High Speed Magnetic Field Pulser

DESIGN DOCUMENT

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Executive Summary

Development Standards & Practices Used

List all standard circuit, hardware, software practices used in this project. List all the Engineering standards that apply to this project that were considered.

Summary of Requirements

List all requirements as bullet points in brief.

Applicable Courses from Iowa State University Curriculum

List all Iowa State University courses whose contents were applicable to your project.

New Skills/Knowledge acquired that was not taught in courses

List all new skills/knowledge that your team acquired which was not part of your Iowa State curriculum in order to complete this project.

Table of Contents

1 Introduction 4

1.1 Problem and Project Statement 4

1.2 Goals and objectives 4

2 4

3 Design 7

3.1 Previous Work And Literature 7

3.2 10

3.3 Proposed Design 7

3.4 Technology Considerations 8

3.5 Design Analysis 8

3.6 11

3.7 11

4 Testing 9

4.1 12

4.2 12

4.3 13

4.4 13

5 Implementation 10

6 Closing Material 10

6.1 Conclusion 10

6.2 References 10

6.3 Appendices 10

List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1 Introduction

1.1 Problem and Project Statement

The Idea of magnetic pulsers is not considered new in today's technological advances. looking at what was done before one can see they successfully did a designing and production of a portable and fast magnetic pulser. However, there are some problems regarding the power dissipation of the circuit which makes it a little less productives and inefficient. So, As a team we want to improve the circuit design and may come up with a faster, stronger, smaller and powerful and very efficient magnetic pulser with great magnetic strength.

1.2 Goals and objectives

For this project, our goal 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 Project Plan

2.1 Task Decomposition

There are 2 classifications of tasks that will be completed that are distinct and related in their goal of completion of the project. The first are tasks that will be completed for the goal of improving our ability to complete a project in general and communicate the results and progress of the project: design reports, status reports, presentations, reflections, etc. The second are tasks that will be completed for the goal of producing the deliverables requested by the client: designing prototype, holding design reviews, and creating the prototype. Each of these types of tasks come with their own risks and challenges that will need to be overcome.

There are three main type two tasks:

1. Create a design version one of a design review.

This is the first major task of the project. In order to complete it the team will need to gain an understanding of the physics behind the circuit and create a design. Once the design is able to meet all of the requirements, it will be presented to our client and advisor. They will provide feedback and prompt a second round of revisions.

2. Update design for design review two

The second design will make improvements on the first and will culminate in the second design review. This design review will hopefully go well and send us forward to the prototyping task.

3. Create prototype of design

This task involves implementation of design that has been approved by the client and advisor.

2.2 Risks And Risk Management/Mitigation

For the first type of task the main challenge will come in the form of communication. Creating a design document or a presentation is not technically challenging, nor is it prone to being thrown off by external forces. The issue that way assise is each team member may not know their responsibilities and tasks may fall through the cracks. To overcome this issue there are three main channels of communication that the team will utilize to eliminate this miscommunication. The first is GitLabs issues which is where a complete description of each task will be laid out and responsibilities will be delegated. The second mode of communication is GroupMe and will be used for more quick informal messaging. Finally, Zoom will be used for video conferencing in which we will have 2 meetings a week, one to plan the tasks we are going to conquer this week and a second to go over the progress of the previous week's tasks with our client and advisor.

For the second type of task challenges come from internal and external sources. This means that the same challenges that faced the first type of tasks will still apply here and the same solution will be utilized to mitigate them. The external challenges are a lot more task dependent. In the initial designs of the prototype we will face the challenge of inexperience with the topic, none of the team members have direct experience working with a circuit like this one and will need to use our diverse electrical engineering backgrounds in order to create a fully realized design. Once the design is created, we will need to build the prototype. There are a number of challenges this task will face. First, due to the coronavirus, there may be lead time issues. There will not be a lot of time between the completion of the design and the creation of the prototype and we will not know what parts we need until the design is complete. To mitigate this we will stick to standard parts and preferably those available from the Iowa State parts shop. Second, there is a limited capacity on the lab use due to the coronavirus so physically building the prototype will also be difficult logistically. For this same reason, it will also be difficult to debug any issues that arise when the design is built. Mitigating this issue can be done by coming to the lab with a clearly thought out plan of attack to quickly complete all tasks.

2.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

There are four key milestones in the project that will be completed in order to achieve success in this project. The two are to complete design reviews of designs that will theoretically meet all the requirements of the prototype. In the second design review the goal will be to have implemented all of the fixes and improvements proposed in the first design review. The final 2 milestones will be

to create a working prototype that meets all specifications, hold another design review and then implement the improvements or fixes.

2.4 Project Timeline/Schedule

Week 5				
14-Sep	15-Sep	16-Sep	17-Sep	18-Sep
Monday	Tuesday	Wednesday	Thursday	Friday
Create Electrical Design				
				Bi-weekly Status Report Due

Week 6				
21-Sep	22-Sep	23-Sep	24-Sep	25-Sep
Monday	Tuesday	Wednesday	Thursday	Friday
Create Lighting Talk		Lighting Talk II		
Create Design document V1				Design Document V1

Week 7				
28-Sep	29-Sep	30-Sep	1-Oct	2-Oct
Monday	Tuesday	Wednesday	Thursday	Friday

		Electrical Design Review I		
				Bi-weekly Status Report Due

Week 8				
5-Oct	6-Oct	7-Oct	8-Oct	9-Oct
Monday	Tuesday	Wednesday	Thursday	Friday
Revise Design				
				Reflection: Areas of Professional Responsibility

Week 9				
12-Oct	13-Oct	14-Oct	15-Oct	16-Oct
Monday	Tuesday	Wednesday	Thursday	Friday
		Electrical Design Review II		
				Bi-weekly Status Report Due

Week 10				
19-Oct	20-Oct	21-Oct	22-Oct	23-Oct
Monday	Tuesday	Wednesday	Thursday	Friday
Build Proof of Concept				
Create Design Doc				

Create Lighting Talk		Lightning Talks: Technical Challenges		

Week 11				
26-Oct	27-Oct	28-Oct	29-Oct	30-Oct
Monday	Tuesday	Wednesday	Thursday	Friday
Troubleshoot Proof of Concept				Finish proof of concept prototype
Design Doc V2				
				Reflection: Engineering Standards

Week 12				
2-Nov	3-Nov	4-Nov	5-Nov	6-Nov
Monday	Tuesday	Wednesday	Thursday	Friday
Create Presention				
Create Final Design Document				
		Create Youtube Video		

Week 13				
9-Nov	10-Nov	11-Nov	12-Nov	13-Nov
Monday	Tuesday	Wednesday	Thursday	Friday
Finish Presentation	Practice Presentiaon			
Finish Final Design Doc	Revise Final Design Doc			
	Youtube Video Due			

Week 14				
16-Nov	17-Nov	18-Nov	19-Nov	20-Nov
Monday	Tuesday	Wednesday	Thursday	Friday
Final Presentations to Panel				
Final Design Document Due				
Weekly Status Report Due				

2.5 Project Tracking Procedures

The project progress will be tracked using gitlab issues. We will adopt an agile-like approach in which we will move tasks across the board each week and present our progress to our clients. At the beginning of the week, the tasks that were completed in the previous week will be discussed amongst the members and we will prepare to present them to the client and mentor in the following day's meeting. Then we will og over the tasks that will be completed throughout this week. Finally, in the following meeting, we will present the tasks that were completed to the clients

and receive feedback.With this feedback we will update the tasks that will be completed in that week.

2.6 Personnel Effort Requirements

For each task on the gitlab issues page there will be a breakdown of subtasks. Each team member will be responsible for declaring a subtask that they will complete. In smaller tasks one person will be asked to complete the entire task. In all cases effort will be taken to ensure that all team members have an even amount of work.

2.7 Other Resource Requirements

The resource that will be required will be determined by the parts in the final design. This is currently being developed.

2.8 Financial Requirements

The total financial cost will likely be less than $100 as it is only one PCB will likely standard parts.

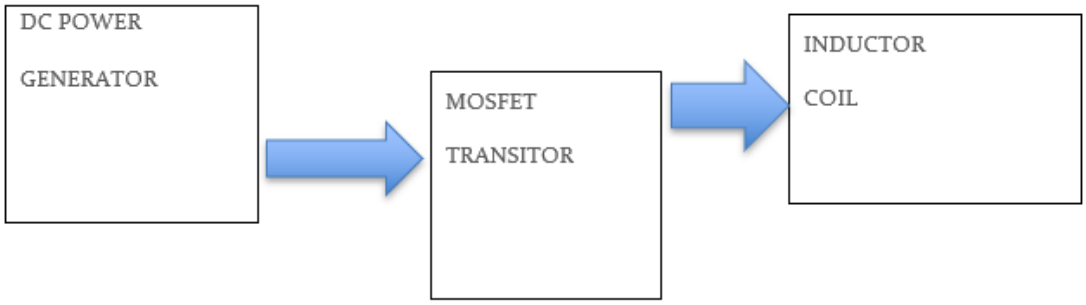
3 Design

3.1 Previous Work And Literature

A previous senior design group had done the same project before and during our meeting with our advisor, we were able to obtain some documents including a schematic done by the previous team. The document helps us understand the requirements of the project

3.2 Design Thinking

For this project, our goal is to design a magnetic pulser with magnetic field strength greater than 500 G pulse. The circuit will have a MOSFET transistor and a small coil that will generate a magnetic field. MOSFET will help us to control the inductor current that we will use to calculate magnetic field strength.



Include any/all possible methods of approach to solving the problem:

- Discuss what you have done so far – what have you tried/implemented/tested?
- Some discussion of how this design satisfies the **functional and non-functional requirements** of the project.
- If any **standards** are relevant to your project (e.g. IEEE standards, NIST standards) discuss the applicability of those standards here
- This design description should be in **sufficient detail** that another team of engineers can look through it and implement it.

3.4 Technology Considerations

Highlight the strengths, weakness, and trade-offs made in technology available.

Discuss possible solutions and design alternatives

3.5 Design Analysis

– Did your proposed design from 3.3 work? Why or why not?

– What are your observations, thoughts, and ideas to modify or iterate over the design?

3.6 Development Process

Discuss what development process you are following with a rationale for it – Waterfall, TDD, Agile. Note that this is not necessarily only for software projects. Development processes are applicable for all design projects.

3.7 Design Plan

Describe a design plan with respect to use-cases within the context of requirements, modules in your design (dependency/concurrency of modules through a module diagram, interfaces, architectural overview), module constraints tied to requirements.

4 Testing

Testing is an **extremely** important component of most projects, whether it involves a circuit, a process, or software.

1. Define the needed types of tests (unit testing for modules, integrity testing for interfaces, user-study or acceptance testing for functional and non-functional requirements).
2. Define/identify the individual items/units and interfaces to be tested.
3. Define, design, and develop the actual test cases.
4. Determine the anticipated test results for each test case
5. Perform the actual tests.
6. Evaluate the actual test results.
7. Make the necessary changes to the product being tested
8. Perform any necessary retesting
9. Document the entire testing process and its results

Include Functional and Non-Functional Testing, Modeling and Simulations, challenges you have determined.

4.1 Unit Testing

– Discuss any hardware/software units being tested in isolation

4.2 Interface Testing

– Discuss how the composition of two or more units (interfaces) are to be tested. Enumerate all the relevant interfaces in your design.

4.3 Acceptance Testing

How will you demonstrate that the design requirements, both functional and non-functional are being met? How would you involve your client in the acceptance testing?

4.4 Results

– List and explain any and all results obtained so far during the testing phase

- Include failures and successes
- Explain what you learned and how you are planning to change the design iteratively as you progress with your project
- If you are including figures, please include captions and cite it in the text

5 Implementation

Describe any (preliminary) implementation plan for the next semester for your proposed design in 3.3.

6 Closing Material

6.1 Conclusion

Summarize the work you have done so far. Briefly reiterate your goals. Then, reiterate the best plan of action (or solution) to achieving your goals and indicate why this surpasses all other possible solutions tested.

6.2 References

List technical references and related work / market survey references. Do professional citation style (ex. IEEE).

6.3 APPENDICES

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar data that does not directly pertain to the problem but helps support it, include it here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc,. PCB testing issues etc., Software bugs etc.