Frequency Domain Method for Measuring Multimode Fiber Bandwidth



Overview

Using a frequency domain instrument, vector network analyzer (VNA), the method measures the complex transfer functions (CTFs) of multimode fibers for a given set of launch conditions.

Key Takeaways

Frequency-domain methods allow precise measurement of multimode fiber bandwidth by analyzing the fiber's complex transfer function and modal delays using a vector network analyzer or optical frequency-domain techniques.

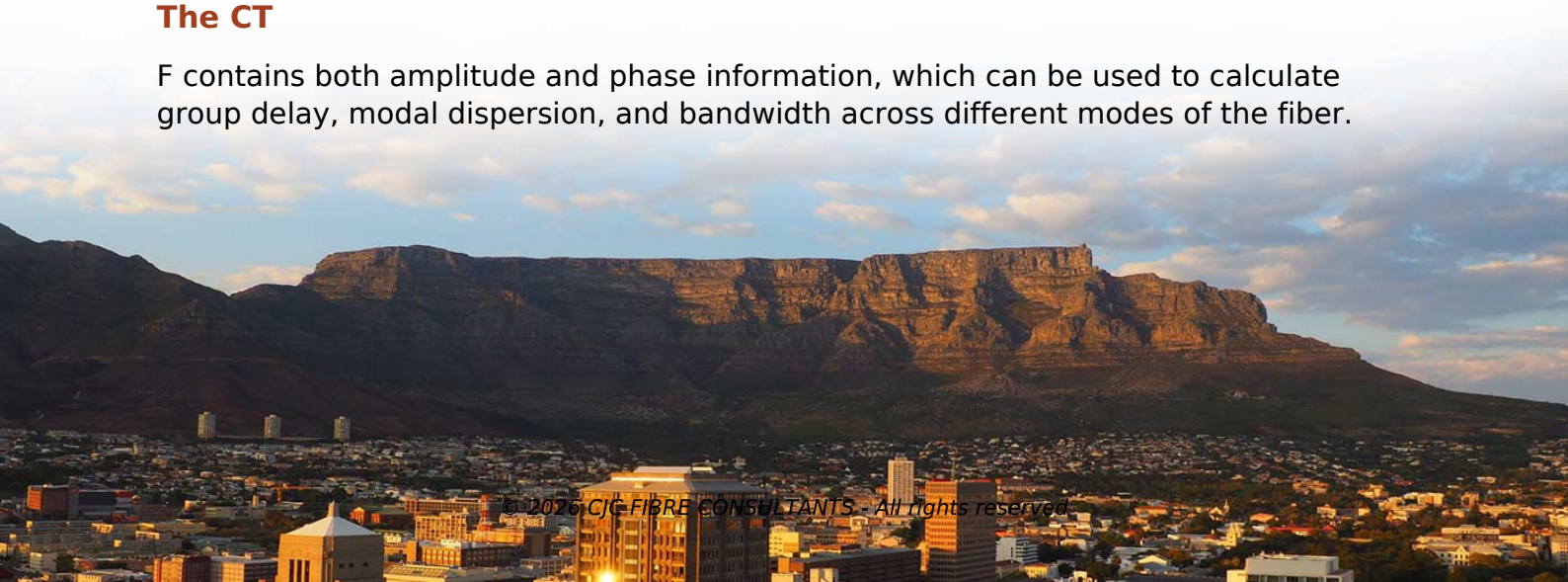
Overview of Frequency-

Domain Measurement

In the frequency-domain approach, a vector network analyzer (VNA) is used to measure the complex transfer function (CTF) of the multimode fiber. An electro-optic (E-O) conversion launches a frequency-swept signal into the fiber, and an optical-electrical (O-E) conversion at the receiving end captures the transmitted signal.

The CT

F contains both amplitude and phase information, which can be used to calculate group delay, modal dispersion, and bandwidth across different modes of the fiber.



© 2026 CJC FIBRE CONSULTANTS - All rights reserved

Differential Mode Delay and Modal Bandwidth

For multimode fibers, differential mode delay (DMD) is a key factor affecting bandwidth. The frequency-domain method allows the extraction of modal group delays for each mode, which can then be used to compute the modal bandwidth. This is equivalent to the time-domain method but offers advantages in precision and ease of measurement over long fiber lengths.

The effective modal bandwidth (EMB) can also be determined by weighting the output pulses according to the mode power distribution, similar to the EMBc calculation in time-domain methods.

Practical Implementation

Setup: Use a VNA with E-O and O-E converters to sweep the input frequency over the desired range. Data Acquisition: Measure the amplitude and phase response of the fiber to obtain the CTF. De-aliasing: Correct for under-sampling and aliasing due to long fiber lengths relative to VNA frequency points.

Inverse Fourier Transform: Convert the CTF to the time domain to recover output pulses and group delay information. Modal Analysis: Extract differential mode delays and calculate modal bandwidth for each mode or core. Bandwidth Determination: Determine the -3 dB bandwidth or worst-case modal bandwidth under general launch conditions.

Advantages of Frequency-

Domain Method

Can measure short and long fiber lengths across multiple wavelengths. Provides simultaneous modal delay and dispersion information. Less complex than equivalent time-domain systems while maintaining comparable precision.

Enables intermodal interference analysis using optical frequency-domain reflectometry (OFDR) for accurate relative modal delay measurements.

Applications

Characterizing graded-index multimode fibers for high-speed data transmission. Evaluating modal dispersion and bandwidth limitations in fiber optic networks. Supporting system design and verification for 10 Gbps and higher multimode fiber systems.

By using the frequency-domain method, engineers can obtain a comprehensive understanding of multimode fiber performance, including modal delays, dispersion, and effective bandwidth, which is critical for optimizing high-speed optical communication systems.

© 2026 CJC FIBRE CONSULTANTS - All rights reserved

Article Content

Differential mode delay and modal bandwidth measurements of

Using a frequency domain instrument, vector network analyzer (VNA), the method measures the complex transfer functions (CTFs) of multimode fibers for a given set of launch conditions.

Measurements of optical fibers using frequency-domain method: from ...

For multimode fibers, we have developed a thorough procedure to conduct differential mode delay measurements and calculate modal bandwidth, equivalent to the time domain method defined by the

Frequency-domain intermodal interferometer for the bandwidth ...

Abstract and Figures A new bandwidth measurement technique for a multimode optical fiber (MMF) using a frequency-domain intermodal interferometer is proposed.

Measurements of optical fibers using frequency-domain method: from ...

Measurements of optical fibers using frequency-domain method: from single mode fiber, polarization maintaining fiber to few-mode, multi-core, and multimode fiber March 2024 DOI:

A comparison of three bandwidth measurement techniques for multimode ...

This paper presents the results of an experiment intended to compare three distinct methods of measuring the bandwidth of a telecommunication grade, multimode optical fiber. The three methods

Multimode Optical Fiber Bandwidth Characterization

In this method a laser diode (OFL or RML) is used to inject power into a test fiber and modulated from a low frequency (for an approximately zero reference level) to a high frequency (in excess of the 3 dB

Optical frequency domain DMD measurement for a multimode optical

Abstract: A novel differential mode delay (DMD) measurement for a multimode fiber based on optical frequency domain reflectometry (OFDR) is proposed. We obtained high-resolution

Differential Mode Delay and Modal Bandwidth

Conversion into the frequency domain reveals the bandwidth from the transfer function H (f), which is defined as the earliest frequency at which the amplitude drops 3 dB below the amplitude

© 2026 CJC FIBRE CONSULTANTS - All rights reserved

Optical Simulation and Design Software | Ansys Optics

Rich Model Library for single-mode and multimode fiber-optic system designs. Mixed-Domain Co-Simulation with PrimeSim HSPICE for integrated electrical

C-band 110-GHz-Bandwidth Thin-Film Lithium Tantalate Modulator

1 Novel Hollow Core Nodeless Antiresonant Leakage Inhibited Fiber with Low Confinement Loss over a Large Bandwidth Nikulin, Ilia / Dainese, Paulo / Nguyen, Dan / Li, Ming-Junet al. | 2026 digital

Differential mode delay and modal bandwidth measurements of multimode ...

We report a frequency-domain method for measuring the differential mode delay (DMD) and bandwidth of multimode fibers (MMFs). Using a frequency domain instrument, vector network analyzer (VNA),

Measuring modal delays of few-mode fibers using frequency-domain method ...

Time-domain measurement methods such as differential mode delay (DMD) measurement for multimode fibers (MMF) can also be used. Such a measurement technique relies on using a

Frequency domain measurements of dispersion in multimode optical fibers

A newly developed technique for directly measuring fiber dispersion in the frequency domain as a function of wavelength is described. A number of germanium- and boron-doped fibers

Modal delay and modal bandwidth measurements of bi-modal optical fibers ...

We propose a simple and robust frequency domain method for measuring modal delay and bandwidth of bi-modal optical fibers. An analytical transfer func

New optical frequency domain differential mode delay measurement method ...

Abstract: A novel mode analysis method and differential mode delay (DMD) measurement technique for a multimode optical fiber based on optical frequency domain reflectometry has been proposed for the

High-speed fiber scanning endoscope for volumetric multi-megahertz ...

A new method was explored to conveniently tune the scanning frequency of a resonant fiber-optic scanner, by properly selecting the fiber-optic cantilever length, partially changing the

(PDF) Wideband microwave frequency response measurement based

© 2026 CJC FIBRE CONSULTANTS - All rights reserved

Abstract and Figures Frequency response measurement, or the forward transmission coefficient (S21) measurement for a two-port network, is the key function of a vector network

Contact Us

Continue your research online:

Website: https://cjcconsultants.co.za
Technical inquiry: https://cjcconsultants.co.za/contact.html

This document is for preliminary research. Verify specifications against current standards, product documentation and project requirements.

© 2026 CJC FIBRE CONSULTANTS - All rights reserved