Fiber-optic power meters have become a workhorse for testing active and passive electro-optic components in engineering and production. Active components include light sources such as laser diodes, pumps, and amplifiers. Passive components include splitters, combiners, connectors, reconfigurable optical add-drop multiplexers (ROADMs), and the fiber itself. You can also use an FO power meter as part of a system to test optical receivers.

For absolute measurements, such as those made on a light source, you can configure an FO power meter for measurements in watts, milliwatts, or decibels referred to 1 mW (dBm). You can also get results in decibels for relative measurements, such as insertion-loss measurements on passive components.

FO power meters come in several configurations. They include stand-alone bench meters, modular systems (chassis and modules), and handheld units. Engineers use bench and modular instruments in the lab and in production, while technicians use handheld FO power meters for installation and maintenance. The online version of this article includes a detailed product chart of bench and modular instruments as well as links to technical resources, www.tmworld.com/2007_12.

Active power
Laser sources must provide light powerful enough to overcome losses in fibers, connectors, splitters, waveguides, and numerous other components. Engineers use power measurements to monitor the production process for semiconductor-based light sources such as laser diodes.

"You can use light-current-voltage (LIV) measurements to monitor processes from die to package and look for changes," said Thad Orosz, product manager at ILX Lightwave. Early detection of process problems can alert process engineers to problems before a device is packaged. You can perform power measurements using continuous-wave or pulsed signal sources (Ref. 1).

Figure 1 shows a typical test setup for measuring power from a light source. In this setup, an FO power meter measures a light source's output power directly, although you can use an optical switch for testing multiple light sources with one meter.

Figure 2 shows a more complex system that tests multiple FO transponders (transmitter/receiver pairs). It combines two FO power meters with other instruments, optical switches, attenuators, and splitters. The optical amplifier (OA) and attenuators vary the optical power and noise, and the fiber spool attenuates and...
adds dispersion to the signal before it reaches the receiver. The test system measures bit-error rate (BER) while it monitors the optical power with the meters and monitors the eye diagrams with an oscilloscope.

**Passive light**

Many engineers use FO power meters to make measurements on passive components such as connectors, splitters, couplers, switches, filters, waveguides, and ROADMs. Insertion loss (IL) is the most common measurement. Other measurements include isolation, wavelength-dependent loss (WDL), and polarization-dependent loss (PDL).

An IL test is simple. You measure optical power from a calibrated light source such as a tunable laser without the device under test (DUT) in the circuit, then you insert the DUT and measure power again. Then, the FO power meter can calculate the difference and report it in decibels with the equation below.

\[ \text{IL} = 10 \times \log \left( \frac{P_{in}}{P_{out}} \right) \]

WDL is essentially IL measured across a span of wavelengths. You can perform a WDL measurement on any component, but it’s a critical measurement for optical filters and ROADMs, which are designed to filter light based on wavelength. A ROADM, for example, is essentially a tunable notch filter that can drop a specific wavelength from a wavelength-division multiplexed (WDM) signal.

**Lighted connections**

Regardless of whether you measure optical power in active or passive components, you need to connect your DUT to an FO power meter. Connecting a light source to an FO power meter (whether or not through an optical switch) is called direct coupling. In this case, the fiber carrying light from the DUT goes directly into the power meter or power-meter head and is held in place by a connector (Figure 3). Many types of connectors are in use today, so make sure your FO power meter or its optical head will accept the connector you use.

For high-power measurements, typically over 100 mW (20 dBm), you can use an integrating sphere to collect the input light and integrate it into a uniform intensity. A photodetector built into the sphere collects a small portion of the light for measurement in the form of a small electrical current.

An integrating sphere has a highly reflective inner surface to reflect the incoming light, producing uniform light intensity. A detector, mounted on the sphere, contains a photodiode. Typically, integrating spheres are external to an FO power meter, but some manufacturers embed the sphere in the instrument.

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Product-comparison chart: **FIBER-OPTIC POWER METERS**

The online version of this article links to a chart of currently available FO power meters in modular, bench, and mainframe formats. Compiled by our editors, the chart lists manufacturers and model numbers and highlights key features such as wavelength, power range, sensor type, and uncertainty for each instrument.

**RESOURCES**

The online version of this article also links to additional sources of information about FO power meters and their applications. Included are articles from Test & Measurement World as well as online application notes.

www.tmworld.com/2007_12
Other sources of measurement error include temperature, WDL, spectral ripple, and noise. Agilent’s Kelly explained that spectral ripple occurs from reflected light that returns to a fiber or its cladding, which can add or subtract from incident light. Noise is also an error source at low power levels, and FO power meters must measure the “dark” current of a light detector.

Calibration tool
Telecom test sets and telecom equipment such as switches, amplifiers, and attenuators often contain embedded power meters that require calibration. “Many FO attenuators, amplifiers, and switches monitor their own output power,” said Matthew Adams, product line manager for JDSU’s test and measurement business. “Embedded power meters require calibration.”

For example, Polatis manufactures optical switches that have embedded attenuators and power meters letting the user set the switching path and output power (Ref 2). The company uses reference FO power meters to calibrate the embedded power meters.

Daniel Shi, a staff test engineer at Coherent, uses power meters to calibrate production-test stations for diode lasers. The test stations use integrating spheres with photodiodes to convert light into current. A data-acquisition card digitizes the current, and a computer displays the measurements. Shi calibrates the system by comparing the station’s reading to that of known-good power meters. He then enters calibration constants into the production systems prior to use.

Single-unit and modular FO power meters appear on many engineering benches and in production test systems. They measure the optical output power of active components and they perform relative measurements such as IL. They’re also used to calculate other parameters such as BER as a function of signal power. T&MW

REFERENCES