E-Bike Motor and Controller

ECE 480 Team 9

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Agenda

Motivation
Support
Design Ideas

Specifications
System Design
Alternators

Hardware
Software
Testing

Results
Improvements
Demo
Motivation
MSU Connection

- Sponsor - Mr. Stephen Blosser, Assistive Technology Specialist, RCPD

- Facilitator - Professor Virginia M. Ayres, Ph.D.
Key Design Idea
Alternator alternative to a DC motor

Short-term Goals
- Alternator as a low-cost alternative to a DC motor
- Create a motor controller for an alternator as motor
- Test novel alternator system

Long-term Goals
- Transform the way personal transportation is used globally
- Make personal electric vehicles affordable and accessible to everyone

“More for less for more” - R.A. Mashelkar
Design Specifications

- Low-cost
- Wide range of speed
- Efficient
- Automatic control for enhanced performance
- Increased torque at low speeds
System Design

- Power supply and DC/DC converters
- Hall-effect throttle and AMS sensor provide inputs to microcontroller
- Microcontroller drives MOSFET circuits
Alternator as Motor

- Typically used as battery charger
- E-Bike: Use concept in reverse!
Motor Controllers

- DC motor controllers vary pulse width
- AC motors use variable frequency drives
- Team 9 design uses pulse at maximum quadrature
Circuit Design

- MOSFETs
- Gate Driving Circuit
- Power Supply Circuit
- Peripheral Connections
Texas Instruments Microcontroller

- TM4C123GH6PMI
- Interface between Circuit and Software
- Connects with rows of pins to the MOSFET driver circuit
- Pulses the MOSFETs at optimal angles
AMS Magnetic Rotary Sensor

- AS5132
- Alternator Software Interface
- Measures Absolute Angles from Magnet - 360 degrees
- Mounts to end of rotor shaft
User Input: Throttle

- User Interface to Software
- Analogue to Digital Converter
Software Algorithm

- Precalculate quadrature angles (at startup)

```c
// the optimal quadrature angle at which to push the rotor is calculated given
// the base angle of the stator coil minus (that is, counter-clockwise) the timing
// angle. This creates a quadrature point around which to pulse the stator.
mOptimalAngle = baseAngle - timing; // for clockwise operation, make this a plus instead.
```

- Read from the sensors

- Determine the correct stator coil to activate

- Activate/deactivate the pins
Testing: Torque

- Key parameter: Torque
- Used to calculate efficiency and power
- Methods of measurement

![Graph: Throttle percentage vs Max torque](image)
Testing: Input Power

![Graph showing Throttle Percentage vs Input Power](image_url)

![Image of a clamp meter](image_url)
Testing: RPM
Overall Level of Success

High degree of success!
Especially for a first prototype

<table>
<thead>
<tr>
<th>Design Specification</th>
<th>Achieved?</th>
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<tbody>
<tr>
<td>Working DC motor alternative</td>
<td>Yes</td>
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<tr>
<td>Inexpensive design</td>
<td>Yes</td>
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<tr>
<td>Wide range of speed</td>
<td>Yes</td>
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<tr>
<td>Automatic controls for enhanced performance</td>
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<tr>
<td>Increased torque at low speeds</td>
<td>Yes</td>
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<tr>
<td>Increased efficiency</td>
<td>Partial</td>
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<tr>
<td>Reverse</td>
<td>Partial</td>
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Cost

- Gate Drivers
- Eliminate Evaluation Board
- Lower Current Mosfets
- Buy components in bulk

<table>
<thead>
<tr>
<th>Part Description</th>
<th>Quantity</th>
<th>Cost of Each Part</th>
<th>Total Cost</th>
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<tbody>
<tr>
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Total Cost: $99.01
Microcontroller Integration into Circuit
Torque Testing with a Dynamometer
Software Improvements to Increase Efficiency
Improvements to circuit design by using MOSFET drivers
Outside Interest

- Texas Instruments future sponsorship
- Marathon grant
- MSU provisional patent application has been filed
Demonstration