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Novel Power Meter Design Minimized Fiber Power Measurement Inaccuracies

APPLICATION NOTE

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Novel Power Meter Design Minimizes Fiber Power Measurement Inaccuracies

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Patented integrating cavity design minimizes variability in fiber power measurements caused by fiber positioning, connector orientation and polarization.

Introduction

Manufacturers of fiber optic components like multiplexers, attenuators, and amplifiers must characterize their products for parameters such as insertion loss and polarization-dependent loss. Insertion loss is usually accomplished by measuring output power variations before and after the component has been connected to a laser source. Polarization-dependent loss is measured by varying the input polarization to the device and measuring the variation in power as the polarization vector is swept through all possible angles. The accuracy of these measurements may be compromised by the power meter used because the meter itself may be sensitive to these types of variations. This is because most power meters are sensitive to changes in polarization as well as uniformity of illumination of the detector surface and position of the fiber end with respect to the detector. In practice, integrating spheres are used to reduce these sensitivities. A new integrating sphere design was developed by ILX Lightwave to reduce the polarization dependent response of their power meter as well as to desensitize the meter to fiber positioning variations. These changes were welcomed by key component manufacturers within the telecom industry and resulted in the awarding of US patent #6,810,161 for the design.

An integrating sphere is a spherical chamber whose inner surface has a very high, spectrally flat, diffuse reflectivity. Light that is input into the chamber through a small opening is reflected multiple times. Because the interior surface has a high diffuse reflectivity, the light is not specularly reflected as would happen with a mirror. Instead, it is reflected multiple times in a continuum of angles lambertian in shape at each bounce. This leads to very strong randomization of the light propagation vector within the chamber which results in extremely uniform illumination as well as a highly randomized polarization state. In a perfect integrating sphere, an output port maybe placed almost anywhere on the chamber and the percentage of light output through the port will be a constant percentage of the light input, regardless (within reason) of launch angle into the chamber or divergence of the input.

The largest problem with integrating spheres is the potential for a light ray to propagate directly from the input port to the output port without being reflected at least twice. In other words, any specular reflections that are incident on the output port increase the sensitivity of the sphere to input launch conditions. This problem is overcome through the addition of a second integrating sphere. By employing a second cavity as well as off-axis input and output ports, multiple reflections and uniform mixing of the reflections leads to increased uniformity of the light that is incident on the photodetector.

As can be seen in Figure 1 from the patent, the integrating chambers are not the same size. By varying both the shape and the size, the coupling efficiency between input and output ports can be optimized or configured for a specific result. In this case, reducing the size of the second cavity reduces the losses due to transmission from the first cavity to the second.

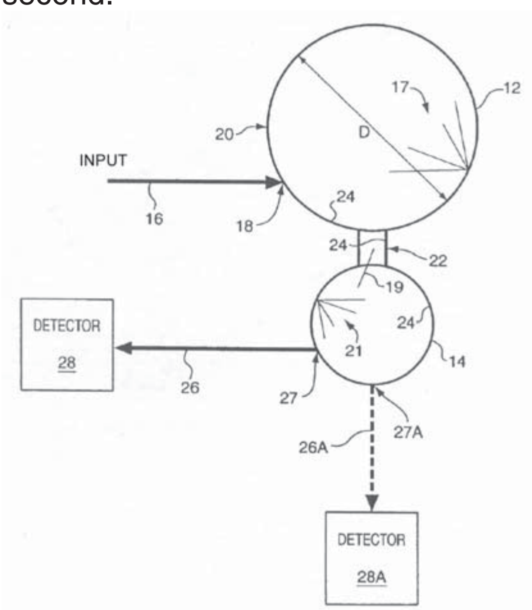

Figure 1

Optical fiber outputs typically have divergences measured on the order of degrees. Capturing all of this light for an accurate power measurement is not possible without careful attention to alignment of the fiber with respect to the photodetector or by using an integrating sphere with an imbedded detector. In direct detector measurements with careful alignment of the fiber to the detector surface, accurate power measurements are possible but at the expense of very strong polarization sensitivity. When using integrating spheres, varying the size of the input sphere allows different maximum divergences to be accommodated. In the design presented, all common single mode and multimode fibers are supported.

Because of the mixing of multiple reflections in both spheres, variations in power measurement due to fiber placement are minimized. This means the repeatability of the measurement has increased as well. Since there is no path for a light ray to pass from input port to output port without at least two reflections, variation in measurements due to polarization state is also reduced.

Since multiple detectors may be mounted to the second chamber, polarization dependency may be further reduced or, with the addition of filters before the detectors, a simple method to measure wavelength is possible.

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 Rev01.050103