Measurement of Large DC Currents with an Optical Magnetometer

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Introduction

Tai-Yang Research Company, as part of a U.S. Department of Energy SBIR project, tested an Optical Magnetometer (OM) at the National High Magnetic Field Laboratory. The original purpose of the OM was to measure the integrated field along a curve in space. The integral of B * dl is useful for large dipole and quadrupole magnets which are used in particle accelerators. One alternative application of the OM is indirect measurement of electrical current by detection of the ambient magnetic field present near the conductor. If magnetic field can be measured in a loop around a conductor, then electrical current can theoretically be determined by a linear scaling factor. The OM is based on the Faraday effect, whereby polarized light experiences an angle rotation proportional to the magnetic field intensity, the distance traveled, and the Verdet constant of the media through which the light travels. The Verdet coefficient is an optical constant specific to a particular material. In this case, the material is a special electro-optic glass manufactured by Hoya Optics.

Experimental

The large DC current facility at the NHMFL was used to supply currents to a dummy load. As current was increased from 500 Amps up to 18,000 Amps the magnetic field surrounding a section of water-cooled conductor was measured using the optical magnetometer.

Results and Discussion

One of two OM systems (The Hinds Instruments based polarimeter) showed a linear relationship between the polarization angle rotation and current, which was expected. See Fig. 1.

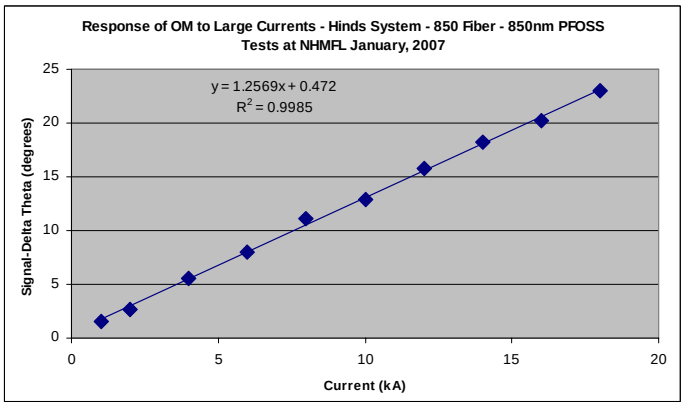

Figure 1. Response of Optical Magnetometer to Increasing DC Current.

Conclusions

Using an 850nm laser source produced better sensitivity than the standard 1550nm source; however the signal-to-noise ratio was much lower. This lower signal-to-noise ratio hampers the use of the OM for inexpensive current measurements, but shows that an optical current measurement system is feasible.

Acknowledgements

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