Fast, Compact, High Strength

Magnetic Pulse Generator

Project Plan I

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1 Introduction

1.1Problem statement &purpose

The idea of magnetic pulsers are not considered new in today's technological advances. The design of previous works have done a great job in successfully designing and producing a portable, fast magnetic pulser. However, there are issues regarding power dissipation of the circuit that makes it slightly inefficient. Our project's purpose is to improve the design and hopefully make it faster, stronger in terms of magnetic strength, smaller and power efficient.

1.2Goals

For this project, our goals is to provide an approach design with a proof of concept prototype that can achieve at least 100 microsecond and the circuit must be able to create a magnetic field with strength of greater than or equal to 500 G pulses. This circuit will have a small coil that generates a pulsing magnetic field at very high amplitudes, very quickly. Other than that, we will try to build a much faster and if possible, a smaller magnetic pulser making it not only efficient but also portable.

2 Deliverables

In two semesters, design and fabricate an electronic circuit with a small coil that can pulse magnetic fields with amplitudes of 500 Gauss at minimum in 1 microsecond.

Semester 1 - Provide design approach with proof of concept prototype that can achieve at least 100 microsecond, 500 G pulses.

Semester 2 - Provide a working final device, professionally fabricated, that meets specifications.

3 Design

3.1 Previous work/literature

There were a previous senior group that had done this kind of project before and during our meeting with our adviser, we were able to see some example of prototypes done by them. We also read their documents which includes their weekly reports, project plan, and design documents which were very helpful to our team. Documentation and specifications will be mentioned under references.

3.2 Proposed system block diagram

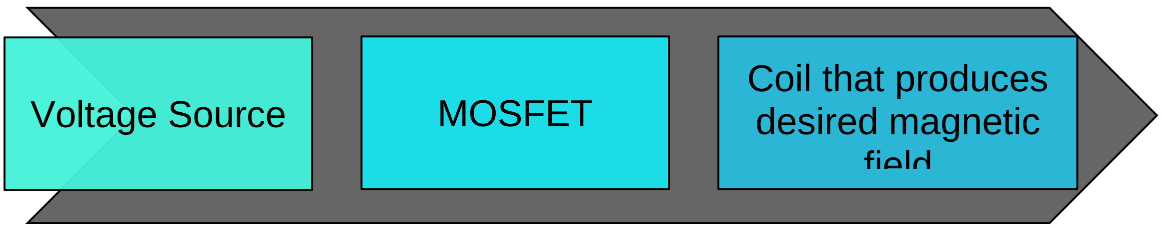


Figure 1: System Level Diagram

3.3 Measurement equipment

For this project, we will need to use an oscilloscope, a function generator, and a gauss meter. The oscilloscope will help us to ensure we are fulfilling our requirement of at least 100 microseconds' pulses. The function generator will give a voltage less than 15V. The gauss meter will help in providing measurements of the magnetic field of 500 G pulses.

3.4 Programs-validation purposes

There are several programs we will be using in the time span of our project. These programs are namely:

i) **MATLAB**

Used for calculations or graph plotting to obtain theoretical values needed in determining values for inputs and achieving design specifications.

ii) **MultiSim / Orcad Cadence Virtuoso**

After theoretical calculations, we will be using both programs to build simulations of our circuits to obtain an approximation of our output.

iii) **Manual Measurements**

The last and most important step is to test our circuit in the laboratory. These will determine whether our calculations and simulations match the real data we measure.

iv) **Others**

For fabrication purposes, we will need to use EAGLE PCB to design the layout of the actual circuit.

4 Project Requirements/Specifications

4.1Functional

For this project, we are looking to design and fabricate a fast, compact, and high strength magnetic pulse generator. Ideally, the electronic circuit with a small coil (inductor) should be able to deliver, at minimum, pulses of magnetic fields with amplitudes of 500 Gauss in 1 microsecond. Naturally, a circuit that can deliver a higher amplitude in less time would be even better. In accordance to its name ‘compact’, the circuit board will also have a dimension no larger than 3.5” by 2”. The circuit will also be supplied with 15V DC source voltage at maximum.

4.2 Non-functional

First and foremost, we need to decide on the most suitable electronic design automation software to use for simulation purposes. NI ModelSim, Cadence Virtuoso, and Eagle PCB (as mentioned above) each has its own advantage and disadvantages. The final design will be sent out to be fabricated onto industrial grade PCB. MOSFET chips will be fitted into sockets which will then be soldered onto the board. This can help reduce the cost as the chips can be easily replaced when burnt instead of purchasing a whole new board. The inductor coil, which will be sticking out of the board, will need to be as small as possible to reduce the probability of user accidentally breaking it. For safety purposes, the final circuit board should be enclosed in insulating materials as the 15V DC source voltage can be dangerous given the right condition. The voltage source will also be attached to the circuit using a secure but convenient system to facilitate setting up the board with a priority in safety of the user.

5 Challenges

In the beginning, we had an unfortunate turn of events when our previous project was cancelled a week before our project plan was due. However, we managed to recover in a fast pace by immediately choosing another project and getting all the specifications we needed through meetings with our advisers. They have been most helpful and understanding about our situation.

Besides that, regarding knowledge of area, all four team members of the group has taken electromagnetic courses prior to this project. We will still need to do more research regarding on achieving results to be as close as possible to our design specifications. Also, as mentioned above, we have the privilege to refer to previous work done by seniors that will help us further understand our goals, oncoming difficulties and a certain level of expectations of our project. Furthermore, MultiSim is a new simulation program we are not familiar with. Wei Shen has taken the responsibility to go through tutorials to learn more about it as he has some experience in a previous course.

Materials and equipment should not be an issue for us as we have fairly good resources provided. Everything we need will be within proximity of our campus. We can fabricate copper circuit boards on campus however final fabrication of the PCB may need a sum of money. There also may be a situation where extra circuit components would need to be ordered. A simple table regarding costs is shown below.

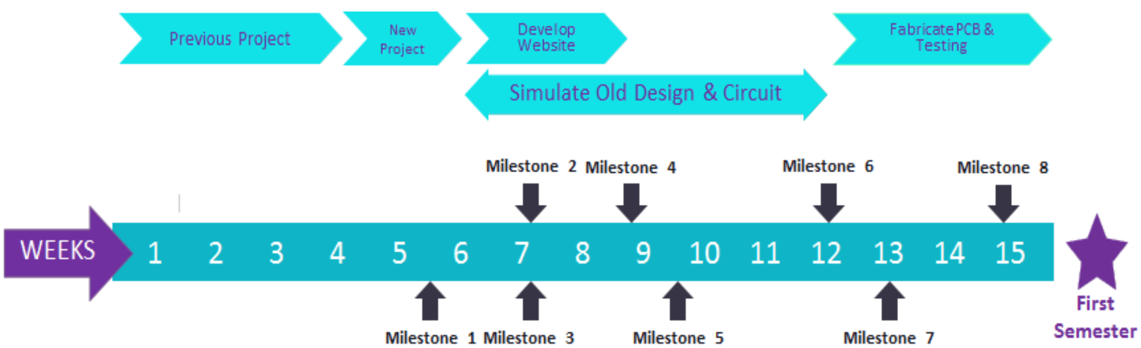
Resources	Obtainability	Cost Estimate
Circuit components	Parts Shop, Digikey	$30
PCB fabrication	Campus	-
Final PCB fabrication	oshpark.com	$20/board
Oscilloscope	Campus	-
Function generator	Campus	-
Gauss meter	Campus	-

Table 1: Cost Estimate (2 semesters)

Final note, every engineer knows that most of the time calculations will differ from real life situations. Therefore any unpredicted deviation of results will surely occur but it is our job to fix them. Our plans are to firstly make the circuit work and then optimize it using our best efforts.

6 Timeline

6.1First semester



Milestones:

1. Simulate simple circuit to explore how MOSFETs act as switches to generate continuous pulses.

2. Read documents from the previous team and additional electromagnetism materials, and explore multiple electronic design automation software for best options in fabricating PCB.

3. Simulate previous team's circuit and understand how it works.

4. Analyze the advantages and disadvantages of the previous team's design.

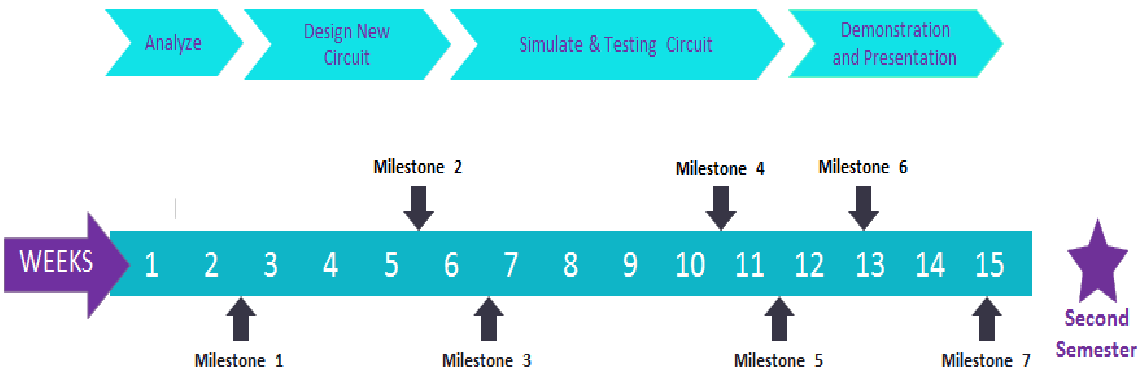
5. Do research to improve the circuit outcome.

6. Fabricate PCB board on campus and solder components onto the board.

7. Conduct trials and troubleshoot the board.

8. Verify board produces output as per specifications.

6.2 Seconder semester



Milestones:

1. Analyze first semester circuit’s advantages and disadvantages.

2. Do research and consult advisers to further improve the circuit performances.

3. Fabricate revised PCB and solder on components.

4. Test and troubleshoot revised circuit.

5. Verify final design produces outputs as per specifications or better.

6. Prepare final design for demonstration and presentation.

7. Demonstration and presentation to client.

7 Conclusions

In a nutshell, our project can be completed within the given time frame despite our initial setbacks as long as we stick to this project plan. Much time was spent to ensure each milestone is given sufficient time period and well phased out. With that in mind, we are positive that we will be able to produce a fast, compact, and high strength magnetic pulse generator that is able to create a magnetic field with strength greater than 500 Gauss in one microsecond. The team is working closely with our advisers to ensure a smooth project.

8. References

1. "May15-30." *May15-30*. N.p., n.d. Web. 19 Feb. 2016. <http://may1530.ece.iastate.edu/>.
2. "Main Page." *High Speed Systems Engineering Lab RSS*. N.p., n.d. Web. 19 Feb. 2016. <http://wiki.eng.iastate.edu/high-speed-systems-engineering-lab/index.php/Main_Page>.
3. "EE 333 : Lab." *EE 333 : Lab*. N.p., n.d. Web. 19 Feb. 2016. <http://tuttle.merc.iastate.edu/ee333/lab.htm>.
4. "NI Multisim and Ultiboard Technical Resources." *Getting Started With NI Multisim*. N.p., n.d. Web. 19 Feb. 2016. <http://www.ni.com/multisim/technical-resources/>.