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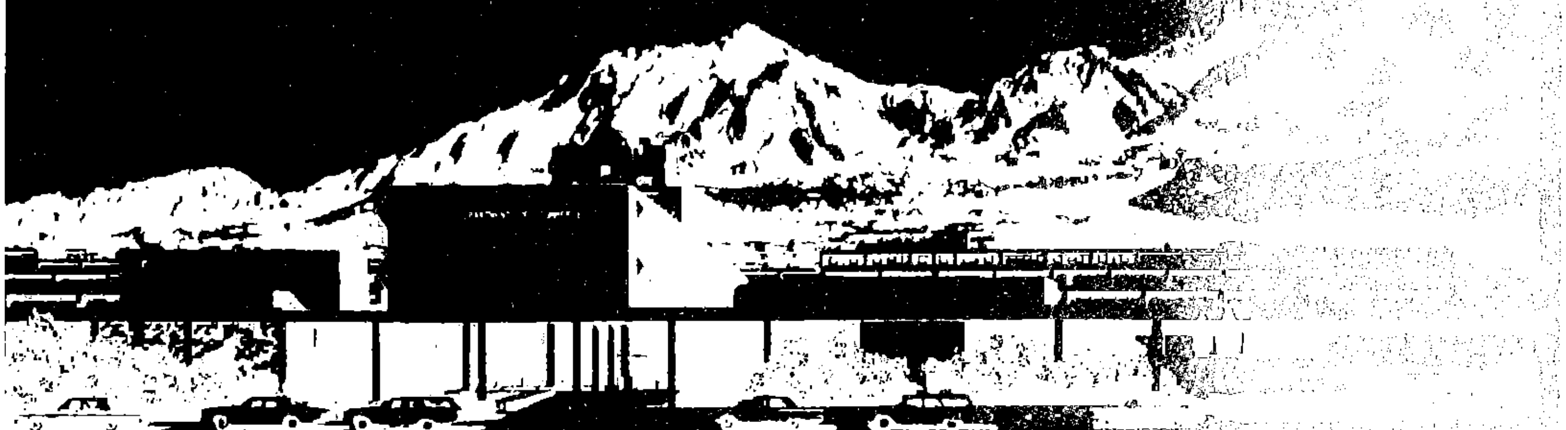

Errors due to connectors in optical fiber power meters

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Abstract

We discuss results of a major potential error source in the use of optical fiber power meters: outputs can vary dramatically when using various types of connectors or even connectors of the same type but from different vendors. We investigate the magnitude of this connector-induced variation by calibrating several types of optical fiber power meters at three telecommunications wavelengths of 850, 1310, and 1550 nm. In these measurements we vary the connector type and connector vendor, and observe the resulting offsets in calibration results. Observed variations of as much as 10% were found, due, presumably, to the different reflection properties of the detectors, windows, and connectors involved. A test meter user, therefore, can expect an error as large as 10% if the optical fiber power meter is used with a different connector (or vendor) than that used for calibration.

1. Introduction

When optical fiber power is measured, radiation is transmitted to an optical fiber power meter through a fiber attached to a detector by a fiber connector and adapter. The proximity of a fiber connector to a detector and its associated window provide an opportunity for reflections to introduce errors in the power readings.[1,2] Even though the measurements using connectors are generally repeatable, the connectors can skew the measurements results. To investigate this issue we conducted a study involving the calibration of optical fiber power meters using various types of connectors. We selected six common connector types: FC/PC, FC/APC, ST, biconic, SC, and SMA from four vendors chosen randomly (the vendors are identified by letters A through D). Calibrations were performed on four types of power meters (the meters are identified by numbers 1 through 4) at three telecommunications wavelengths: 850, 1310, and 1550 nm.

2. Measurement system

The system depicted in Figure 1 was used to perform the calibrations. As a reference we used a commercially available, electrically calibrated pyroelectric radiometer (ECPR).[3] The detector is approximately 8 mm in diameter and has very low reflectance over the wavelength range. The pyroelectric sensor is made of lithium tantalate and is covered with a gold-black coating.

The calibration system contains three laser sources and a positioning stage for comparing the outputs of the ECPR and the test meter. All the optical fibers in the system are single-mode. Each laser source plate contains a laser diode whose output is transmitted through a fiber to a fiber splitter from which about 1% of the energy travels through a fiber to a monitor. Power changes (for example, due to diode laser instability) are taken into account by the monitor readings. The fiber jumper cables are stationary during the calibrations. Power is coupled directly into the pyroelectric detector or the test meter. The incident power was about 100 μW.

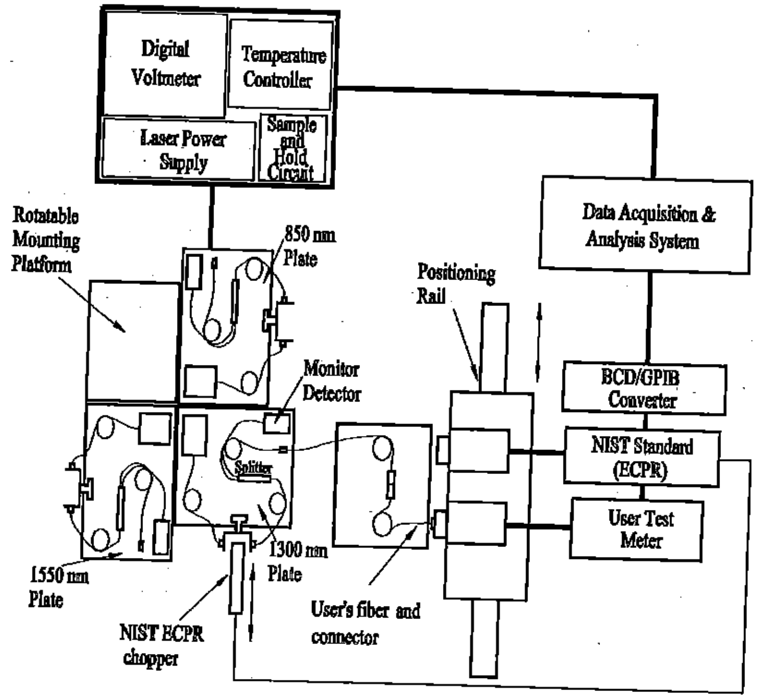

Figure 1. The measurement system.

Table I. Connector study variables.

Connector Types: FC/PC, FC/APC, ST, biconic, SC, and SMA
Connector Vendors: A-D
Wavelength: 853, 1307, and 1549 nm
Meter/Detector Type: Meter 1 (Si & Ge remote sensors; angled), Meter 2 (InGaAs fiber-pigtailed sensor), Meter 3 (Ge sensor with window; not angled), and Meter 4 (windowless Ge sensor; not angled).

3. Results

The measurement variables are given in Table I; the results are reported in the form of Figures 1-8. Due to the format of this paper, we included only a few of the measurement results. We performed 5 data runs for each measurement; the data show that the repeatability of measurements performed with a specific connector is reliable. The connector's offset is consistent. Figures 1-4 depict the results for four power meters and six connectors referenced to an FC/PC connector for vendor C. The largest differences occurred for the germanium power meter with a window (the sensor was not angled). Placing a sensor at a small angle will decrease the reflection between the sensor, the sensor window, and the connector. The observed differences were more than 10%. Figures 5-8 depict the results for four power meters and four connector vendors referenced to ST connector for vendor A. Again, the largest differences (8%) were observed for the germanium power meter with a window. Vendor B's connectors caused a greater offset than that caused by connectors of all other vendors.

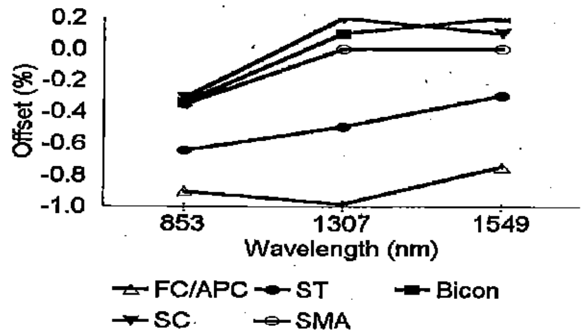

Figure 2. Si & Ge power meter (angled); referenced to FC/PC for vendor C.

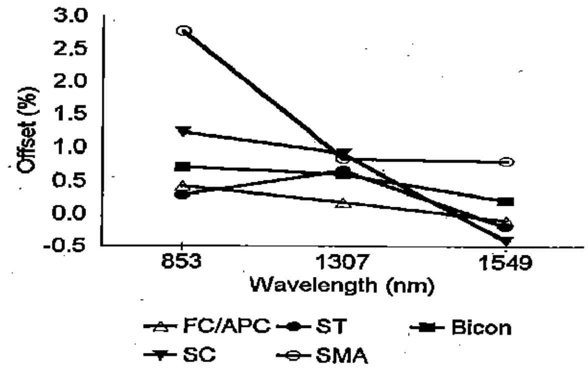

Figure 3. InGaAs power meter (fiber-pigtailed); referenced to FC/PC for vendor C.

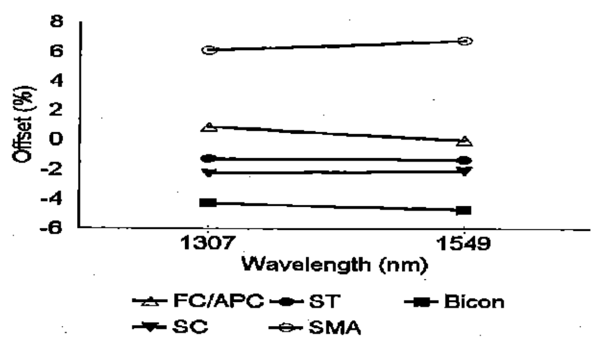

Figure 4. Ge power meter with window (not angled); referenced to FC/PC for vendor C.

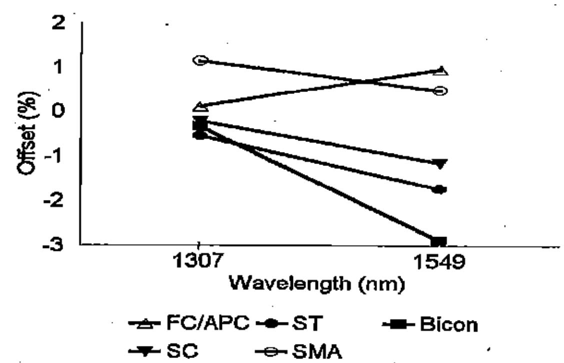

Figure 5. Ge power meter without window (not angled); referenced to FC/PC for vendor C.

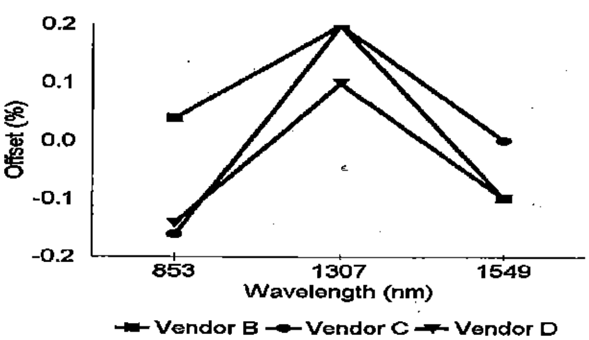

Figure 6. Si & Ge power meter (angled); referenced to ST for vendor A.

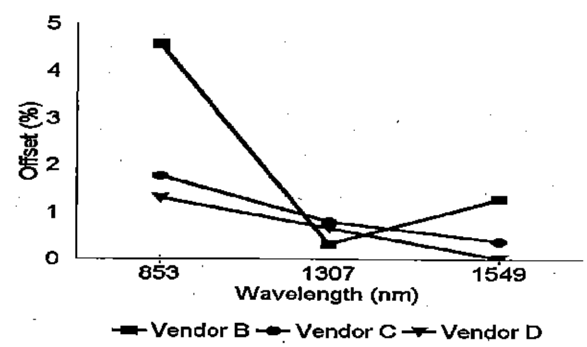

Figure 7. InGaAs power meter (fiber-pigtailed); referenced to ST for vendor A.

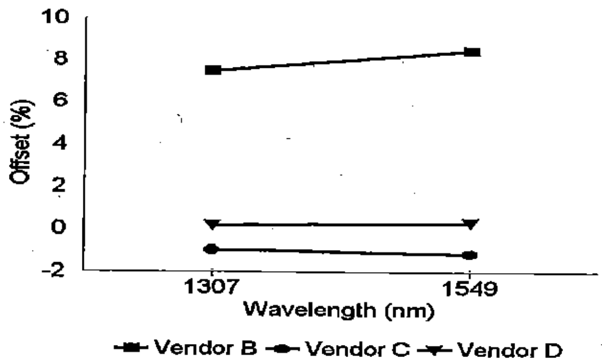

Figure 8. Ge power meter with window (not angled); referenced to ST for vendor A.

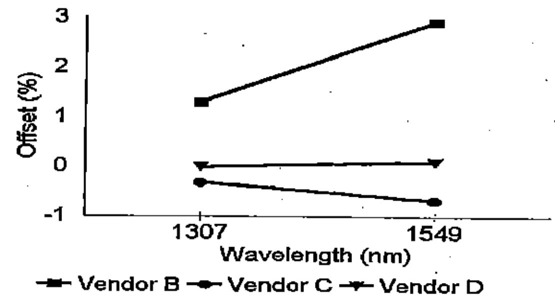

Figure 9. Ge power meter without window (not angled); referenced to ST for vendor A.

4. Conclusions

We found significant measurement offsets resulting from the use of various connectors and a variability within a single connector type obtained from different vendors. Thus, errors could likely occur when changing types of connectors or connector vendors on fibers connected to optical fiber power meters. For accurate measurements during the calibration of the instrument, we suggest that the meter owner should be aware of the connector's effects. A transfer standard, whose output is insensitive to the connector types, is a useful tool when determining effects due to various connectors. The connector adapter used with the connector is an integral part of the measurement.

The magnitude of the errors is wavelength-dependent. The offset is small if a connector does not have a reflecting surface or a power meter sensor is angled. A connector with a reflecting surface will cause the meter to read incorrectly, usually higher. It is very important to calibrate an optical fiber power meter with the same type of a connector used in the actual measurement.

Acknowledgments

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3. R.J. Phelan, Jr. and A.R. Cook, "Electrically Calibrated Pyroelectric Optical-Radiation Detector," Applied Optics, Vol. 12, p. 2494, October 1973.