Fast, Compact, High Strength Magnetic Pulse Generator Project Plan

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Index

Introduction

Problem Statement
A solution for designing magnetic field generation devices for a small-scale, low power, and low cost has been difficult to achieve. Magneto-optic systems often use this form of technology as an alternative to a switch in optical communications. The switch required for these communication methods must be designed to be extremely fast and dynamic. The design of this switch to be integrated onto silicon-based technologies has become a challenge for our client.

Objective
In this project, we are designing and fabricating an electronic circuit to solve the stated problem for our client. This circuit will have a small coil that generates a pulsing magnetic field at very high amplitude very quickly. Our client is having difficulties in accomplishing this task with all design specifications included in the design.

Deliverables

First Semester
Detailed design approach
At least one prototype to show proof of concept

Second Semester
Detailed design approach, schematic, and layout
Professionally fabricated PCB with optional mechanical enclosure
Precise project documentation
Working final unit

Specifications

The new system designed during this project will be expected to meet the following criteria.

Functional Requirements
1. Our circuit board will have dimensions of less than or equal to 3.5" x 2".
2. The circuit must be able to create a magnetic field with strength of greater than or equal to 500 Gauss.
3. We will use a DC voltage source of less than or equal to 15 Volts.

Non-functional Requirements

1. In our final design, the circuit will be enclosed in some fashion.
2. Our circuit design created in EAGLE PCB and tested will eventually be fabricated onto a PCB.
3. Create a simple way to attach a DC voltage source to our circuit design.

Concept Sketch/Details

Systems Level Diagram

Figure 1 shows a simple systems-level diagram that divides our project into two main fragments: the MOSFET and the coil. One project group will work on the MOSFET implementation while the other project group works on coil research and design.

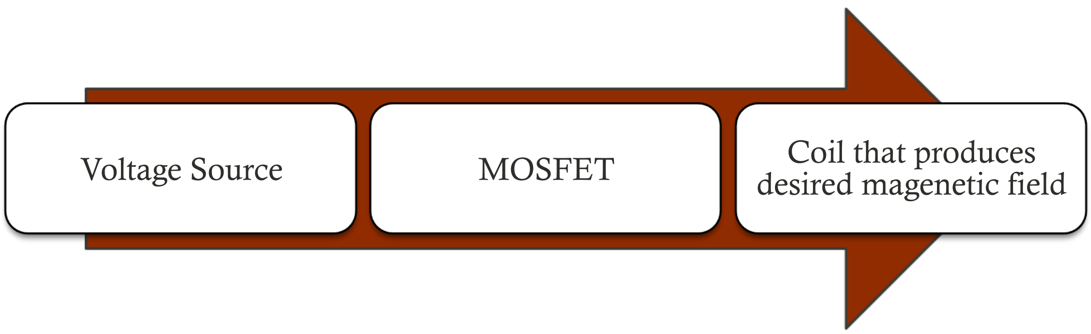

Figure 1: Systems Level Diagram

Initial Circuit Design

Figure 2 shows initial circuit design we have in testing for our magnetic field. To begin our exploration, our team has demonstrated setting up a pulse generator to create a continuous pulsed waveform with a pulse width of 1 second, a period of 2 seconds, a high amplitude of 5V, and a low amplitude of 0V. We set up a MOSFET circuit using an LED with a 330 Ohm resistor as a load. This “acts” similar to what an inductor would as a load. We had VDC set at 5V, and connect the output from the pulsed waveform to the gate pin of the MOSFET. We see the light illuminate for 1 second in 2 second intervals showing a very similar concept of how a magnetic field is generated. Once we get into testing with the coil, there will only be minor changes. The circuit will be replacing the LED with a coil, and the pulse waveform will be much faster. After going over this activity and understand concepts, ideas, theories, etc. the rest is simply optimization.

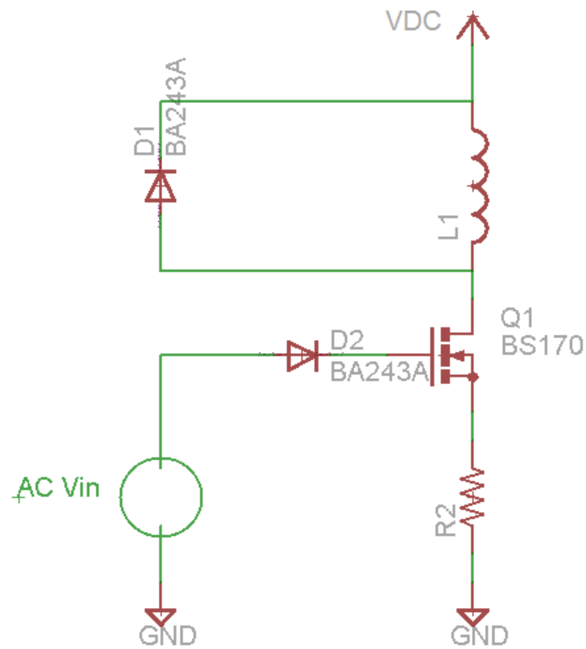

Figure 2: Initial Circuit Design

Measurement Equipment
The requirements specified for our project will require us to use an oscilloscope, a function generator, and a gauss meter. The oscilloscope will allow us to ensure we are meeting our requirement of 1µs pulses. The function generator will provide a voltage no greater than 15V for our purposes. The gauss meter will assist in providing measurements of the magnetic field, which has a specified strength of 500 Gauss.

User Interface Description

Testing Purposes
For testing purposes and calculations, our team has created multiple scripts to aid in our understanding of how our design is intended to run with the specifications we provide as a user. Understanding how to go back and forth from calculating current and magnetic field will help us when we need to optimize the circuit. With the scripts, we will be able to answer concepts such as how increasing the current affects how much magnetic field is generated.

1. MATLAB script that asks the user to input the number of turns, length, radius, *magnetic field (in Gauss)* and then calculates the current required to generate that field ***for a single short coil***.

2. MATLAB script that asks the user to input the number of turns, length, radius, *current (in Amps)* and then calculates the magnetic field required generated ***for a single short coil.***
3. MATLAB script that asks the user to input the number of turns, radius, *magnetic field (in Gauss)* and then calculates the current required to generate that field ***for a Helmholtz coil***.
4. MATLAB script that asks the user to input the number of turns, length, radius, *current (in Amps)* and then calculates the magnetic field required generated ***for a Helmholtz coil.***

After creating a schematic that meets ours parameter requirements, we will need to create a PCB. To do this, we will use Eagle PCB software created by Cadsoft. Eagle provides a simple layout editor, which provides us a platform to easily design a fabricatable board. From there, we can simply export our layout to sites (such as Oshpark.com) as a "gerber file" and they will provide us with a board that we can solder the surface mount components to.

Marketable Application

In terms of user interface for this project, we don't believe that we will require an input from a user in a marketable application. Once the PCB is hooked up to a power source, and the source is turned on, our circuit will do its job and generate magnetic pulses. We have discussed potentially inserting a switch in addition to the MOSFET we are using. It would be designed so that we could turn on the voltage source, and the circuit would only pulse if we flipped the switch (or pressed a button).

Work Breakdown Structure

Each member of our group is expected to remain actively engaged in our project throughout both 1st and 2nd semesters. In order to ensure that the project plan is carried out effectively, we have assigned particular roles to each group member. Member roles include:

Team Leader: Communicate the most with advisor and client
Team Webmaster: Responsible for the project Web design and maintenance
Team Communication Leader: Coordinate the weekly reports, project plans, design document, etc.
Team Key Concept Holder: Responsible to keep the newest idea, developments, and needed changes to be implemented
Team Commissioner: Accomplishes a particular action when a member of the team needs it completed

Because we have such a large, skillful group, we decided it would be best if we divided up the work into two separate teams:

The Coil Team: Look at the properties of inductors
The MOSFET Team: Look at the switching options for driving the inductor

Team Member	Team Role	MOSFET/Coil team
Adam Kaas	Team Leader	Coil
Gregory Fontana	Team Co-Webmaster	MOSFET
Meiyong Himmtann	Team Co-Webmaster	MOSFET
Brittany Duffy	Team Communication Leader	MOSFET
Megan Sharp	Team Co-Key Concept Holder	Coil
Brandon Dixon	Team Co-Key Concept Holder	MOSFET
Alain Ndoutoume	Team Commissioner	MOSFET

Resource Requirements

Resource	How will we get it?	Estimated Cost
PCB Fabrication	Sparkfun.com	$10/board
Multimeter	Provided by client	N/A
Oscilloscope	Provided by client	N/A
EAGLE PCB	Provided by client	N/A
Circuit Components	Parts Shop/Digikey	<$100
Total		**<$110**

Project Schedule

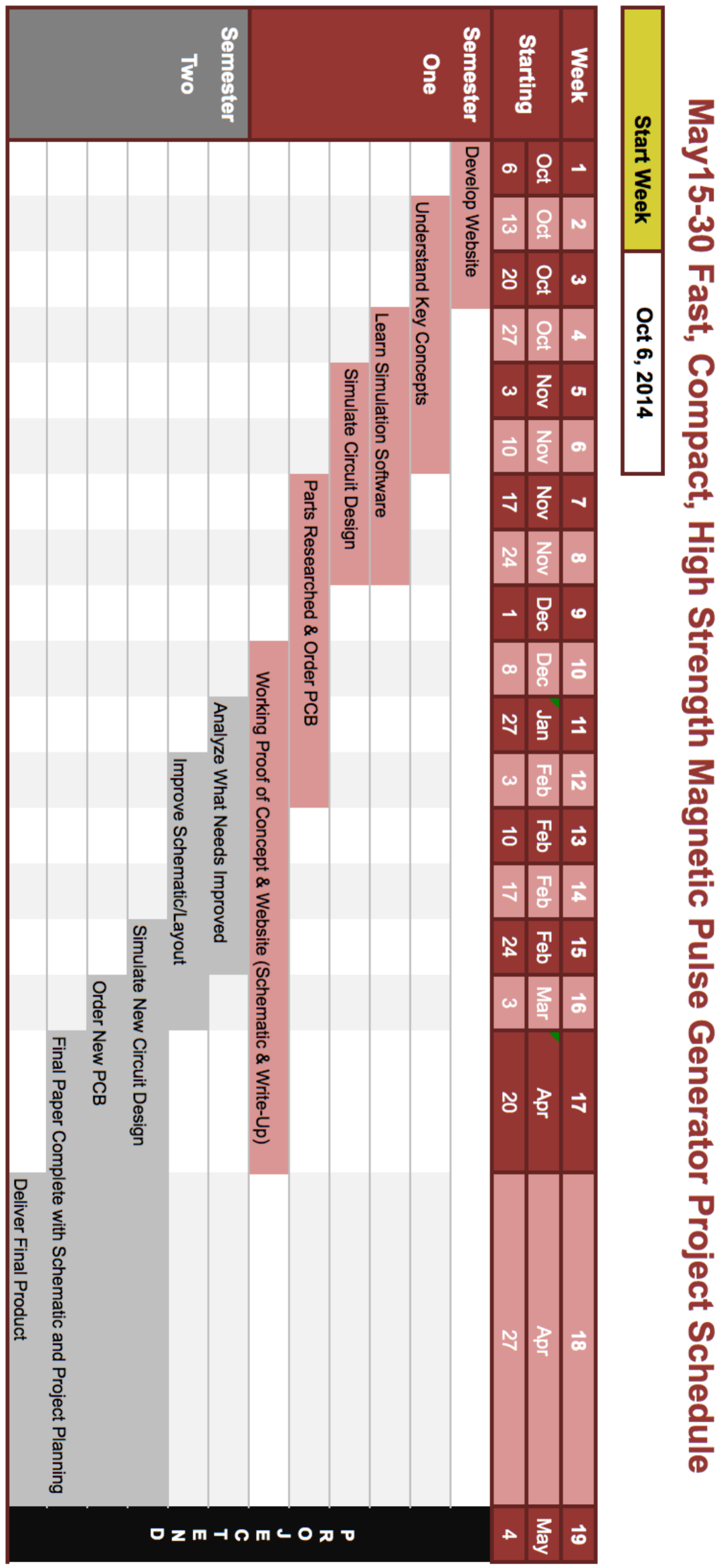

Figure 3: May15-30 Project Schedule

Risks

Risks to the Project Timeline

One of the biggest risks that we may encounter during this project is receiving all parts of the project on time after we design our circuit and the ordering of the PCB. Our goals are to order the correct parts on digikey.com to minimize the probability of getting wrong parts. Another issue we may face is to make sure that our theoretical values match our practical values in the lab. We can only go so far with computer analysis in generating high magnetic fields. During testing in lab, components may burn; therefore, we should order enough parts in case that kind of incident happens in the lab.

Physical Dangers

The largest physical risk is getting burnt while testing our circuit. Other risks include getting shocked by medium range voltages. Following proper lab procedure, such as turning off the power before we handle circuit components, will ensure that no one gets harmed.

Market/Literature Application

Our circuit design has many modern-day applications across a wide range of scientific tools. Similar circuits to our project can be used in the medical field such as transcranial magnetic stimulation and neuroscience. Transcranial magnetic stimulation is a noninvasive method to study the brain's functions and interconnections. It induces weak electric currents using a rapidly changing magnetic field. Future investigation is being done on how our circuit is applicable in other scientific technologies.