EE/CPRE/SE 491 Weekly Report 3 Meeting Times 2:00 – 3:00 P.M. Mondays in TLA
Date: Week of February 12, 2018
Group Number 4

High Current Pulse Generator for the Application of Transcranial Magnetic Stimulation

Clients/ Advisors: Priyam Rastogi, Neelam Gaunkar, Jayaprakash Selvaraj, Dr. Mani Mina

Project Objective: Over the course of 2 semesters, design, fabricate, and test a high-current pulse generation device for use in TMS research.

- Objective of Circuit
  - Peak Current of 2 KA +10% (EMF feedback must be considered)
  - Peak Current Sustained for 400 µs
  - Rise/fall time of 100 µs
  - Up to 36 Hz pulse frequency (Commercial Benchmark)
  - Circuit Input is 120 V wall outlet.
  - Range of Load - 5 micro-Henry (min) to Max(Undefined)
  - 10 pulses a minute max
  - Circuit shall be biphasic
  - The device shall output multiple waveforms (Square, Sawtooth, etc.)

Team Members:

Brian Kirkpatrick: Head of Circuit Design
Jon Rothfus: Head of Micro-Controllers, Team Communications Leader, Webmaster
Tania Alvarado Carias: Head of Electrical Safety
Abdul Bahashawn: Head of Rectification Circuits
Yan Wang: Head of Component Selection
Curtis Richards: Team Leader

Sub Teams:

Chassis Design: Tania, Curtis, Yan	-Meets Thursdays 2:00-2:30 p.m. Howe
Rectification Circuit: Abdul, Yan, Brian	-Meets Fridays 11:30-12:00 p.m. Marston
Power Circuit: Tania, Curtis, Abdul	-Meets Fridays 2:00-2:30 p.m. TLA
Micro Controller: Jon, Brian	-Meets Wednesdays 1:15-1:45 in TLA

Weekly Summary:

- Power Circuit:

The power team met with some tasks to be done ahead of our meeting. Abdul was to research and report on whether we should use one capacitor, or several in series. He provided some insightful knowledge in our sub team meeting, and after some deliberation we decided on several capacitors in series. This will allow any resistance to become smaller, and the cost of the capacitors should go down as well. We found our total capacitance for capacitive storage part of the circuit to be around .055 Farads. We calculated capacitance using a 6% voltage drop will occur across the load during the 400-microsecond interval based on the mouse pulsar paper. With the peak current as 2000 A, the only other factor in our circuit capacitance was the initial voltage. Originally, we tried the same voltage used in the mouse pulsar paper (200V) to find a total capacitance value of .065 Farad. However, by having an initial voltage of 240V, our team will be able to reduce the amount of capacitance needed and be able to directly charge the capacitors from an input voltage of 240 Vdc, meaning we will no longer need a voltage step down circuit. These effects should all decrease the total cost me may accrue.

A new sub circuit in the power circuit design, regenerative circuit, was also discussed and added. Instead of turning off the switching component to stop the pulse, another switch enables an uncharged capacitor bank to be connected to the load. With the regenerative capacitor bank in effect, the 2000A peak will no longer be thrown into a non-conducting switching device. It will instead be used to charge the capacitors, which in turn can be used to recharge the capacitor bank. The drawbacks to this addition of the circuit are the fact it will cost more money and complicates circuit design but increasing the life of our switching components may make up for its shortcomings.

- Chassis Design:

The chassis team's design this week, we have decided on the material for our "box". We went with a mixture of wood and metal to keep the wood from burning, our design will essentially be a big box. We will created slits on the bottom and a hole on top that can potentially fit a fan if necessary.

- Micro-Controller (M.C.):
    - Created basic Matlab GUI prototype with several buttons for controlling LEDs. Connected GUI to arduino via script and tested communication. Can successfully turn on/off/blink LEDs at different frequencies using buttons on Matlab GUI.
    - Began experimenting with Matlab scripting language and libraries.
    - Researched methods of monitoring resistances with Arduino for the application of temperature sensing using resistive temperature sensors.

- Rectification Circuit:

Downloaded and did the tutorial for Eagle software and discussed the design of the rectification circuit. Built a simple rectification design through a circuit building software. Assigned individual works for the upcoming week (designing, simulating, and building a smaller

model of voltage doubler). Also, decided on building a rectifier instead of buying it. Decided on using Eagle PCB Builder for any simulations needed. Discussed what components needed.

Accomplishments of the Past Week:

Each member is to write up a reflection on their work throughout the week. The reflections can be found at https://iastate.app.box.com/folder/46145323949

Pending Issues:

I. Schedule Sub Group Meeting Times
Power Circuit - Meets Fridays 11:15-12:00 p.m. TLA
Chassis - Meets Thursdays 2:00-2:30 p.m. Howe
Rectification - Meets Fridays 11:30 a.m.-12:00 p.m. Marston 2200
M.C. - Meets Wednesdays 1:15 - 2:00 in TLA

II. Project Plan
a. Present Individual Sections
i. Jon - Section 1
ii. Chuck - Section 2.1-2.5
iii. Tania - Section 2.6-2.9
iv. Abdul - Section 2.10-2.13
v. Brian - Section 3-3.2
vi. Yan - Section 3.3-3.5
vii. Section 4 - Everyone as necessary
b. Combine Sections
The document is under reports folder in the Senior Design Google Drive.

New Business:

III. Due Dates
a. Weekly Report to be filled out by Saturday at midnight

IV. Team Reports
a. Update your sub team sections accordingly

EE/CPRE/SE 491 Weekly Report 3
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Group Number 4

Meeting Times 2:00 – 3:00 P.M. Mondays in TLA

Individual Contributions:

Group Member	Accomplishments	Time Worked This Week	Total Time Worked
Abdul	Spent some time going over whether or not to use an individual large capacitor or multiple smaller ones. Learned a little bit about Eagle PCB Builder. Read about voltage doublers, rectifiers, and transformers to understand how they work.	4	8
Yan	Downloaded and walked through the Eagle software. worked on a spreadsheet for budget. Looked through some components for our rectification circuit. Discuss the details of our chassis design and how we will go about it for cooling due to our design being a box which will be designed so hot air can travel from the top of the box with fresh air circulating from the bottom.	4	8.5
Jon	Created simple Matlab GUI prototype with buttons for turning on and off LEDs on the Arduino and tested to verify Matlab communication with Arduino. Was able to turn on/off/blink LEDs by clicking GUI buttons. OK. Investigated current sensing shunt resistor options on the market and found 1 option that meets the current/power values our peak current of 2000 A would require with a reasonable price and size. Investigated temperature sensor options for monitoring circuit hotspots. Found 1 surface mount resistive sensor option that could be used with Arduino in a voltage divider configuration to determine temp of components. More investigation is needed and testing is needed.	4	10
Brian	Researched into the voltage multipliers, built an Eagle version and another in Falstad. Tested the various output configurations to allow for some flexibility to our design.	3.5	7
Tania	Evaluated pros and cons of metal as possible material for chassis design box. Researched more about the resistive circuit for safely discharging the	2.5	7.5

	capacitors		
Chuck	Researched and designed regenerative circuit. I also researched wood chassis. I drew out our designed circuit. (see 2-18-18 reflection for Curtis Richards)	9	18

Deliverables:

- Semester 1:
  1. Early Concept Implementation and Simulation
  2. Design Circuit with High Current Carrying Components
  3. Programming of Micro-Controller to Control Pulses
  4. Select and Order Components
  5. Assembly of Components

- Semester 2:
  1. Testing of the Pulsar
  2. GUI

Individual tasks to be completed before next meeting:

Everyone:

Check Capacitor Calculations from the mouse paper.

- Project Plan
  - Complete individual subsections
  - Develop a Gantt Chart
- Weekly reflection
- Rectification Team
  - XFMR
  - Buck converter, switch-mode power supply, or SEPIC?
  - Start initial circuit design
- Power Team
  - Which Switching Component to Use?
    - Price
  - What capacitor do we use?
  - After capacitor is chosen, relay the circuit input to the rectification.
- Chassis Team
  - Which material to use?
  - IR Camera
  - Boyd Lab
  - Cooling Method
- M.C.

- temp sensor
- Current Sensing Resistor
- Get first Matlab GUI window up

Yan- Start a Part Excel sheet

Chuck- Wire Diameter Calc

Summary of Weekly Advisor Meeting:

We met with our advisors, and reported our finding for the switching components. We talked about designing future circuit parts.

Questions for Next Client Meeting: