Adaptive Magnetic Power System (AMPS)

TEXAS A&M UNIVERSITY Engineering

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ROBOTICS TEAM & LEADERSHIP EXPERIENCE

Intro & Problem Definition

Electrically powered bicycles (e-bikes) have become popular in recent years as a reliable mode of transportation. Despite their environmental benefits, e-bikes remain expensive and are often limited by efficiency and range. The AMPS project aims to develop a "self-sustaining" e-bike capable of generating its own power to extend its range and further reduce its carbon footprint. This will be achieved by retrofitting a traditional manually driven bicycle into an efficient, cost-effective, and energy-regenerative system.

Approach & Methods

The AMPS project seeks to accomplish its mission of sustainability and efficiency through several avenues.

Work Areas

- "Ground-up" motor/generator and motor driver design
- Continuously variable transmission (CVT) to operate within peak motor / generator efficiency
- Electromechanical pedal-assisted generation
- Small scale renewable energy harvesting

Electrical

This project comprises of two complementary electrical systems: power delivery and power generation.

Both systems require precise signal timing and proper power management to ensure reliable, efficient, and safe operation.

Motor Driver Electronics

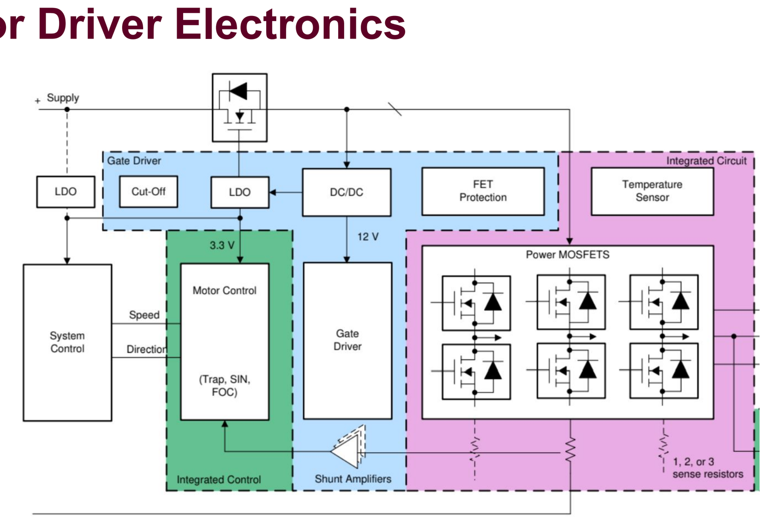

Figure 1. *BLDC Motor Driver*

- **Motor Control:** Takes system control signals (Target velocities/torque) and turns them into PWM signals to send to the gate driver.
- **Gate Driver:** The "Medium Voltage" stage. Transforms the logic-level signals, amplifying them to a level capable of driving the power MOSFETs.
- **Power Stage:** The "High Voltage" stage. Directly connected to the battery and responsible for powering the motor according to the gate driver.

Power (Generation) Electronics

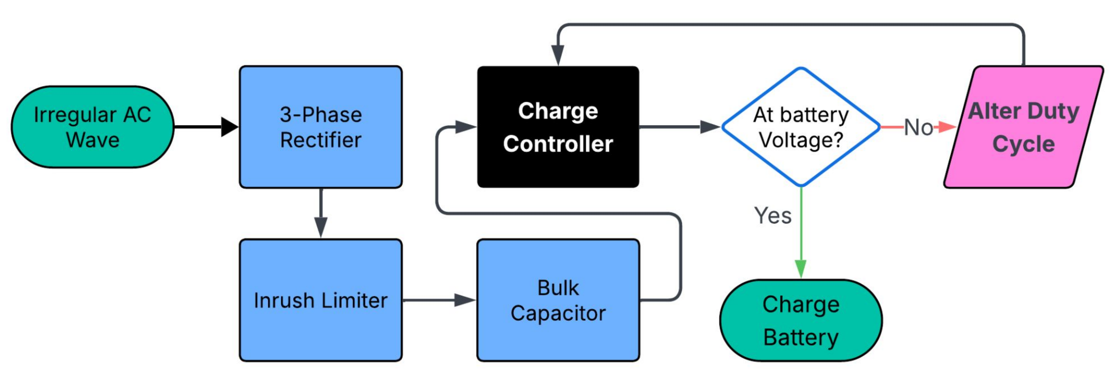

Figure 2. *Process diagram of power generation management system*

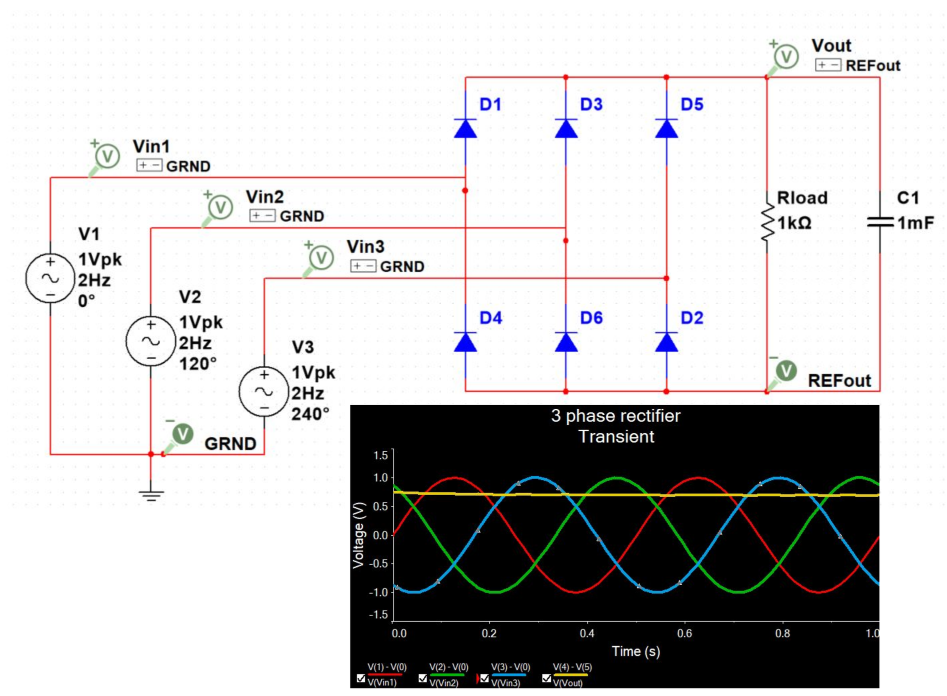

Figure 3. *Simulated 3-Phase Rectifier Circuit and Output*

Generator / Motor

The endeavor of designing a motor from the ground-up will allow AMPS complete control over the architecture of its power delivery / generation unit, while providing members with invaluable experience in electromechanical design. The Fall 2025 semester comprised of topological and materials based research resulting in the following:

- **Radial Outrunner BLDC Design** selected as optimal for AMPS applications (simpler to manufacture, widely studied, higher torque.)
- Motor core selection to build design around ***[Figure 4]***. Based upon power and torque requirement calculations: **~1kW 75 Nm max draw.**
- Members installed and learned Ansys Maxwell software for electromagnetic device simulation. Also pictured in ***Figure 4.***

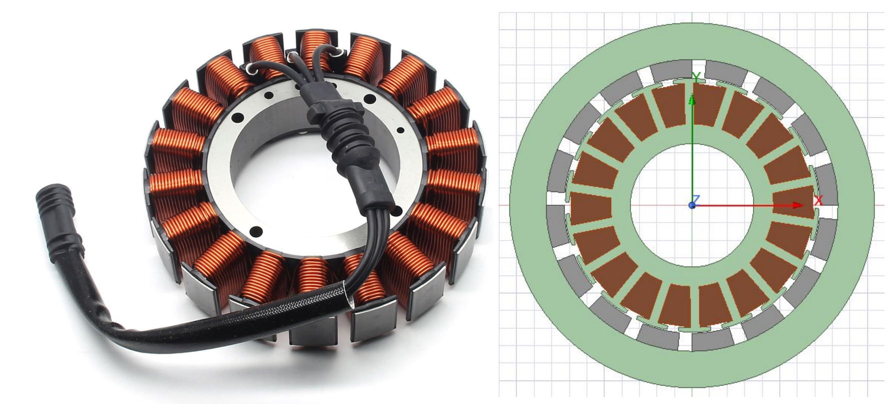

Figure 4. *Selected Stator Core and its Ansys Equivalent*

Mechanical

Every motor / generator operates at maximum efficiency within a certain RPM band. In order to maintain the maximum efficiency, an infinite and variable gear ratio is needed. The team selected an Electronic CVT (ECVT) system ***[Figure 5]***, for the following reasons:

- Can achieve efficient regenerative braking through the planetary gear system within the ECVT.
- Planetary gear system can accept two different inputs to amplify an output.
- Working on swapping the output to achieve maximum efficiency on both input and output of the motor / generator.

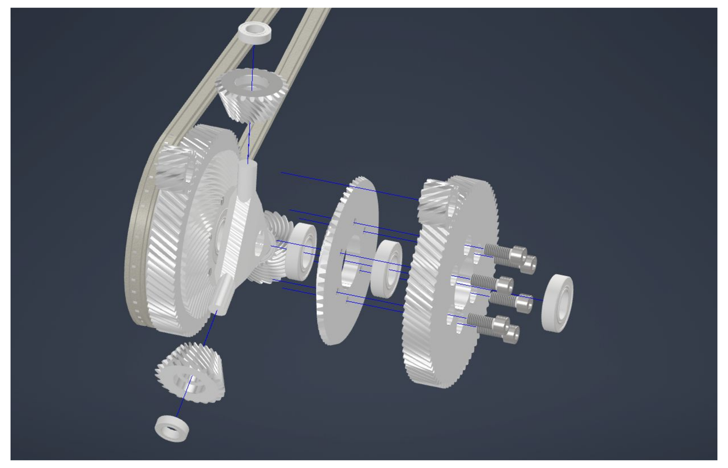

Figure 5. *Exploded CAD of the ECVT*

Software

Primary focus has been on accurate waveform capture, the foundation for the feedback loops that will drive safe power management in the system.

Oscilloscope Program

- Gathered data from AC wave generator and plotted the changes in voltage over time.
- Implemented proof of concept voltage bound detection software through ESP32 ADC pin and built in LED.

Motor Control

- Researched motor control methods to increase and decrease the speed for a BLDC motor using a PWM duty cycle so that the voltage levels remain within a upper and lower threshold while the motor is moving.

Next Steps

Electrical

- Complete motor driver design and charge controller design

Generator / Motor

- Carry out detailed motor simulations in Ansys
- Refine and test power module design

Mechanical

- Construct prototype of full orbital CVT
- Perform calculations to minimize size while maintaining proper RPM band
- Begin designing unfolding solar panel system

Software

- Refine AC wave reading software
- Integrate charge controller feedback loop

Team Pictures

Figures 6, 7 & 8. *Project Members AMPin' it up*