2. Requirements, Constraints, And Standards

2.1 REQUIREMENTS & CONSTRAINTS

2.1.1 FUNCTIONAL REQUIREMENTS

The motor controller must be able to spin the motor in either direction under controlled current from 0-3500 electrical rpm.

The controller should be able to support voltage ranges seen by electric bikes and as high as used by solar cars, 48-135VDC (constraint). The controller shall be capable of a continuous 50A current draw (constraint).

The motor controller supports receiving CAN messages for configuring settings on the motor controller as well as real-time use (such as throttle control, cruise control, regenerative braking control). It will also send CAN messages for statuses (such as RPM, voltage and current, and errors). These CAN IDs can be configured so that they better support the specific application they are in and can match the CAN IDs of other motor controllers for ease of swapping controllers. The CAN bus shall be capable of 250k operation.

The controller should also support non-CAN based communication for basic use. For example, there may be an analog input for throttle and regenerative braking, a GPIO for direction, and a waveform of varying frequency for reporting RPM.

2.1.2 RESOURCE REQUIREMENTS

The use of a microcontroller is required to drive at least 6 PWM channels using 3 complex timers designed for motor control (constraint). The microcontroller must also have other timing means not already occupied with PWM output.

If the microcontroller does not have hardware for handling CAN, a separate chip for CAN messages will be used and can communicate with the main microcontroller over an auxiliary communication bus such as SPI or I2C.

Additional communication is also required in order to be easily swappable with other motor controllers. This includes an analog input for throttle and regenerative braking control as well as GPIO for direction control. While these parameters can be specified in CAN messages, not all systems using this motor controller will be using CAN to interface with motor controllers.

The current-carrying switches must be capable of handling a peak current spike four times the steady state average to permit the use of low-inductance motors (constraint). Multiple switches in parallel are permitted given other functional and physical requirements are met.

2.1.3 PHYSICAL REQUIREMENTS

The motor controller shall fit in the footprint of existing motor controllers for solar vehicles (constraint). Those motor controllers act as a maximum since they match the highest power this controller will be used for and are larger than less powerful electric bike controllers. The maximum recommended size is 200mm*200mm*100mm in size.

The high voltage inputs and motor power terminals shall be bolt down lugs protected from environmental contamination with adequate electrical isolation to prevent arcing. Low voltage control and communication shall occur through weather resistant connectors.

The controller shall be able to continuously function with an ambient environment temperature of 0-45 degrees Celsius (constraint).

The weight shall be no greater than 4kg (constraint).

2.1.4 AESTHETIC REQUIREMENTS

The motor controller shall have appropriate labels for safety purposes meaning there must be adequate rooms for warnings such as high-voltage (constraint). Other labels for ports and terminals should be made clear.

2.1.5 USER INTERFACE REQUIREMENTS

The labels included on the motor controller, as mentioned above, shall be written out clearly. This means there is more than just a "+" for a positive terminal, but specifically labelling what positive terminal it is in such a way that it cannot be confused with any other possible input/output to/from the motor controller.

The interface used to troubleshoot and configure the motor controllers from a computer may be done over command line or a GUI. In either case, documentation for commands should be made clear through provided documentation. In a GUI, the UI shall be clean, professional, and well organized. Naming, spacing, and coloring of elements shall be consistent and follow regular patterns to improve the user experience.

2.1.6 USER EXPERIENCE REQUIREMENTS

The user should be able to easily navigate the documentation to mechanically mount their motor controller and electrically connect their motor controller by including all the necessary specifications.

Configuring the motor can be done by navigating to the necessary option (either via command or GUI) and adjusting a parameter and saving/uploading the parameter to the controller. The User shall be able to save settings externally for safe-keeping

2.1.7 ECONOMIC/MARKET REQUIREMENTS

The final cost of the motor controller should be less than one fifth of what is available for powering solar vehicles and should be comparable to a high-end electric bike motor controller. Our target is less than $2000.

Components shall be accessible through public distributors (Digikey, existing stock, etc..) for order in the event of a replacements.

2.2 ENGINEERING STANDARDS

Engineering standards are important because they ensure safety and guarantee functionality. These are vital to ensuring that the things we use daily are reliable and safe. They also allow for an increase in the simplicity of both product development and use since they can reduce the need for unnecessary duplication. They can also codify best practices to spread the institutional knowledge to all those involved in that field of practice.

- IEEE 1547 - Standard for Interconnecting Distributed Resources with Electric Power Systems
    - This standard outlines requirements for safely interconnecting distributed energy resources (like solar and wind) with electric power systems, focusing on performance, safety, and reliability.
- IEEE 1149.1 - Standard Test Access Port and Boundary-Scan Architecture
    - This standard defines a boundary-scan architecture for testing and debugging integrated circuits and circuit boards, allowing access to internal signals for easier diagnostics without physical probes.
- IEEE 1554 - Standard for Software Engineering in the Life Cycle of Digital Systems
    - This standard provides guidelines for software engineering throughout the life cycle of digital systems, emphasizing structured practices for development, testing, and maintenance to improve software quality and reliability.

All of these are applicable in some way to what we intend to accomplish. The first applies to connecting the battery-powered motors to wall power. The second is directly relevant because the need to test and debug integrated circuits and allow for access to internal signals is essential if someone needs to debug our motor controller or when we need to during product development. The third is also applicable because we are writing the software required for this system to run, so adhering to this standard is essential for the system's reliability.

The most significant modification to adhere to these standards is with IEEE 1554. This is important because it directly applies to what we are doing and outlines how to structure our software delivery process, from development to testing to deployment. This guide outlines a structured approach recommended for the board's development.