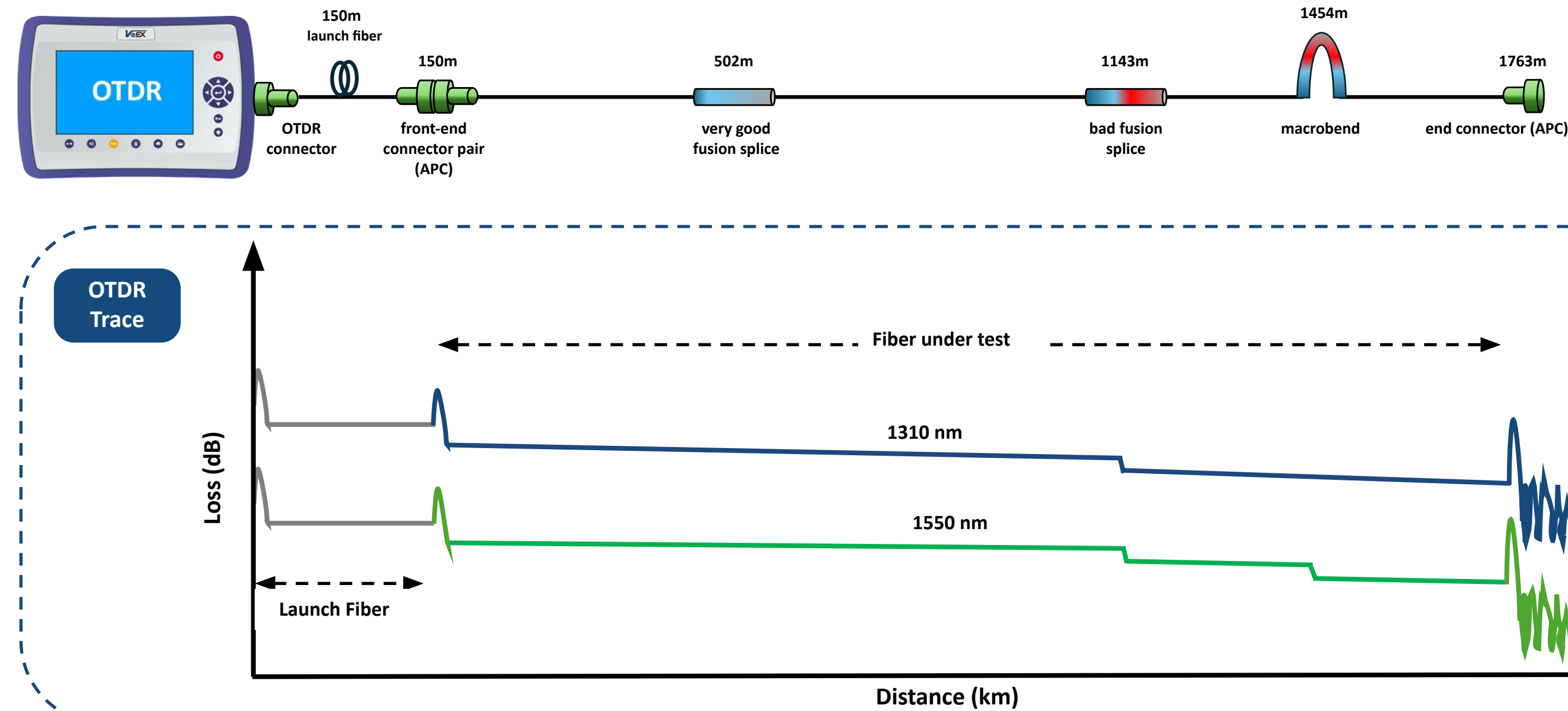
- Determines approximate length of a fiber that can be measured - Larger dB values typically mean longer distance capability
- Determines approximate cumulative loss that can be measured in a fiber link
- Determined by a combination of the total laser pulse power and sensitivity of the photo-detector including electronics
- One-way fiber loss (dB) from the extrapolated backscatter level to a given noise level or SNR on the trace – see below



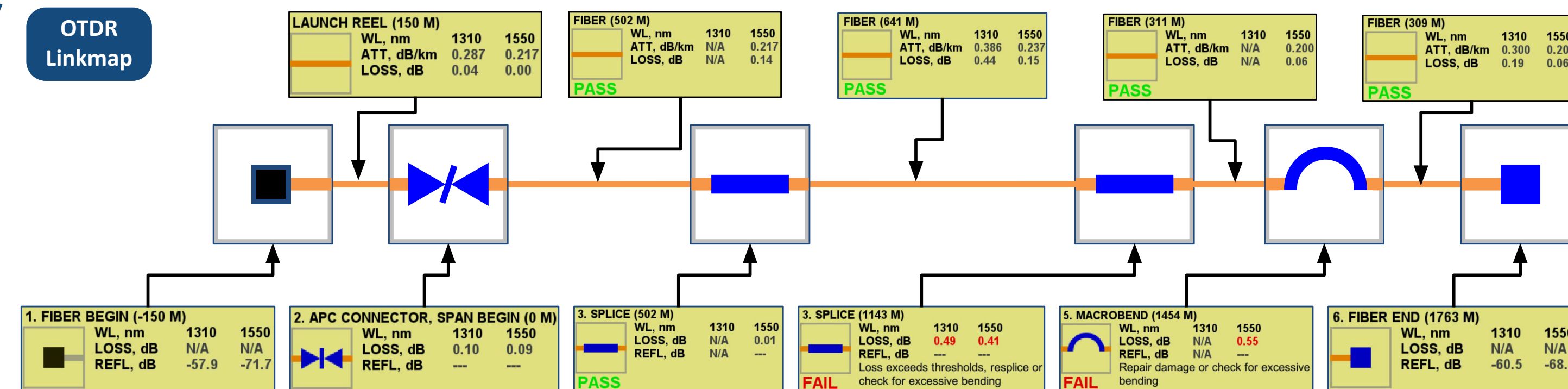
Industry Standard Definitions:

- Telcordia GR-196-CORE12 (2010): Based on 98% peak noise, using a 3-minute averaging time, a 2 km (20 μ s) pulse and G.652 fiber
- IEC 61746: Approx. 6.6 dB less than Telcordia's measurement range (good indicator of an OTDR's “useful” measurement range)

Trace | Linkmap Analysis



OTDR Linkmap

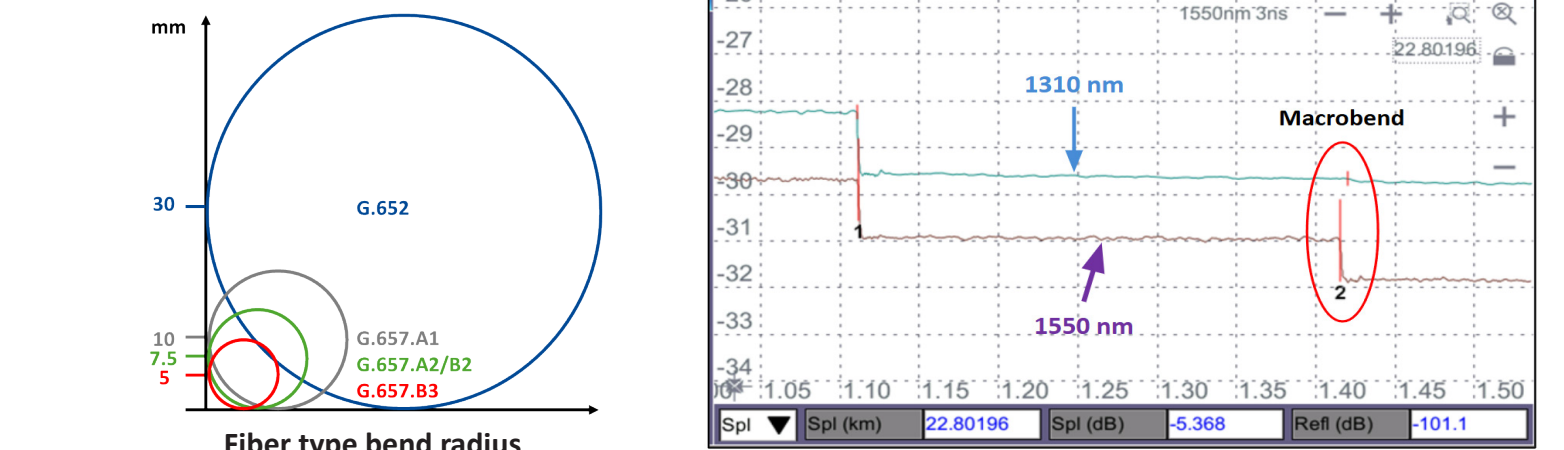


Bending Anomalies

What are Macrobend & Microbend losses?

- Bends are non-reflective events and are more prominent at longer wavelengths (1550 nm and higher)
- Fiber must be tested at a minimum of two or three wavelengths to correctly identify bends from other non-reflective events
- Macro-bend:** Excessive bending of a fiber above a critical curvature value forcing light to escape
- Micro-bend:** Stresses along length of the fiber (mechanical or delamination deforming the core)

Bend insensitive fiber types (G.657 variants)
help mitigate macrobending losses



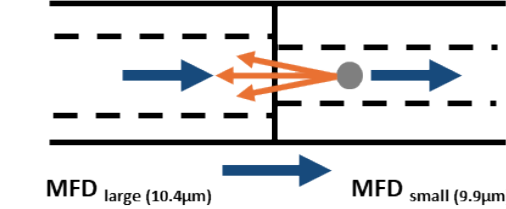
Gainers | Losses

What are Gainers?

- In certain situations, an OTDR will display a fusion splice with a power increase or “gain” value
- Two fibers with different backscatter coefficients are spliced together
- Two fibers (G.652 to G.657A/B) with different Mode Field Diameters (MFD) are spliced together

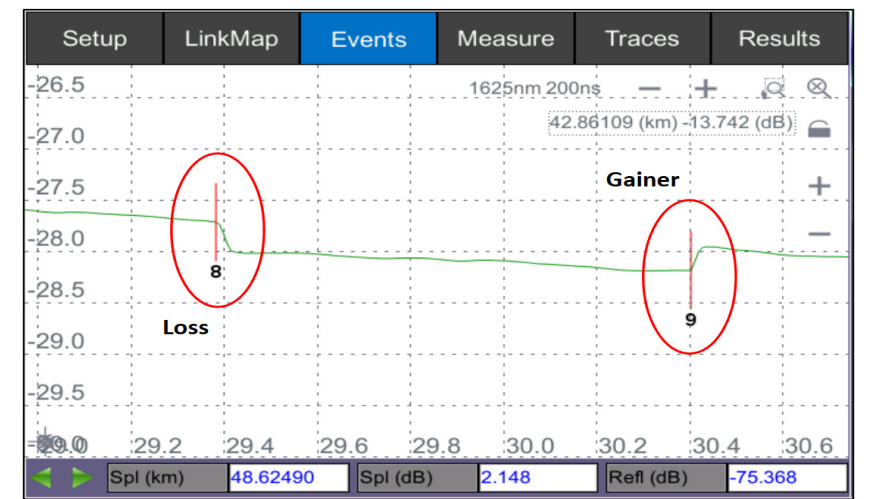
Note: Perform bi-directional averaging of the OTDR trace to obtain correct loss values for each direction

Mode Field Diameter Mismatch

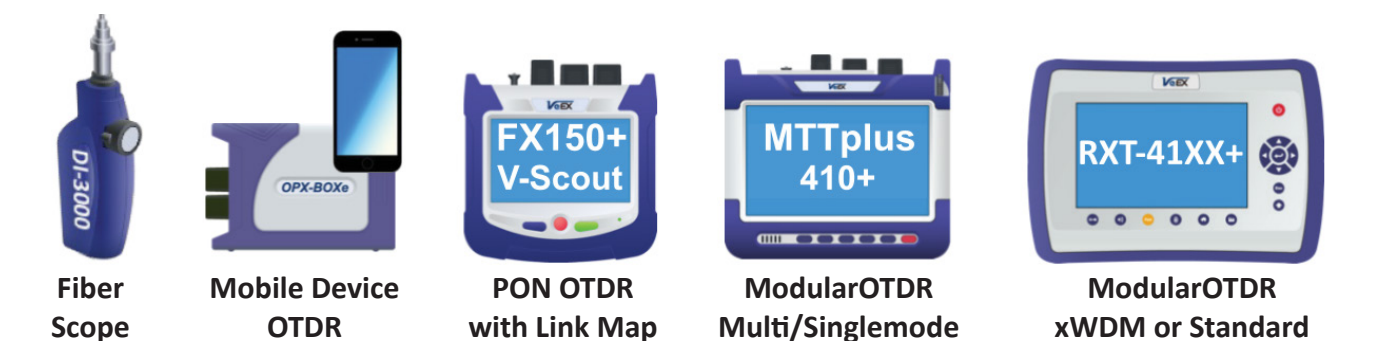


What causes Losses?

- Fiber attenuation (dB/km)
- Splices (fusion or mechanical)
- Connectors
- Bending (Micro & Macro)
- Passive devices (Mux, splitters)



VeEX OTDR | Accessories



Primary OTDR Settings

Wavelength/s

- Optical fibers are normally tested or characterized at or close to the operating wavelengths:
 - Multimode fibers at 850 nm and 1300 nm (out-of-service)
 - Singlemode fibers at 1310 nm, 1550 nm and 1625 nm (out-of-service) or at 1625 nm or 1650 nm (in-service)
 - Longer wavelengths (1500 nm, 1625 nm) are used to identify and troubleshoot macrobending and microbending anomalies

Distance Range*

- Typically referred to as the display range and should be set to approximately 25% longer than the fiber under test

Resolution*

- Spacing between data points influencing distance accuracy – more sampling points provide higher resolution and vice versa

Pulse Width*

- Controls the duration and the amount of light injected into the fiber:
 - Short pulses provide lower backscatter levels, shorter dead zones, higher resolution, and lower dynamic range
 - Long pulses provide higher backscatter levels, longer dead zones, lower resolution, and higher dynamic range

Averaging & Real Time*

- Time the OTDR acquires and averages data sampling points to improve signal-to-noise (SNR) ratio
- Longer averaging is needed when short pulses are being used to test longer fibers, higher resolution and optimized Dead Zone
- Real Time is when little or no averaging is performed - often used during splicing operations to view changes as they happen

Index of Refraction (IOR)*

- Ratio of the speed of light in a vacuum compared to the speed of light traveling in a fiber
- OTDR uses IOR ratio and measurement time to determine the fiber's length – wrong IOR will result in wrong distance accuracy

Notes*:

- Customizable settings in Manual OTDR or User profiles. In Auto mode, some settings are automatically configured by the OTDR

Understanding Dead Zones

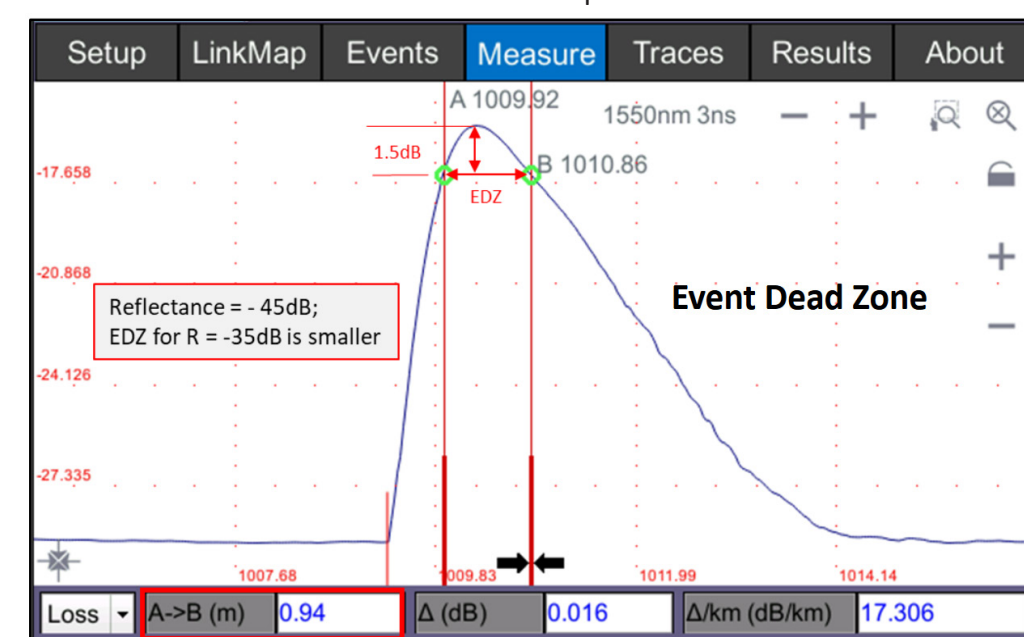
Definition

Distance where the OTDR is unable to detect or measure an event following a Reflective event (Fresnel reflection) resulting in a measurement “blind-spot”

- Directly related to pulse width (small pulses = smallest dead zone)
- Directly related to optical connector finish (smaller reflectance = smaller dead zones)
- Directly influenced by optical connector type polish (UPC vs APC)
- Dirty or damaged optical connectors!

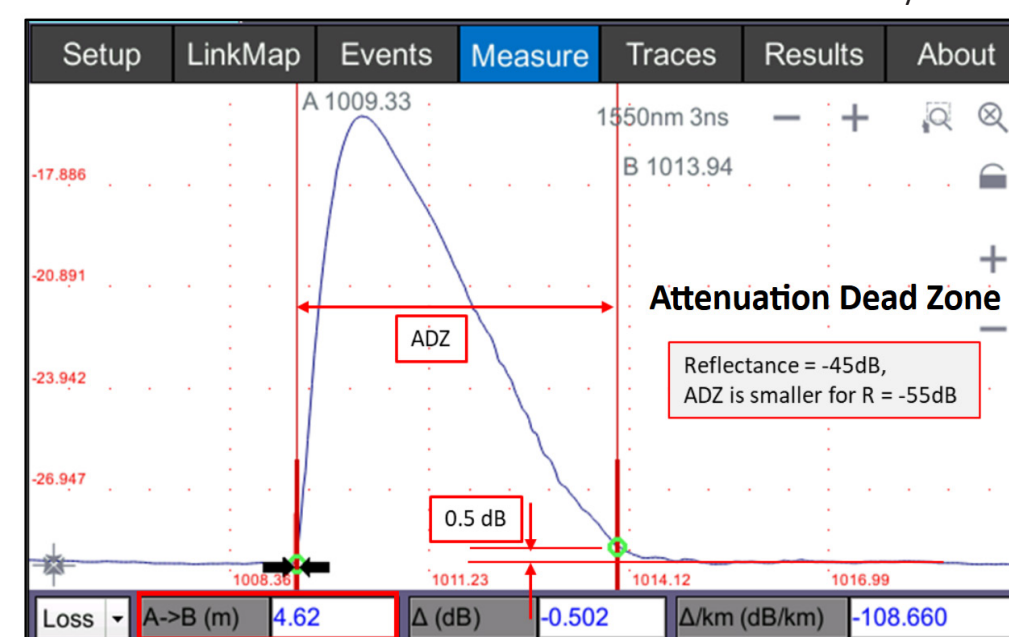
Event Dead Zone

- Minimum distance where two consecutive reflective events can be resolved when measured 1.5 dB below peak



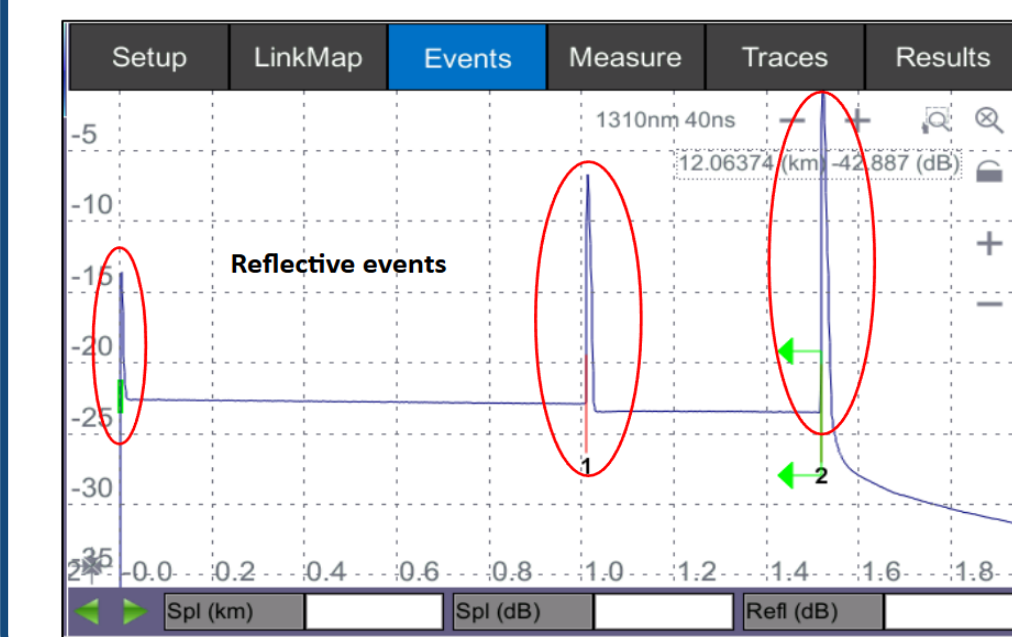
Attenuation (Loss) Dead Zone

- Minimum distance after a reflective event where a non-reflective event can be detected and measured to within ± 0.5 dB accuracy



What causes Events?

- Any abnormality in the fiber causing loss or reflection (except scattering)
- Any connection/s including fiber damage such as cracks or breaks
- Any bending anomaly such as macro-bending or micro-bending
- Any passive device such as a Mux, Splitter or Tap in PON networks
- Any mechanical or fusion splice
- An OTDR trace usually contains several reflective and non-reflective events including front-end and fiber end reflections.



Event Types

Reflective Events

- Caused by air-gaps in the fiber - connections, mechanical splices, breaks, ...
- Have reflective properties contributing to total optical return loss (ORL)
- Produce echoes along the OTDR trace (false events)

Non-reflective Events

- No reflective properties and have a loss or “gain” value only
- Caused by fusion splices, macrobends, very good APC connections, ...

