

Lowering the Cost of Optical Power Measurements



Introduction

Over the last few years, the demand for optical networks has exploded. An increasing number of communications manufacturers are designing products to capitalize on the high bandwidth and smaller size of fiber-optic components over their copper counterparts. In fact, many industry experts project that the optical network component industry will grow at 40 percent for the next three years. This growing opportunity has optical component manufacturers elated with the demand. At the same time, they are searching for faster, more cost-effective ways to automate the manufacturing process.

Generally, companies must verify and calibrate optical components for manufacturing, quality assurance, research, production test, etc. Although the types of tests vary depending on the components being manufactured, optical power measurement is common across all optical devices and procedures.

Optical Power Measurements

Optical power measurement is one of the most common measurement in the optical network component industry. There are several optical power sensors that convert light to an electrical signal, the most common of which uses photodiodes that output current. This low-level current passes through a transimpedance amplifier that applies a gain and converts the signal to voltage. Sensors on the market are tailored to general and specific applications depending on their specifications, materials, and design. The main factors to consider when selecting a sensor are detectable wavelength (nm), power range (W), measurable area (sq in.), and response (rise) time. If an optical sensor that meets your application criteria cannot be located, you can simply choose from the thousands of baseline detector devices such as photodiodes and phototransistors, and use an appropriate amplifier to create a conditioned signal readable by a plug-in data acquisition (DAQ) board or oscilloscope. Figure 1 shows a typical photodetector response curve.

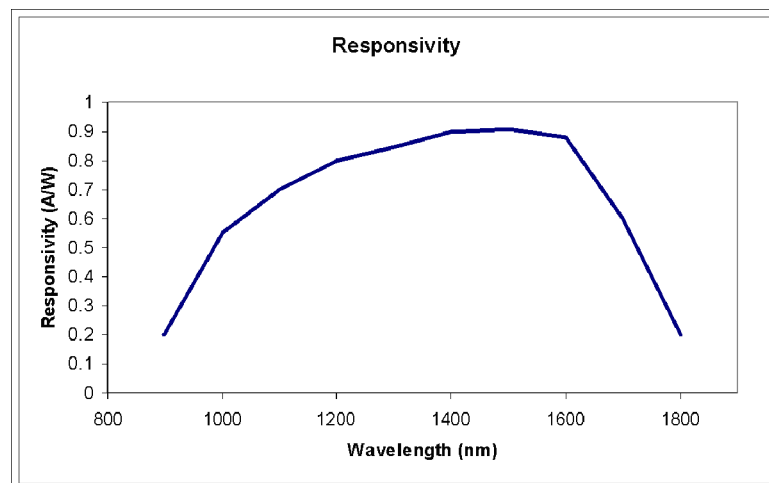


Figure 1. Example of a Typical Infrared (IR) Photodetector Response

A data acquisition system or a voltmeter reads the voltage returned by the sensor and converts it to an optical power response. Figure 2 illustrates a typical computer-based optical power measurement system. Both the voltage reading and the energy response are sensor dependent and often depend on the wavelength being analyzed. The measures of power are generally expressed in watts (W) or decibels re milliwatt (dBm), while test application values, such as insertion loss, are measured in decibels (dB).

Measuring the optical loss or insertion loss of an optical component is a very common test. In such a test, the device under test (DUT) is placed in between a light source and an optical power meter. The source emits a signal into the DUT. Examples of sources include tunable lasers from New Focus (newfocus.com) and continuous-wave lasers from Exfo (exfo.com). These sources are generally specialized devices to output signals with wavelengths in the optical transport bands. The power meter measures the intensity of the light as it enters and exits the DUT. By measuring the light both before and after the DUT, the amount of power loss inside the DUT is calculated.

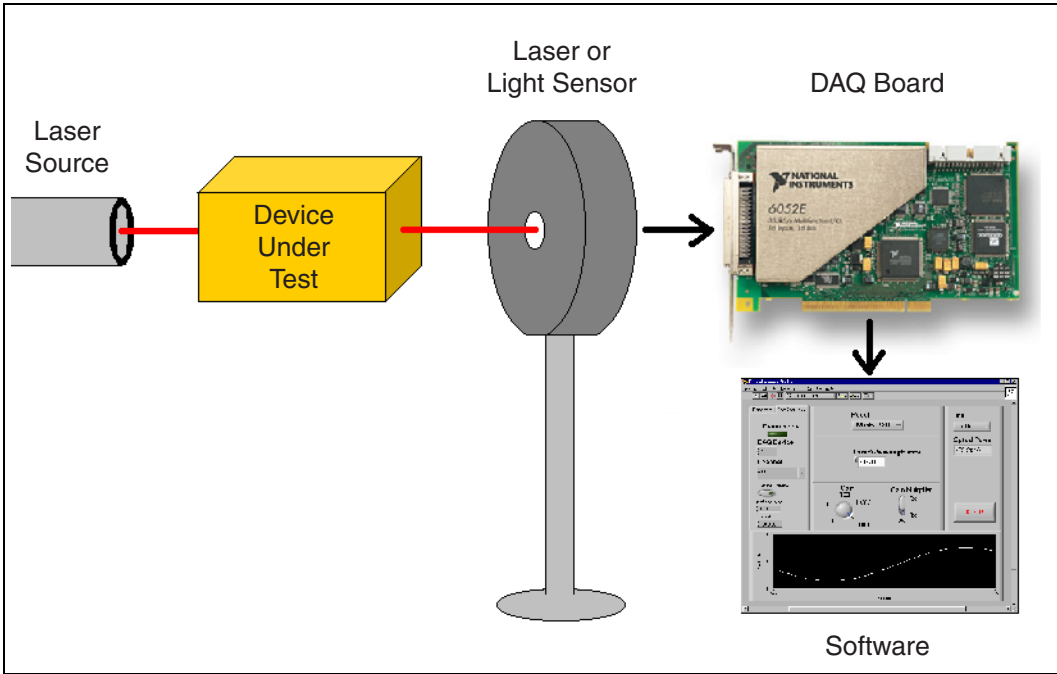


Figure 2. PC-Based Optical Power Measurement System Using a DAQ Plug-In Board and LabVIEW

Optical Power Meter versus DAQ Board

The optical power meter (OPM), the instrument traditionally used to measure optical power, is a stand-alone device with one or two input channels. OPMs convert a sensor input to a power response based on the sensor response table. A computer-based system using a plug-in DAQ board can digitize the signal from an optical sensor and perform the same optical power measurements with lower cost, faster performance, better flexibility, and easier system integration. In addition, a 16-bit DAQ board is accurate to within less than 0.008 percent – three orders of magnitude better than the average sensor.

Price

In Figure 3, we compare the price per channel of three systems:

1. A stack of four 2-channel optical power meters with eight sensors and one GPIB controller board with four GPIB cables
2. One system with one optical power meter module with one sensor, and one 8-channel optical switch module in a control box.
3. One National Instruments PCI-6052E high-resolution DAQ board with eight optical sensors, BNC terminal block, and cable.

It is clear from Figure 3 that the DAQ system is the least expensive of the three configurations. When using all eight channels, the DAQ system costs approximately \$10,000, which is about half the cost of a stack of optical power meters and about \$2,000 less expensive than the optical switch configuration.

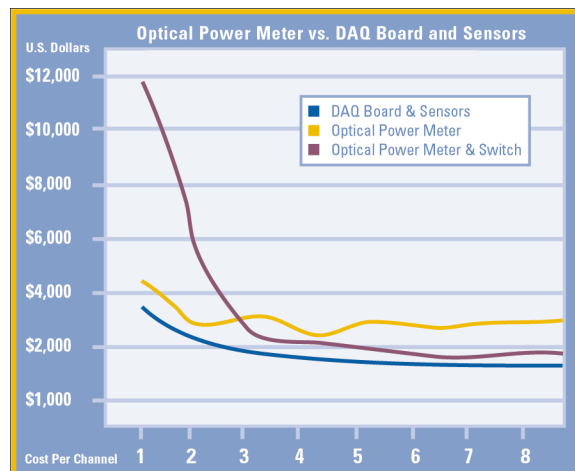


Figure 3. Price Comparison of Optical Power Measurement Systems Using Stand-Alone Optical Instruments versus a Plug-In DAQ Board

Performance

By implementing a DAQ system with an optical sensor, you can measure and test your units in a fraction of the time needed by stand-alone GPIB instruments or optical switches. Some switches take 180 ms to route a signal. In that time, the PCI-6052E can make 7492 optical measurements (provided you have a fast enough optical sensor). Another benefit of NI hardware is the RTSI Bus, which directly connects DAQ, Vision, and Motion boards for precise synchronization of functions. With RTSI Bus, the boards can use the same clock, and triggers. Measurements, movements, and pictures are synchronized every time they are taken.

Flexibility

In addition to providing improved performance, the DAQ system is flexible and easy to update. The DAQ board reads voltages and converts the voltage readings to power values through software. Therefore, it is compatible with a variety of photodetectors from many vendors within the voltage range of operation of the DAQ board. It requires only the calibration factor of the sensor to translate the signal to real power values. With simple software changes, you have a wider choice of sensors. In addition, you can also use the same DAQ board to measure other signals such as thermocouple signals, waveforms, and circuitry responses. For example, you can set up the eight channels on the PCI-6052E to read any combination of these signals. Moreover, it provides two analog output channels to output waveforms or control voltages, eight bidirectional digital lines to turn on/off equipment, and two general-purpose counter/timers to generate TTL pulses or measure time precisely. More importantly, when used in a production environment, these PC-based systems can be adapted and modified as the process model changes.

Integration

By using an integrated platform, you can easily use DAQ, motion control, GPIB, serial, and image acquisition components from NI. You can take advantage of programming examples in LabVIEW, Measurement Studio, and TestStand. One example application is optical components precision alignment. With a PC-based system, you can obtain up to 40 times faster alignment yet require much less bench space. You can synchronize optical power measurements, control motion axes, and analyze video inputs to achieve the best hardware performance. Using an integrated platform, you can decrease development time, perform faster measurements, increase throughput, and maintain a smaller support staff.

Calibration

You can calibrate optical power measurement systems based on plug-in DAQ boards and optical sensors to provide values traceable to National Institute of Standards and Technology (NIST). Many plug-in measurement products are shipped with a certificate of conformance and calibration, which give you the documentation you need to satisfy your ISO-9000 requirements and provide traceability to NIST. A photodetector calibration curve would relate the response level to the wavelength. Calibrated optical sensors have uncertainties that can be used with the calibrated specifications of the DAQ boards to calculate the total uncertainty of the system.

Hardware Components

The following table presents a list of hardware used in an optical power measurement. Use this guide to help you locate components for your system.

Device	Company	Model
DAQ Board	National Instruments	PCI-6052E
Cable	National Instruments	SH68-68-EP
Terminal Block	National Instruments	BNC-2120
Light/Laser Sensor	New Focus	2001

DAQ Board

Many National Instruments multifunction DAQ devices can be used to make these power measurements. National Instruments delivers accurate measurements, high resolution, long reliability, and minimum noise. For example, the PCI-6052E is a high-channel-count, high-accuracy (16 bits), and high-speed (333,000 samples/s) DAQ device. The 6052E directly connects with the BNC-2120 to provide eight BNC analog input channels, which is ideal because BNC cables are used for most photo receivers.

Laser Sensors

Many vendors make light sensors suited for different wavelengths of light. Examples of sensors include visible and infrared photodetectors from New Focus (newfocus.com), Thorlabs (thorlabs.com) and Thermo Oriel (oriel.com). In the example described below, the sensor is New Focus model 2001, which performs visible light measurements (400 to 1060 nm). It has a power range of 1 μW to 10 mW, and uses standard coaxial connection. The sensors can also be calibrated using the standard DAQ calibration tools in LabVIEW.

Software Components

LabVIEW is used extensively for research and development, manufacturing, production, and testing of optical components. NI developed applications free of charge to measure optical power and power loss (see explanation below). The following examples were designed to read one and two sensors, respectively. However, they can read several sensors with simple modifications.

LabVIEW

With LabVIEW, you can drive optical power measurements. LabVIEW is a powerful package that integrates readily with buses such as GPIB and serial RS-232/485 and also equips the user with the power of Excel, SQL, and the Internet. LabVIEW has statistical analysis such as average, max/min value, standard deviations, data chart, data trend, curve fitting, data logging to disk, and database.

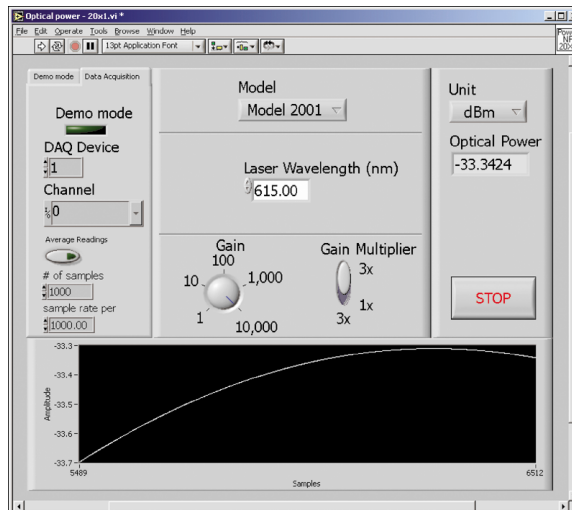


Figure 4. LabVIEW Front Panel for an Optical Power Measurement Application

An example LabVIEW optical power measurement front panel is shown in Figure 4. You can download this example from ni.com/telecom/ and select Opto Electronics. This example is divided in three sections – acquiring the sensor data, converting voltage to power, and presenting the results, as in Figure 5.

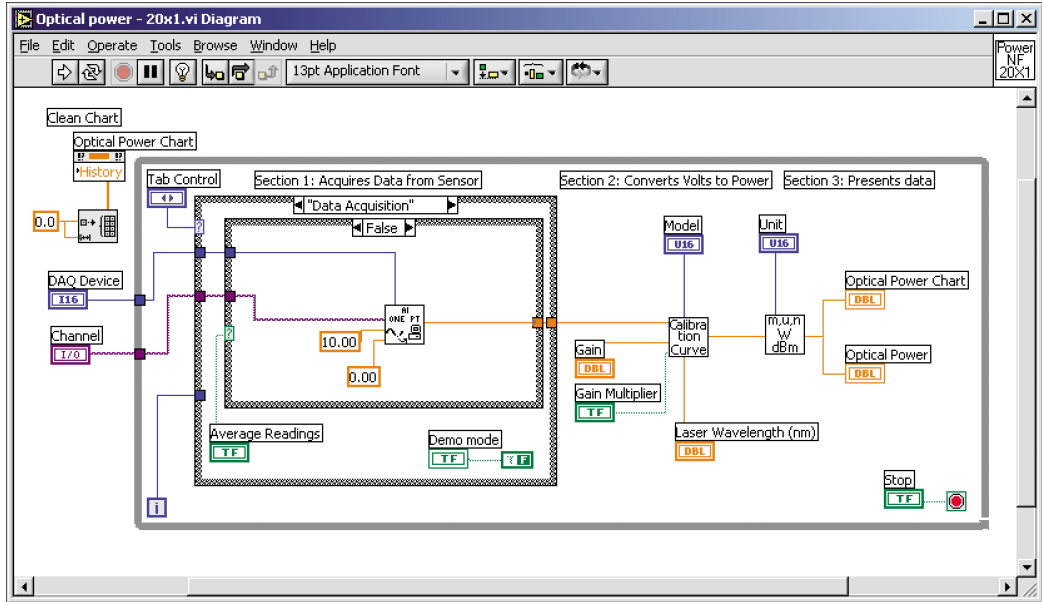


Figure 5. Example LabVIEW Block Diagram for an Optical Power Measurement Application



In Section 1, the VI acquires the voltage data from the sensor using a data acquisition function – AI sample channel.vi. This function reads the data from the sensor. You may also select an option to average the input to improve accuracy. The example can run without a DAQ board or any hardware in “Demo Mode.” In which users may select an average voltage and the deviation for the simulated input.



The Calibration Curve VI, in Section 2, converts the voltage acquired in Section 1 to a power value. The user selects gains, wavelength, and model of the sensor. With the sensor setups, the conversion VI converts the voltage to an optical power value in watts.



Section 3 presents the values read on the optical power display. A selection of units is available (W, mW, μ W, nW, pW, and dBm). The example also has a historical chart that helps the user to identify trends and compare data.

Power Loss Example Application

NI also developed a LabVIEW example for optical power loss. Using this example, you can compare the optical power of two sensors. The example follows the same structure of the optical power measurement example with three sections – acquiring the sensor data, converting voltage to power, and presenting the results.

The two main differences are in the sections for acquiring data and presenting the results. On the acquiring data section, two channels of data are measured from two sensors instead of only one sensor in the optical power example. In addition, the result displayed is the difference between the two measurements representing the power loss from one sensor compared to the other sensor.

Conclusion

As the demand for optical components continues to soar, optimizing design validation and manufacturing test of these components is crucial. Using open standard PC-based systems is not only an economical solution but also a tool that can be used to save manufacturing space, reduce development time, increase manufacturing speed, and enhance hardware integration. Synchronizing production hardware for optical power measurements, motion control, vision, and test brings improved performance to the measurement and automation world. In addition, impressive cost savings and performance enhancements are realized.

National Instruments provides hardware and software tools that capitalize on computer technologies to create high performance measurement and automation systems. Using advanced plug-in DAQ boards in combination with high-speed photodetectors and transimpedance amplifiers, you can realize fast, accurate optical power measurements. Large optoelectronics companies have announced 10 to 15-fold improvements in production cycles achieved using National Instruments plug-in DAQ boards as well as synchronized motion and vision boards. (See December 2000 press release, *Fiber-Optic Manufacturers Realize Up To 10X Performance Gains Using National Instruments Software and Hardware*.) By using an open industry standard, such as PXI or CompactPCI, you can build a flexible and scalable solution for optical power measurement, component alignments, and production test.



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