Electrical Baja Conversion Project (eBaja 2022)

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The Baja Brothers

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Abstract

Every year NAU has students who are associated with the Society of Automotive Engineers (SAE) who design and build vehicles to compete in the SAE competition. Our team will be representing NAU by competing in this competition with the school's first electric vehicle. The objective of this project was to convert a mechanical Baja vehicle into an electrical vehicle by combining the skills and knowledge of Mechanical and Electrical Engineers. The Electrical Engineering sub-team specialized in all the electrical aspects of the project: replacing the gas engine with a battery pack, an electric motor and controller, designing an auxiliary system, and building an additional battery for more runtime. This team also had to focus on the industry-wide safety standards for electric vehicles, battery charging, and power management.

Problem Statement

The eBaja vehicle must be converted to run exclusively on electric power. This was accomplished by mounting a custom-made battery to the vehicle and testing its capabilities to determine its strength and endurance. Since the battery powers a Permanent Magnet Synchronous Motor to propel the vehicle, load tests were designed to find the limits of how long the battery can run and its maximum safe output. The results of these tests enabled precision adjustments to the system in order to protect the battery and vehicle

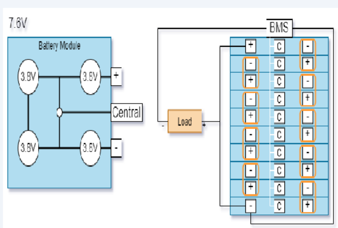

Figure 1: Battery Schematic

Important Requirements

- The Battery will power the vehicle system for at least 20 minutes at 50% throttle.
- Auxiliary lights will be supplied by 12V via DC-DC Step converter to provide illumination for safe driving.
- Emergency circuit breaker switch inside the cabin for the driver to reach in case of emergency.
- The vehicle will complete one loop in a parking lot to demonstrate performance.

Acknowledgements

The team would like to offer special thankyou to our client, Dr. Venkata Yaramasu, for his expertise and guidance throughout the year. He was kind enough to let us use the AMPERE lab for our workspace and testing. We want to also give thanks to Mahsa Keshavarz and Dr. Robert Severinghaus for weekly meetings and support throughout this project. Finally, we wanted to give thanks to Kyle Winfree for expanding our budget on this project.

Design

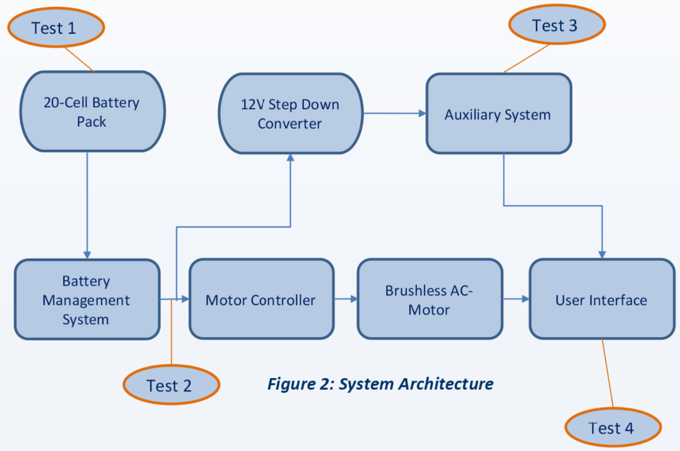

Figure 2: System Architecture

- Powered by a custom-built 5.2kWh battery pack.
- Integrated Battery management system balancing cells and administering charging and discharging operations.
- Motor controller inverts DC power to AC and consists of a starter switch, gear shifter, and throttle.
- The auxiliary system begins with a Buck-converter that delivers a 12V power supply to all the vehicle's accessories.
- User-interface allows access to subsystems through sensors, switches, and displays.

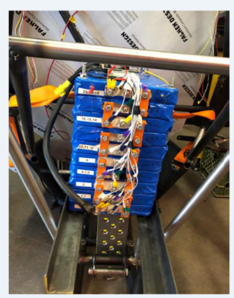

Figure 3: eBaja Battery

- Fabricated mounts for battery and motor
- Vehicle is designed for offroad terrain
- Vehicle runs off 80V battery pack

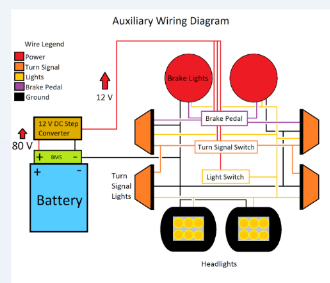

Figure 4: Auxiliary System Schematic

- The design provides a 12V auxiliary supply using a step-down converter
- Power's headlights, taillights, two turn signals and break lights
- System is controlled by switches in drivers' compartment
- Provides illumination for safe driving

Testing and Results

Load Test design

- Demonstrated batteries' capacity to Continually discharge
- DC-Generator driven by eBaja motor
- Generator acted as a loaded resistance
- Throttle allowed current control
- Simulated resistive torque applied to the motor

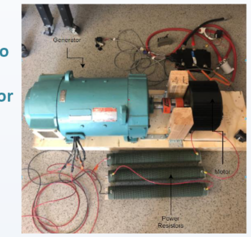

Figure 5: Generator Load Test

Test 1 – Loaded Current Test

Determine the amount of current coming out of the battery at different throttle positions while the system was loaded. It was assumed the current leaving the battery would have a linear relationship with throttle position.

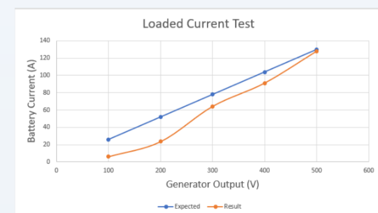

Figure 6: Max Current Test

- Battery did not perform as expected
- At max throttle, battery outputted 128 Amps
- Restrict throttle to lengthen runtime

Test 2 – Loaded Longevity Test

Determine how long the battery can power the system while under load. The battery was assumed to be able to run at least 20 minutes.

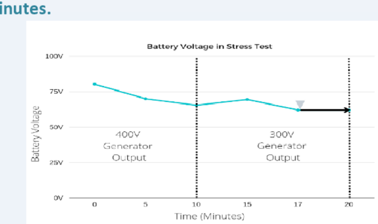

Figure 7: Longevity Test

- System died after 17 minutes and 36 seconds
- Voltage drop from 80v to 60v
- Battery temperature rose to 93 degrees
- Motor was generating around 1500 RPMs