Optical Current Detector using Faraday Rotation in a Terbium Gallium Garnet Crystal

Chance Ornelas-Skarin, Justin Lee, Sam Vargas, Mindy Saylors, Ozdal Boyraz

Department of Electrical Engineering, University of California, Irvine

Introduction

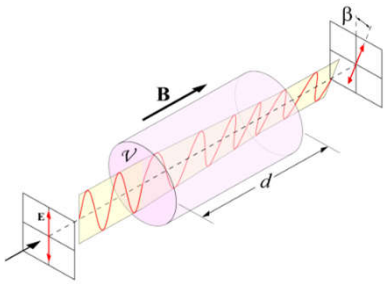

Figure 1: Visualization of Faraday Effect [1].

- Current transformers are used to detect current through a power line. However, they are both expensive and tax the system performance.
- Optical Current Detectors use the magnetic field of a wire to detect current, and does not heavily tax the system.
- The modularity of Optical Current Detector and its affordability makes this alternative solution to calculating current much more lucrative.

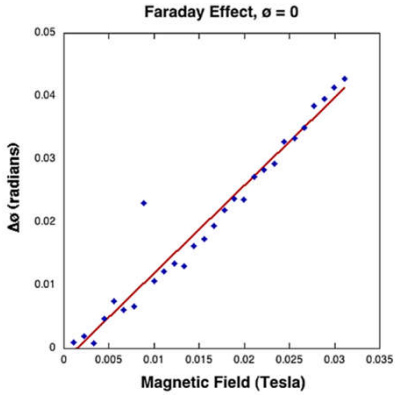

Figure 2. The relation between magnetic field and angle of rotation when polarizers are 45º to each other [1].

Research Plan

Phase 1: Getting voltage/polarization readings for one pass through the crystal. The crystal is placed next to a wire and a laser goes through the crystal once. The voltage measurements are recorded.

Phase 2: Sending the voltage signal through an FPGA to digitize the signal.

Phase 3: Getting voltage/polarization readings for one hundred passes through the crystal

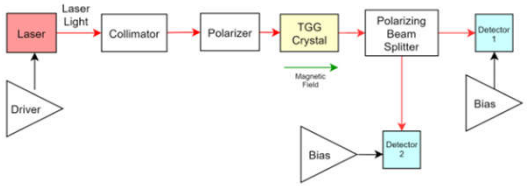

Figure 7: Diagram of the setup used for the first pass of light.

Methods

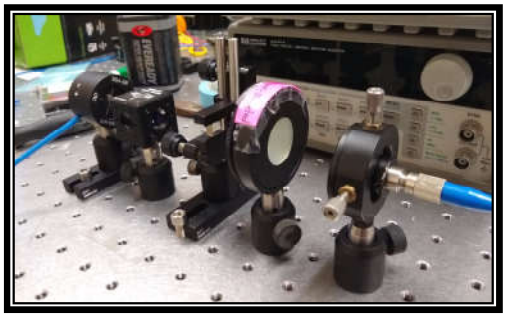

Figure 3: Picture of the first pass setup

- The setup consists of a polarizer, a beam splitter, a collimator, and a photodetector.
- Specialized optical equipment is used in order to make a robust prototype and also hold the crystal safely.

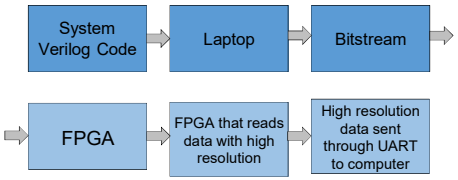

Figure 5. FPGA Component prototyping Process

- The current setup uses an FPGA to get the voltage difference across a resistor connected to a photo detector.
- A fiber coupled laser is collimated, narrowing the beam. This sends a stronger signal to the photodetector.
- The signal is processed and smoothed out in the FPGA and is sent to a computer to process the data to convert voltage to current.
- Low noise amplifiers will be added to the design to boost the signal before being read.

Preliminary Results

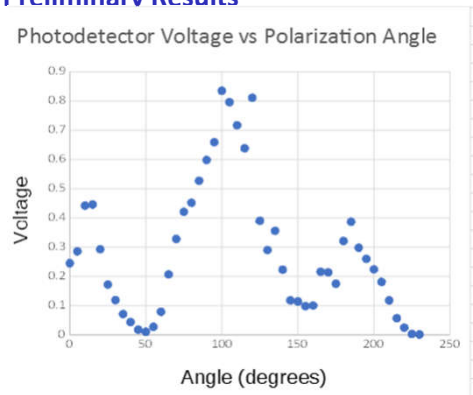

Figure 6. Diagram of the phase angle and voltage for the polarizer without the crystal.

- Currently we have observed the faraday effect using a highly sensitive power meter and a magnet where the change in received power is in the nW range for one pass .

Discussion & Conclusions

- The first pass tests were not entirely successful as there is not enough of a Faraday Effect generated by two limiting factors:
  1: The magnetic field strength
  2: The length of the light passing through the crystal
- The experimental setup will be repeated with a stronger magnetic field and measures taken to increase the length that the light passes through the crystal
- Set up the mounting system for the magnet to by measured at varying distances.
- Our future direction includes setup for a multiple pass system with a dielectric mirror.
- This would include creating a fully portable implementation based off of the FPGA implementations that could be used to test the current detector on a power line.

References

[1] Padmaraju, Kishore Faraday Rotation Dept of Physics and Astronomy, University of Rochester, New York, June 1996

[2] Andrew Koller, State University of New York at Stony Brook Laser Teaching Center, and Brien McMahon. A magneto-optical tachometer based on the faraday effect, Nov2000. 1, 5

Acknowledgements

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