

Fast, Compact, High Strength Magnetic Pulse Generator Final Project Plan

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1 Introduction

1.1 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.

1.2 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 proposal.

2 System Description

2.1 Concept Sketch

Figure 1 shows a block diagram of the concept our team is implementing. This outlines our process of taking a DC source voltage to run through our circuit, which contains a magnetic pulse generator. This source voltage combined with the magnetic pulse generator will then create a magnetic field with strength of 500 gauss every microsecond.

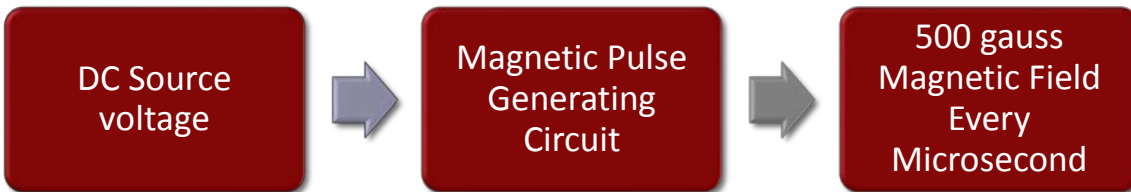


Figure 1: Block Diagram of Concept

2.2 Systems Level Diagram

Figure 2 shows the process our design team has cycled through to meet design specifications.

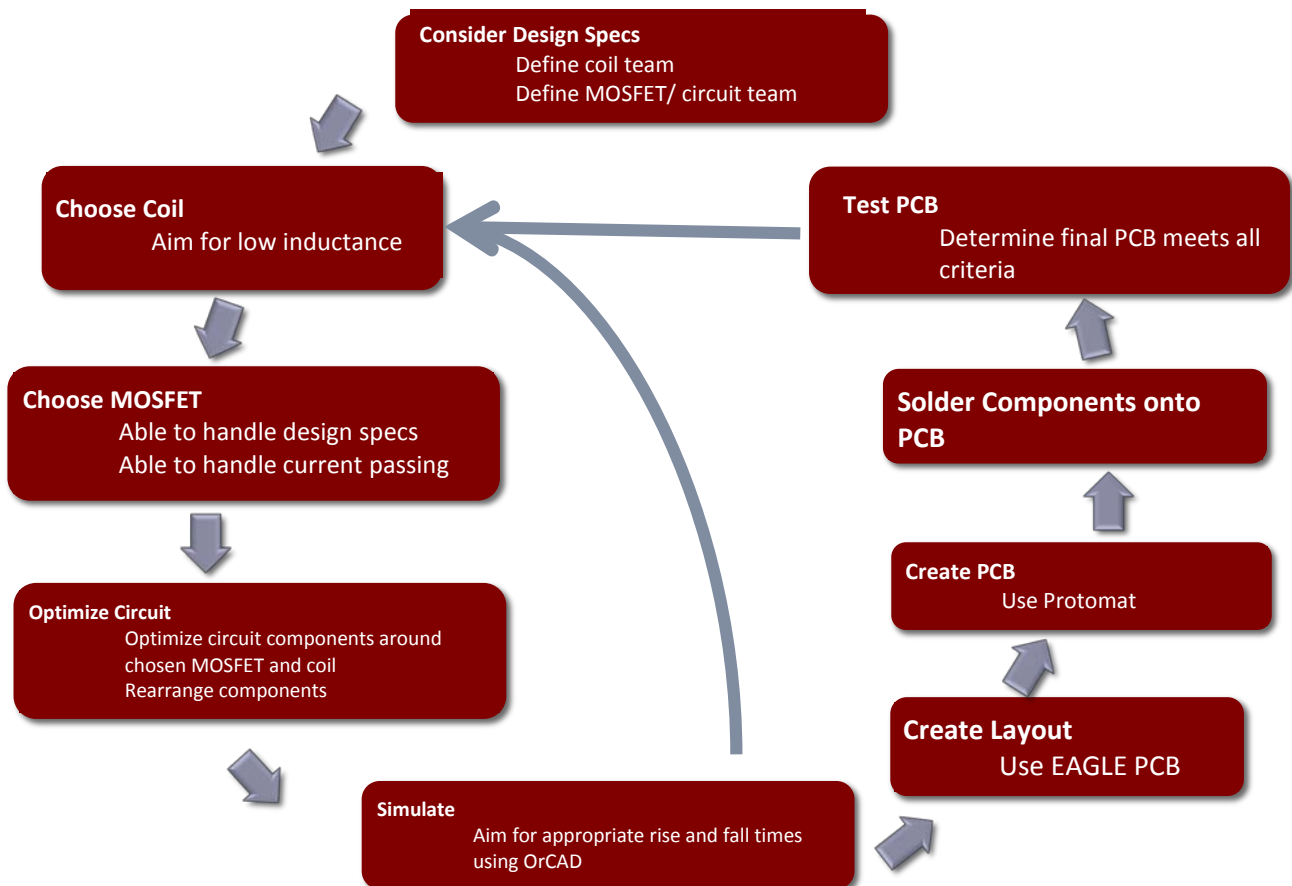


Figure 2: Systems Level Diagram

2.3 Process Details

In the next few sections, the design details for our previous project version, present project version, and future stages are explained.

2.3.1 Blinking LED

2.3.1.1 Schematic

After creating a schematic that meets our parameter requirements, we created a PCB to represent a way to produce a magnetic field. To do this, we used Eagle PCB software created by Cadsoft to design the schematic (Figure 3). Eagle provides a simple layout editor, which provides us a platform to easily design a board that can be fabricated. The schematic and layout of the circuit was transferred to a GERBER file to fabricate the physical circuit in the workshop. The GERBER file was uploaded to the Protomat S62 to create the physical printed circuit board. To test the circuit, the parts were bought online through www.digikey.com. We then soldered the components onto the PCB (Figure 4) and concluded the circuit did in fact produce a blinking LED. An inductor to obtain a magnetic field can then replace the LED.

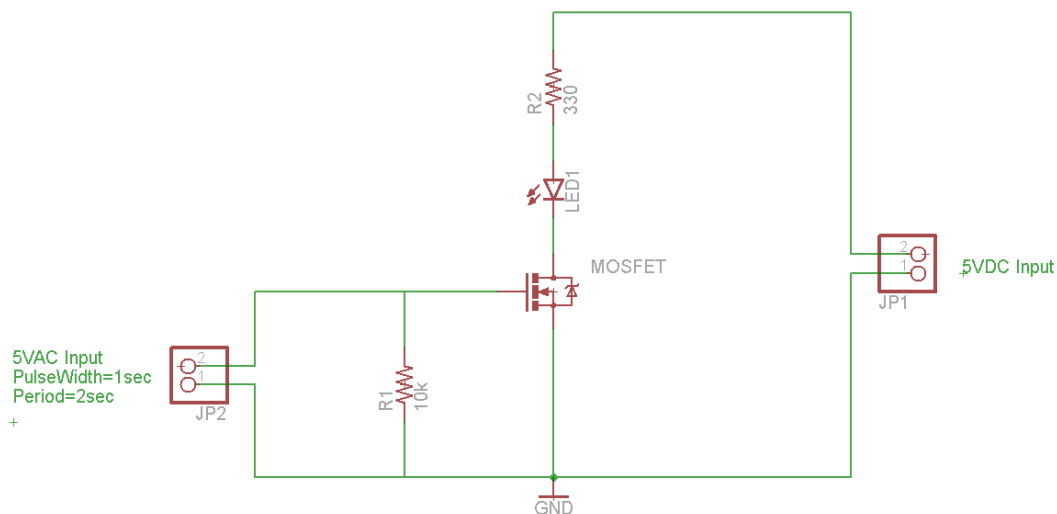


Figure 3: Eagle PCB Test Schematic

After further simulation and design, we concluded that this design needed to be more complex in order to meet requirements.

2.3.1.2 Computer-Aided Design & Printed Circuit Board

Figure 4 shows the basic blinking LED circuit with a SOT-23 packaged MOSFET. The PCB was created using the Protomat S62. This circuit is very similar to the magnetic pulse generator circuit that is our current prototype discussed in section 2.3.2.

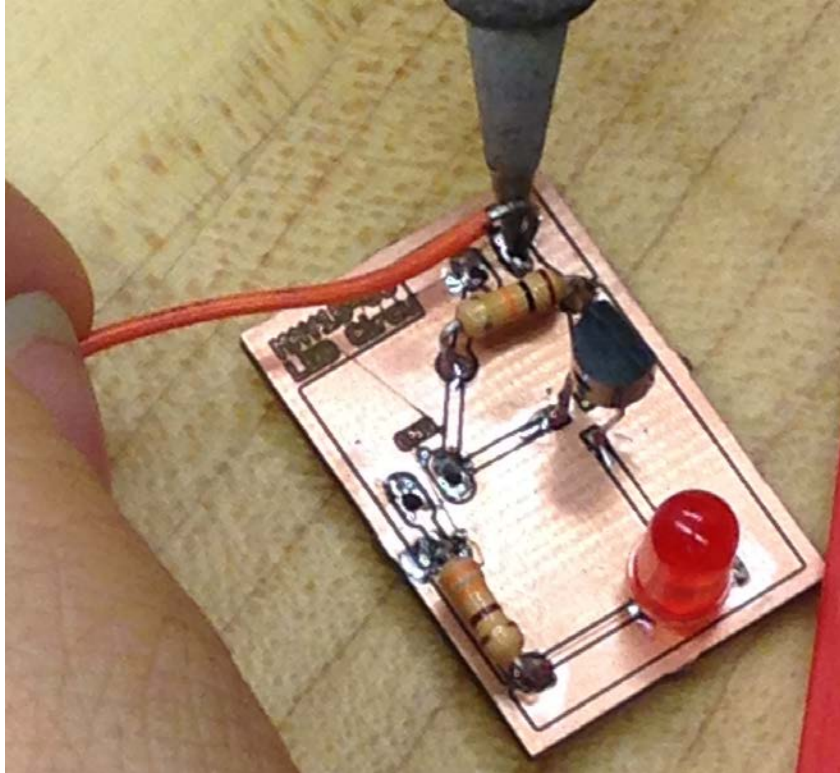


Figure 4: Soldering Components onto PCB

2.3.2 Current Prototype

Our current prototype can be described in five main parts: coil, MOSFET, diode, capacitors, and resistors. For preliminary purposes, the design is using one coil and one MOSFET. In the future, we may be using two coils and two MOSFETs in an edited circuit design. Below,

2.3.2.1 Simulation and Creation

OrCAD was used in the simulation and creation of the circuit. Figure 5 shows the circuit designed for our first prototype containing our coil. The MOSFET used in this drawing is the part we chose for our prototype as the manufacturer provided us a SPICE file. We ensured our coil had an inductance that was realistic based on calculations of expected parameters. We added a large diode in parallel with the coil to prevent back EMF from entering into the MOSFET. Capacitors were added in series with our 15 volt power supply to combat the inherent inductance of the wire from the power supply and reduce switching time. We also added a 0.05 ohm current sense resistor to have a way to test the current flowing through the inductor. The current seen through the resistor should match the current through the inductor when the MOSFET is on. This will allow us to use that current in our magnetic field calculations to determine the strength of our magnetic field. The following sections will go into more detail on circuit components.

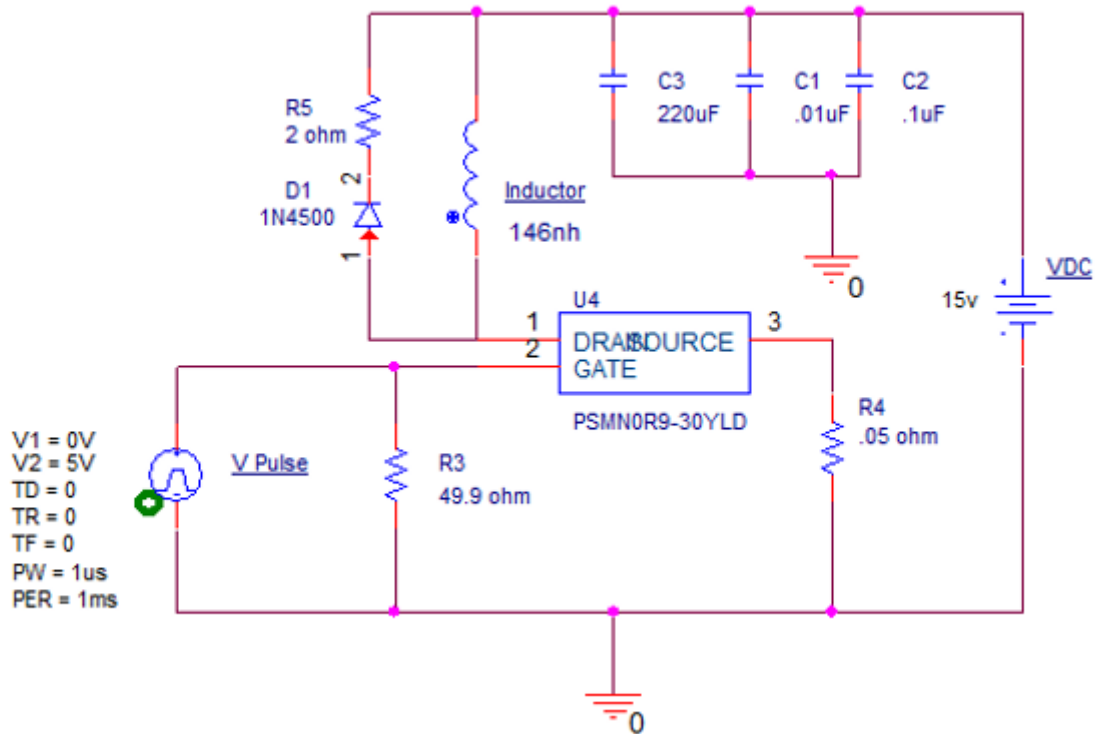


Figure 5: OrCAD Schematic

In Figure 6, a plot of current through the inductor is provided. We are showing, based on the parameters indicated in Figure 7, that we can expect to see current maxing out around 58 amps with a pulse time of approximately 1.6 microseconds. Once our circuit has been populated, we will test our actual results and begin researching ways to decrease our rise time and our fall time.

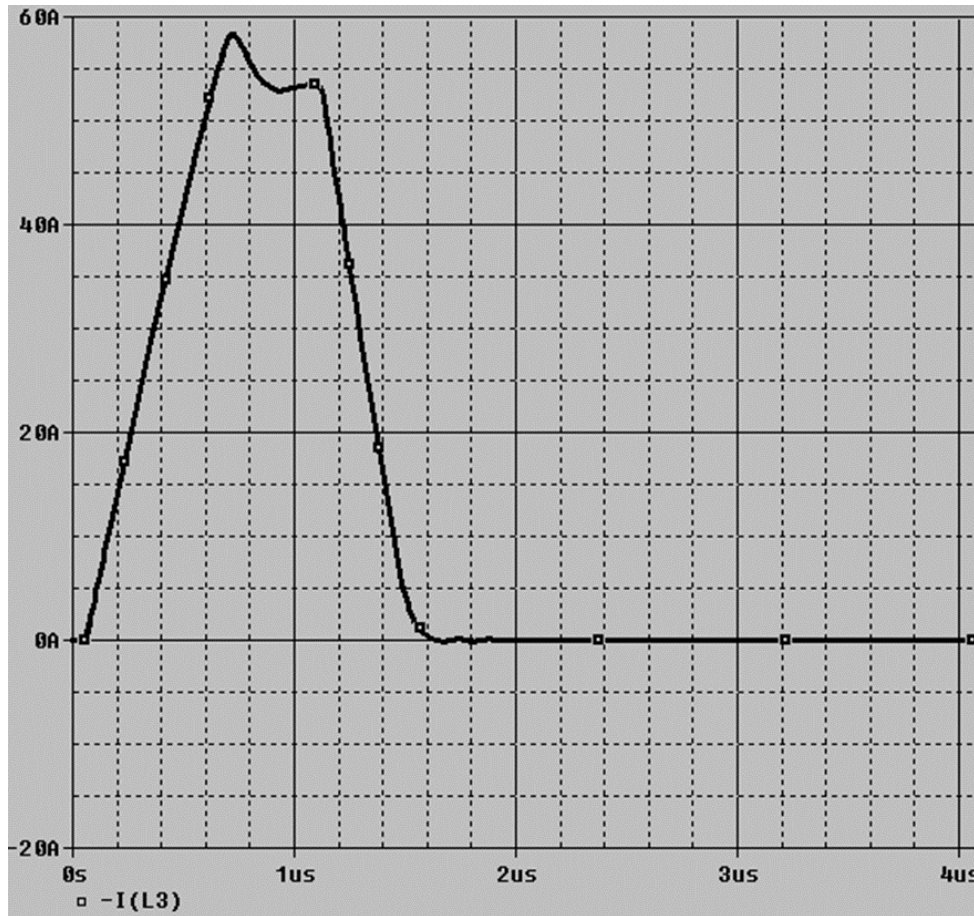


Figure 6: OrCAD Simulation

2.3.2.2 Coil

The coil used in this project will have great impact on the final product. We will try two different types of coils: a single coil and a Helmholtz coil. We will test both to see which yields the best results. The coil is a necessary part of the circuit because when current is put through the coil, this will generate the 500 gauss magnetic field. This magnetic field will be generated at the center of the coil. For the Helmholtz coil this means the magnetic field will be generated between coil 1 and coil 2. We calculated the magnetic field for a single coil using the equation below:

$$B = \frac{\mu NI}{\sqrt{l^2 + 4R^2}} = 0.057865 \text{ Teslas} = 578.65 \text{ gauss}$$

We calculated the magnetic field for a single coil using the equation below:

$$B = \frac{\mu(0.7155)NI}{R} = 0.05 \text{ Teslas} = 500 \text{ gauss}$$

The resistance and the inductance will both affect the functionality of the coil. The resistance lowers the current which also lowers the magnitude of our magnetic field; therefore, the lower the resistance of the coil, the easier it is for the magnetic field to reach 500 Gauss. Our team did a simple test by measuring the resistance of a five turn coil with an Agilent 4263 Model B LCR meter and measured resistance at 0.084Ω . Based on this, we expect our final resistance to be under or close to 0.1Ω . However, resistance of the coil is not something we have researched or tested in depth this semester. We have considered it negligible on existing OrCAD simulations. Once we have a working prototype, this will be something that we measure and include. The inductance can affect our rise and fall time. Since we have a requirement of a $1\mu\text{s}$ pulse width and 1ms period, we have to take the coil inductance into consideration when working to achieve this. Coil inductance for the single coil is found using the equation below:

$$L = \frac{\mu N^2 (\pi R^2)}{\sqrt{l^2 + 4R^2}} = \frac{(4\pi \times 10^{-7}) 5^2 (\pi * (3 \times 10^{-3})^2)}{\sqrt{(1 \times 10^{-3})^2 + 4(3 \times 10^{-3})^2}} = 146\text{nH}$$

Coil inductance for Helmholtz coil is for using the equation below:

$$L = 2\mu(0.7155)N^2\pi R = 2(4\pi \times 10^{-7})(0.7155)(\pi(3 \times 10^{-3})^2) = 423.7\text{nH}$$

This semester we have calculated possible coil dimensions including theoretical inductances for both a Helmholtz coil and a single coil configuration. When constructing coils, we use a 6mm diameter (3mm radius). The length of a five-turn coil is close to 1mm in length, which can be used as a guideline to find the length based on the number of turns. Below are the coil calculations for each of type of coil. More information on how we used MATLAB for testing is provided in section 4.2.

Note: Here are relevant variables for this section:

μ : permeability of free space ($4\pi \times 10^{-7}$)

N: number of turn of a coil (dimensionless)

R: radius of a coil (meters)

l : length of a coil (meters)

L : inductance of a coil (henries)

B : magnetic field of a coil (teslas. 1 tesla=10,000 gauss)

I : current through a coil (amperes)

2.3.2.2.1 Single Coil

Figure 4 shows that 5 turns of the single coil provides 48.41 Amps at 500 gauss. The script to generate this graph is shown in Figure 5.

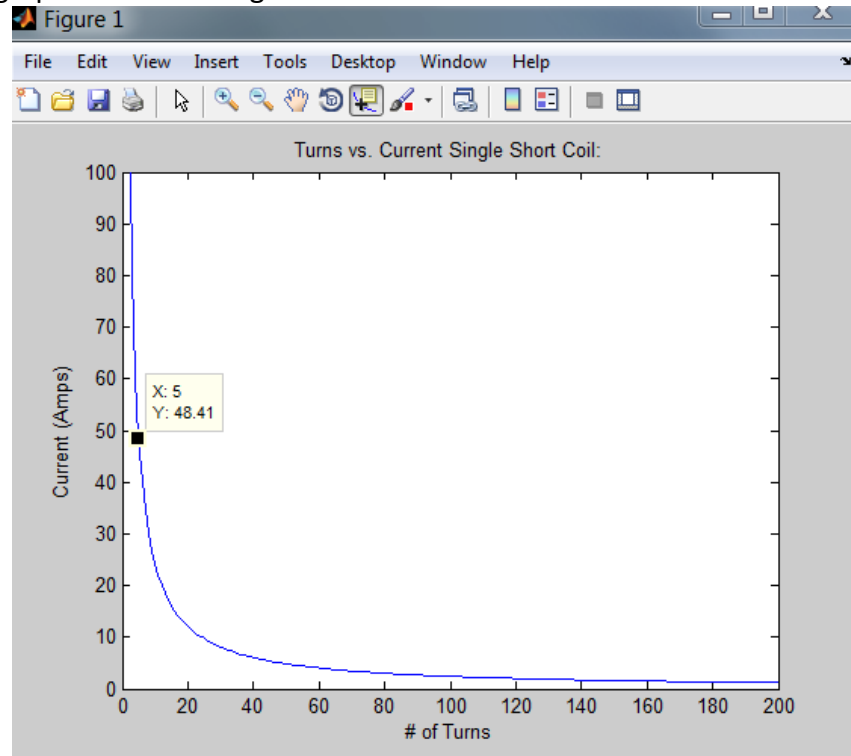


Figure 7 : Single Coil, 5 turns at 48.41 Amps providing 500 gauss

```

I_vs_N_table_Single.m  I_vs_N_table_Helmholtz.m  +
1 -   num_rad = input('How many radii do you want to enter?');
2 -   r(num_rad)=0;
3 -
4 -   for k = 1:num_rad
5 -       r(k) = input('Give the first radius you want to graph (in mm.)');
6 -   end
7 -
8 -   N = [1:1:200];
9 -   I = zeros(1,200);
10 -
11 -  for j = 1:num_rad
12 -      for i = 1:1:200
13 -          I(i) = (0.05*r(j)*.001)/(N(i)*4*pi*10^-7*0.7155);
14 -      end
15 -      figure(j)
16 -      plot(N,I)
17 -      str = sprintf('Turns vs. Current Helmholtz Coil: R = %f', r(j));
18 -      title(str);
19 -      xlabel('# of Turns'); xlim([0,100]);
20 -      ylabel('Current (Amps)'); ylim([0,60]);
21 -  end

```

Figure 8: Script to Generate Figure 7

2.3.2.2.2 Helmholtz Coil

Figure 6 shows that 5 turns of the single coil provides 33.37 Amps at 500 gauss. The script to generate this graph is shown in Figure 7 and has an inductance of 423nF. This inductance is higher than what we would want in a final design; however, the physical design of a Helmholtz coil may be more advantageous for some applications.

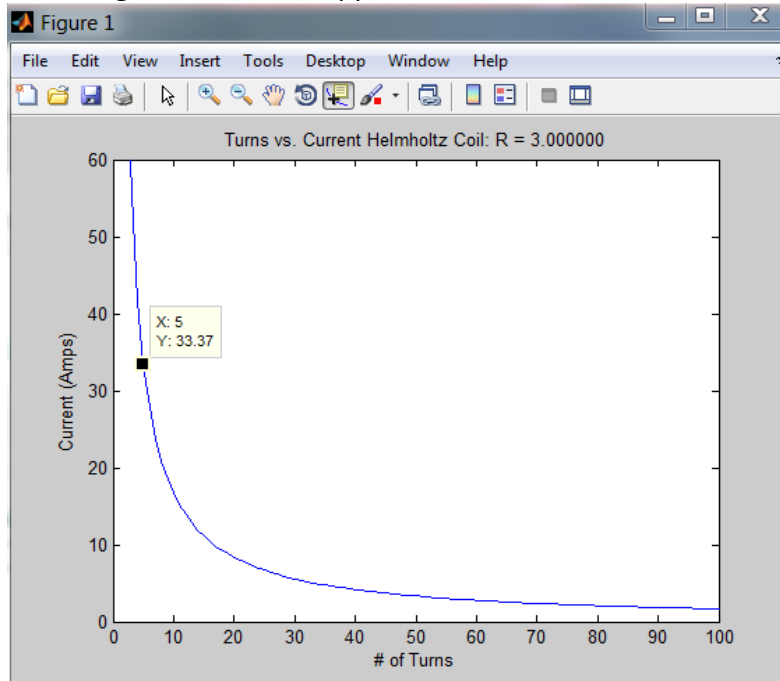


Figure 9: Helmholtz Coil, 5 turns at 33.37 Amps providing 500 gauss

```

I_vs_N_table_Single.m  I_vs_N_table_Helmholtz.m  +
1  $num_rad = input('How many radii do you want to enter?');
2  $r_init(num_rad)=0;
3
4  $for k = 1:1:num_rad
5  -   r = input('Give the radius you want to graph (in m.)');
6  -   $end
7
8  -   l_init = input('What length do you want to work with (in m)?');
9  -   l = l_init;
10
11  -   N = [1:1:200];
12  -   I_s = zeros(1,200);
13
14  -   $hold on
15  -   $grid
16
17  -   $for j = 1:num_rad
18  -   for i = 1:1:200
19  -     I_s(i) = (0.05*sqrt(1^2 + 4*(r)^2))/((4*pi*10^-7)*N(i));
20  -   end
21  -   % figure(j)
22  -   plot(N,I_s)
23  -   str = sprintf('Turns vs. Current Single Short Coil:'); % R = %fmm, r(j));
24  -   title(str);
25  -   xlabel('# of Turns'); xlim([0,200]);
26  -   ylabel('Current (Amps)'); ylim([0,100]);
27  -   $end
28  -   $xlabel('# of Turns'); xlim([0,200]);
29  -   $ylabel('Current (Amps)'); ylim([0,100]);

```

Figure 10: Script to Generate Figure 9

2.3.2.3 MOSFET

As section 3.3.1 has shown, calculations prove that the current through the coil will be approximately up to 48.1 Amps for the single coil meaning the MOSFET will need to handle at least a pulsing current of 55 Amps, just in case. Most importantly, this MOSFET meets a number of design specs:

- Drain to Source Voltage (V_{DS}) must be able to handle 15V or more
- Current channel must be able to handle the current load through the coil (approximately 25 Amps)
- Surface mount component

The MOSFET chosen was designed for fast switching. The chosen MOSFET for this circuit design includes the specs above as well as:

- N- channel, operates using a positive input voltage and faster switching
- Industries first MOSFET using Schottky technology to deliver high efficiency, low spiking performance without high leakage current
- Suited for high switching frequencies resulting in a soft-recovery
- Low parasitic inductance and resistance
- V_{DS} rated up to 30 V
- Pulsed, peak drain current rated up to 1888 A
- More information: http://www.nxp.com/documents/data_sheet/PSMN0R9-30YLD.pdf

2.3.2.4 Capacitors

Capacitors near the voltage input hold a charge, effectively reducing the time it takes for the coil to get a current running through it by reducing the input inductance, and increasing the time taken between each pulse. Using our present calculations for the current and voltage, we have decided to use three capacitors of values .01uF, .1uF, and 220uF. The equations below gave us a minimum (base) value we could use for the total capacitance. This equation assumes that we have 25 Amps of current in our inductor and a pulse width of 1us.

$$\frac{\text{Current} * \text{Pulse Width}}{\text{Voltage}} = \text{Capacitance}$$

$$\frac{25 \frac{\text{Coulomb}}{\text{second}} * 1 * 10^{-6} \text{seconds}}{15 \text{Volts}} = 1.67 * 10^{-6} \text{Farads}$$

For a circuit like ours, it's common practice to take this minimum value and multiply it by 100 or more. Our total capacitance used in our circuit is 220.11uF, which is roughly 130 times larger than our base value. The .1uF and 220uF capacitors we are using are tantalum capacitors, because their internal resistance is low.

2.3.2.5 Diode

EMF voltage occurs when the waveform generator goes from its upper voltage to lower voltage. In EMF voltage, the change in current over the change in time becomes negative. The inductance doesn't change, hence giving a negative voltage across the coil. Because the change in time will be very small, the magnitude of the negative voltage will be very large. Without a diode, this large negative voltage will reach the MOSFET and potentially ruin the MOSFET. We have chosen a large diode in parallel to the coil that prevents back EMF into the MOSFET.

Specifications include:

- Fast recovery time
- High reverse breakdown voltage
- Surface mount component
- More information: <http://www.digikey.com/product-detail/en/STTH3R02S/497-6085-2-ND/1653882>

2.3.2.6 Resistors

In our design we will be using a 49.9Ω surface mount resistor. Previously in our design we decided upon a 50Ω resistor, but in the end chose 49.9Ω . The 49.9Ω has enough power dissipation and lowered our cost by about \$14. Placing the 49.9Ω resistor provides expected results without having to worry about the 50Ω natural resistance of the waveform generator.

A 2Ω resistor is placed in series with the diode. This is because without the resistance, the current would continue to loop between the coil and diode because there is no place for the energy (heat) to dissipate. Because OrCAD makes all wire resistances ideal (zero), we may not need this 2Ω resistor in our physical circuit. The wires and connections may cause enough resistance for this energy to dissipate elsewhere.

Our design also contains a current sensing resistor with a value of 0.05Ω . Due to the difficulty of testing the magnetic field of our circuit, by placing a current sensor in our design, the current sensor will be a way to test that our design is producing a result by measuring the drain current through the MOSFET. If we are expecting to use 20-25A, we should expect to see a 1.00-1.25V drop across the resistor, thus changing our gate-to-source voltage from 5V to 3.75-4.00V. It is something we need to account for, and ideally we wouldn't have the resistor as part of our circuit. It is primarily for testing purposes.

2.3.3 Future Project Version

In the future, we would like to explore how adding a core material to the coil can improve the functionality of our circuit by assisting in creating a larger magnetic field. This may allow us to reduce our pulse width by not requiring quite so much current to achieve the same performance.

Currently we have a 0.05 ohm current sense resistor that we would ideally like to remove as it is hindering our performance by reducing our gate-to-source voltage, thus reducing the current.

Methods of accurately measuring our magnetic field without the current sense resistor are being discussed with our client.

2.4 Functional Equipment

The functional equipment required in this project are the power supply which is supplying 15 volts DC to our circuit and the function generator that is providing a 5 volt pulse to our MOSFET.

2.5 User Interface for Marketable Applications

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 begin performing 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).

3 System Requirements

Our magnetic pulse generator is a simple notion that has two key parts: a coil and a MOSFET that will act as a switch. While the idea is simple, the specifications make this project a challenge. Our team has divided up the work into a group working on the coil and a group choosing the MOSFET and circuit design. For the project to succeed, there has to be constant communication between the two groups. The physical specifications of the coil will affect the inductance of the circuit and will affect the fall time that the MOSFET (switch) will be able to give us.

3.1 Deliverables

The following are the deliverables over the course of the next two semesters.

3.1.1 *First Semester*

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

3.1.2 *Second Semester*

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

3.2 Specifications

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

3.2.1 *Functional Requirements*

- The circuit must be able to create a magnetic field with strength of greater than or equal to 500 gauss.
- The circuit must be able to generate the magnetic field every microsecond.

3.2.2 *Non-functional Requirements*

- Our circuit board will have dimensions of less than or equal to 3.5" x 2".
- In our final design, the circuit will be enclosed in some fashion.
- We will use a DC voltage source of less than or equal to 15 volts.

3.3 Assessment of Proposed Solution

3.3.1 *PCB Issues*

When creating the PCB from the proposed Eagle layout, the Protomat S62 can damage the board, creating unpredictable, notched lines. These nicks and notched lines can affect the performance of the circuit, with a chance of disabling the circuit altogether. With our first

circuit design, we were able to create a few damage-free PCBs, enabling us to get our desired result. For time's sake, we have used the Protomat S62 for our PCBs, and it has caused us very few problems. However, for our final circuit design, we will order the PCB from OSH Park (www.oshpark.com). By ordering from OSH Park the trade-offs made will be the time waiting for the shipment and cost, but in exchange the quality of the PCB will be higher.

3.3.2 Specifications Challenge

After completing the LED blink circuit and the first EMP generating circuit, we have a better idea of what direction we should be heading, and what struggles we will be facing moving forward. Our future goals are simply to optimize the circuit to meet the functional requirements and discover if we can exceed those requirements. All of our calculations have been in regards to meeting our field strength of 500 gauss, so we believe we can easily meet this criterion. With this being said, we believe our biggest challenge is meeting the frequency requirement with quick rise and fall times.

3.3.3 Other challenges and issues

Extensive testing will need to be done to measure the magnetic field output for strength and consistency, voltage and current generation, inductive coupling, arcing, heat distribution, and how different magneto-optic materials affect all of these characteristics.

4 Test Plan

To achieve proper functionality, appropriate testing must be completed on the device. We have set up a process to ensure we test our device thoroughly throughout the design phase. Our testing process is shown below in Figure 7.

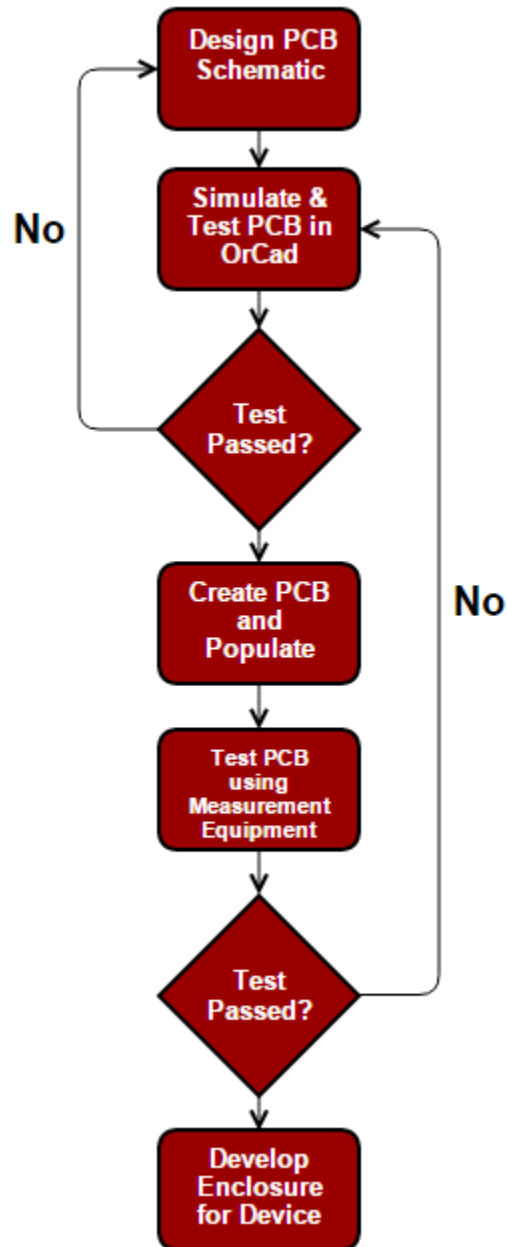


Figure 11: Testing Procedure

4.1 Functional Equipment

The requirements specified for our project will require us to use an oscilloscope, a function generator, and a current sense probe. The oscilloscope will allow us to ensure we are meeting our requirement of $1\mu\text{s}$ pulses. The field strength will be verified analytically with 0.05Ω current sense probe. We decided that the high speed system lab's gauss meter is not able to read the magnetic field fast enough to get accurate and precise readings.

4.2 User Interface Test Calculations

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 questions 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**.

4.3 Validation Test

- We shall verify using a standard ruler that the circuit board dimensions are less than or equal to $3.5'' \times 2''$.
- We shall verify analytically that the circuit generates a magnetic field with strength of greater than or equal to 500 gauss.
- We shall verify using an oscilloscope that the circuit generates a magnetic field every microsecond.
- We shall verify using a multimeter our DC voltage source is less than or equal to 15 volts.

5 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:

Leader: Communicate with advisor and client. Organize work needed to be complete. Lead team meetings.

Webmaster: Responsible for the project web design and maintenance.

Communication Leader: Coordinate and finalize the weekly reports, project plans, design document, etc. Delegate work as necessary.

Systems Leader & Commissioner: Accomplishes any particular action when a member of the team needs it completed when it is outside of other responsibilities.

Simulator: Responsible for performing simulations in OrCAD to verify preliminary designs will be functional.

Coil Designer: Responsible for the creation and calculations associated with the coil.

Layout Designer: Responsible for creating the PCB layout for the circuit.

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

Table 1: Team Breakdown

Team Member	Team Role
Adam Kaas	Leader
Gregory Fontana	Simulator
Meiyong Himmtann	Webmaster
Brittany Duffy	Communication Leader
Megan Sharp	Coil Designer
Brandon Dixon	Layout Designer
Alain Ndoutoume	Systems Leader & Commissioner

6 Resource Requirements

At this point in the project, we have anticipated the required parts to complete the project. Each bill of materials is organized by prototypes use for hardware and software, testing prototype components, and final product components. We plan on creating at least three prototypes, so the total cost is subject to change, but will remain quite low.

Table 2: Prototype Hardware and Software

Item	Where to Obtain	Quantity	Cost Per	Total Cost
OrCAD Software	http://www.orcad.com	1	\$-	\$-
EAGLE PCB Software	http://www.cadsoftusa.com	1	\$-	\$-
MATLAB	http://www.mathworks.com	1	\$-	\$-
MOSFET	digikey.com	6	\$0.50	\$3.00
Resistor	digikey.com	10	\$0.10	\$1.00
Coil wire (3m)	Iowa State High Speed Systems Lab	1	\$-	\$-
Coil glue	Iowa State High Speed Systems Lab	1	\$-	\$-
Insta-set (fast dry glue)	Iowa State High Speed Systems Lab	1	\$-	\$-
Tweezers	Megan Sharp	1	\$-	\$-
exacto knife	Megan Sharp	1	\$-	\$-
Ruler	Iowa State High Speed Systems Lab	1	\$-	\$-
Balsa Wood	Iowa State High Speed Systems Lab	1	\$-	\$-
Charcoal (used for winding)	Iowa State High Speed Systems Lab	1	\$-	\$-
Sandpaper (for coil)	Iowa State High Speed Systems Lab	1	\$-	\$-
Soldering Station	Iowa State Parts Shop	1	\$-	\$-
Solder	Iowa State Parts Shop	1	\$-	\$-
PCB Fabrication	Iowa State Parts Shop	3	\$-	\$-
Total				\$4.00

Table 3: Testing Prototype Components Cost

Item	Description	Quantity	Cost Per	Total Cost
Multimeter	Iowa State Senior Design Laboratory	1	\$-	\$-
Oscilloscope	Iowa State Senior Design Laboratory	1	\$-	\$-
DC voltage Supply	Iowa State Senior Design Laboratory	1	\$-	\$-
gauss Meter	Iowa State Senior Design Laboratory	1	\$-	\$-
Total				\$-

Table 4: Final Product Cost

Item	Description	Quantity	Cost Per	Total Cost
MOSFET	digikey.com	10	\$1.98	\$0.50
Coil	Iowa State High Speed Systems Lab	1	\$-	\$-
Resistor	digikey.com	1	\$0.10	\$0.10
PCB Fabrication	oshpark.com	1	\$10.00	\$10.00
Total				\$10.60

7 Project Schedule

May15-30 Fast, Compact, High Strength Magnetic Pulse Generator Project Schedule

Start Week **Oct 6, 2014**

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Notes																		
Starting	Oct 6	Oct 13	Oct 20	Oct 27	Nov 3	Nov 10	Nov 17	Nov 24	Dec 1	Dec 8	Dec 15	Dec 22	Dec 29	Jan 5	Jan 12	Jan 19	Jan 26	Feb 2	Feb 9	Feb 16	Feb 23	Mar 1	Mar 8	Mar 15	Mar 22	Mar 29	Apr 5	Apr 12	Apr 19	Apr 26	May 3	May 10	May 17	May 24	May 31			
Semester One	Develop Website																																					
	Understand Key Concepts																																					
	Learn Simulation Software																																					
	Simulate Circuit Design																																					
	Parts Researched & Order PCB																																					
	Working Proof of Concept & Website (Schematic & Write-Up)																																					
	Analyze What Needs Improved																																					
	Improve Schematic/Layout																																					
	Simulate New Circuit Design																																					
	Order New PCB																																					
	Final Paper Complete with Schematic and Project Planning																																					
	Deliver Final Product																																					
Semester Two																																						

Table 5: Project Schedule

8 Risks/Feasibility Assessment

8.1 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 goal is through effective simulation we hope to order the correct parts the first time. 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 of various incidents that can happen in the lab. So far we are waiting for some of our parts to be ordered which need to be approved by our mentor first. The project is feasible in the frame time that we are expecting to deliver our final paper next semester, if any major incidents do not occur.

8.2 Physical Dangers

The largest physical risk is getting burnt or shocked while testing our circuit. Following proper lab procedure will ensure that no one gets harmed.

9 Market/Literature Application

This circuit can be used in many applications. To put it simply, anywhere someone needs fast switching or circuit could prove to be beneficial. Our client will be using the circuit in his research as part of a Sagnac configuration interferometer. Future investigation is being done on how our circuit is applicable in other scientific technologies.

The concept of a magnetic pulse generator has been researched in the past. Looking at what has been researched and published, parts of our project goals, such as a fast magnetic pulse generator or high energy have been designed previously. There are some patents on different designs and methods such as a Fast High voltage Modulator Circuit, patented in 1997. This design included a transformer and three MOSFETs. The Fast High voltage Modulator Circuit pulses at about 10 nanoseconds. In comparison to our design, the patented design is stackable and has more components.

10 Conclusion

At the end of this semester, we will have a functioning electromagnetic pulse generating circuit that can produce a one us pulse of 500 gauss with a period of one microsecond. To alter our original designs to function like an EMP generator, we have added capacitors, resistors, a diode to control back EMF to the MOSFET, and a coil. By continuing research, design, and test the end result will be a professionally fabricated working device.

10.1 Client

Iowa State University High Speed Systems Engineering Lab
Contact: John Pritchard

10.2 Team Information

Table 6: Team Contact Information

Team Member	Team Role	Email Address
Adam Kaas	Leader	ajkaas@iastate.edu
Gregory Fontana	Simulator	fontana@iastate.edu
Meiyong Himmtann	Webmaster	himmtann@iastate.edu
Brittany Duffy	Communication Leader	baduffy@iastate.edu
Megan Sharp	Coil Designer	megsharp@iastate.edu
Brandon Dixon	Layout Designer	bmdixon@iastate.edu
Alain Ndoutoume	Systems Leader & Commissioner	alain@iastate.edu

10.3 Advisors

Dr. Mani Mina (Senior Instructor, Dept. of ECpE) – mmina@iastate.edu

John Pritchard (Graduate Student) – johnp@iastate.edu

Robert Bouda (Graduate Student) - nybouda@iastate.edu

11 Appendix

11.1 Abbreviations

AC - Alternating Current

CAD - Computer-Aided Design

DC - Direct Current

EMF- ElectroMotive Force

LED - Light-emitting Diode

MO- Magneto-Optic

MOSFET - Metal-Oxide-Semiconductor Field Effect Transistor

PCB - Printed Circuit Board

TMS- Transcranial Magnetic Simulation