# Automated Multi-Diode Laser System for WDM Couplers Insertion Loss Measurements

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# ABSTRACT

Insertion loss is an important parameter used to characterize passive fiber-optic components, such as WDM couplers and variable optical attenuators. This article describes an automated insertion loss measurement system which incorporates 980 nm, 1310 nm, 1529 nm and 1561 nm DFB lasers and two internal fiber optic standards. Insertion loss measurements collected with the system for WDM couplers and internal standards are presented. The system repeatability was validated by measuring the insertion loss for a WDM coupler six times at 980 nm, 1310 nm, 1529 nm and 1561 nm over 3 days period. The standard deviation calculated for the insertion loss measurements is less than 0.11 dB and the %CV is less than 1%.

Keywords: Distributed Feedback Laser (DFB) Diode Laser, Fusion Splice, Insertion Loss, Internal Fiber Optic Standard, Optical Switch, Polarization Scrambler, Single-Mode Fiber, Splice Loss, Wavelength Division Multiplexing (WDM) Coupler

# 1. INTRODUCTION

A wavelength division multiplexing (WDM) coupler is a passive fiber optic component which is used for combining a number of communication channels onto the same optical fiber simultaneously. In a WDM communication link each communication channel transmitted along the optical fiber is assigned to a slightly different wavelength and separated before the detectors by means of a WDM coupler and narrow bandpass filters. As such, the optical fiber high bandwidth is utilized for transmitting multiple channels or optical signals via a single-mode or multimode optical fiber. A

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typical end-to-end fiber optic communication link consists of electrical-to-optical converter (which includes a diode laser), isolator, variable optical attenuator, electro-optic modulator, WDM multiplexer, optical fiber, Er-doped fiber amplifier, WDM demultiplixer, optical filters, optical-to-electrical converter (which include a photodiode) and an amplifier (Keiser, 1999; Wagner & Kobrinski, 1989; Junichiro & Nosu, 1984; Bergano, 1996; Borella, Jue, Banerjee, & Ramamurthy, 1997; Sunak, 1988; Fontana & Grasso, 1994).

There are many applications for fiber optic communication links in industry. For example fiber optic communication links are widely used for transmitting analog and digital video signals, telephone conversations and computer data (Keiser, 1999; Wagner & Kobrinski, 1989; Junichiro & Nosu, 1984; Bergano, 1996; Borella, Jue, Banerjee, & Ramamurthy, 1997; Sunak, 1988; Fontana & Grasso, 1994).

Insertion loss (IL) is an important parameter for characterizing WDM couplers and fiberoptic components. The magnitude of IL can impact the fiber link power budget, design and the amount of signal delivered to the detection modules. The fiber link insertion loss budget includes losses due to the optical fiber, fiber connectors and passive/active optical components.

A search for granted US patents turned four patents dealing with fiber-optic components insertion loss measurement systems (Yu, 2004; Longhurst, 1992; Electronic Industries Association, 1990; Brininstool, 1987). The four patents describe the use of single light source system for IL measurements and none reported the use of fiber optic standards for monitoring the measurement system stability overtime. Moreover, none of these patents reported the use of 980 nm IL measurement capabilities.

This article describes a fully automated measurement system for measuring WDM couplers insertion loss at discrete wavelengths, namely, 980 nm, 1310, 1529 and 1561 nm with high speed and accuracy. Moreover, the article describes the use of fiber optic standards for monitoring the measurement system stability and drift. Examples for insertion loss measurements collected with the system for three WDM couplers are provided. Additionally, measurements collected for WDM couplers over long period of time to validate the measurement system repeatability are presented.

# 2. MEASUREMENT SYSTEM DESCRIPTION

As depicted schematically in Figure 1, the automated WDM insertion loss measurement system consists of four major parts: four discrete DFB diode laser sources, polarization scramblers, internal calibration standards, and two radiation detectors.

To simulate true non-polarized light conditions, linearly polarized light emitted from three DFB pigtailed diode lasers  $(1310 \pm 2 \text{ nm}, 1529)$  $\pm$  2 nm and 1561  $\pm$  2 nm) was depolarized by passing the laser beams through polarization scramblers. Similarly, the output beam generated from  $978 \pm 2$  nm diode laser was depolarized by passing the beam through a polarization scrambler equipped with HI980 fiber (Corning, Inc) (Electronic Industries Association, 1990). Here, it is worth noting that the DFB lasers output beam stability is rated at +/- 0.005dB over 15 minutes period and +/- 0.03 dB over 24-hours period. As illustrated in Figure 1, the 1310 nm, 1529 nm and 1561 nm excitation wavelengths were selected during the measurement by activating the 1x4 optical switch and the 980 nm excitation wavelength was selected by activating the 1x1 optical switch. Since the SMF-28 fiber becomes multimode at wavelengths less than 1260 nm (Electronic Industries Association, 1990), a separate leg of the measurement system was instrumented with HI980 fiber based polarization scrambler and 1x1 optical switch for transmitting the 978 nm laser beam. Table 1 lists the key optical parameters for the SMF-28 and HI980 fibers. As depicted in Figure 1, the 980 nm radiation and 1310-1560 nm spectral bands were combined using 1x2 980/1550 WDM coupler. The guided beams were monitored during any measurement cycle by a wavelength meter inserted into the optical path and placed behind the 1x2 WDM coupler. Two radiation detectors (A & B) equipped with integrating spheres were used to measure the laser beams emerging from the coupler SMF-28 and HI980 legs simultaneously. To achieve high measurements repeatability, the integrating spheres fiber holders are designed to center the fiber into the V-grooves and to apply no pressure on the fiber.

All devices used in the insertion measurement system were controlled via a PC equipped with a GPIB board and all pigtailed components were fusion spliced to ensure the minimum splice loss at each fiber-to-fiber interface. 5 more pages are available in the full version of this document, which may be purchased using the "Add to Cart"

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