Control Platform Using Silicon Carbide (SiC) MOSFETs and CAN Bus Protocol

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Goals

- Explore the characteristics of SiC MOSFETS in a motor control application for high temperature and high power conditions.  
- Design a motor control system capable of regulating a motor’s RPM and monitoring gate temperatures, motor drive voltage, and motor drive current.  
- Implement CAN-bus communication protocol to control a second “Slave” simulated motor control system using LEDs.  
- Construct a PC GUI to control the systems via USB.

Overview

PC Display: A computer will house the LabView graphic user interface that gives a user control of the master and slave system motor rpm, direction and on/off state.

MCU: The Cypress PSoC 5LP microcontroller utilizes a PID feedback control loop to regulate PWM output signals in accordance to the instructions coming from the PC and sensory information. Other tasks also include the prevention of shoot-through current, communicating the slave level MCU, displaying all sensory information to an LCD.

Sensors: The control platform includes temperature, speed, voltage, and current sensory capabilities. All the sensory data is processed through decoders and A-D converters within the MCU and utilized in the feedback control as well as displayed on the LCD Display. Once the data is obtained it is sent to the MCU for further decision making.

Gate Drivers: The main purpose of the gate drivers is to provide a fixed voltage between the MOSFETS’ gate and floating source in order to activate or deactivate the devices. Furthermore, gate drivers also provide the necessary decoupling between the MCU and the H-bridge.

H-Bridge & Motor: The H-bridge design is a solution for bidirectional motor drive. It is comprised of four SiC MOSFETs that generate a path for current depending on the desired rotation direction of a brushless 12V DC motor. The H-bridge design utilizes a capacitor in parallel with Vcc and ground to protect the components.

LED Slave: The slave system is autonomous from the motor control system of the master level, employing LEDs rather than motor control. CAN bus interface is utilized as a communication link between the master and the slave MCUs.

LCD Display: All sensory information and communication from the LED Slave will be displayed on the Master MCU’s LCD Display for monitoring.

Results

GUI Control System Design

System Integration

PCB Design

CAN Bus Protocol Hardware Setup

Conclusion & Metrics

As this project serves as a proof of concept, its performance metrics are largely based on the successful design of the system.

- Sensors:
  - Temperature: Range of 2 to 150 C, Accuracy of +/- 1.5 at Extremes.
  - Motor RPM: Accuracy of +/- 1 RPM for 3 to 65 RPM (limited by Motor Range)
  - Motor Drive Voltage & Current: Detects Locked Rotor/Protects Over-current
  - Control: Feedback control of Motor RPM by power regulation using hardware (PWM and MCU) and software (PID control algorithm, sensor utilization).

- Communication: 500 kbps Two-way between the slave and master MCU using CAN Bus, as well as 9.6 kbps one-way USB comm between LabView and master MCU.

- SiC: Operating Range of -55 to 200 C, Switching Speeds < 45ns.

Ethics

All facets of this project are in accordance with both Micropac’s Code of Ethics as well as the IEEE Code of Ethics. Our goal is to put first the safety, health and welfare of the public and second, to deliver a high quality, cost effective design. All software and hardware design elements for the project were developed by the team or obtained in an ethical manner.

Figure 1. System Block Diagram

Figure 2. LabView GUI

Figure 3. Complete Control Platform

Figure 4. Printed Circuit Board

Figure 5. CAN Diagrams

PCB Design Details
- Layers 1 & 4: I/O  
- Layer 2: Ground  
- Layer 3: 5V/12V Sources  
- Dimensions: 3in x 5in  
- 0.008in I/O Traces  
- 0.022in Power Traces

Figure 6. Printed Circuit Board