Project Name: High Current Pulse Generator for the use of Transcranial Magnetic Stimulation.

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Problem Statement:

High current pulse generating (HCPG) machines for the use of transcranial magnetic stimulation (TMS) available on the market only allow for their use with proprietary coil designs from the manufacturer.

Project Objective:

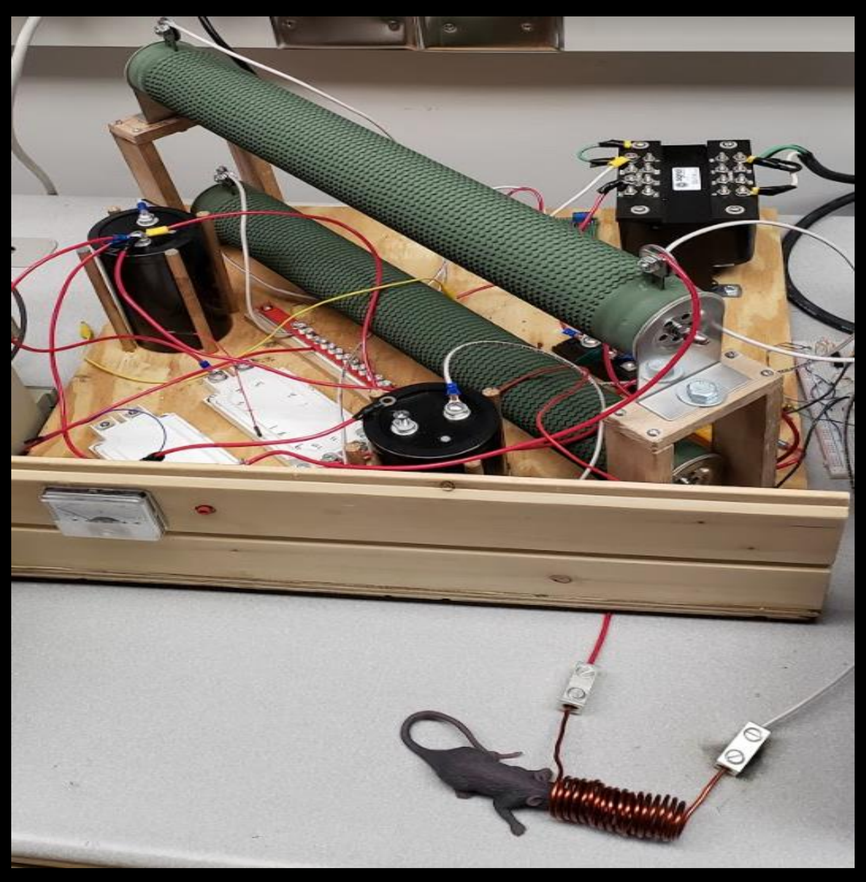
Design, build and test a HCPG machine for the laboratory environment to enable economical and accurate testing of different TMS coil designs.

Functional Requirements:

- Peak Current 2000 amperes Sustained for 400 microseconds
- Rise or Fall Time of 100 microseconds
- Machine Powered by a 120V_{rms} Wall Outlet
- 10 Pulses a Minute
- Graphical User Interface (G.U.I)
- Machine can Accept a Wide Range of Inductive Coil Design

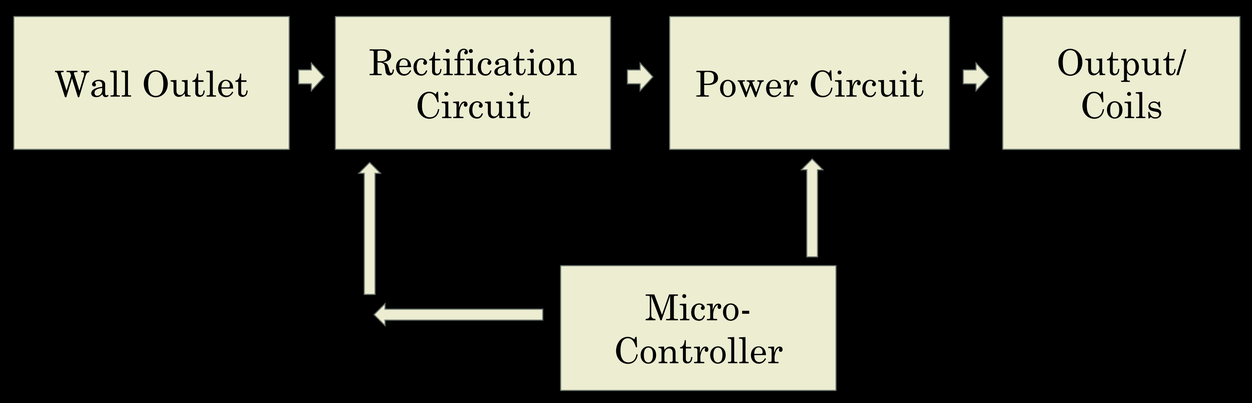
Non-Functional Requirements:

- Multiple Rectifiers are Available for Backup in the Event of Damage
- User Friendly G.U.I.
- Heavy Duty Chassis
- Built in Analog Voltmeter
- Fans to Increase Circuit Cooling
- Less Expensive than Similar Generators on the Market



The photo above is our circuit and testing set up with fake mouse.

Block Diagram:



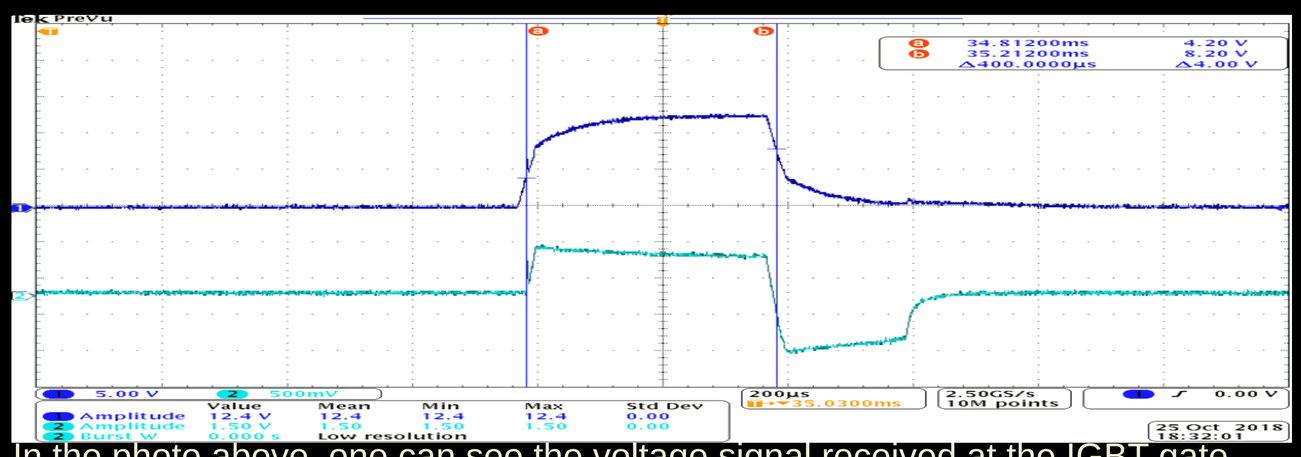
Technical Details:

To increase the peak current level and decrease cost the team took advantage of Kirchhoff's Current Law, all currents entering a node must be equal to the currents leaving the node, by designing modular legs of capacitor and insulated gate bipolar transistors (IGBT) in series. By increasing or decreasing the amount of capacitor/IGBT modules, one can change the design by ±500 Amperes per module. The cost of each module is approximately $210.

Testing and Results:

The HCPG was ran through many tests to simulate heat dissipation, usability, and maximum current. For safety, the circuit was tested with only one capacitor/IGBT module at first, then a second module was added to prove design concept. Despite small component failures, like our IGBT gate controlling op amp failing due to a floating ground, our design concept was proven with little change to the power circuit during testing. The maximum current tested was 1900 amperes.

The current proved difficult to chart because of the nonlinearity of the load (Inductive Coil). We were able to find a reliable measurement of current by finding the magnetic field produced by the coil and calculating backwards by approximating the solenoid. $B = \mu n I$



In the photo above, one can see the voltage signal received at the IGBT gate on top (blue), and the voltage signal across the load (green). Note the reverse polarity of the signal at the end due to the nature of inductors. This backwards electromotive force (emf) is dissipated through a 1kW, 100 Ohm resistor. The photo below shows the peak gaussmeter measurement of magnetic field (milliTesla) of the coil.

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