

Modal Bandwidth Measurement Method



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Optical
Fiber

MM19

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Scope

This information describes the current reference methods for measuring the modal bandwidth of Corning® multimode optical fibers.

General

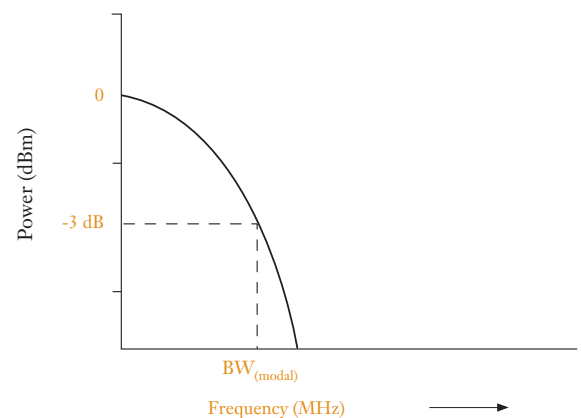
A fiber's information carrying capacity is limited by the distortion of optical pulses propagating through an optical fiber. Two independent sources of pulse distortion are intermodal and chromatic dispersion.

Intermodal (or modal) dispersion is caused by the different group velocities of the various modes of light propagating in a multimode fiber. Modal dispersion effects can be minimized by improved index profile control. Chromatic dispersion is caused by the different wavelengths of light within a pulse propagating at different velocities. Chromatic effects can be minimized by using a sufficiently narrow spectral width source.

The modal bandwidth of a multimode fiber is determined from the optical output power frequency spectrum. The frequency at which the amplitude drops three decibels [dB] relative to the zero frequency component of the fiber is defined as the -3 dB bandwidth (or modal bandwidth) of the fiber (see Figure 1).

Output Power Frequency Spectrum

Figure 1



Measurement Description

Overfilled launch (OFL) condition: A spectrally and temporally narrow pulse of light is launched through a mode scrambler into the full length of fiber using the apparatus shown in Figure 2. Since the power distributions of lasers vary from one to another, a mode scrambler is used to generate a spatially, angularly and uniformly overfilled launch condition to assure consistent measurement results.

Restricted mode launch (RML) condition: The restricted mode launch bandwidth measurement launch condition is created by filtering the overfilled launch condition (as defined above) with a special 23.5 μm fiber, also referred to as the restricted mode launch (RML) fiber as shown in Figure 3. The special RML fiber has a 23.5 $\mu\text{m} \pm 0.1 \mu\text{m}$ core diameter, a 0.208 ± 0.01 numerical aperture, and a graded index profile with an alpha of approximately 2 and an OFL bandwidth greater than 700 MHz-km at both 850 and 1300 nm. The RML fiber is at least 1.5 meters in length to eliminate leaky modes; and is less than 5 meters in length to avoid transient loss effects. The light exiting the RML fiber is then coupled into the fiber under test.

Measurement: Modal bandwidth is measured by the time domain technique. The pulse at the output of the fiber under test is sampled discretely by a high-speed oscilloscope. A Fourier Transformation then is applied to the sampled pulse to obtain the corresponding frequency domain representation.

The optical output power frequency spectrum of the fiber is calculated by dividing the output pulse frequency spectrum by the reference frequency spectrum, point by point (frequency by frequency). The first frequency component in the fiber's frequency response whose magnitude is one-half (equals -3 dB) the magnitude of the zero frequency component is defined as the minus three decibel (-3 dB) optical power bandwidth (modal bandwidth) of the fiber.

Measurement Conditions

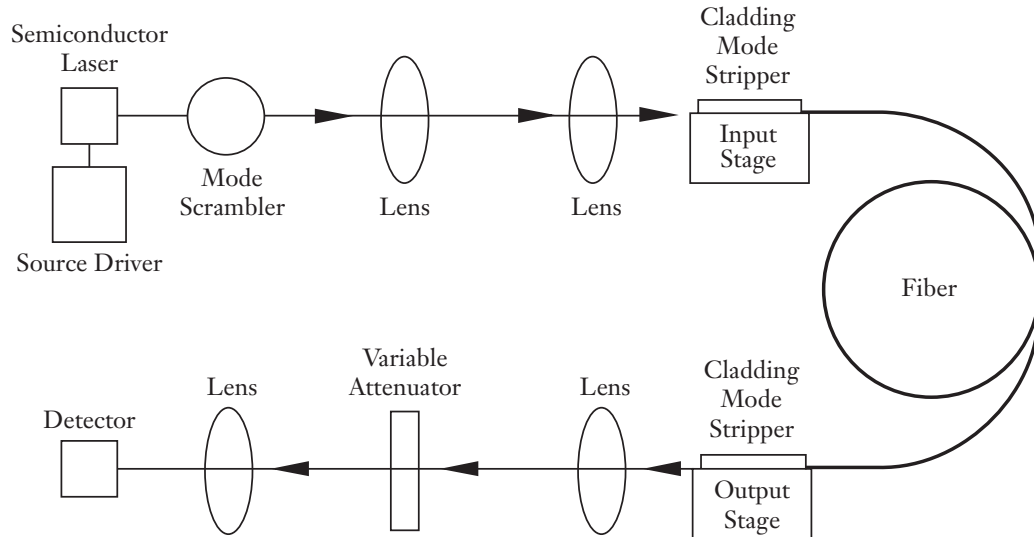
The fiber is wound with near zero tension onto a large diameter (36 cm) measurement spool to provide a measurement condition which will not influence the accuracy of the measurement result. The fiber ends are stripped of coating and prepared with end angles less than 2° with near perfect mirror surfaces. Mode stripping is provided to assure the removal of cladding modes.

Parameter	OFL Conditions	RML Conditions
Fiber Length	Full Length	Full Length
Spot Size	$\geq 62.5 \mu\text{m}$, or $50 \mu\text{m}$	$= 23.5 \mu\text{m} \pm 0.1 \mu\text{m}$
Numerical Aperture	≥ 0.275 , or $.200$	$= 0.208 \pm 0.01 \mu\text{m}$
Source Spectral Width	850 nm < NIDL (Normalized Intermodal Dispersion Limit) per FOTP 204 1300 nm \leq 10 nm Full Width at Half Maximum (FWHM)	850 nm < NIDL (Normalized Intermodal Dispersion Limit) per FOTP 204 1300 nm \leq 10 nm Full Width at Half Maximum (FWHM)
Pulse Duration	≤ 400 ps FWHM	≤ 400 ps FWHM
Measurement Wavelengths	850 \pm 10 nm 1300 \pm 10 nm	850 \pm 10 nm
Other	The semiconductor laser is coupled to a mode scrambler producing a nearly Lambertian output approximately 62.5 μm in diameter	The RML launch condition is created by filtering the mode scrambler created OFL condition with the special 23.5 micron core RML fiber

Apparatus to Measure Modal OFL Bandwidth

Figure 2

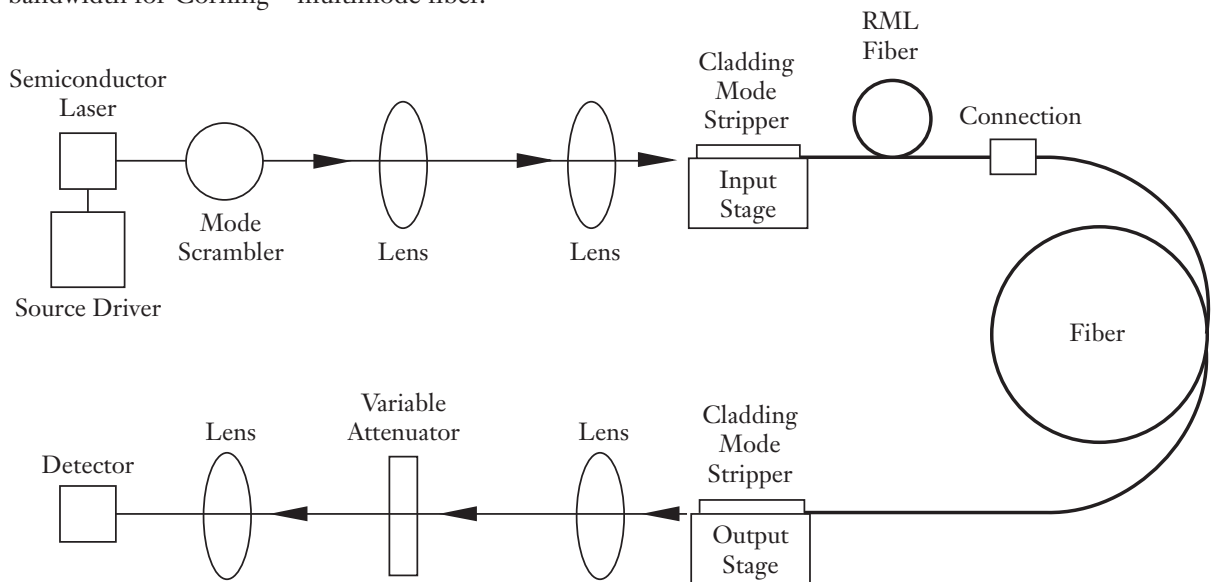
Figure 2 shows the apparatus used to measure the optical pulse broadening and calculate the modal OFL bandwidth for Corning® multimode fiber.



Apparatus to Measure Modal RML Bandwidth

Figure 3

Figure 3 shows the apparatus used to measure the optical pulse broadening and calculate the modal RML bandwidth for Corning® multimode fiber.



References

EIA/TIA-455-51A (FOFTP-51), Pulse Distortion Measurement of Multimode Glass Optical Fiber Information Transmission Capacity.

EIA/TIA-455-54A (FOFTP-54), Mode Scrambler Requirements for Overfilled Launching Conditions to Multimode Fibers.

EIA/TIA-455-204 (FOFTP-204), Measurement of Bandwidth on Multimode Fiber.

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