Open Source 100kW Electric Vehicle Controller/Inverter

To be used with an AC Induction Motor

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Abstract

The Open Source 100kW Electric Vehicle Controller/Inverter acts as the bridge connecting the driver and motor. Interpreting the driver's actions, the controller will take swift action, instructing the inverter to supply appropriate power for the motor.

Description

This inverter is an open source design that is available for anyone to modify, improve or replicate the design. This design is intended to be a replica of the open source design provided by Camosun College (abstract: http://www.circuitcellar.com/microchip2007/winners/abstracts/MT2291_abstract.pdf). Intentional changes to the design include snubber circuits added to the IGBT for noise reduction.

The inverter drives the AC induction motor (ACIM) capable of 100kW. This design is specifically for a GM EV1 motor to be ran at 80kW. The input to the inverter will be a 300V battery pack in the vehicle. Three IGBTs will be used to form the 3-phase signal for the AMIC.

The controller is used to interpret user input, and output a PWM signal for the IGBTs. The input is a CAN Bus signal, then Space Vector Modulation is used to create a PWM output signal. A micro processor board will be used to interpret the CAN Bus signal, implement Space Vector Modulation and output the appropriate PWM. The board design will need to be designed for low noise applications. A DC/DC converter will be used to take the vehicle battery power down to the appropriate voltage for the micro processor board. The Space Vector Modulation software is based on Microchip's motor control application. PID control will be used to tune the response of the motor.
Background, Benefits, and Social Impacts

In the world of global warming, fluctuating gas prices, and dependency on foreign oil, need for alternative energy is continually growing. Although electric transportation dates back to the 1800's, crude oil became cheap, abundant, and there is no waste after refinement. Add in the potential of gasoline, and it is easy to see why oil and internal combustion engines dominate the market.

Electric motors have recently been reintroduced into the transportation market. The push for zero emissions and better mileage makes electric drive terrains a suitable alternative to gasoline. Compared to the internal combustion engine, electric motors are more efficient, produce zero emission, maintenance free, and quieter.

It looks good on paper, but there are two main issues with electric vehicles. One is batteries which, until recently, don't hold as much energy as fuel and have a slow recharge time. The other is cost of the controller/inverter, which can cost $20,000. This is why Camosun College created the Open Source 100kW Electric Vehicle Controller/Inverter. Having the product open source allows other people to use, access, and redesign the product for different applications or updating.

The Open Source 100kW Electric Vehicle Controller/Inverter was produced about a year ago. Therefore, reviews and replicas of the controller/inverter are few and far to come by. Building this product is a logical step in the open source design. It will give the communities of electric vehicle makers and open source developers a complex overview of the design. Others then can build up or redesign the controller/inverter as they see fit (just as Linux does).

As electric vehicles become more popular on the road, new challenges and opportunities arise. Electric grids will have a new strain from charging demand. Dealerships will need new technician skills and will lose reoccurring profit from vehicle oil changes. Battery demand and technology will increase, opening up new markets and jobs.

With hybrids being recently introduced into the market, there has been a growing concern about battery disposal. There are four common batteries used in current vehicles: Lead-acid, Nickel-cadmium (NiCd), Nickel-metal hydride (NiMH) and Lithium-ion (Li-ion). Lead-acid is used in normal vehicles to supply the 12 volt electrical system. The pose an environmental hazard when disposed in a land fill however, these batteries can and have been recycled for some time. NiCd also poses an environmental hazard but can also be recycled. However, NiCd is not a common as Lead-acid, therefore recycling is less common. NiHM is commonly used in hybrids, and don't pose as an environmental hazard; Nickel is considered semi-toxic. Ford, Honda, and Toyota (three major hybrid auto makers) all recycle batteries from their hybrid vehicles. Li-ion is the most talked about battery for the future. They are already commonly used in cell phones, laptops, cameras, and other consumer electronics. Although lithium is not considered harmful to the environment, recycling is an option because of the gross amount of lithium batteries found in consumer electronics. There are other battery options that are currently being researched including silver-zinc, zinc-air, and aluminum.

This project can help pave the path for electric vehicles. An open source controller/inverter will help make technology more readily available and make the electric vehicle more feasible. As progress in the design continues, so do the steps towards an inexpensive product for the common user.

Comparison of Similar Products

Zilla Z2K
-\[ \text{Vin} = 72V - 348V \]
- Max Current @ 300V = 1770A
- Continuous Current @ 300V = 600A
- PWM frequency = 15.7kHz
- Power Drives = IGBT
- CAN Bus input

Curtis 128-65xx
- Vin = 48V – 80V
- Continuous Current = 550A
- Power Rating = 51.3kVA

Piktronik SAC40
- Vin = 96V – 300V
- Continuous Current = 280A
- CAN Bus input

AC15 Gen2
- Vin = 240V – 450V
- Continuous Current = 580A

**Development and Demonstration**

Most of the project is going to be following the Camosun design, using their schematics and code provided by them ([ftp://ftp.circuitcellar.com/pub/Circuit_Cellar/2008/217/](ftp://ftp.circuitcellar.com/pub/Circuit_Cellar/2008/217/)). The important issue is noise interfering with the IGBT. Snubber and wiring will be carefully looked at to reduce noise. The IGBT will also need to be cooled. Even though the IGBTs are ran much lower than their full potential, they will be driving a considerable amount of power. Heat will increase noise and decrease the life of the IGBT. The VRI can provide CNC machining for water cooling and mounting.

The VRI will also provide the testing platform(s). They have three phase power, high power DC supplies and motors. Although the VRI has an EV1 motor and a large ACIM out of an electric bus, a smaller and cheaper motor is likely to be used for initial testing. If time allows, the final product may be tested in a fully electric vehicle.

Certain safety precautions should be taken when dealing with electric vehicles. This system is designed to take a 400V DC input and output a 100kW three phase signal. Underwriters Laboratories has developed some standards for working on electric vehicles. These standards include UL 2202, UL 2231 and UL 2251. These standards will be taken into consideration during development along with thoughtful grounding, insulation and exposed circuitry.