E-Bike Motor and Controller

ECE 480 Team 9

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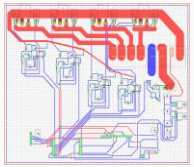
Agenda

Motivation

Specifications

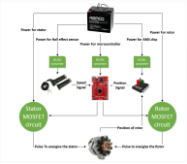
Hardware



Results

Support

System Design

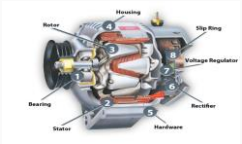


Software

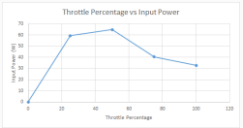
Improvements

Design Ideas

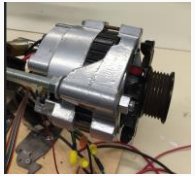
Alternators



Testing



Demo

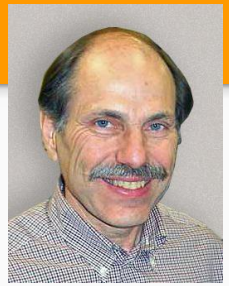


Motivation

AsianAID
Give Hope TODAY

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

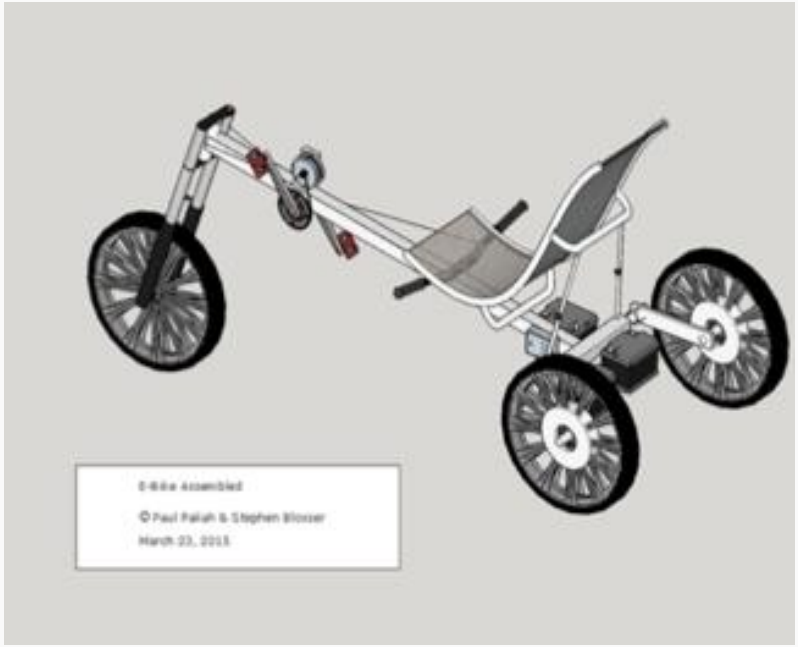
Long-term Goals

- ❑ 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

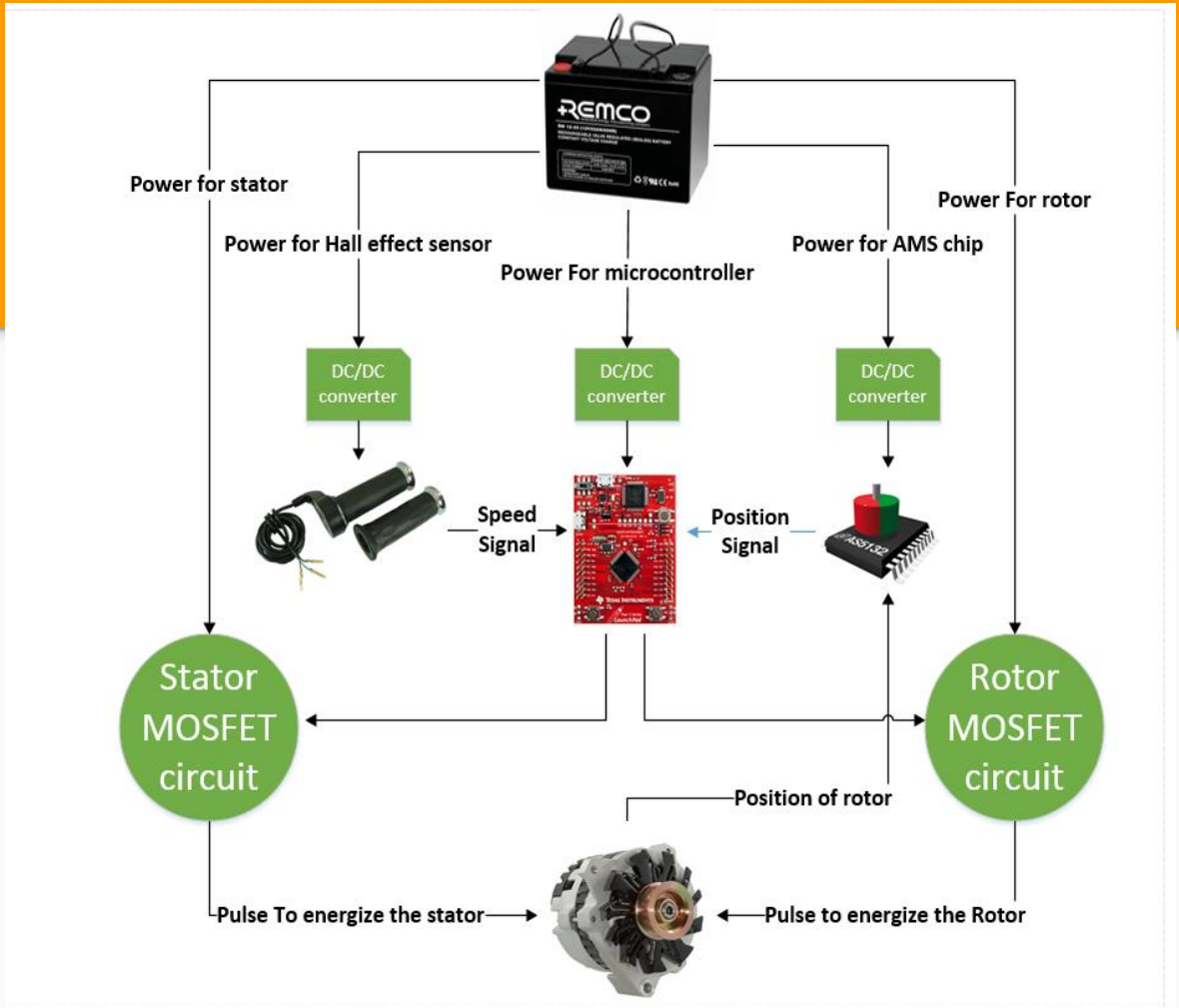
Design Specifications

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



System Design

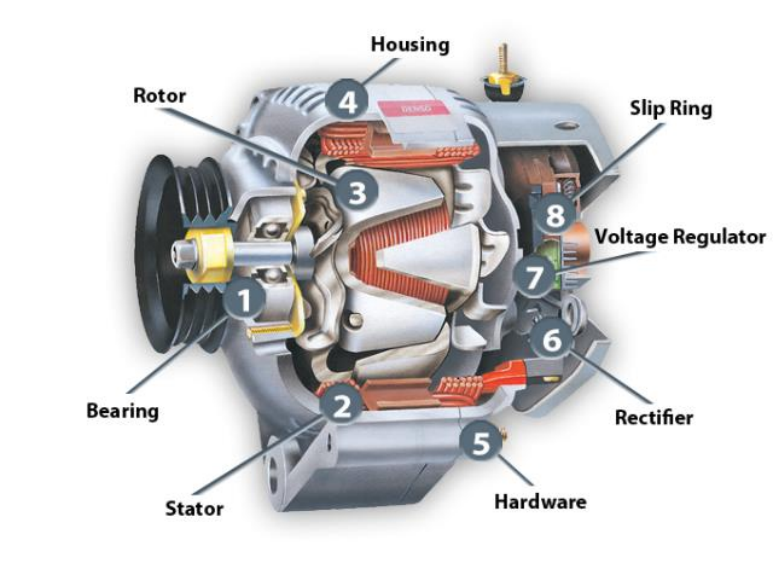
- Power supply and DC/DC converters
- Hall-effect throttle and AMS sensor provide inputs to microcontroller
- Microcontroller drives MOSFET circuits



Alternator as Motor

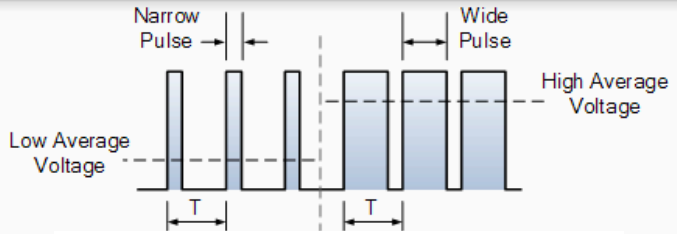
- Typically used as battery charger

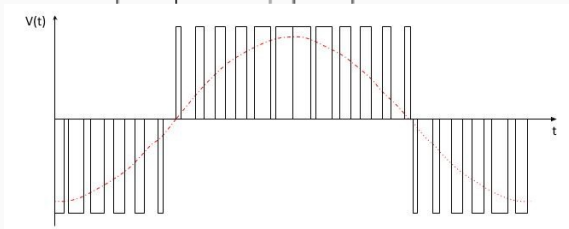
- E-Bike: Use concept in reverse!

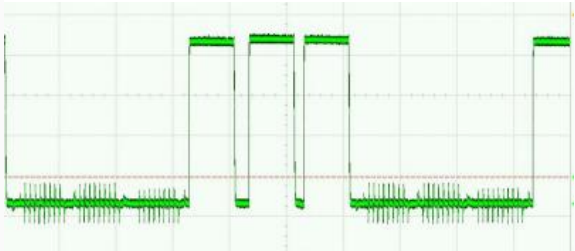


Motor Controllers

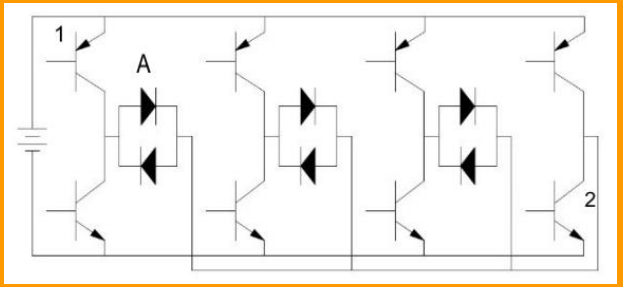
- DC motor controllers vary pulse width
- AC motors use variable frequency drives
- Team 9 design uses pulse at maximum quadrature



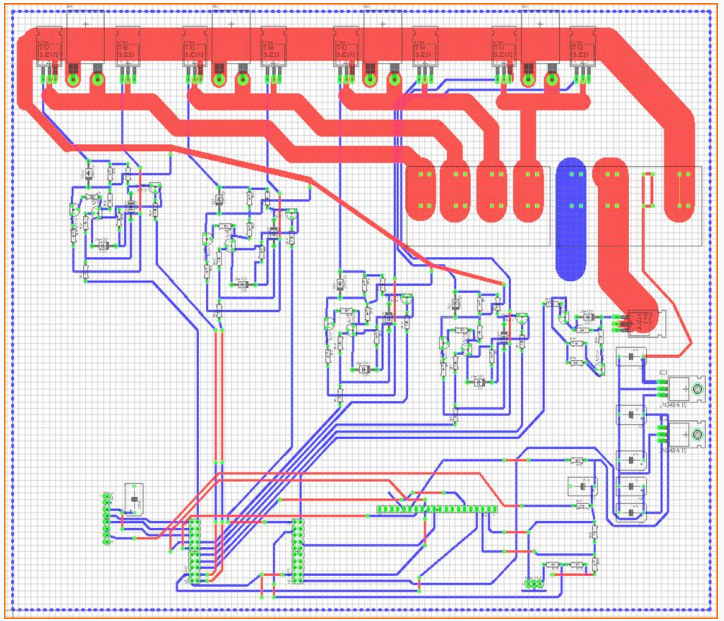




Circuit Design

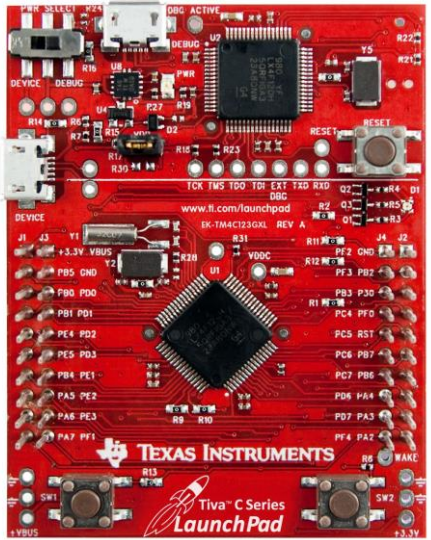


- MOSFETs
- Gate Driving Circuit
- Power Supply Circuit
- Peripheral Connectio



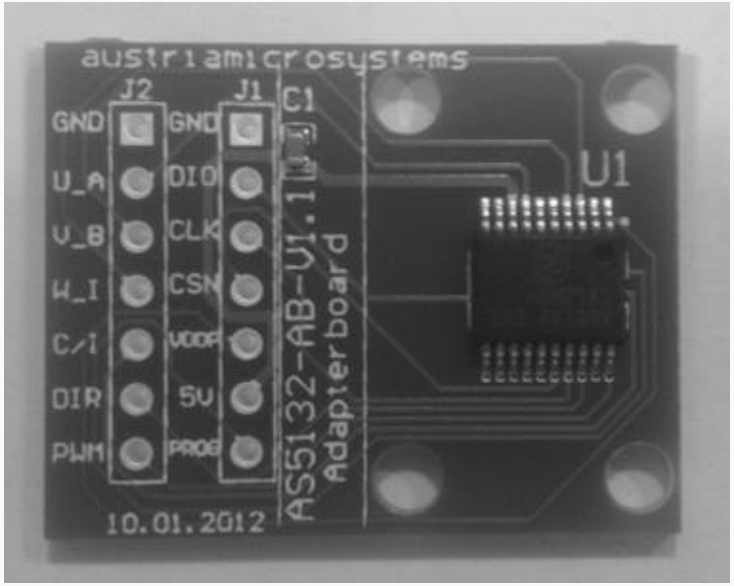
Texas Instruments Microcontroller

- 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

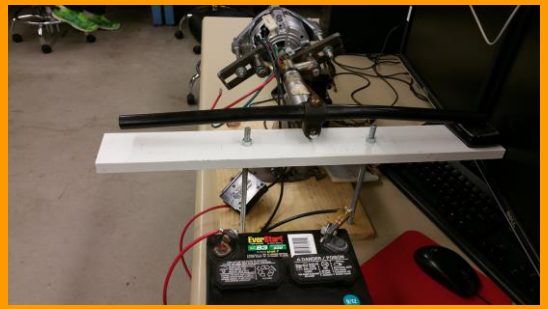
Software Algorithm

- ❏ Precalculate quadrature angles (at startup)

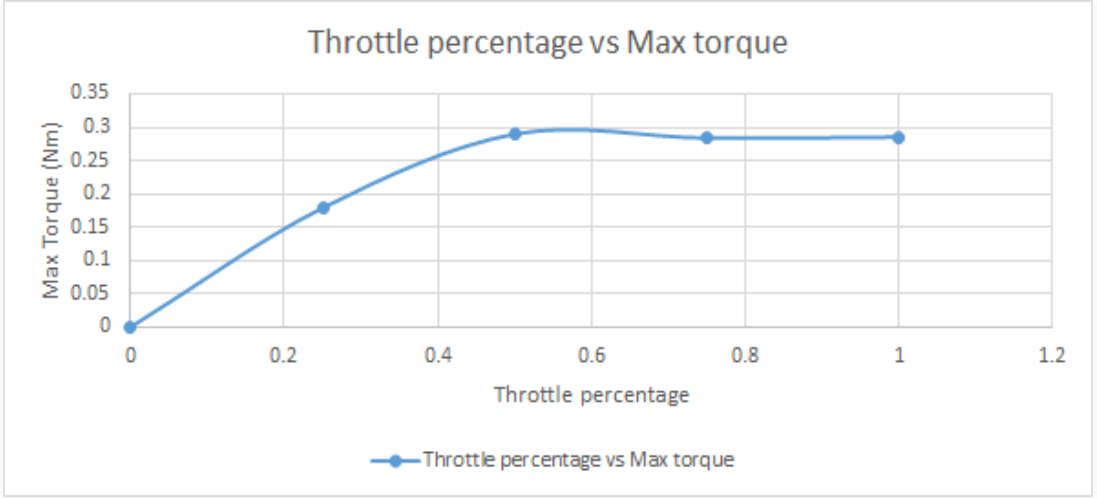
```
// the optimal quadrature angle at which to push the rotor is calculated given
// the base angle of the stator coil minus (that is, counter-clockwise) the timing
// angle. This creates a quadrature point around which to pulse the stator.
mOptimalAngle = baseAngle - timing; // for clockwise operation,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

- ❏ Read from the sensors
- ❏ Determine the correct stator coil to activate
- ❏ Activate/deactivate the pins

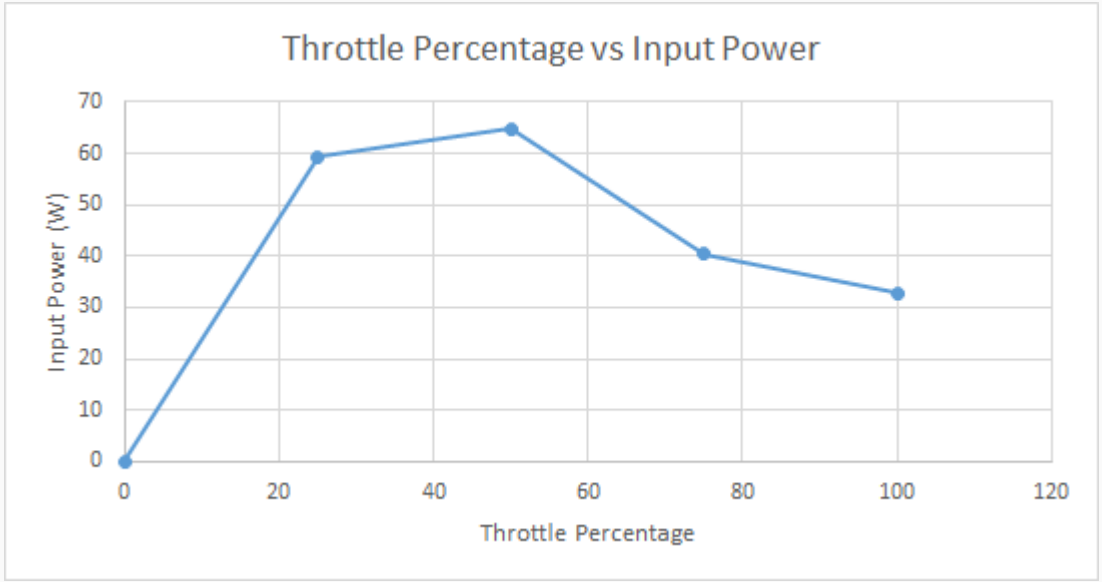
Testing: Torque



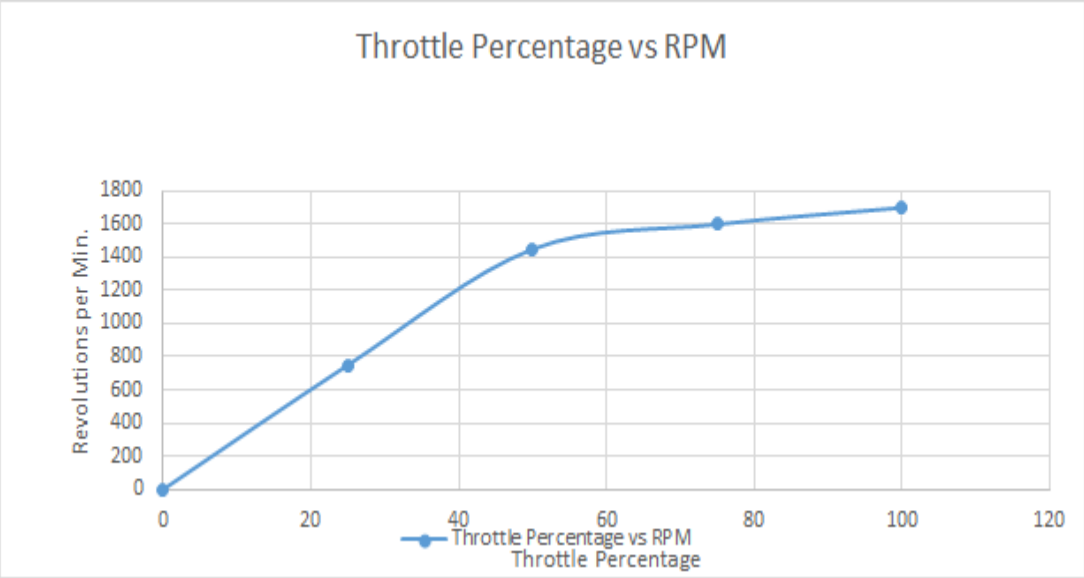
- Key parameter: Torque
- Used to calculate efficiency and power
- Methods of measurement



Testing: Input Power



Testing: RPM


Throttle Percentage vs RPM
Revolutions per Min.
1800
1600
1400
1200
1000
800
600
400
200
0
0
20
40
60
80
100
120
Throttle Percentage vs RPM
Throttle Percentage

Overall Level of Success

High degree of success!

Especially for a first prototype

Design Specification	Achieved?
Working DC motor alternative	Yes
Inexpensive design	Yes
Wide range of speed	Yes
Automatic controls for enhanced performance	Yes
Increased torque at low speeds	Yes
Increased efficiency	Partial
Reverse	Partial

Cost

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

Part Description	Quantity	Cost of Each Part	Total Cost
1/4' x 1/8' Magnets	1	$0.38	$0.38
AMS AS5132 Rotary Sensor	1	$6.30	$6.30
Hall Effect Throttle	1	$14.99	$14.99
Recovery Power Rectifier	4	$1.59	$6.36
MOSFET N-Ch 100V 100A	5	$0.83	$4.13
MOSFET P-Ch 100V 76A	4	$2.16	$8.64
12 V Battery	1	$11.50	$11.50
Automotive Alternator	1	$20.00	$20.00
Voltage Regulators	2	$1.55	$3.10
Header Pins	5	$0.10	$0.50
Color Coded Resistors	47	$0.03	$1.41
9V Zener Diodes	9	$0.10	$0.90
1N4003 Diodes	4	$0.14	$0.56
Capacitors	7	$0.15	$1.05
5ft 10 AWG Wire	1	$2.70	$2.70
TM4C123GXL Microcontroller	1	$13.49	$13.49
20A Circuit Fuse	1	$3.00	$3.00
Total Cost			**$99.01**

Forward to Production

- ❑ 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