

How to construct fiber optic delay for a router

Article Overview

A fiber optic delay line introduces a precise, controllable delay by routing optical signals through a measured length of fiber, which can be integrated with routers or RF-over-fiber systems.

Understanding Fiber Optic Delay Lines

A fiber optic delay line (ODL) works by converting an electrical or RF signal into an optical signal, transmitting it through a fiber of specific length, and then converting it back to electrical form at the output. The delay is determined by the fiber length and its refractive index, with light traveling slower in fiber than in a vacuum (approximately 204,000 km/s for standard quartz fiber with refractive index ~ 1.468). Fiber delay lines are preferred over coaxial or crystal-based delays because they are smaller, lighter, low-loss, and immune to electromagnetic interference.

Calculating the Required Fiber Length

To achieve a desired delay t_d , use the formula:

$$L = v \cdot t_d$$

where L is the fiber length, $v = c/n$ is the speed of light in the fiber, c is the speed of light in vacuum, and n is the fiber's refractive index. For example, a 5 μ s delay requires roughly 1 km of standard single-mode fiber.

Fabrication and Construction

- o **Fiber Selection:** Choose single-mode fiber for minimal dispersion and loss. Polarization-maintaining fibers may be used for RF or high-precision applications.
- o **Cutting and Measuring:** High-accuracy optical fiber cutting devices (OFCDs) combined with optical frequency domain reflectometry (OFDR) or optical vector analyzers (OVA) allow fiber lengths to be cut with micron-level precision.
- o **Splicing:** Fiber pigtails are spliced to achieve the exact length. Fusion splicing ensures low-loss connections and maintains signal integrity.
- o **Delay Adjustment:** For tunable delays, free-space optical paths with movable mirrors or micrometer-controlled fiber loops can adjust the effective optical path length. Electrically controlled versions use servo motors with encoders for sub-picosecond resolution.
- o **Integration:** The optical delay line is connected to the router or RF-over-fiber system. The input converts the electrical signal to optical, the fiber introduces the delay, and the output converts it back to electrical form.

Practical Considerations

- o **Temperature Effects:** Fiber length and refractive index vary with temperature, affecting delay. Use

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temperature-stable fibers or compensate in design .

- o Multipath or WDM: Multiple fiber spools or wavelength division multiplexing (WDM) can create variable delays or replicate multiple channels for testing .
- o Loss Minimization: Keep splices and bends minimal to reduce attenuation. Single-mode fibers and high-quality connectors improve performance . By following these steps, you can construct a precise, low-loss fiber optic delay line suitable for routers, RF systems, or high-speed optical networks.

Even small delays can impact performance, especially for applications that rely on real-time communication.

Accurately calculate the propagation delay and total latency in your fiber optic network. Understand how distance, refractive index,

How to Calculate Optical Fiber Latency: this technical article from M2 Optics breaks down how optical fiber latency is calculated.

Traditional RF and Microwave delay line technology requires long, bulky, electrical transmission lines to delay electrical signals for a

Rack-mount Time Delays / Delay Lines For test lab or data center applications with several fibers to larger fiber counts,

Fiber optic delay lines play an important role in a wide range of applications, including complex communication

Download the full application note for an in-depth explanation of the fiber optic delay line technology from Eastern OptX, and how it

Optical time delays come in both active time delays and passive time delays. Learn the difference in delay types and which one

Free Network Latency Calculator to measure delay, RTT, and distance-based latency. Perfect for WAN, fiber, and wireless planning.

Use this fiber propagation delay calculator to estimate one-way delay, RTT, velocity factor, route slack, splice allowance, and optical

A fiber optic delay line uses optical fiber to introduce a controlled delay into an RF or microwave signal path. In RF over Fiber

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Customized, high-precision optical time delay solutions for addressing fiber optic latency and timing applications in data centers and

We propose a novel scheme for fabricating high-accuracy optical fiber delay lines (OFDLs). The fabrication system

This paper provides a new quantitative analysis method for performance calculation and improvement of the optical

The modulated optical signal may be divided into multiple paths and coupled into multiple fiber spools, each with a

A miniature style delay line provides up to 13 picoseconds delay in a miniature package. The unit takes up little more space than an

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