**Divide and Conquer Group F**

**Variable Frequency Drive Controlled Electric Racing Kart**

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**Project Description**

The design of a variable frequency drive controlled electric racing kart is motivated by the growing popularity of electric vehicles in the automotive industry and the steady transition away from internal combustion systems in automobile engine design. As limited oil reserves becomes a steadily growing problem in the economy, the motivation for the implementation of electric vehicle systems is clear. Specifically, this project is intended to implement an electromobility system on a small scale, that is, the system will be housed in a racing kart chassis. This would allow for a lightweight, easily accessible, portable, and relatively low cost automotive system which could be easily scaled up to a full-scale vehicle. Furthermore, our project will include the design and construction of custom LiFePo4 battery banks to power the vehicle, this battery bank will include smart technology including individual cell voltage monitoring, multiple-zone temperature monitoring, and of course fully balanced charging. These features will add to the physical protections for reverse polarity, over-current, and over-temperature. All of this data from various sensors around the vehicle will be processed and displayed real-time to the user via LCD displays and web data.

The advantages of electromobility are clear. As outlined by Volkswagen Group of America as part of their service training for the basics of electric vehicles, environmental advantages of electric vehicles include reduced CO2 emissions, reduction of noise emissions, and the awareness of the consumption of raw materials. Efficiency is another motivation for the design of such systems, electric drive motors have an efficiency of up to 96% compared with internal-combustion engines that have an efficiency of 35-40%. On a societal level, growing electromobility would allow for the increased demand for vehicles with lower consumption and emissions profiles. These are a few of the many advantages of electromobility in the automotive market.

This project is feasible precisely because of the advantages of electromobility to conventional combustion engines. The drive train design is significantly simplified mechanically because traditional vehicle components like the transmission, clutch, mufflers, particulate filters, fuel tank, starter, alternator and spark plugs are not required. In addition, apart from the reduction gearbox on the electric drive motor, the electric vehicle does not have any additional lubrication requirements. This project is intended to allow for the team to investigate the use of feedback controls and power electronics to drive a three-phase AC induction motor, learn significantly more about general automotive system design and implement additional data tracking features within the driver’s seat of the vehicle. The system will track power output, 2-axis acceleration, regeneration rate, total regenerated power, etc.

**Requirements Specifications**

The final prototype must: achieve speeds down to, or below, 1Hz at the motor shaft. The drive must be capable of achieving a power delivery of over 15kW peak, approximately 20 hp. The specific specifications of power will depend greatly on available funding, as high power AC motors are costly. Furthermore, we would like our inverter portion of the drive to be greater than 90% efficient. We will require that the battery packs we design have individual-cell monitoring for voltage and slightly more large scale monitoring of temperatures throughout the packs. Further data acquisitions we require are: vehicle speed, motor power consumption, motor temperature, power being regenerated, power offset from regeneration, two-axis acceleration data, and power switch temperature.

We will require DC-DC regulation from the output of the battery bank so as to ensure a specified voltage supplied to the power switches providing three phase power to the AC motor. This process will incur losses, so a relatively high efficiency (80-90 percent) will be required. In addition, the system will incorporate regenerative braking to perform as a kinetic energy recovery system. Whether or not an active regenerative braking system will be incorporated is still to be researched, though it is likely that the feature will be incorporated when the throttle is released (passive regenerative braking). While the throttle is not pressed the electric motor will act as an electric generator. This energy will either be stored electronically in a bank of capacitors and buffered between the battery bank or routed directly to the battery bank via a voltage regulation circuit for recovered energy.

For data that is sampled from the motor appropriate transducers will be required. A sensor to read data from the motor will interface with the encoder to provide motor rpm data to the PID control block of the variable frequency drive. As a part of the digital signal processing system there will need to be appropriate algorithms placed to perform anti-aliasing of the data (low pass filtering to band limit continuous time signals like motor rpm), appropriate sampling techniques, and analog to digital conversion.

We will be using a microcontroller to monitor and regulate various data related to our project. At this moment, this data includes, but is not limited to, the speed of the motor, the charge level of the battery, the temperature of the battery, and the regenerative braking status. The information acquired will be stored in the memory of the microcontroller and will be updated in real-time. This data will be used in the LCD display of the variable frequency drive so that the user will be able to keep watch of various parameters, as well as troubleshooting and development.

The microcontroller will be gathering various inputs from parts of the variable frequency drive. We will use various calculations to transform these inputs into the units we wish to display. These calculations will then be stored directly into the microcontroller’s memory. These values will then be used for the LCD display. Inputs will be ideally be collected as fast as possible so that the display will be showing accurate real-time data.

The LCD display will display real-time data from various parameters of the vehicle under normal operation including: speed (mph), battery voltage (charge level), battery temperature, regenerative braking status (at lower speeds it will drop off).

**Estimated budget**

Motor……………………………. $2000

Chassis…………………………. $400

LiFePo4 Cells………………….. $1000

Supercapacitors……………….. $300

Filtering Caps………………….. $50

Inductors……………………….. $150

Wire…………………………….. $150

Hardware…………………….... $100

ICs (rough estimate)................ $300

**Total……………………………. $4450**

**Initial Project Milestones**

**Spring:**

Below are the last dates of each month throughout the semester. Although an immense amount of research will be taking place during the whole semester, the following goals are to be expected by each date.

February 29th:

* Divide and Conquer revised
* AC motor selected and detail (specifications, limitations, etc.) reported
* VFD Control options selected
* PWM logic design started
* lcd display selected and data logic design started
* simulation circuit design started
* 60 pages of the report written

March 31st:

* Project design finalized
* SImulation of project finalized
* 100 pages of the report written

April 15th:

* Research on limitations, restrictions, etc finalized
* Project simulation tested and revised.
* 120 pages of the report written and reviewed

**Fall:**

A significant amount of research into the selection of the specific AC induction motor to use for the drivetrain will be required, as this will dictate the design of the control block for the variable frequency drive and the associated power electronics for the power path of the system. Therefore, this is the primary milestone for the Spring 2016 semester.

Once the motor has been selected, the design process will pivot to the development of the appropriate controls with feedback loops to ensure proper operation of the variable frequency drive and motor. By no means is the digital logic and data handling a secondary concern, though its implementation will be dependent on appropriate selection and design of the hardware for the drive train system.

