Adaptive Magnetic Power System (AMPS)

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TEXAS A&M UNIVERSITY ROBOTICS TEAM & LEADERSHIP EXPERIENCE

Intro & Problem Definition

Despite their benefits, e-bikes remain expensive & are often limited by efficiency & range. The AMPS project aims to develop "self-sustaining" e-bikes with extended range & reduced carbon footprint. This will be achieved by retrofitting a traditional manual bicycle into an efficient, cost-effective, & energy-regenerative system. Current pursuits involve pedal-driven electromechanical power generation, & solar-powered modular friction drive.

Generation Type & Subsystems

Pedal-Driven Electromechanical

- Motor Driver
- Continuously Variable Transmission (CVT)
- Oscilloscope
- Power Electronics

Solar-Powered Modular

- Friction Drive Motor
- Throttle & Control System
- Solar Panels

Pedal-Driven Electromechanical

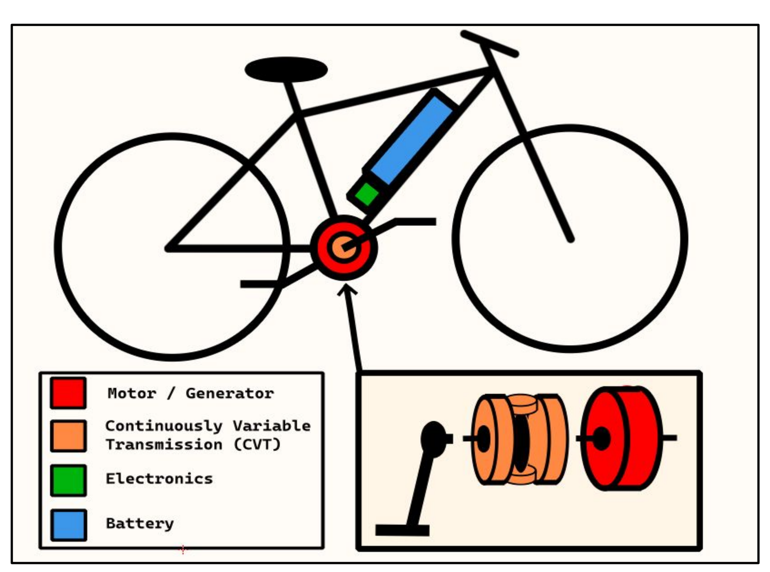

Figure 1. *Pedal - driven electromechanical power generation - system diagram*

Motor Driver

- **Control Logic:** ESP32 sends logic-level signals to motor, using hall sensors to sense motor winding location.
- **Signal Conversion:** Gate drivers step-up voltage (3.3 - 12 V) to drive high-voltage MOSFETs.
- **Motor Control:** MOSFETs deliver power to motor (3-Phase Trapezoidal signals) based on microcontroller logic.

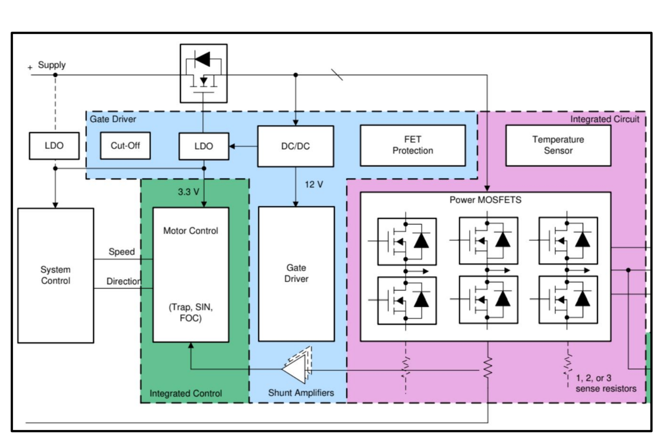

Figure 2. *BLDC Motor Driver*

Continuously Variable Transmission (CVT)

An ideal system is fed a constant-frequency AC source for consistent behavior of frequency dependent components.

To meet this constraint, a system must be designed that transforms variable frequency input into constant 60 Hz

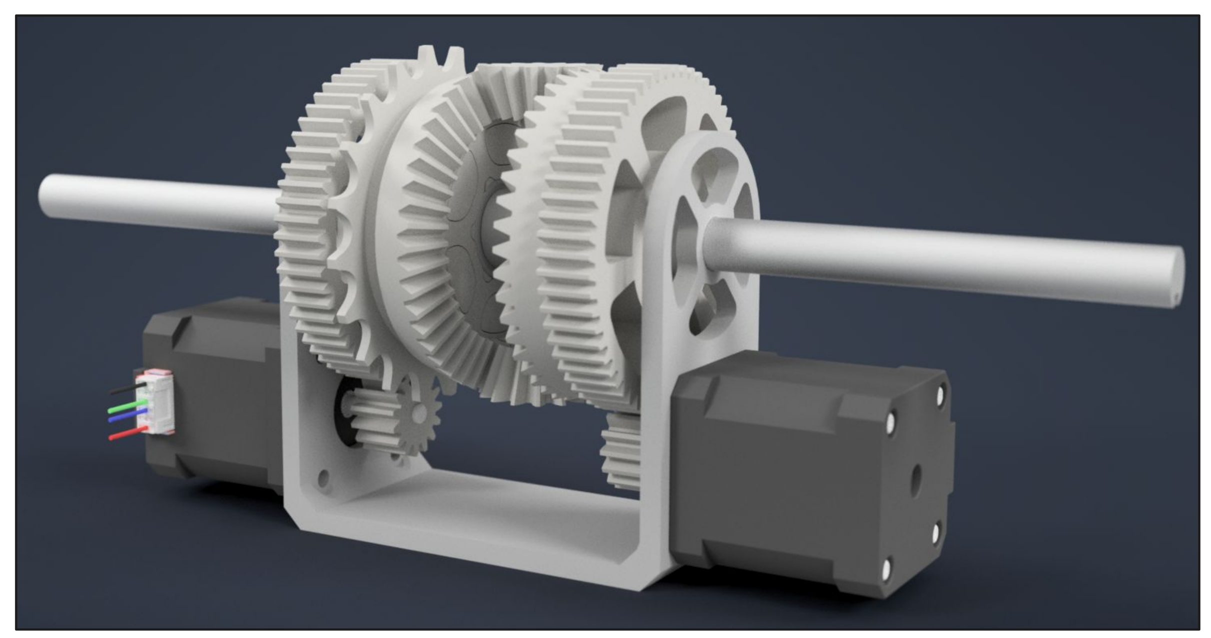

Figure 3. *CVT Version 4.0*

Version 4 uses straight cut gears instead of helical ones to improve efficiency along with having a lower DP.

Oscilloscope

Varying voltage affects duty cycle of boost converter. Varying RPM must alter CVT gear ratio. Onboard feedback loops are necessary to capture this data.

Circuit

AC waveform is analyzed using ESP32 Developer Board. ESP32 can handle 0 - 3.3V, but desired waveforms are greater magnitude, & include negative voltage regions.

Solutions:

- Potentiometer to scale waveforms.
- DC biased voltage divider to center waveform around 3.3/2 = 1.65.
- Clamping diodes to clip wave if above allowed range.

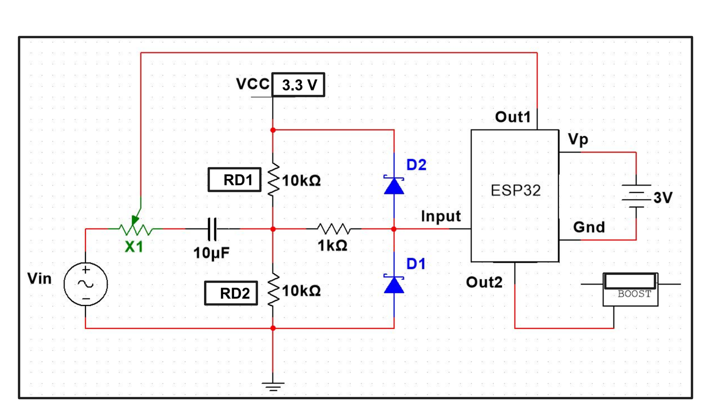

Figure 4. *Oscilloscope System Schematic*

Software

Code is written to read and plot the modified waveform. The original waveform values are obtained by using known circuit elements with the following equation:

$$V_{input} = \frac{V_o}{\left(\frac{R_D}{\sqrt{(R_{pot}+R_D)^2+\left(\frac{1}{wC}\right)^2}}\right)}$$

Figure 5. *Input waveform deduction formula*

Power Electronics

Power electronics includes a 3-phase rectifier and a boost switching converter. ΔV ≈ 1% of average.

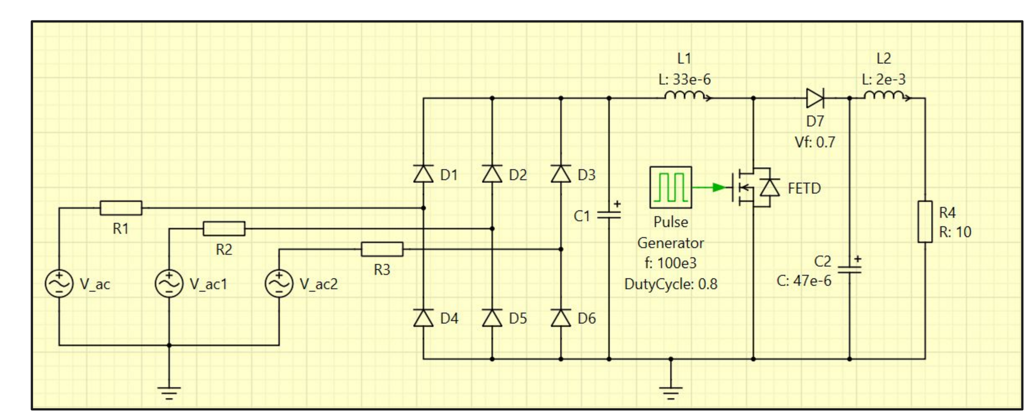

Figure 6. *Power electronics system built in PLECS*

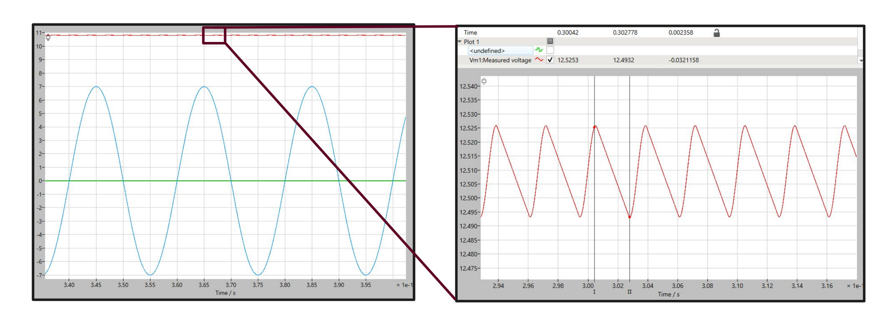

Figure 7. *Simulated rectifier output current (blue), output voltage (red, enlarged)*

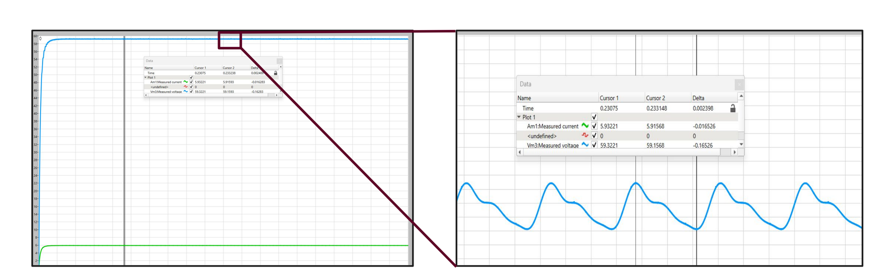

Figure 8. *Simulated Rectifier output current (green), output voltage (blue, enlarged)*

Solar-Powered Modular

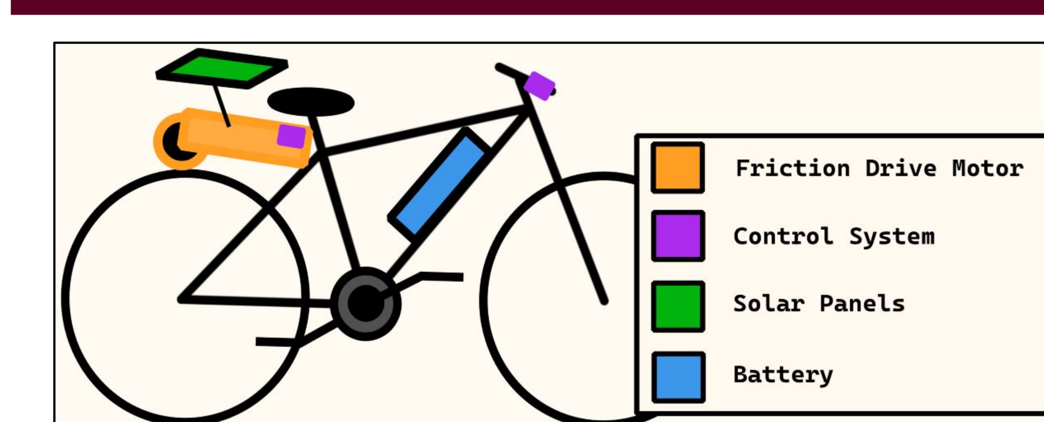

Figure 9. *Solar power generation modular drive - system diagram*

Friction Drive Motor

System will be wirelessly controlled and modular, suitable for a wide range of wheeled personal mobility devices. The system prioritizes ease of integration, minimal component wear, and reliable torque transmission across varying operating conditions with the potential of regenerative braking.

Goals

- Motor Torque: 0.655 N*m
- Normal Force: 21.47 N
- Friction Coefficient:0.8

Throttle & Control System

Wireless system shall support speed control input and system status feedback (battery level, fault conditions, usage trends) with less than 100ms of latency.

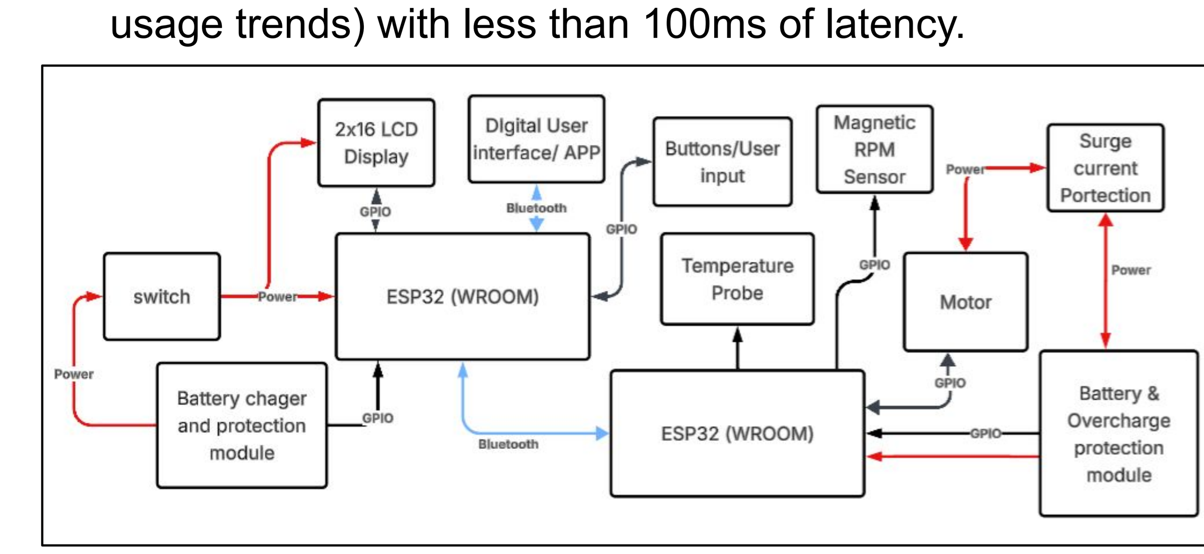

Figure 10. *Control system sketch & electrical block diagram*

Solar Panels

This system will be charged via wall outlet adapter, having the option to passively charge while parked - with onboard solar panels. Solar panels will be rated for 12V, 200W. Current focus is on "sun-tracking" solar panels that always face towards direction of maximum illumination.

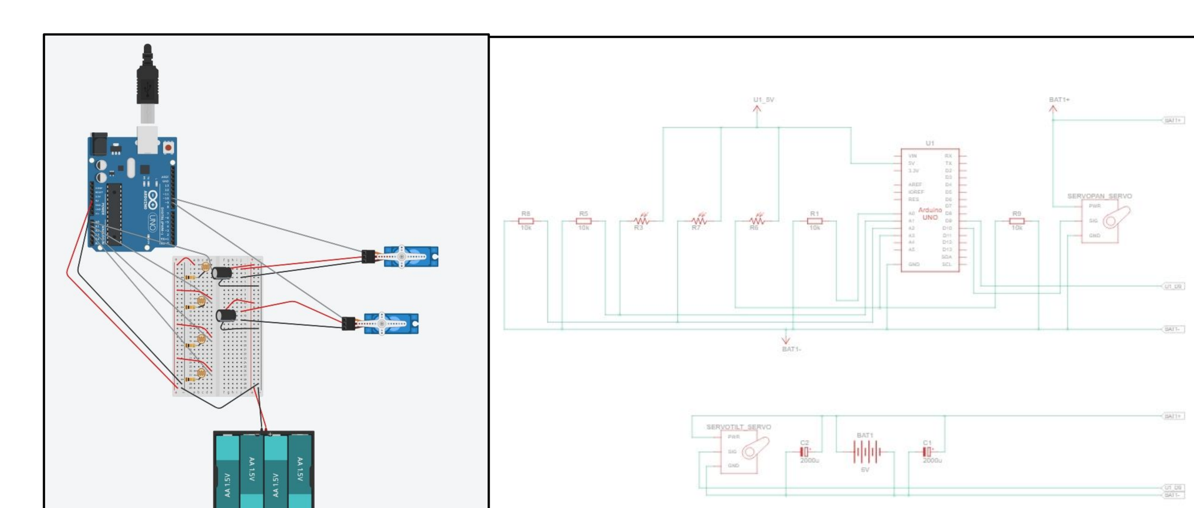

Figure 11. *Solar tracker v1 - High level connections(left) Circuit schematic (right)*