Greensteam Project: Generator/Battery Charger

Adrien Sanding: Spring Quarter 2020 Project Report

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Final Notes:
Any of my rough sketches, notes, and ideas will be available here to view.

Project Summary:

The purpose of this project is to create an engine that converts landfill wastes into usable energy. For this quarter, emphasis was placed on ideal engine design, and conceptual plans for the furnace and mechatronic systems.

My part in the project was designated into the mechatronic systems, more specifically, introducing a chargeable battery capable of keeping the system in motion, as the primary energy output of the system would be from the engine. Furthermore, sensors would be placed on the engine to be able to monitor the system's consistency and efficiency. alongside team member Michael Delessio, I was also tasked to work on a CNC router to be able to get it in working condition.

The Greensteam project has three major goals:

1. development of novel designs for engines and generators that leverage contemporary technologies, including for instance direct linear electrical generation and sensor driven mechatronic valve systems.
2. Development of efficient clean furnace boiler systems, leveraging automated sensor driven real-time control, with the goal of providing sustainable power and clean destruction of urban, industrial and agricultural waste, including plastics and composite materials.
3. the development of robust, simple and efficient small-scale external combustion mechanical and electrical power systems for isolated and off-the-grid situations.

Mechatronic Systems

Part A: DC Generator

Problem: Convert a portion of the engine's mechanical energy into DC electricity to charge and use it:

"the solenoid steam valve will need a high peak current 24vdc source, so your design will need to output clean smoothed 5v - no more than 500mA...as well as unfiltered 24v. Note that a sawtooth wave power source is better than a smoothed source for driving inductive loads (motors, coils…).

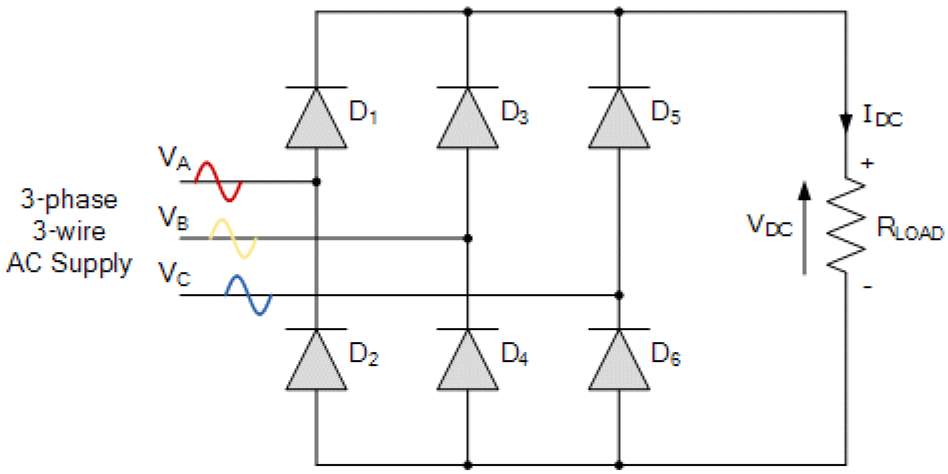
"Alternatively, going with 12 as base, and breaking that down to 5 and up to 24…"

Concept: While a DC motor needs an electrical input to produce a motor output, it is also capable of receiving a motor input to produce a motor output. In turn, having the system's crankshaft also spin the motor we'll be able to create a circuit to charge batteries in order to have auxiliary power on standby to support the system.

Motors: There are three different options for Motors to use: Stepper, Brushed (BDC), and Brushless (BLDC). Each bring in their own pros and cons.
Stepper Motors are good for small scale situations. It provides a 2 phase output that will require a full bridge rectifier and capacitor to create a True DC signal. They are high torque but work only well on low RPMs (~1000-1200 RPM maximum).

Brushed Motors require high RPM's to perform properly. However, due to the more mechanical properties of these motors, noise and vibrations can significantly affect the stability of the motor. This is in part of the brushes within the BDC causing the alternating polarity which keeps the motor moving. These brushes do wear out in time though due to this necessary friction, and so in the long term maintenance will be required to keep the system running at a high rate.

Brushless Motors: are a bit strange as they are the hybrid of the two. While needing a fast RPM to provide a solid output, they are capable of producing efficiencies for a longer lasting period of time at a low noise level. However, if we're to retrieve the output from them, we will need a rectifier to retrieve true DC. In certain cases, such as with the test motor I ran math on, we would be working with a 3 phase BLDC. Therefore, like the stepper motor, we would need a 3 phase rectifier and capacitor instead of a full bridge, in order to get the full power output of the motor.



I believe in a full scale project, a BLDC motor will be the ideal way to go, as not only are they longer lasting, but capable of producing necessary outputs given the design of the system. Using a test part's specifications, I will first determine the kV of the system, defining how much voltage will be produced at a certain RPM. While this value is usually meant for input voltage to output rotation, if works conversely as well.

With the sample motor, I was able to calculate a kV of 351.3 RPM/V, meaning to at least get a 12V output, the motor would need to spin at about 4215.6RPM. While potentially not achievable from the engine alone, gears will allow for a ratio to be found that'll allow an efficient transfer of the engine's mobility to the BLDC. However, it will not be until an engine is set up that we can determine what gear ratios we'd need to assemble.

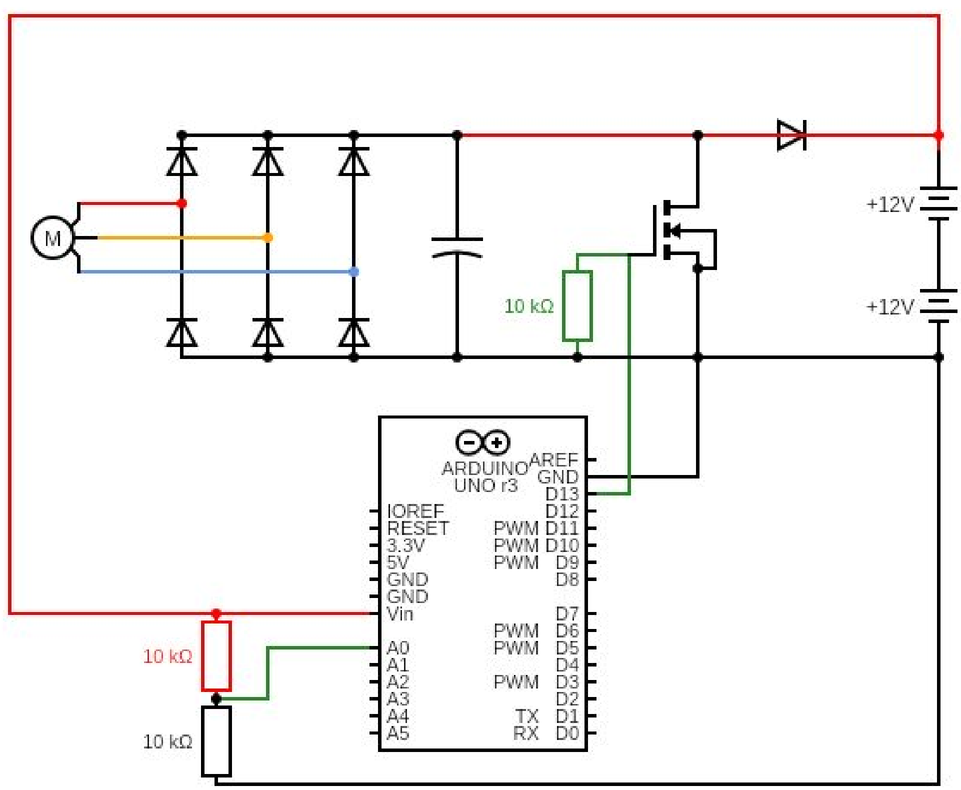
Components:

Keeping with the model of using a BLDC, the components other than the motor will be a gear train to maximize the motor input, a 3 phase rectifier and capacitor after to maintain a digital output from the motor's spin, and then finally the batteries, which will store the resulting energy received. In order to prevent overcharging the battery, a Battery monitor will allow for a person to physically see the battery ratings of the system, as well as the circuit will implement a MOSFET with proper cooling in order to allow the arduino to stop the system from charging the battery upon reaching full capacity. Overall, with all these components together, it should be possible to keep the auxiliary batteries working at optimal capacity.

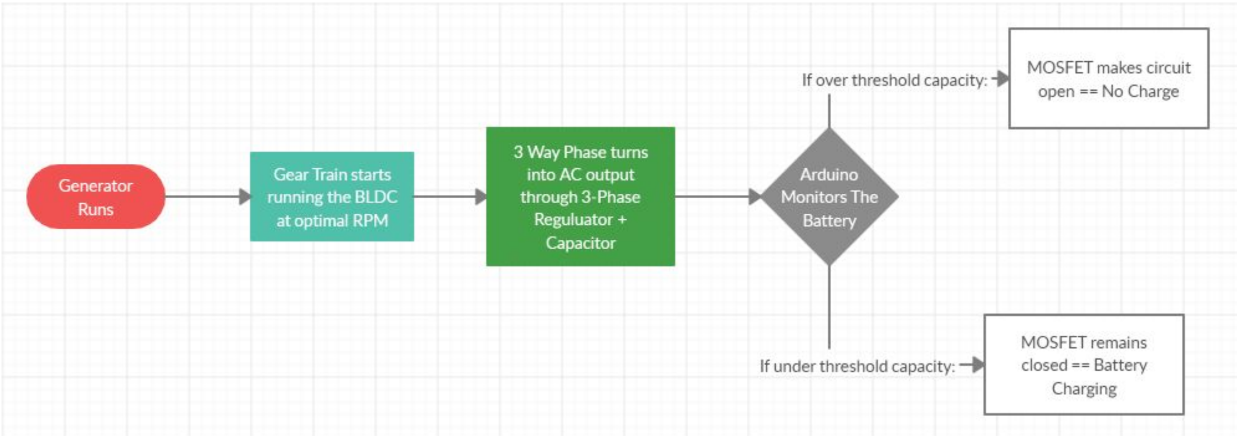
3-Phase Rectifier +Capacitor: These components will allow all of the analog waveform to convert into the absolute digital output. The Digital waveform will be from 0-the Max Voltage emitted from the motor, and will directly feed into the circuit.

MOSFET: This N-Channel MOSFET will need to be given a heatsink for the drain as well as be placed in a spot without any chance of touching metal. This component allows the Arduino to open and close the charging circuit based off the battery levels it's reading. When under the threshold, the Gate is powered on allowing the current to flow, if above and the battery is in a healthy state, the gate is closed off and the flow will stop.

Circuit Diagram:



Arduino Control Blocking:



While only a rough sketch, this is all of the components altogether. The battery will be powering the Arduino whilst getting charged, and will be monitored through pin A0 to see the battery levels.

The motor's DC output will wait on the Gate of the MOSFET to open, and once the Arduino determines that the battery is able to receive charge pin D13 powers the VGth to allow the current to flow and charge the battery.

Conclusion:

Honestly, the biggest issue throughout this whole process was how theoretical this all was. The lack of being able to test out equipment during the social distancing lead to a lot of challenges just due to the fact that I have a challenge understanding electronics. While YouTube videos have been a significant help in regards to getting a sense of how some of these systems work, nothing beats being able to test it all out yourself. While I know my work here is really all based on hypotheticals and leads, I truly believe that what I researched will be useful practically, and in turn transition to the system smoothly.