Fiber Characterization Guide

Introduction

Fiber Characterization is defined as a series of tests taken on a fiber optic span to determine the integrity of the fiber, installation practices, and performance for a desired transmission rate (OC-48 or faster) and/or Service to be implemented (DWDM). There are 5 tests taken to qualify a fiber:

- **Optical Return Loss (ORL)**
  1550nm wavelength, from both fiber ends
- **OTDR**
  1550nm & 1625nm wavelengths, bi-directionally averaged
- **Power Meter and Light Source (LTS)**
  1550nm & 1625nm wavelengths, bi-directionally averaged
- **Polarization Mode Dispersion (PMD)**
  1550nm wavelength, single ended
- **Chromatic Dispersion (CD)**
  1520nm to 1630nm at 10nm wavelength increments, single ended

Industry Standards

- **Power Loss** - FOTP-171 / EIA-455-171 Attenuation by Substitution Measurement for short length Multi-mode graded index and Single-mode optical fiber cable assemblies
- **Optical Return Loss (ORL)** - FOTP-107 / TIA/EIA-455-107A Return Loss for Fiber optic components
- **OTDR** - FOTP-59 / TIA/EIA-455-8 Measurement of Fiber Point Discontinuities Using an OTDR and FOTP-8 TIA/EIA
- **PMD** - TIA-455-124 – FOTP124 – Polarization-mode Dispersion Measurement for Single-mode Optical Fibers by Interferometry Method
- **Chromatic Dispersion** - FOTP-175 / TIA-455-175-B Measurement Methods and Test Procedures-Chromatic Dispersion

Thresholds (typical)

- **ORL**: $\geq$ 27dB
- **Loss Readings:** $\leq$ 0.25dB/Km + 0.3dB/splice + 0.5dB/connector pair (bi-directional)
- **OTDR:** $\leq$ 0.25dB/Km + 0.3dB/splice + 0.5dB/connector pair (bi-directional)
- **PMD:** < 40ps for 2.5GB/s, 10ps for 10GB/s, 2.5ps for 40GB/s
- **CD**: 16640ps/nm for 2.5GB/s 1040ps/nm for 10GB/s, 65ps/nm for 40GB/s

Description of Tests

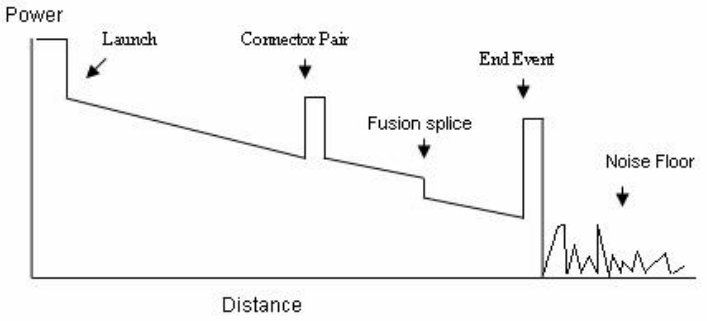
Optical Return Loss (ORL)

- ORL measures the total light reflected back to the transmitter caused by the fiber and the components including connector pairs, mechanical splices, etc.
- ORL provides a reading of the light that does not reach the opposite end of the fiber
- ORL determines the overall fiber plant efficiency
- Reflective events include all connector pairs and mechanical splices
- ORL is measured as a + dB reading
- The higher the ORL reading the better the reflections in the fiber under test

OTDR

The OTDR sends a light pulse down the fiber and measures the return signal power and travel time in order to calculate the fiber distance as well as loss of the fiber under test. Once the loss and distance are obtained they are plotted and a fiber trace is created.

As well as plotting the optical distance of a fiber, the trace will show events such as splices and connector pairs.



To accurately measure events, OTDR traces should be taken bi-directionally and averaged.

Since Fiber Characterization testing is typically done on single mode fiber, typically OTDR traces are taken at 1550nm and 1625nm wavelengths to cover the C-band and L-band transmission windows.

Power Meter and Light Source

A Power Meter and Light Source combination (Loss Test Set) is the most accurate way to provide end to end loss readings on an optical span, including the fiber attenuation and the initial and end connectors of the fiber under test.

A power meter and light source is used to send a **continuous wave** light from the source to the power meter. The difference in power is the total span loss.

Site A	Port	1550 Loss (dB)	1625 Loss (dB)	1550 Average Loss (dB)	1625 Average Loss (dB)	1550 Loss (dB)	1625 Loss (dB)	Port	Site B
Utica	1	1.54	1.65	1.70	1.81	1.86	1.97	1	Frankfort
Utica	2	1.33	1.42	1.45	1.59	1.56	1.75	2	Frankfort

dBm = 10 log Power $_{Out}$ ÷ 1mW

Loss = Power $_{In}$ - Power $_{Out}$

Polarization Mode Dispersion

Polarization Mode Dispersion (PMD) is the result of light traveling down a fiber along different paths. Each path will have a slightly different length which will result in different arrival times for each component of light traveling. The difference in the arrival times is PMD. This "differential delay" is PMD and is measured in picoseconds (*ps)* of delay.

PMD is performed at 1550nm with a broadband light source. The test is performed by taking several scans of the fiber under test. The result documented is the worst case result as the total delay and coefficient of the fiber under test. The PMD is fitted to a Gaussian curve and determined to pass or fail based on industry standards.

SONET	Bit Rate	Bit Time	Delay
OC-48	2.5Gigabit/sec	401.88ps	40ps
OC-192	10Gigabit/sec	100.47ps	10ps
OC-768	40Gigabit/sec	25.12ps	2.5ps

Chromatic Dispersion

Chromatic Dispersion (CD) is a result different wavelengths traveling at different speeds of the non zero spectral width of transmitters. Since transmitters are actually made up of several wavelengths and each wavelength travels at a different speed, the difference in arrival time of each wavelength causes pulse spreading or (chromatic) dispersion. This phenomenon is measured in ps/nm.

CD tests are typically set up to measure across a variety of fiber types. For example, a typical CD set up would measure from 1520nm to 1630nm in 10nm increments. The results are then plotted and graphed. The results include the dispersion slope, zero dispersion point and delay ps/nm.

- Chromatic Dispersion is NOT a pass/fail reading
- The results determine if dispersion compensation is required
- The results are required for network engineering for proper transmission and network element requirements and placement

SONET	Bit Rate	Total Dispersion
OC-48	2.5Gigabit/sec	16640ps/nm
OC-192	10Gigabit/sec	1040ps/nm
OC-768	40Gigabit/sec	65ps/nm