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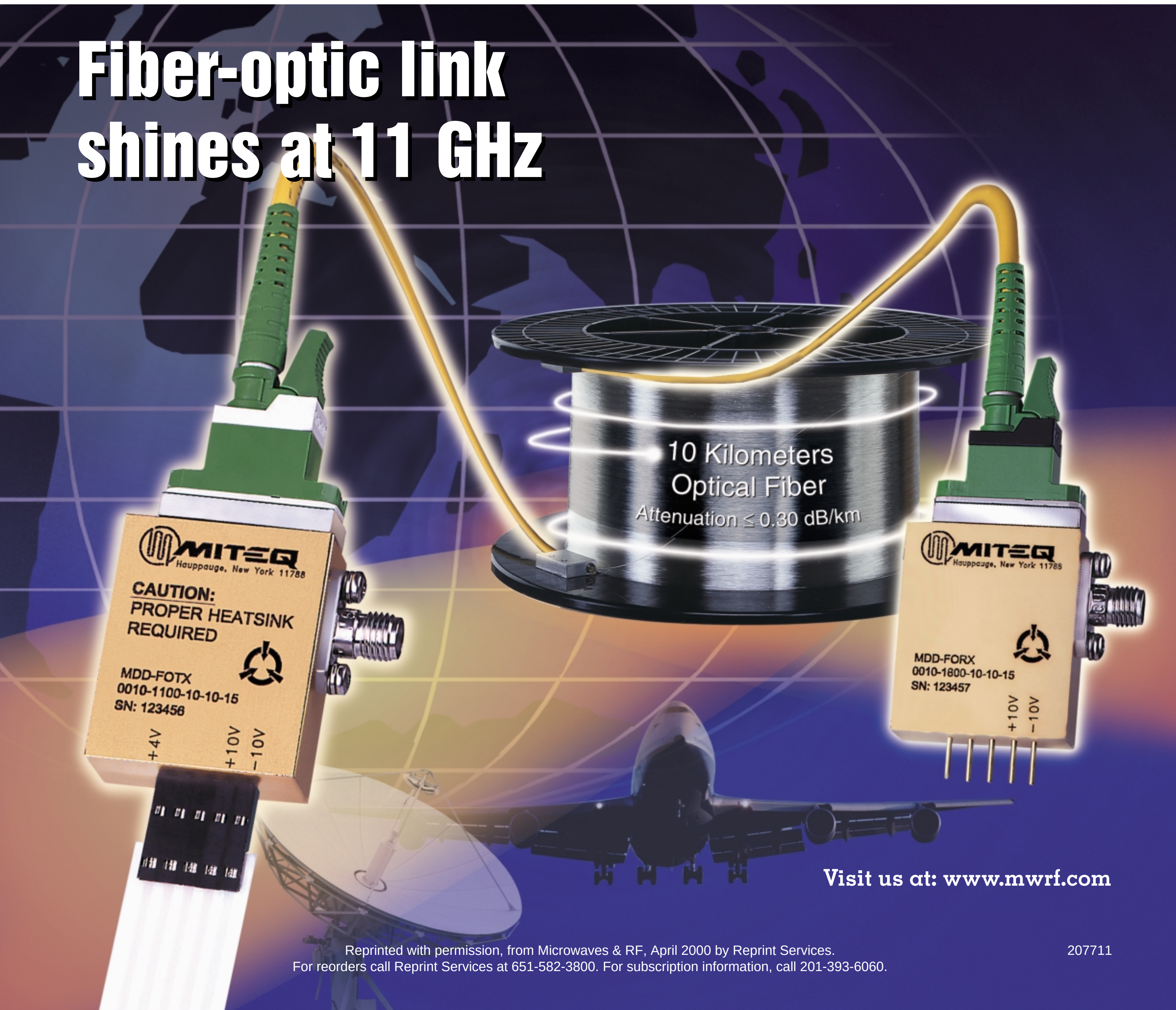

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Fiber-Optic Link Connects 10-GHz Signals

This self-contained, wide-bandwidth fiber-optic link actually delivers signal gain while maintaining low system noise figure.

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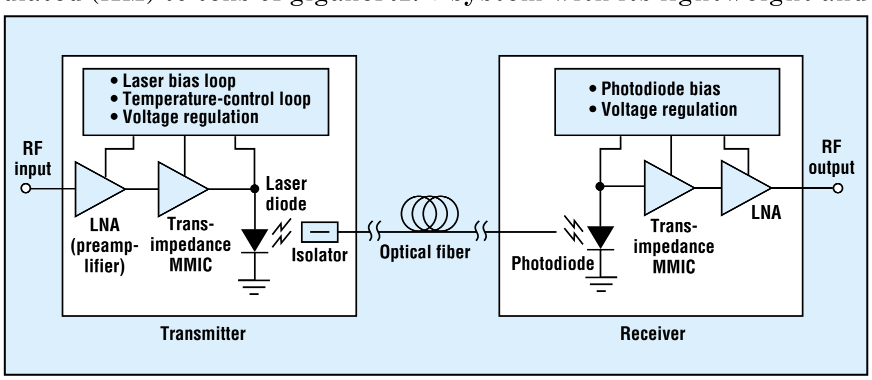
FIBER-OPTIC technology has improved steadily in recent years to where optical links are now viable replacements for coaxial lines even at bandwidths as wide as 10 GHz. The MDD series from MITEQ, Inc. (Hauppauge, NY) is such a family of high-speed, high-bandwidth links, offering a 3-dB bandwidth of 1 to 11 GHz with low noise figure and generous link gain over single-mode fiber-optic cables. The links feature 50-Ω input (I) and output (O) interfaces for ease of connection to RF and microwave systems.

System designers who need to transmit RF and microwave signals over a distance of more than a few hundred meters will appreciate the advantages that a fiber-optic link has to offer versus a conventional cable transmission. Typically, a single-mode optical fiber has less than 0.5-dB attenuation per kilometer and is capable of carrying light signals that are direct amplitude modulated (AM) to tens of gigahertz. Translating this into a specific application means that a system designer can capitalize on these attractive features and transmit a very large volume of data, voice, and video signals over a long distance without regeneration.

With the increased use of complex electronic systems on aircraft and ships where weight and space are at a premium, an optical-fiber system with its lightweight and small volume becomes even more attractive. An optical link offers several other advantages:

1. It is virtually immune to electromagnetic interference (EMI) and humidity, which are of paramount importance especially in the confines of a ship or an aircraft.
2. It is not very susceptible to interference from lightning.
3. It is a relatively secure transmission media.

A typical application for a fiber-optic link, which emphasizes the various advantages of fiber-optic communications, is in the use of a remote antenna. An antenna site may consist of several receiver antennas spaced some distance from the central station. Due to the relatively high loss of coaxial copper (Cu) cable, it is often necessary to construct an equipment bay station directly adjacent to an antenna, which is impractical in the case of multiple antennas. Low-noise amplifiers (LNAs), frequency downconverters, and other types of equipment in the bay station are required in order to process the signal so as to allow the user to operate in the presence of a high-loss coaxial cable. Assuming 3-dB attenuation per 30 m of cable for a polystyrene coaxial cable at C-band frequencies, even a 50-dB-gain LNA at the front end would lose its



1. The MDD fiber-optic links consist of direct-modulated receiver and transmitter modules with simple 50-Ω input and output connections.

THE LOW-NOISE AND LOW-TRANSMISSION-LOSS CHARACTERISTICS OF THE MDD SERIES OF FIBER-OPTIC LINKS MAKES IT WELL-SUITED FOR WIDE-BAND POINT-TO-POINT COMMUNICATIONS SYSTEMS.

effectiveness after a few hundred meters. With optical fiber, the attenuation and the attenuation slope (not to mention shifts in phase and group delay), which is quite evident in coaxial cable, is almost nonexistent. By performing an electrical-to-optical conversion close to the feed of the antenna, the signal can be transmitted a few kilometers over fiber without significant attenuation. This technique allows all signal-processing equipment to be located in a single facility that is virtually independent of its geographic location. Fiber-optic links also simplify the logistics of building a large earth station, which have multiple antennas that have to be well-separated in order to avoid side-lobe interference. Fiber-optic links are easy to install and are less expensive to maintain than their coaxial counterparts. Other typical applications may include phased-array antennas, delay lines, conformal antennas, and point-to-point links between facilities.

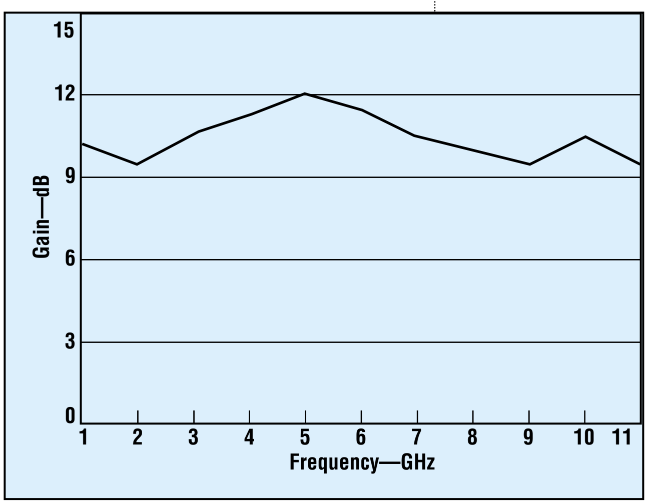
The MDD series of self-contained fiber-optic links from MITEQ is ideal for many of these broadband applications. They provide for RF-to-RF connections (Fig. 1) with a 3-dB bandwidth from 1 to 11 GHz (Fig. 2), noise figures as low as 15 dB (Fig. 3), and overall link gain of typically 10 dB. These features along with its small size and ability to be easily inserted into a system make this product an ideal replacement for its coax counterpart. The low-noise and low-transmission-loss characteristics of the MDD series make it well-suited for wideband point-to-point communication (Fig. 4).

The MDD link operates at a wavelength of 1550 nm with peak-to-peak group delay of only 0.1 ns for a 1-km link distance. The transmitter achieves optical output power of 4 to 9 mW with power-supply requirements of 270 mA at +10 VDC, 12 mA at −10 VDC, and 750 mA (maximum) at +4 VDC. The receiver portion of the link requires 150-mA current at +10 VDC and 10-mA current at −10 VDC. The link, which is designed for operating temperatures of −30 to +60°C, features a nominal output third-order intercept point (IP3) of +7 dBm at 4 GHz.

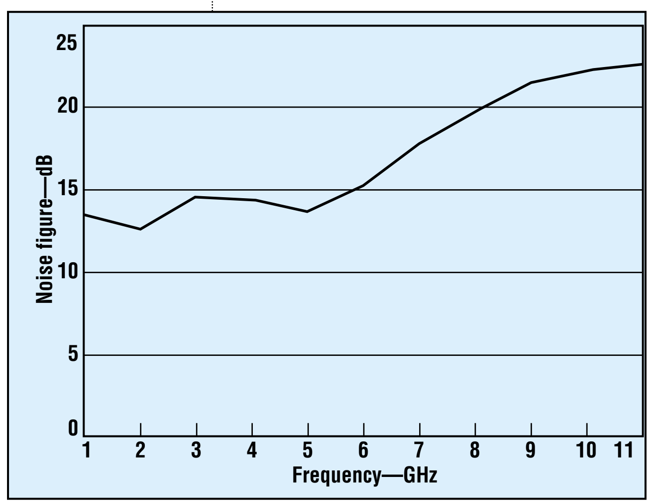
The link consists of a transmitter and a receiver assembly that employ direct AM. In this design, the bias current of the laser is modulated by the incoming microwave signal that, in turn, modulates the amplitude of the laser output. When compared to a system using an external modulator, the direct-modulation technique has lower cost and lower optical insertion loss.

Integrating MITEQ's wideband LNA technology into the optical transmitter, the firm's engineers have been able to achieve a significant improvement in the noise figure (see table) compared to similar types of products. In addition, the MDD series of transmitter/receiver modules can be specially configured to match specific applications (i.e., with lower noise figures, higher intercept points, etc.).

It should be noted that many direct-modulation fiber-optic links suffer from high insertion loss and limited dynamic range. This is in part due to the large impedance mismatch between the approximate 10-Ω impedance of a laser diode and the typical 50-Ω impedance of a microwave system. To improve the dynamic range of the link, a gallium-arsenide (GaAs) monolithic-microwave-integrated-circuit (MMIC) transimpedance amplifier was developed by Thomson-CSF Detexis (Paris, France) in order to optimally match the RF system with the laser diode.



2. The 3-dB bandwidth of the MDD fiber-optic links is 1 to 11 GHz.



3. The noise figure of the MDD fiber-optic links is 14 dB at 4 GHz.

The normally diverging optical output of the laser diode is first collimated to pass through an optical isolator and then focused into the fiber core. The optical alignment and connectorization of the modules is performed by Diamond S.A. using their E-2000 plug-in optical connector.

To make the MDD link easy to use, the modules have been designed to be self-contained. The transmitter module has built-in thermal stabilization using a thermoelectric cooler (TEC). This cooler maintains the laser diode at a constant temperature by using feedback from a thermistor that is on the laser carrier. Laser-diode thermal stabilization helps minimize laser wavelength drifting. A good heat sink is necessary for the transmitter module to allow the TEC to shunt the heat effectively.

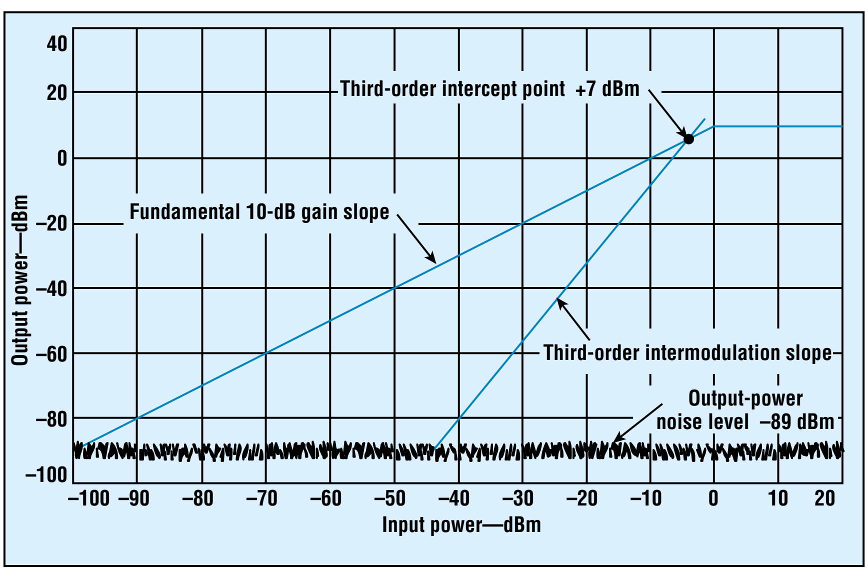
In addition, a second feedback loop in the control circuit senses the output of a photodiode that is located at the back facet of the laser to maintain the laser optical power at a constant level through the laser aging process. Both of the modules are provided with built-in regulators, reverse voltage polarity protection, and they are available in a hermetically sealed package.

The MDD fiber-optic link at a glance

Operating wavelength	1550 nm
3-dB bandwidth	10 GHz (1 to 11 GHz)
Input/output transfer characteristics	10 dB (nominal)
Noise figure	14 dB (nominal) at 4 GHz*
Output third-order intercept	7 dB (nominal) at 4 GHz**
Group delay (peak-to-peak)	0.1 ns (nominal)
Input VSWR	1.25:1 (nominal)
Output VSWR	1.25:1 (nominal)
Input/output impedance	50 Ω
Transmitter optical power	4 to 9 mW
Nominal DC power	Transmitter *** +10 VDC, 270 mA −10 VDC, 12 mA +4 VDC, 750 mA (maximum)
	Receiver +10 VDC, 150 mA −10 VDC, 10 mA
Optical input/output connectors	DIAMOND E-2000
RF input/output connectors	SMA female
Physical dimensions	1.43 × 2.47 × 0.48 in. (3.63 × 6.27 × 1.22 cm)
Operating temperature	−30 to +60°C
Storage temperature	−54 to +125°C

* Lower noise figure is available. ** Higher IP3 units are achievable.
*** Transmitter requires heat sinking.

Fiber-optic links are often associated with digital communications and fast data rates, although they are also powerful transmission media for analog communications systems. Analog fiber-optic links have traditionally been used in cable-television (CATV) systems to handle the transport of complex multichannel signals. More recently, these links are widely used within buildings and office campus environments to distribute cellular signals without the deleterious effects of phase distortion, signal loss, and EMI. Due to the minimal group delay of fiber-optic links (nominally 0.1 ns peak-to-peak for the MDD series) and low loss, in-building cellular signals carried by optical cables do not require the additional equalization and gain commonly used in coaxial lines.



4. The wide dynamic range of the MDD fiber-optic link derives from MITEQ's strong background in LNA design.

The link is designed for analog applications to 11 GHz. It offers all of the advantages of fiber-optic technology, with simple 50-Ω interfaces for ease of interconnection with existing microwave systems. **MITEQ, Inc., 100 Davids Dr., Hauppauge, NY 11788-2086; (631) 486-7400, FAX: (631) 436-7430, Internet: http://www.miteq.com.**