EE/CPRE/SE 491 Weekly Report 5 Meeting Times 2:00 – 3:00 P.M. Mondays in TLA
Date: Week of February 26, 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 2:00-3:00 p.m. Marston
Power Circuit: Tania, Curtis, Abdul	-Meets Fridays 11:15-12:00 p.m. TLA
Micro Controller: Jon, Brian	-Meets Wednesdays 1:15-1:45 in TLA

Weekly Summary:

- Power Circuit:

  Our original power circuit design was abandoned. The thyristor, (IRK 230-20) the design was dependent on, could not be sourced. We could not locate any other equal thyristor or switching device, so we began a redesign with the restriction the components we design with must be able to be ordered and shipped from Digikey or Mouser by spring break.

  Our "Design Plan B" is based off Kirchhoff's Current Law: All currents entering a node must be equal to the currents leaving the node. The capacitor bank was already supplying equal parts of current in parallel that would sum to the current across the node, so by having a switching component in series with each capacitor the amount of current the switch would see is less than what would be seen across the load. To dissipate the current in the load, we introduce a diode and resistor pair in reverse polarity across the circuit. While delivering the pulse our diode is non-conducting, but when the switch is turned off, the load reverses polarity and turns our dissipation diode into a conducting path for our load current to move through the resistors. These details can be better understood after looking at the "Design Plan B" document located in our group cy-box.

  We were able to still meet all the expectations of the circuit as laid out in previous meetings, but the regenerative circuit was not easily translated into the new design on such short notice. The decision was made to leave that portion of the circuit out, with the possibility we may return to the idea in the future after a working prototype has been established. One portion were the design is more successful however is in its designed "modularity". Each capacitor/switching line is equal to one resistor/diode dissipation line, both connected at the same node. We will build and test the circuit adding one capacitor/switch line at a time to our node. This will provide great safety as we test the circuit. By building and testing in this method we hope to avoid past teams' shortcomings of overloading all their switching components at once.

- Chassis Design:
  - Decided to cut the dimensions of the box in half since we will be building for the monophasic circuit during this semester. During spring break we will build the wooden box with 1.5' x 1.5' dimensions so we have it ready to start implementing the circuit parts after spring break.
- Micro-Controller (M.C.):
  - Experimented with PWM (pulse frequency, duty cycle) using various Arduino methods to determine suitability for switching control of IGBT or other switching devices.
  - Wrote function to receive a serial command from Matlab GUI and produce a PWM pulse on Arduino output pin. Pulse produced has nominal frequency of

36Hz with pulse width of 400 microseconds and a total of 10 pulses according to design requirements.
    - Created and tested simple circuit to sample analog inputs from photoresistor with Arduino. Wrote function to send captured analog data to Matlab over serial connection.
    - Currently this pulse command is pulsing an LED. The next step will be putting a scope on the output to verify timing and waveform, then experimenting with this pulsing function to control switching of an IGBT or another switching component.
- Rectification Circuit:
    - Our circuit will remain the same, however since it is now monophasic we only need one rectification circuit.
    - Goal will be to solder the diodes onto a blank PCB board that is similar to how the breadboard works.

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

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

New Business:

I. Design Document - Have your Sections Done by Saturday at Midnight

Section 1: Jon

Section 2: Chuck & Brian

Section 3: Abdul & Tania

Section 4: Everyone as needed

II. Components

Yan is to have a complete list ready by Thursday for Mina and Friday for Zambreno's Approval. Send to Priyam first!!! Have a nice worded letter explaining the high cost. Bring up Priyam's experiment last weekend where 1000 Amps does not work. Also talk about safety.

Individual Contributions:

Group Member	Accomplishments	Time Worked This Week	Total Time Worked
Abdul	More in-depth research on components will be used in the project by other sub-teams to make sure I have a solid understanding of how parts of the design work together. More reading about the specific IGBT will be used. Finally, did so research for using LED that indicates when the capacitors are fully or partially charged.	3	17
Yan	Sent a letter to clients and advisor for a budget to be approved, checked the spreadsheet to make sure everything was written in the correct area	2.5	16.5
Jon	Experimented with PWM (pulse frequency, duty cycle) using various Arduino methods to determine suitability for switching control of IGBT or other switching devices. Wrote function to receive a serial command from Matlab GUI and produce a PWM pulse on Arduino output pin. Pulse produced has nominal frequency of 36Hz with pulse width of 400 microseconds and a total of 10 pulses according to design requirements. Created and tested simple circuit to sample analog inputs from photoresistor with Arduino. Wrote function to send captured analog data to Matlab over serial connection. Currently this pulse command is pulsing an LED. The next step will be putting a scope	5	19

	on the output to verify timing and waveform, then experimenting with this pulsing function to control switching of an IGBT or another switching component.		
Brian	Researched into electromagnetic relays and solid state relays datasheets. Found a cost efficient solid state relay that will allow us to control using the Arduino. Looked into methods of indicating to the Arduino the state of the capacitor to perform the mechanical isolation of the rectification circuit.	5	18
Tania	Met with Chuck after he finalized the Power Circuit Plan B to decide upon resistors and calculate which wattage values would be the most efficient while at the same time being cost effective. Met with an electrical power professor to discuss physical and circuit safety of our circuit design.	4	16
Chuck	Our original power circuit design was abandoned because of our switching component, or anything equal, is not possible to acquire in our restricted time. Redesign of Power Circuit took much of my time this week, for we took a new approach of designing around only components that are available. This new design can be seen in the cy-box under "Design Plan B" Chassis decided upon a build plan based off of building around the circuit. A bill of materials was finalized, and ordering should take place next week.	13	40

Deliverables:

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

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

EE/CPRE/SE 491 Weekly Report 5 Meeting Times 2:00 – 3:00 P.M. Mondays in TLA
Date: Week of February 26, 2018
Group Number 4

Individual tasks to be completed before next meeting:

Everyone:

- Weekly reflection
- Rectification Team
    - Start parts list
- Power Team
    - Which Switching Component to Use?
        - Price
    - Find parts for capacitors, resistors, diodes, and relays.
    - Calculate Design B
    - Tania & Chuck
        Current Limiting Resistor
    - Abdul
        LED for when there is charge in the capacitors.
- Chassis Team
    - Have initial design done for Monday
    - IR Camera
- M.C.
    - Test serial transmission of data from Arduino to Matlab
    - Plot received data in real time in Matlab

Summary of Weekly Advisor Meeting:

We roughed out a new power circuit design as described in the power circuit portion of this document. The rest of the meeting was spent putting together a deadline for our bill of materials. It would be finished Wednesday, and sent to Dr. Mina, and Dr. Zambreno on Thursday for approval.