Electric Superbike Off-Board Charger

P15261

By Tucker Graydon, Joe Droleskey, Brian Hebbard, Christopher Liess
About EVT

• Student run team at RIT dedicated to promoting the viability of electric vehicles

• Created a high performance motorcycle to race in the eMotoRacing all-electric race series
Project Scope

• Most Electric Vehicles have their chargers built into the vehicle
• EVT designed their motorcycle to utilize an off board charger to reduce weight
• Must conform to J-1772 charging standard
• Have variable input and variable output
Customer Requirements

1. Power Requirements
   a. The charger must be capable of charging a battery from full discharge to full charge in no more than 4 hours while using the J-1772 standard charging station
   b. The charger must also be capable of operating through standard 120V 15A 60Hz wall outlets. While in this low power mode, the charger must be capable of charging the battery in no more than 12 hours
   c. The charging system must automatically detect and switch between the low and high power modes

2. Control Requirements
   a. The charger must be able to output voltage and current to within 20% of the nominal values in either mode. These outputs must also be regulated to within 1% of their set values
   b. The charger must be able to vary voltage and current through both software and a user interface

3. Communication Requirements
   a. Needs to conform to the J-1772 communication protocol for use in high power mode
   b. During all modes of operation, the charger must be capable of communicating over CAN
Battery Theory

• The EVT Motorcycle utilizes sets of Xalt HP Lithium Polymer (Nickel Manganese Cobalt) Batteries
• Because this is a Lithium Polymer the battery must be charged according to the charge curve
• The charge curve to the left is a generalized Li-Po curve
• Constant current (at constant voltage) is applied to the terminals (Stage 1)
• Once the maximum allowed voltage is reached the current cuts off (Stage 2)
Full System Overview
Safety

- SAE J1772 charging standard
- Key lock switch on case
- Emergency stop button
- Monitoring system
AC-DC Rectifier Stage

- Vienna “Dual Boost” rectifier topology
- Chosen for optimal performance characteristics
- Designed to convert 120/240 VAC to DC Voltage
- Designed to receive 63 A at 240 VAC
DC-DC Converter Stage

- Steps down the rectified signal via PWM from a microcontroller
- Uses 7 pairs of high-power MOSFETS connected via welding cable and bus bars
- The high current output made using a PCB impossible
- This design was developed and iterated on, and also applied to the AC-DC subsystem
Microcontroller

- A Teensy 3.2 was selected due to the existing CAN communication support
- The Teensy reads battery voltage levels in from the motorcycle
- Using PWM outputs the Teensy controls the AC/AC rectification frequency and the DC/DC regulation level.
- In the event of voltage runaway, overheating, or communication loss the teensy can stop applying current to the battery pack.
Final Product

Results Achieved

• Variable AC input $1-15\text{V}_{\text{p.p}}$
• DC regulation from 20-80% of the max rectified value
• Output filtering yields final $V_{\text{p.p}}$ of 100mV
Results VS Customer Requirements

1. Power Requirements
   a. J-1772 Charge Speed: 4 Hours
   b. Wall Charging Speed: 12 hours
   c. Automatic Input Detection

2. Control Requirements
   a. Output voltage and current to within 20% of nominal values; regulated to within 1% of their set values
   b. The charger must be able to vary voltage and current through both software and a user interface

3. Communication Requirements
   a. Needs to conform to the J-1772 communication protocol for use in high power mode
   b. During all modes of operation, the charger must be capable of communicating over CAN
Future Suggestions/Improvements

• Re-design the layout of the DC-DC regulator
  • The current double stacked design used more cable than it needed to
  • The AC-DC subsystem looks much cleaner and uses far less cable
    • Consider applying this layout in future iterations

• Re-design Gate drivers
  • Original gate drive design did not work as intended, a new method is needed in order to regulate higher voltages
Suggestions/Improvements Continued

• Variable Current Limiting on the output
  • Original current limiting was not variable, variable current control is needed

• Team Composition
  • All designing was electrically based
Special Thanks

• To our guide Professor Slack
• The Electric Vehicle Team
• RIT KGCOE Staff