Electric Vehicle Optimization Team 2

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Advisor: Dr. Juan Ordonez

Background

- Cabin electronics drain semi-truck batteries.
- Cold weather conditions reduce battery output.
- Hotel System of Charging

- Sponsor presented the design team with two major problems:
  - ✦Current range is unsatisfactory
  - ✦Cannot operate in -29°C (-20°F)

Overview

Goal Statement:

- "To increase the current range and operable conditions of the electric vehicle by utilizing a secondary power source in efforts to apply this to semi-trucks."

Objectives

- Increase the lower temperature limit to -29°C.
- Document the current system performance.
- Incorporate a generator.
- Integrate a battery monitoring system.
- Ensure the vehicle can charge while running.

Proposed System

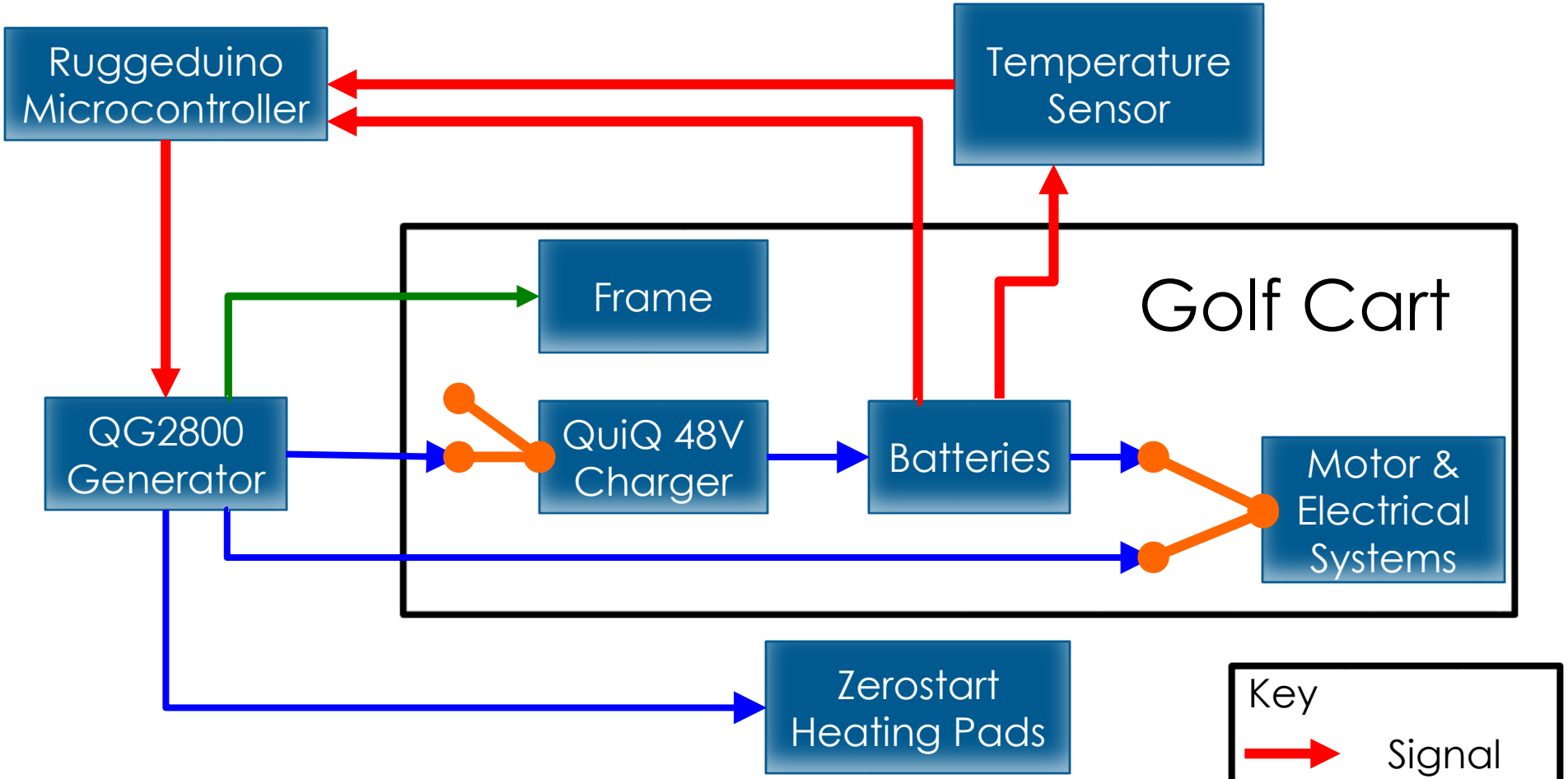


Figure 1. Simplified system diagram of design for golf cart.

Motor Power Supply Circuit

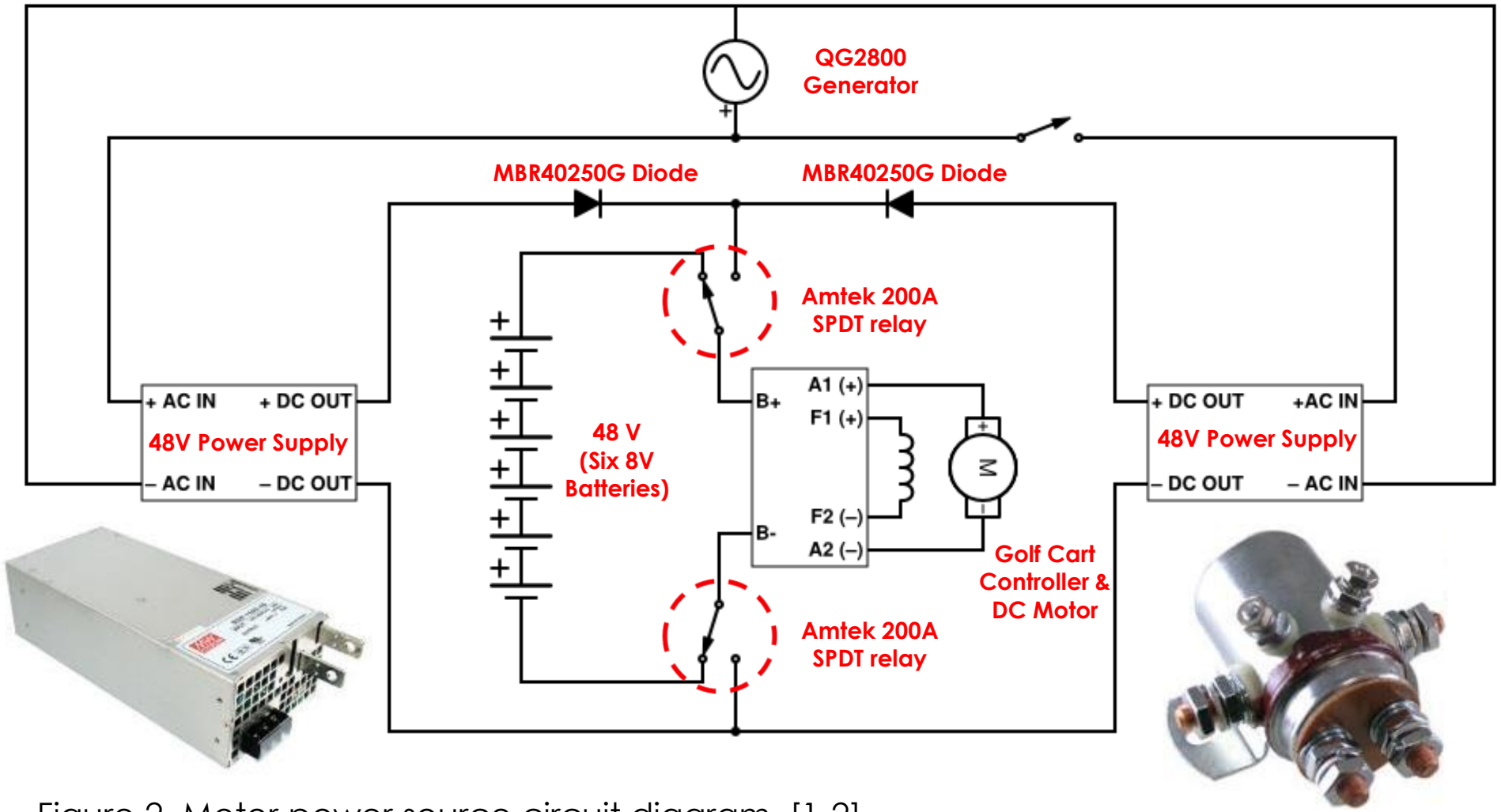


Figure 2. Motor power source circuit diagram. [1-2]

Heating Pad and Charger Circuit

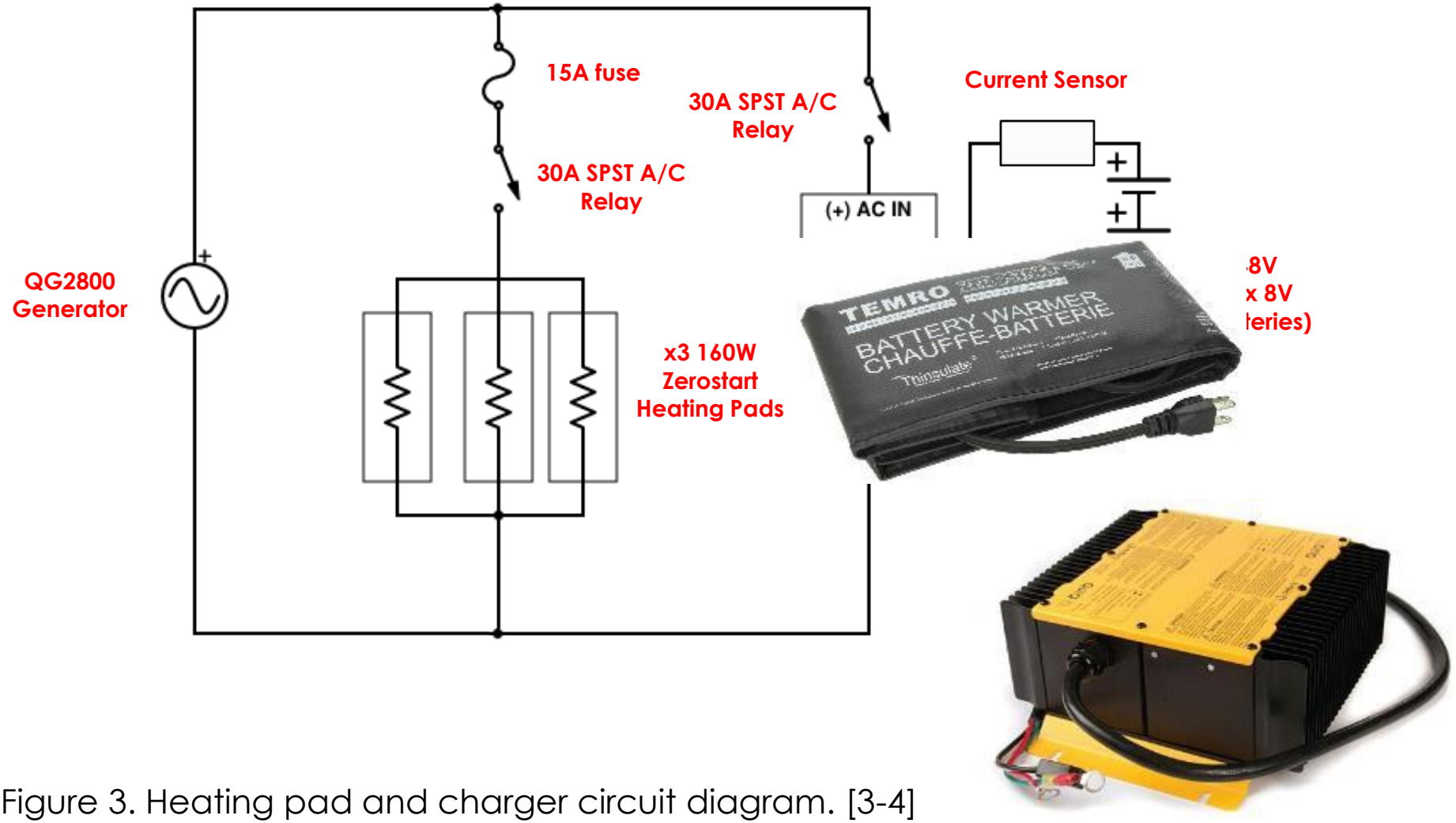


Figure 3. Heating pad and charger circuit diagram. [3-4]

Control Circuit

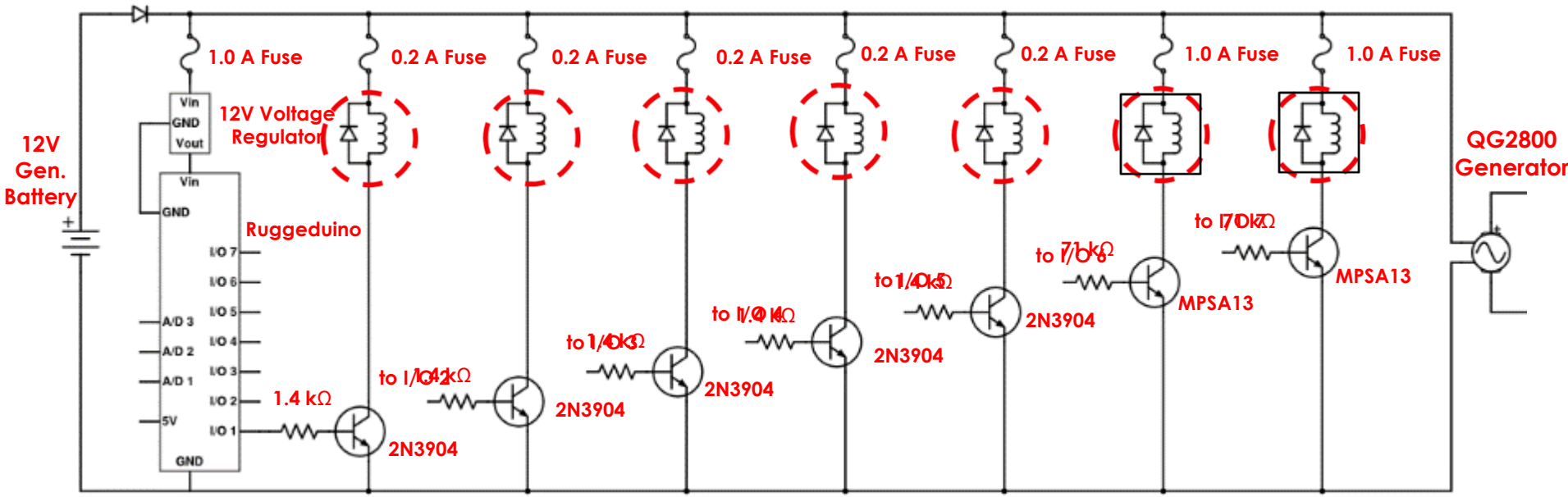
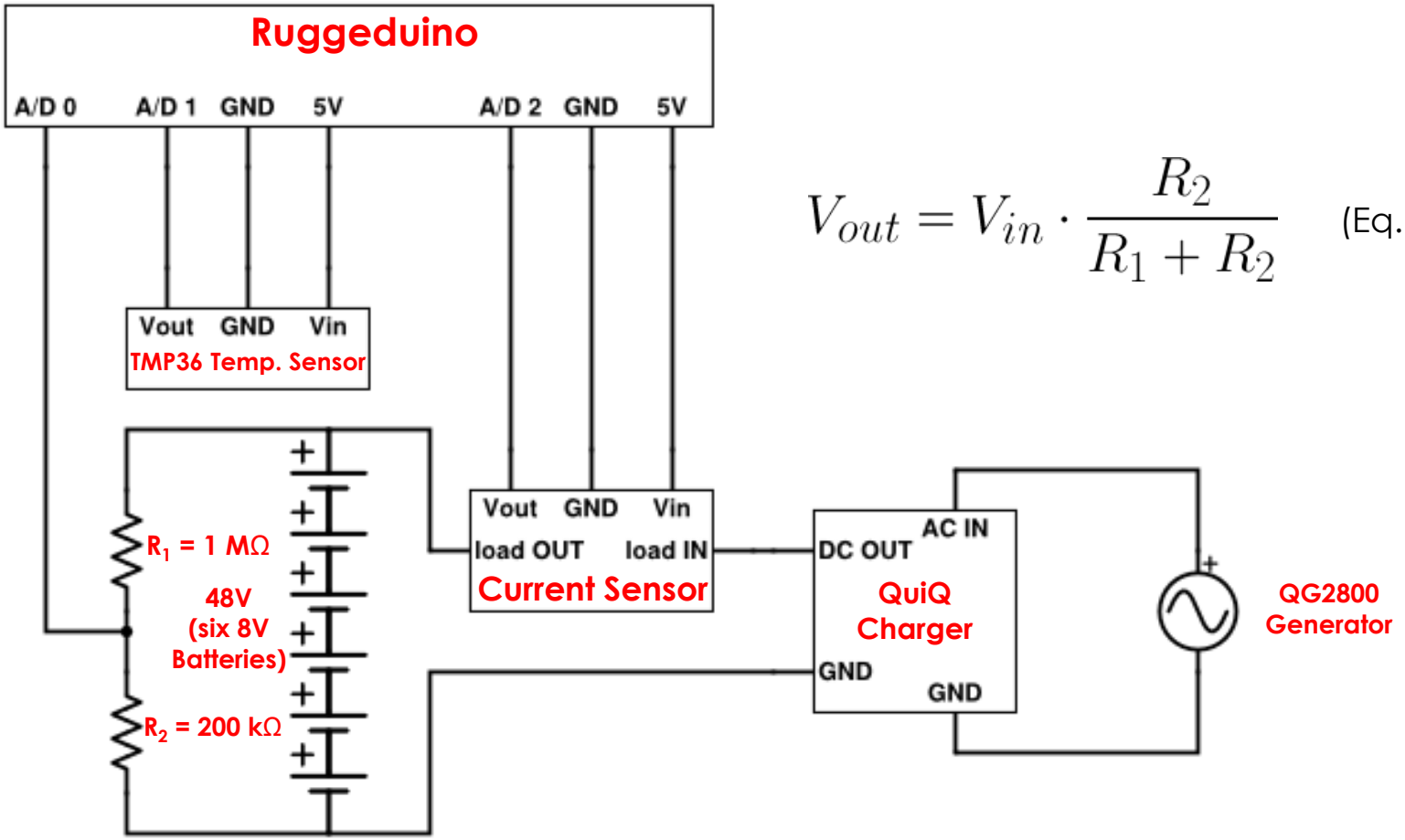


Figure 4. Control circuit diagram.

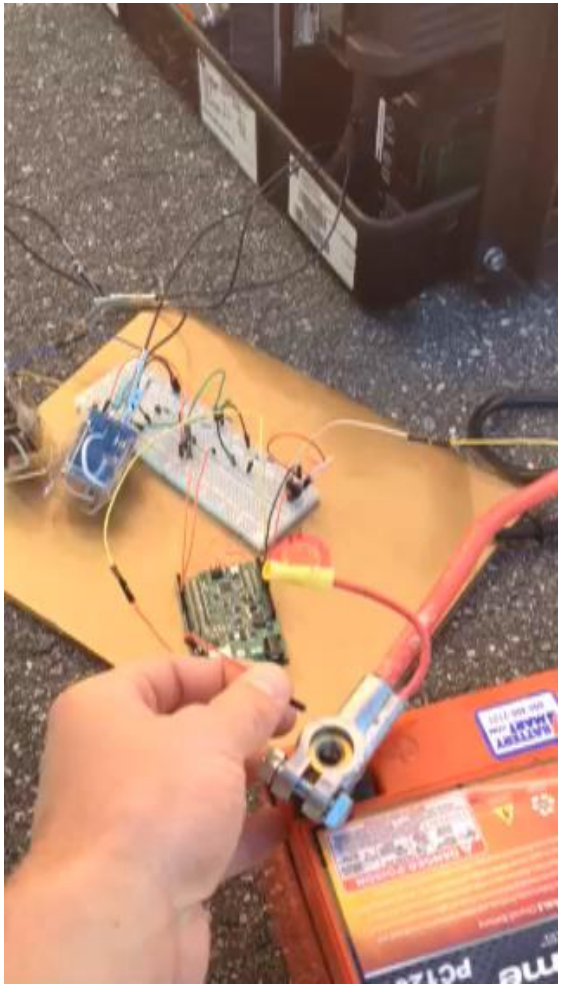
Sensor Inputs



$$V_{out} = V_{in} \cdot \frac{R_2}{R_1 + R_2} \quad \text{(Eq. 1)}$$

Figure 5. Simplified sensor input circuit diagram.

Generator Start-up Video



Video 1. Generator startup.

Risks

- Could drain generator battery
  - A majority of electronic components run off the generator battery.
    - Microcontroller
    - Temperature sensor
    - Relays
    - Generator
- Noise in temperature & voltage readings
  - Possibly change mechatronic states when not necessary.
  - Can fail to turn on generator to power heating pads, charger, and/or motor.
- Surge currents
  - When the generator is activated.
  - When switching the motor power source from the generator to the batteries.
- Power Supplies
  - If they do not start up together current could flow from one power supply to the other potentially damaging one of the supplies.

Generator Mount

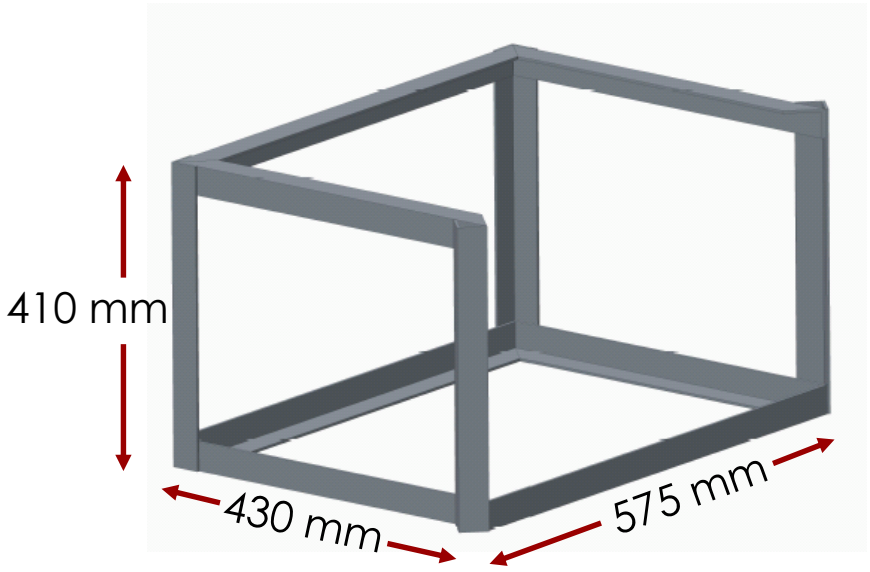


Figure 6. Initial mount design concept.

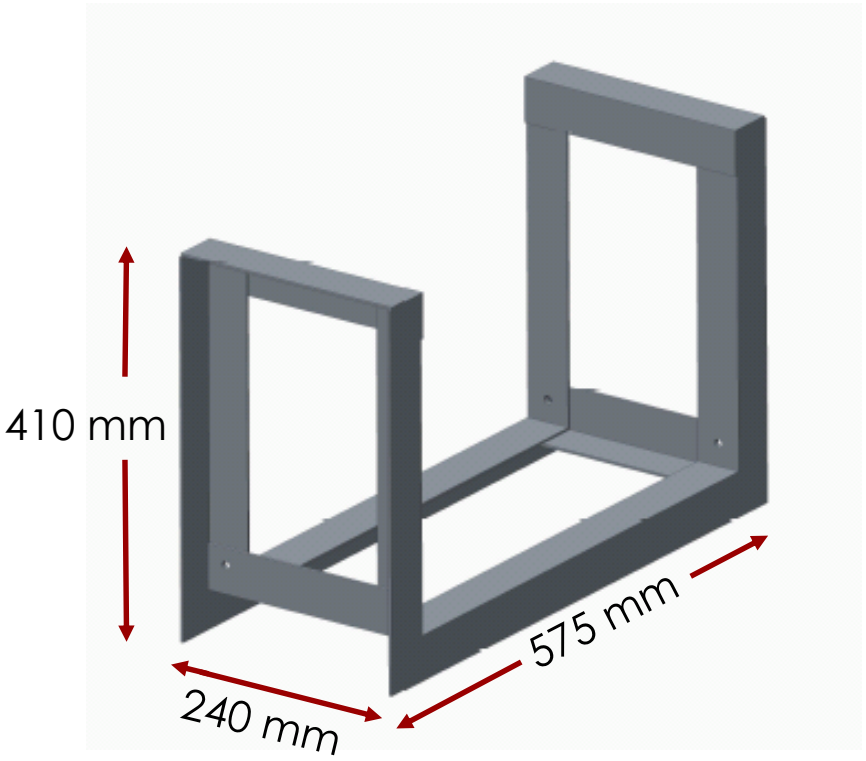


Figure 7. Second revision of mount design concept.

Final Mount Design

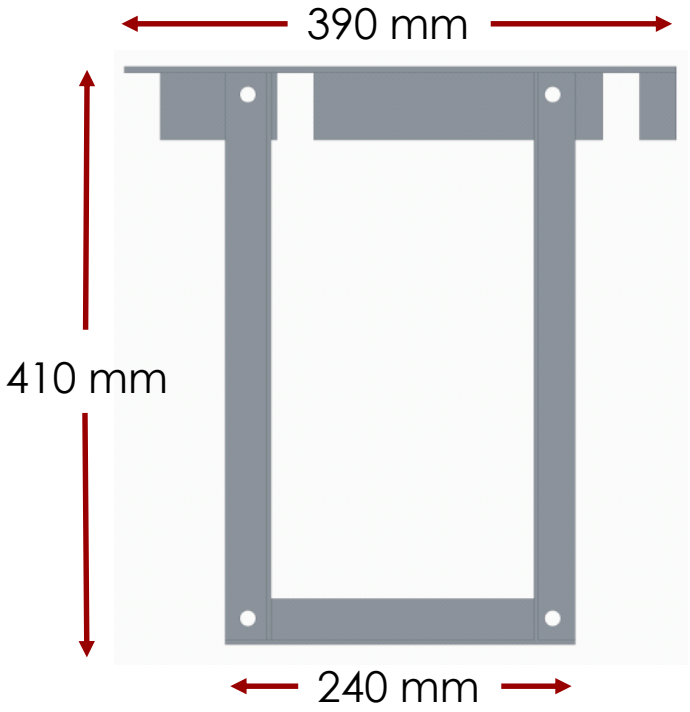


Figure 8. Final generator mount design.

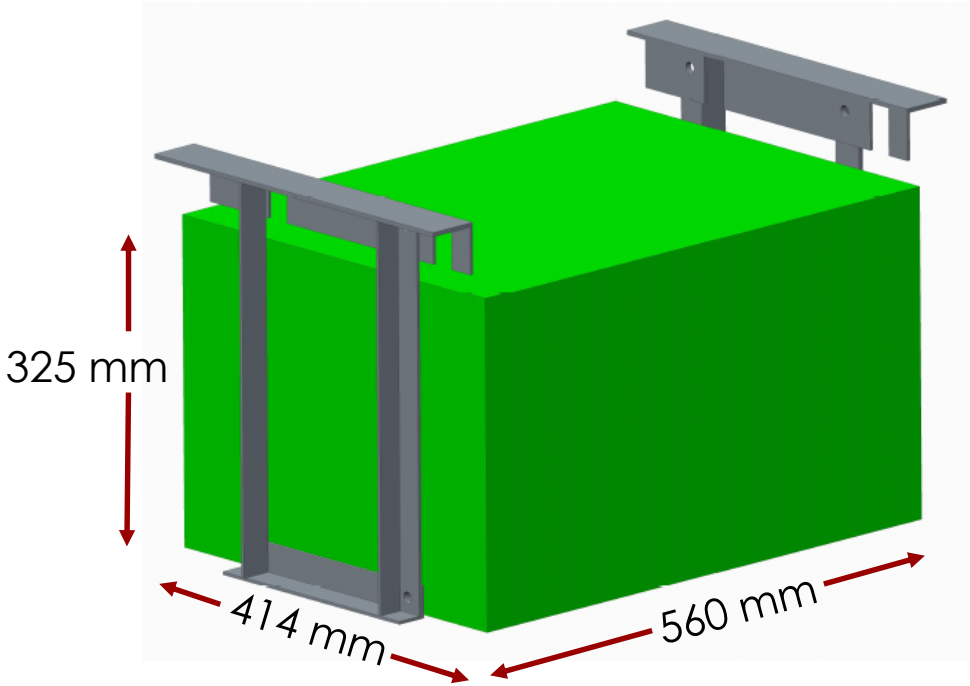


Figure 9. Assembly of mount attached to generator.

Generator Mount Analysis

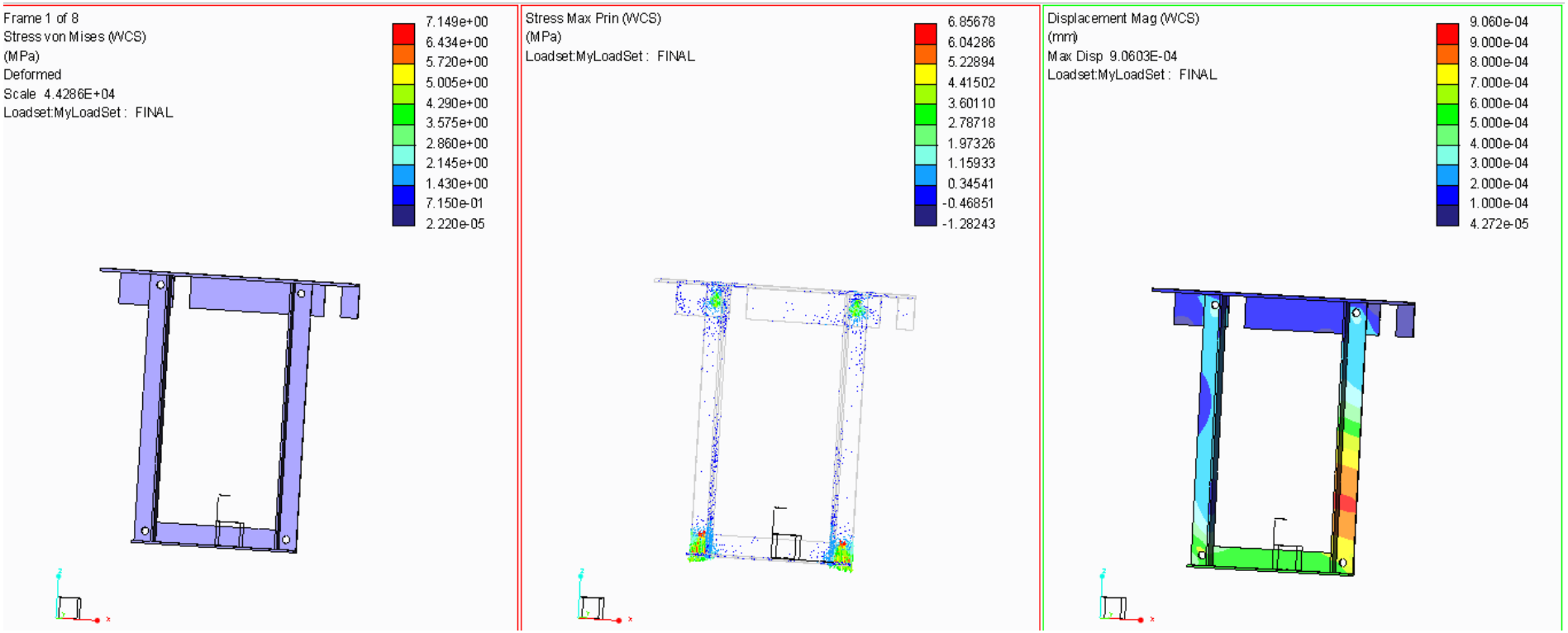


Figure 10. FEA stress and displacement analysis of final mount design.

Mount Technical Specifications

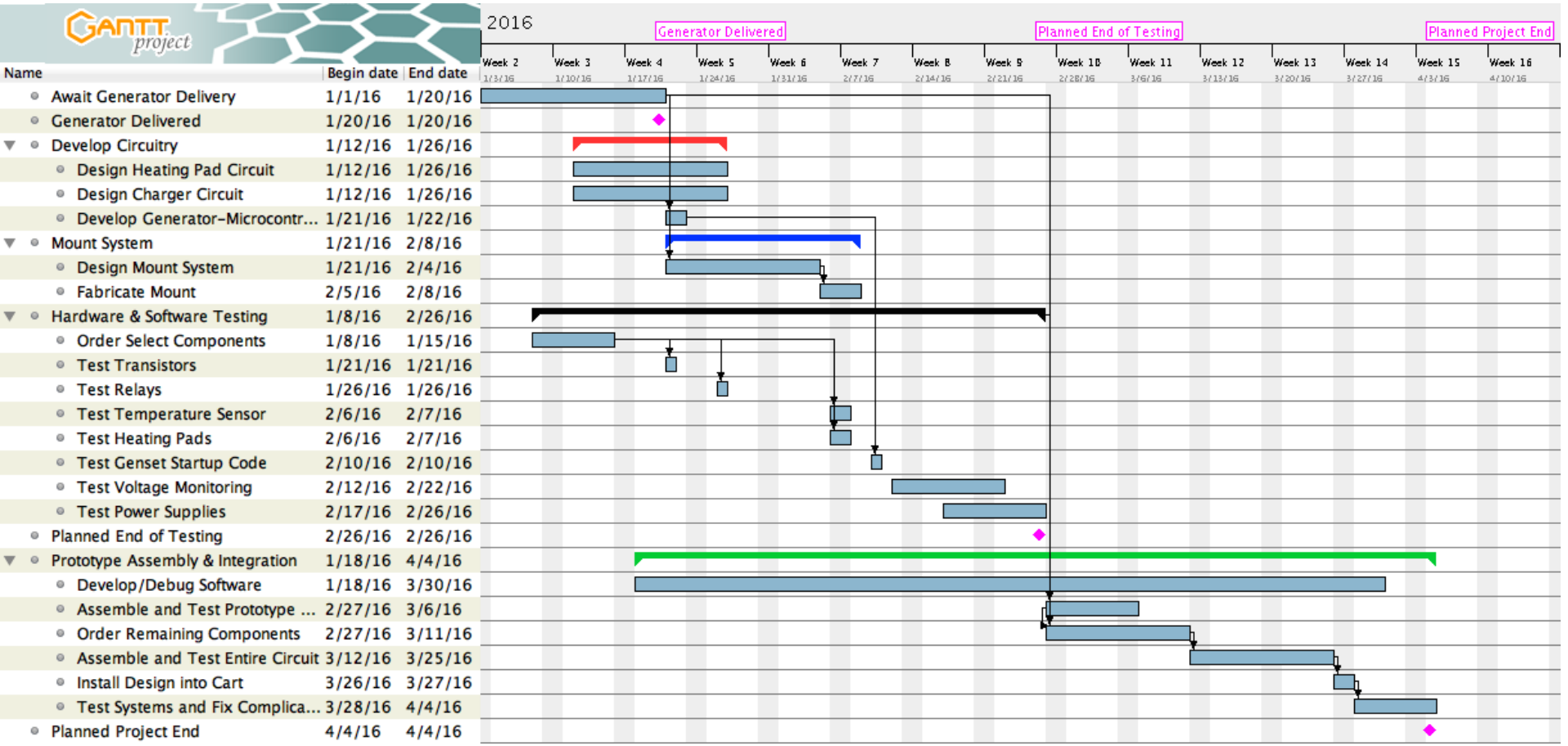
- 1 ¼" x 1 ¼" x ⅛" and 2" x 2" x ⅛" Steel Angle
- Hot rolled, low carbon steel
- Its 90 degree angle adds strength and rigidity
- Fastened together with 3/8" grade 8 bolts
- Lock washers and Loctite Threadlocker to prevent bolts from unfastening from vibrations.

Figure 11. Photograph of generator mounted to rear of cart.

Challenges

- Presently the golf cart is not in working condition.
  - ✦Batteries require charging
  - ✦Charger is not functioning
- Difficult to test entire system at cold temperatures.
- Maximum Charge threshold value is a function of temperature.
  - ✦Experimentally determine the relationship.

Gantt Chart



Name	Begin date	End date
Await Generator Delivery	1/1/16	1/20/16
Generator Delivered	1/20/16	1/20/16
Develop Circuitry	1/12/16	1/26/16
Design Heating Pad Circuit	1/12/16	1/26/16
Design Charger Circuit	1/12/16	1/26/16
Develop Generator-Microcontr...	1/21/16	1/22/16
Mount System	1/21/16	2/8/16
Design Mount System	1/21/16	2/4/16
Fabricate Mount	2/5/16	2/8/16
Hardware & Software Testing	1/8/16	2/26/16
Order Select Components	1/8/16	1/15/16
Test Transistors	1/21/16	1/21/16
Test Relays	1/26/16	1/26/16
Test Temperature Sensor	2/6/16	2/7/16
Test Heating Pads	2/6/16	2/7/16
Test Genset Startup Code	2/10/16	2/10/16
Test Voltage Monitoring	2/12/16	2/22/16
Test Power Supplies	2/17/16	2/26/16
Planned End of Testing	2/26/16	2/26/16
Prototype Assembly & Integration	1/18/16	4/4/16
Develop/Debug Software	1/18/16	3/30/16
Assemble and Test Prototype ...	2/27/16	3/6/16
Order Remaining Components	2/27/16	3/11/16
Assemble and Test Entire Circuit	3/12/16	3/25/16
Install Design into Cart	3/26/16	3/27/16
Test Systems and Fix Complica...	3/28/16	4/4/16
Planned Project End	4/4/16	4/4/16

Figure 12. Project timeline

Conclusion & Future Plans

- Fabricated generator mount.
- Tested Generator startup code.
- Began testing of voltage monitoring circuit.

Future Plans

- Voltage Monitoring
  - Test voltage divider circuit with generator automation code.
  - Determine battery voltage and temperature relationship.
- Generator Integration
  - Design generator exhaust system.
  - Design and fabricate propane tank mount.
- Mechatronic
  - Order remaining components.
  - Calibrate hardware with software.

References

[1] *RSP-1500-48 Power Supply*. 2016. Web. 15 Feb. 2016.

[2] *Amtek 200A Relay*. 2016. Web. 15 Feb. 2016.

[3] *Zerostart 160W Heating Pad*. 2016. Web. 15 Feb. 2016.

[4] *Quiq 48V Battery Charger*. 2016. Web. 15 Feb. 2016.

[5] "Ruggeduino-ET." Rugged Circuits. N.p., n.d. Web. 09 Nov. 2015.

[6] "TMP36 - Analog Temperature Sensor." Adafruit. N.p., Web. 09 Nov. 2015.

Questions?

Mechatronic System Objectives

- Control when generator turns on and off.
- Control when heating pads are on.
- Monitor the battery temperature.
- Monitor the battery voltage.
- Control the motor power source.
- Control when the batteries are charging.

State Diagram

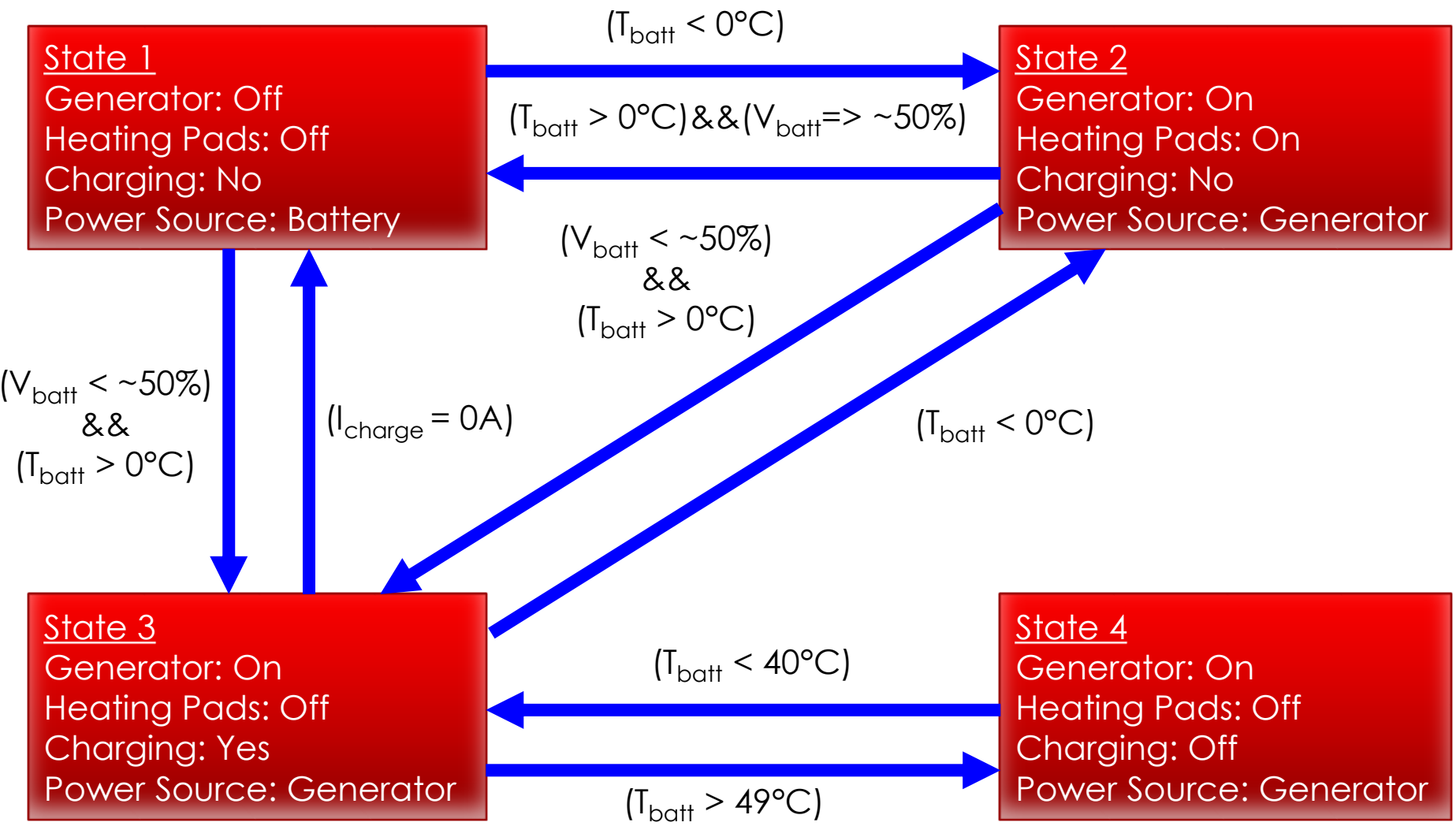


Figure 13. State Diagram of the proposed mechatronic system.

Microcontroller & Sensor

- Ruggeduino-ET
  - 6 analog input pins
  - Can run on input voltage of 3.5V to 30V
  - Operable at temperatures from -40°C to +85°C
  - 68.6 mm x 54.4 mm

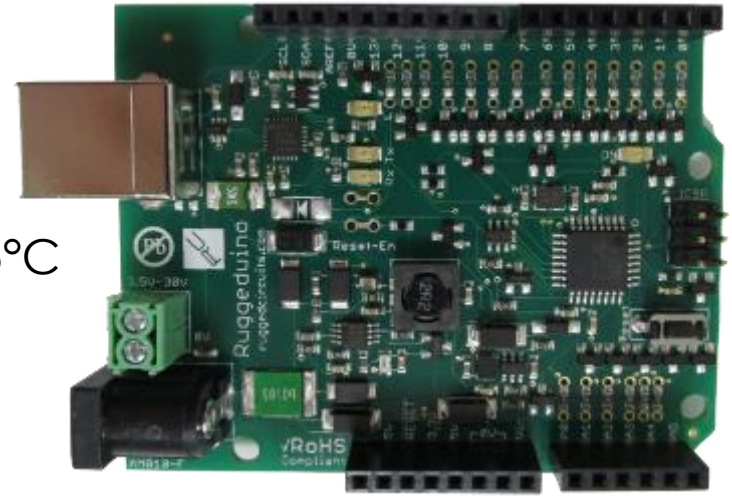
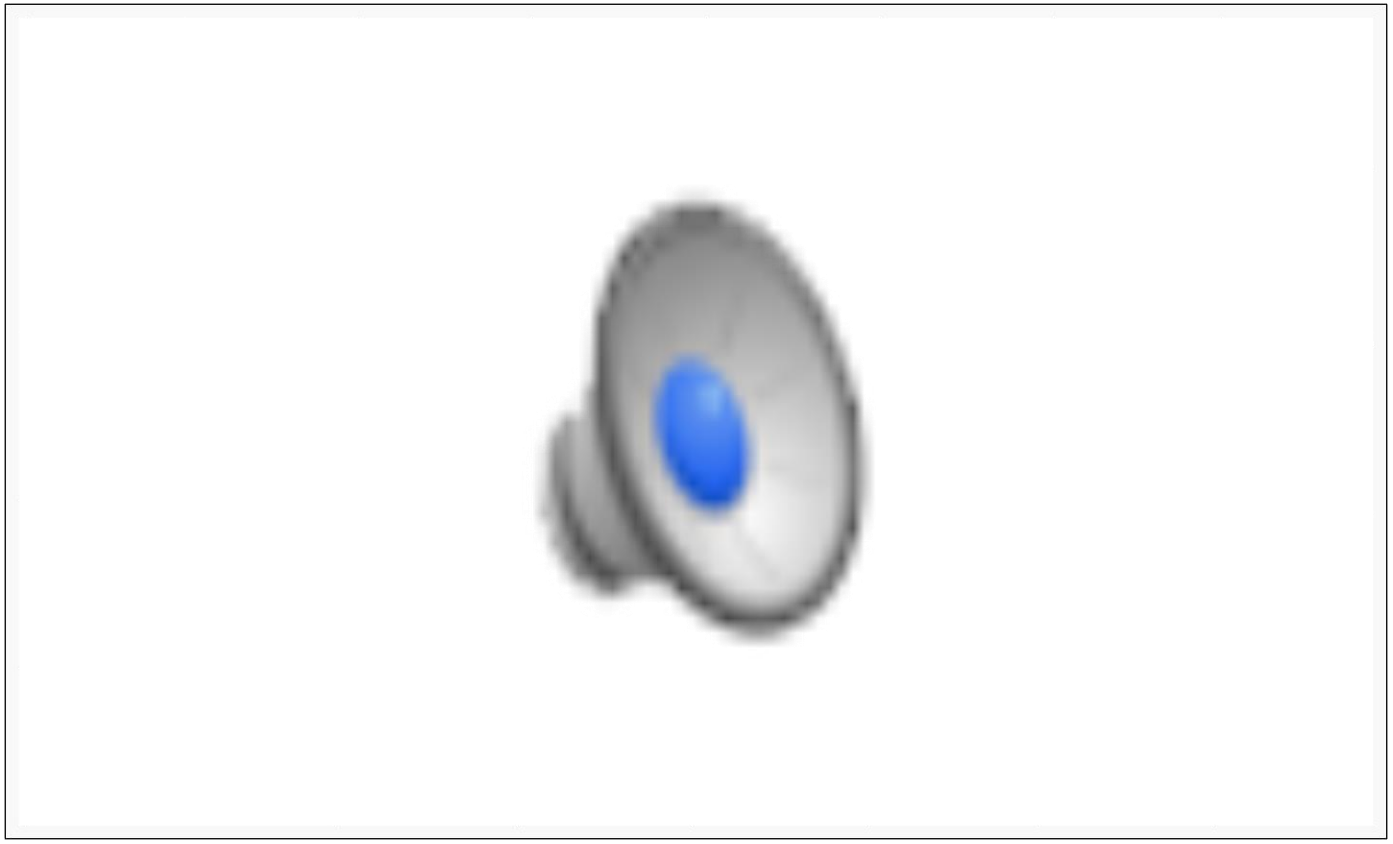


Figure 14. Ruggeduino-ET Board [5]

- TMP36 Analog Temperature Sensor
  - Low voltage operation (2.7V to 5.5V)
  - -40°C to +125°C temperature range

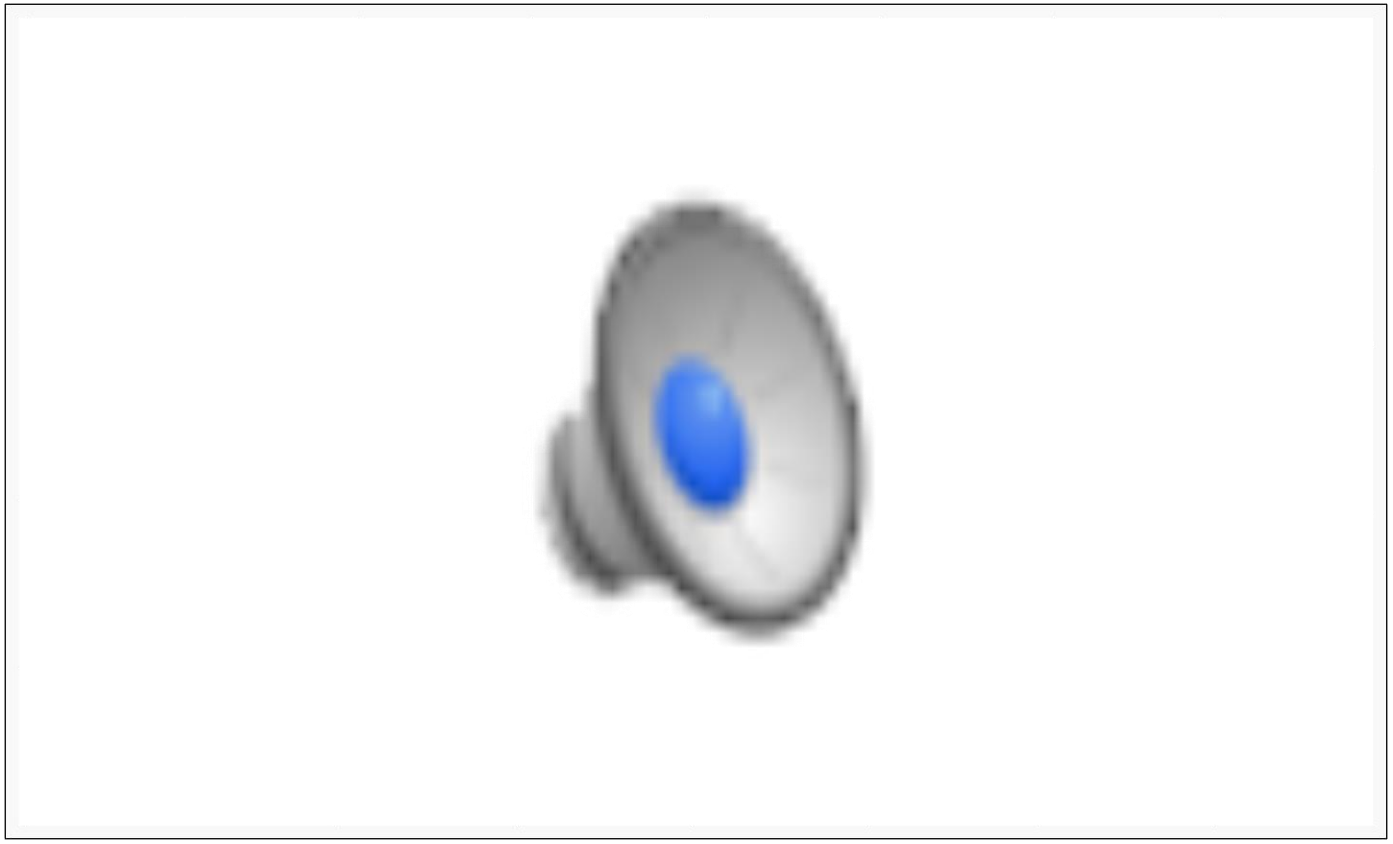
Figure 15. TMP Sensor. Quarter for scale [6]

Transistor Test



Video 2. Testing of the transistor to turn on a LED.

Relay Test



Video 3. Testing of the relay to turn on a LED in a separate circuit.