Group 2.5: DC to Three-Phase Motor Controller

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Sponsor: Texas State University

Overview

Texas State University has begun constructing a car to participate in the American Solar Challenge. A DC to a three-phase variable speed motor controller will be designed and fabricated for a three-phase traction motor using a variable frequency drive. The overall goal of this project is to convert a DC signal, supplied by a 240V battery pack, to a three-phase AC output by building a three-phase inverter. A successful completion of Team Mu's contribution will guide the American Solar Challenge project closer to completing a working solar race car and participating in the endurance competition representing Texas State University.

Problem Statement

Upgrade existing DC to DC high power switching circuit to a three-phase AC output driven by a traction motor controller.

Approach

This assignment for this project is converting a DC signal into a three-phase variable frequency drive output. The software interface of the microcontroller will accomplish the adaptation to frequent variation of speed and torque the car will simulate by generating DC pulse-width modulated signals with changing frequency and duty cycle to adapt to the throttle position. Hardware components are assembled based on the three-phase circuit.

Boundary Conditions

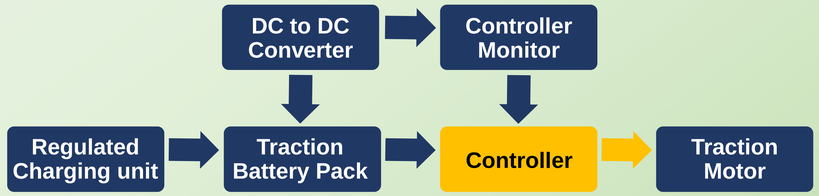
- ► 0 - 240V from battery supply pack
- ► 600ns – 1200ns turn-on delay for IGBT
- ► 300A – 440A DC collector current for IGBT
- ► 3.3V – 5V for microcontroller operating voltage
- ► 6V – 20V input voltage for microcontroller
- ► Maximum current draw for the microcontroller is 50 mA for the 3.3V pin
- ► Max clock speed of microcontroller is 16 MHz

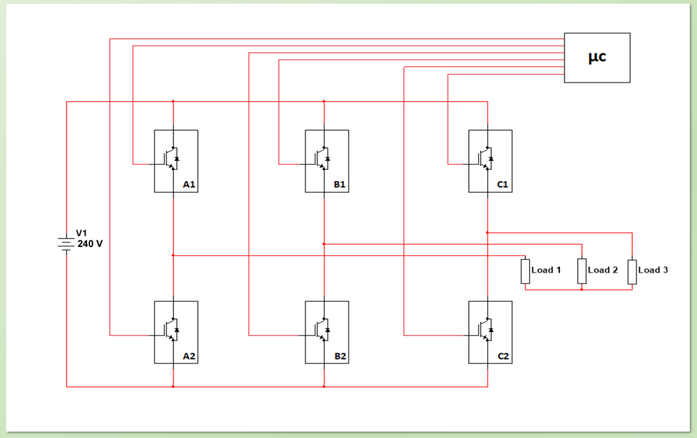
Background Information

- ► A basic three-phase inverter consists of three single-phase inverter switches each connected to one of the three load terminals.
- ► The three switches are coordinated so that one switch operates at each 60 degree point of the fundamental output waveform, which creates a six step line-to-line output waveform.
- ► A Variable Frequency Drive is used to generate three-phase AC outputs at variable frequencies in order to drive 3-phase synchronous motors at various speeds.

The American Solar Challenge

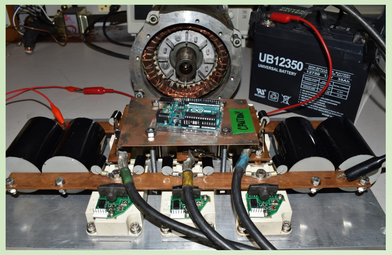
The American Solar Challenge (ASC) is a collegiate level endurance competition which entails: design, build, and drive solar-powered vehicles in a race across the United States. It is is a long-distance race of 1,975 miles spanning across seven states over the span of eight days. ASC originated in 1990 with Sunrayce USA, which started as a result of GM's Sunraycer solar car winning the first World Solar Challenge in 1987.





Test Case/ #	Specifications	Results	Compliant?
1. Pulse Width Modulation	Signal have a deviation within ± 5%	Signal has a deviation within ±3%	Yes
2. Soft Start	Motor increasingly powers up	Working code, not tested with motor	Yes
3. Variable Frequency Drive	90% or higher accuracy	Works on oscilloscope, not tested with motor	Yes
4. Isolation Circuitry	90% or higher accuracy	90% or higher accuracy	Yes
5. Traction Motor Performance	Working three-phase motor	Working three-phase motor	Yes
6. Temperature Redirection	Heat tank redirect 80% of temperature	Heat tank redirect 80% of temperature	Yes
7. High Power Output	Expected output of 1.6kW	Expected output of 7.2kW	Yes

Project Outcome



Team Members

(Left) Alex Rangel, Stephen Akanji, Migdalia Blanco, (Faculty Advisor) Nathan England (Right)

Redefinition of Project

- ► The major redefinition of this project is when the team decided to change the conduction angle from 120 degrees to 180 degrees.
- ► Another adjustment of the project included the change in the microprocessor used. From the beginning, the FRDM-KL46Z board, to the STM32F0 Discovery board, and then the Arduino Uno Rev3 board.
- ► The three-phase AC motor we planned to use initially changed due to the motor not working.

Why is this a good Senior Design Project?

- ► Provides some background in power electronics and power engineering. Provides knowledge and skills/experience of power systems and the electrical apparatus connected to such systems.
- ► By participating in the American Solar Challenge, Texas State's Ingram School of Engineering will be able to participate in this collegiate level endurance competition and expand its engineering recruiting pool to showcase the full potential of its students.

Conclusions

The product built is a three-phase inverter and can be used on any induction motor. Our product is able to be configured to any AC electric motor system by modifying code and still stay within the constraints of the ASC guidelines.

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American Solar Challenge

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