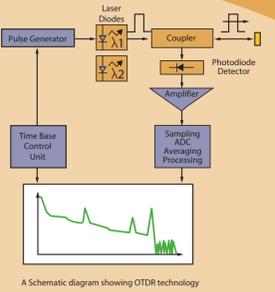# Understanding Optical Time Domain Reflectometry

OTDR Block Diagram

The optical time domain reflectometer (OTDR) injects an optical pulse into one end of the fiber and analyzes the backscattered and reflected signal that returns.

An operator at one end of a fiber span can measure and localize attenuation, event loss, reflectance, and ORL.

A Schematic diagram showing OTDR technology

(Block diagram labels: Laser Diodes, Pulse Generator, Coupler, Photodiode Detector, Amplifier, Time Base Control Unit, Sampling ADC Averaging Processing)

What Does an OTDR Measure?

An OTDR detects, locates, and measures events on fiber links. It requires access to only one end of the fiber.

Attenuation (also called fiber loss)
Expressed in dB or dB/km, this represents the loss or the rate of loss between two points along the fiber span.

Event Loss
The difference in the optical power level before and after an event, expressed in dB.

Reflectance
The ratio of reflected power to incident power of an event, expressed as a negative dB value.

ORL (Optical Return Loss)
The ratio of the reflected power to the incident power from a fiber optic link or system, expressed as a positive dB value.

How to Configure the Main OTDR Settings

Pulse Width
The pulse width controls the amount of light injected into a fiber.

A short pulse width enables high resolution and short dead zones but less dynamic range.

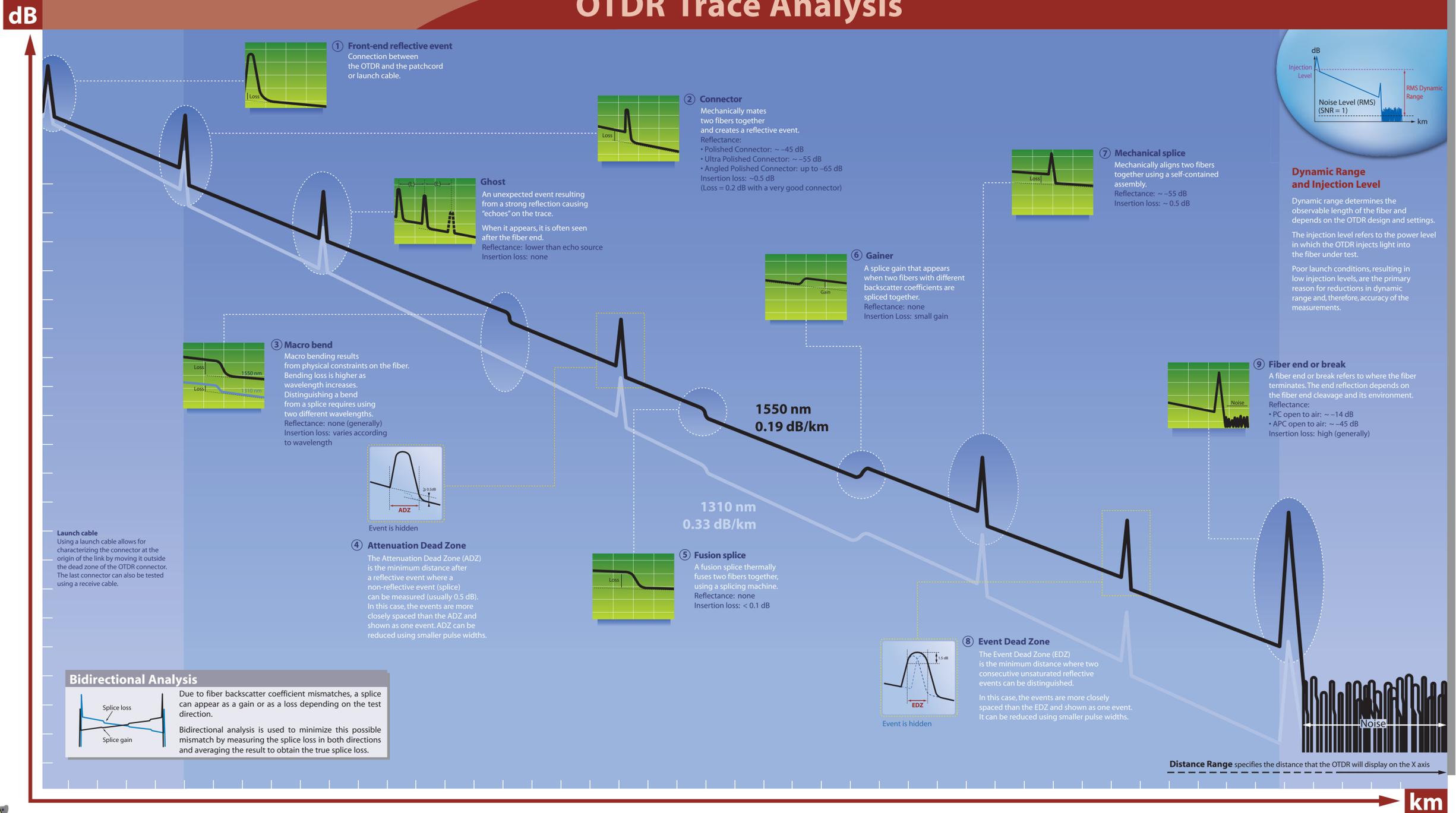A long pulse width enables high dynamic range but less resolution and large dead zones.

Acquisition time
The time during which the OTDR acquires and averages data points from the fiber under test. Increasing the acquisition time improves the dynamic range without affecting resolution or dead zones.

Index of Refraction (IoR)
The IoR converts the time that the OTDR measures to distance and displays it on the trace.

Entering the appropriate value for the fiber under test will ensure accurate measurements of fiber length.

⚠ **To obtain accurate measurements, always clean connectors prior to OTDR testing!**

OTDR Trace Analysis

dB

① Front-end reflective event
Connection between the OTDR and the patchcord or launch cable.

② Connector
Mechanically mates two fibers together and creates a reflective event.
Reflectance:
• Polished Connector: ~ −45 dB
• Ultra Polished Connector: ~ −55 dB
• Angled Polished Connector: up to −65 dB
Insertion loss: ~0.5 dB
(Loss = 0.2 dB with a very good connector)

Ghost
An unexpected event resulting from a strong reflection causing "echoes" on the trace.
When it appears, it is often seen after the fiber end.
Reflectance: lower than echo source
Insertion loss: none

③ Macro bend
Macro bending results from physical constraints on the fiber. Bending loss is higher as wavelength increases. Distinguishing a bend from a splice requires using two different wavelengths.
Reflectance: none (generally)
Insertion loss: varies according to wavelength

④ Attenuation Dead Zone
The Attenuation Dead Zone (ADZ) is the minimum distance after a reflective event where a non-reflective event (splice) can be measured (usually 0.5 dB). In this case, the events are more closely spaced than the ADZ and shown as one event. ADZ can be reduced using smaller pulse widths.
ADZ — Event is hidden

⑤ Fusion splice
A fusion splice thermally fuses two fibers together, using a splicing machine.
Reflectance: none
Insertion loss: < 0.1 dB

⑥ Gainer
A splice gain that appears when two fibers with different backscatter coefficients are spliced together.
Reflectance: none
Insertion Loss: small gain

⑦ Mechanical splice
Mechanically aligns two fibers together using a self-contained assembly.
Reflectance: ~ −55 dB
Insertion loss: ~ 0.5 dB

⑧ Event Dead Zone
The Event Dead Zone (EDZ) is the minimum distance where two consecutive unsaturated reflective events can be distinguished.
In this case, the events are more closely spaced than the EDZ and shown as one event. It can be reduced using smaller pulse widths.
EDZ — Event is hidden

⑨ Fiber end or break
A fiber end or break refers to where the fiber terminates. The end reflection depends on the fiber end cleavage and its environment.
Reflectance:
• PC open to air: ~ −14 dB
• APC open to air: ~ −45 dB
Insertion loss: high (generally)

1550 nm 0.19 dB/km
1310 nm 0.33 dB/km

Launch cable
Using a launch cable allows for characterizing the connector at the origin of the link by moving it outside the dead zone of the OTDR connector. The last connector can also be tested using a receive cable.

Dynamic Range and Injection Level

Dynamic range determines the observable length of the fiber and depends on the OTDR design and settings.

The injection level refers to the power level in which the OTDR injects light into the fiber under test.

Poor launch conditions, resulting in low injection levels, are the primary reason for reductions in dynamic range and, therefore, accuracy of the measurements.

(Inset labels: dB, Injection Level, Noise Level (RMS) (SNR = 1), RMS Dynamic Range, km)

Bidirectional Analysis

Splice loss
Splice gain

Due to fiber backscatter coefficient mismatches, a splice can appear as a gain or as a loss depending on the test direction.

Bidirectional analysis is used to minimize this possible mismatch by measuring the splice loss in both directions and averaging the result to obtain the true splice loss.

Distance Range specifies the distance that the OTDR will display on the X axis

km

(Fiber link schematic labels: Launch cable, Fiber link, ① Front-end reflective event, Connector pair, ③ Macro bend, ④ Connector pair, Fusion splice, ⑥ Fusion splice, ⑦ Mechanical splice, ⑧ Connector pairs, ⑨ Fiber end)

Products

OTU-8000 — Optical Test Unit for the ONMS
T-BERD®/MTS-8000 — Scalable Optical Test Platform
T-BERD®/MTS-6000 — Compact Optical Test Platform
T-BERD®/MTS-4000 — Multiple Services Test Platform

To learn more, visit **www.jdsu.com/fibertest**

We wrote the book on Fiber Optic Testing. Visit us online for your free copy.

Fiber Optic Testing

JDSU

Understanding Optical Time Domain Reflectometry