Proposal to the Independent Projects/Research Opportunities Program
for a project on

Pulsed Magnetic Field Design and Implementation For a Faraday Rotation Experimental Setup

submitted by

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Thomas Foulkes, Electrical Engineering

Executive Summary

Simply, this research project for the 2012 Spring Quarter involves the process of designing, testing, and constructing a circuit that will generate a pulsed magnetic field for a Faraday rotation experimental setup. The research team is requesting $750 to purchase both electronic components such as high voltage AC capacitors and high current diode switches and materials for the construction of: a high current solenoid, a power supply, pulse shaping circuit, and shielding for high voltage and signal integrity. Thomas Foulkes will be working on this project with Dr. Syed and Dr. Herniter primarily in DL108 for academic credit.

Detailed Project Description

By passing light through a system in a magnetic field, Faraday rotation experiments reveal a linear relationship between the rotation of the electric field vector of polarized light and the magnitude of the corresponding magnetic field. Currently, an alternating current Faraday rotation setup has been used in DL108 for Faraday rotation measurements. However, only a maximum of 2 Amperes can be safely applied to the solenoid in the Faraday rotation setup before compromising the integrity of the solenoid. This relatively small amount of current in turn generates a proportionally small magnetic field inside the solenoid, which only yields rotations that are fractions of arcminutes. Thus, a larger magnetic field would provide two significant advantages for researchers. First, a larger magnetic field would in turn produce larger rotations, which would significantly increase both the accuracy and precision of the results from Faraday rotation experiments. In turn, this would allow researchers to distinguish significant differences between different mediums tested, which before would have been impossible due to overlaps in experimental error within the small rotation region. Moreover, the large, short-lived magnetic field, which is currently not available to any researchers at RHIT, would also allow for the investigation of non-linear effects of systems. Since particles might respond differently to large, short-lived magnetic fields, having the ability to change pulse shape allows for an inquiry into the dynamics into the underlying magnetic moment of a system.

With the help of Dr. Herniter, preliminary design work has been completed and some initial work has been completed in PSpice. Please refer to Figure 1 for the working version of the circuit that will produce a high current pulse.
Figure 1: Circuit for the Generation of a High Current Pulse

Utilizing carefully selected electronic components, a large current pulse (one to three kilo-Amperes) will be allowed to pass through a solenoid for a very short time (one to five milliseconds) in order to produce a pulsed magnetic field (through calibration) of high magnitude (1.5 to 3 Tesla). After some preliminary research, it was determined that high voltage capacitors and high current diodes would be essential to the construction of the circuit to produce the pulsed magnetic field. These specialized capacitors and diodes are not available through either RHIT’s Physics or Electrical Engineering parts rooms. Thus, these electronic components and materials will have to be purchased from industry suppliers. This research project will provide invaluable insight for the student into both the engineering process of designing a circuit to meet specific design specifications and the use of PSpice©, which is a program used in both academic and industrial settings. Success for this engineering research project will be based first on the successful construction and verification of a circuit, that can produce a pulsed current large enough to generate a subsequently pulsed magnetic field, and finally on the successful systems integration of this circuit with the rest of the Faraday rotation setup. In conclusion, this research project will not only enhance the range of exploration for Faraday rotation experiments and provide a large, short-lived magnetic field previously not available to RHIT researchers, but also will substantially prepare the student for a future career in Electrical Engineering.

Budget

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>High Voltage Capacitors</td>
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<tr>
<td>High Current Diode Switches</td>
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<tr>
<td>Custom Solenoid Components</td>
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<tr>
<td>Shielding Components</td>
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<tr>
<td>Miscellaneous Pulse Shaping Electronics</td>
<td>PH / EE Parts Room</td>
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Total Request $750