Hardware Requirements Specification

for

Flux Capacitor

Version 1.0

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1. EXECUTIVE SUMMARY

1.1 Project Overview

The *Flux Capacitor* is a remote battery monitoring system for typical 12V car batteries. In this case, it is the *Optima Yellowtop D35* due to the intended audience. The targeted client is the Electric Vehicle Club at *Earl of March Secondary School* participating in the *Waterloo EV Challenge*, requiring this type of battery for a 60 minute race.

1.1 Purpose and Scope of this Specification

The purpose of this project is to monitor the State of Charge(SOC) of the battery during the 60 minute race for the 12V Optima Yellowtop D35 Battery. By displaying this value, the driver of the vehicle will be able to optimally determine when to conserve or discharge the battery's capacity during the race. The tasked designer for this product is Frank Li and will be managed by Mr. Gordon Roller to ensure the success of the product and the requirements of the 2020 EV Club and the Ontario TEJ4M curriculum are met. The proposed deadline for this will be the race day, May 25.

2. PRODUCT DESCRIPTION

2.1 Product Context

There are many other RBMS in the market that are incredibly costly. Typically, these products including this one will be self-contained products that just require to be connected to the 12V battery.

2.2 User Characteristics

The intended audience consists of Secondary Students who have minimal knowledge of the inner-workings of this product's system. The technical expertise required is simply to understand SOC of the battery, thus, just the battery capacity. The product should have a clear display to quickly show the driver values during the race.

2.3 Assumption/Risks

Since the purpose of this project is to be used in the EV challenge, it is assumed the monitored battery is the Optima Yellowtop D35. Different batteries will not work effectively with this system. The necessary parts can be attained, but there will be a risk packaged with the speed of delivery. In addition, the Flux Capacitor will require pre-simulated data to function properly. These simulations need to be done on a paid software that requires a good amount of expertise.

2.4 Constraints

The method used for determining the battery percentage is heavily dependent on the preciseness of the sensors. In addition, the analog values of the sensors must be changed to digital signals in order for the microcontroller to process, thus, the quality of this BMS is also constrained by the sampling rate and the bit size. Another possible constraint, but it can be easily resolved, is the memory size of the microcontroller. The amount of memory may limit the sampling rate and quantity.

2.5 Dependencies

The basic structure of this product is reliant on simulations that must be done on simulation software such as *MATLAB*'s *Simulink.* These simulations will act as a look up table for the microcontroller. As for the sensors, its sampling and analog to digital conversion has to depend on the microcontroller being able to determine the SOC from theoretical data. In particular, the current sensor is dependent on the arrival of a specific electrical component, the shunt. The temperature is also dependent on the arrival of the electrical component, the thermocouples.

3. REQUIREMENTS

3.1 Functional and Hardware Requirements

3.1.1 Functional Objectives

Req#	Requirements	Comments	Date Rwvd	Customer Reviewed/Approved
HRS-3.1.1.1	The RMBS shall be able to last for the length of the race, 60 minutes.	Requires its own power source capable of powering a master controller and 3 ADC slaves.	03/04/20	EV Club Approved
HRS-3.1.1.2	The RMBS shall be able to display the SOC to the driver through a display on the steering wheel.	Requires a LCD screen display to be mounted on the steering wheel.	03/04/20	EV Club Approved

3.1.2 Mechanical Chassis

Req#	Requirements	Comments	Date	Customer

			Rwvd	Reviewed/Approved
HRS-3.1.2.1	The RMBS should be able to fit in a box.	The dimensions of this box will need to be under 10” by 10” by 5”.	03/04/20	EV Club Approved
HRS-3.1.2.2	The container should be easily accessible and be able to open.	The inner of the container should be split into two halves. One consisting of the master microcontroller and the other half split into thirds for each sensor.	03/04/20	EV Club Approved
HRS-3.1.2.3	The RMBS should be lightweight.	The box should be made out of plastic and fairly block-like.	03/04/20	EV Club Approved

3.1.3 Sensors

Req#	Requirements	Comments	Date Rwvd	Customer Reviewed/Approved
HRS-3.1.3.1	The Flux Capacitor requires a current sensor.	A current sensor is needed for this specific method of battery monitoring, hence, the name is Coulomb Counting.	03/04/20	EV Club Approved
HRS-3.1.3.2	The Flux Capacitor requires a voltage Sensor.	The voltage sensor is required to determine the initial open circuit voltage.	03/04/20	EV Club Approved
HRS-3.1.3.3	The Flux Capacitor requires a temperature monitor.	Temperature is needed to ensure %error/weight factor since temperature is influential on the flow of current.	03/04/20	EV Club Approved

3.1.4 Electrical Components

Req#	Requirements	Comments	Date Rwvd	Customer Reviewed/Approved

HRS-3.1.4.1	The RMBS requires a Shunt to be attached onto the Battery.	The shunt will be able to decrease the current by a factor that is readable by a microcontroller without frying it.	03/04/20	EV Club Approved
HRS-3.1.4.2	The RMBS requires a thermocouples to be attached onto the Battery.	The heat from the battery will need to be used to provide a voltage through thermocouples for a sensor to determine temperature.	03/04/20	EV Club Approved
HRS-3.1.4.3	The RMBS requires its own power source. A 5V power source.	The required microcontroller requires 5V power source as reference for the ADC ICs and to power itself for 60 minutes.	03/04/20	EV Club Approved

3.2 User Interface Requirements

Req#	Requirements	Comments	Date Rwvd	Customer Reviewed/Approved
HRS-3.2.1	The RMBS shall have a save button.	Database required on pc to download the data.	03/04/20	EV Club Approved
HRS-3.2.2	USB port to arduino to debug and deploy code.	Arduino development environment required on pc.	03/04/20	EV Club Approved
HRS-3.2.3	Switch to turn on and off the RMBS.	The switch acts as the start of the race and the end of the race.	03/04/20	EV Club Approved

3.3 Hardware Interface

3.3.1 Internal Interfaces

Req#	Requirements	Comments	Date	Customer

			Rwvd	Reviewed/Approved
3.3.1.1	The master microcontroller needs to be connected to 3 slave ADC ICs with I2C protocol.	The central arduino controller will have analog pins 4 &5 for data and timing. THe master arduino will perform the SOC algorithm while the slaves perform ADC.	03/04/20	EV Club Approved

3.3.2 External Interfaces

Req#	Requirements	Comments	Date Rwvd	Customer Reviewed/Approved
HRS-3.3.2.1	USB port required for reprogramming, debugging, and extraction of data.	Database and Arduino IDE required on pc.	03/04/20	EV Club Approved
HRS-3.3.2.2	Shunt Connector	Shunt to be connected to battery and ADC to be connected to the shunt. The shunt should be 700 A shunt.	03/04/20	EV Club Approved
HRS-3.3.2.3	Display Connector	LCD with save button to be connected to the arduino.	03/04/20	EV Club Approved
HRS-3.3.2.4	Thermocouple connector	The thermocouple should be of type K.	03/04/20	EV Club Approved
HRS-3.3.2.5	Voltage Connector	The thick AWG battery wires need to be connected to 1M ohm and 100k ohm resistors in series to reduce by a factor of 11.	03/04/20	EV Club Approved
HRS-3.3.2.6	ADC ICs connector	Signals are read by 12 bit Analog to digital converter with a	03/04/20	EV Club Approved

		1000Hz frequency. 3.3V to be used as reference. All three slaves connected to arduino through analog pins 4 and 5.		

4. REQUIREMENTS CONFIRMATION/STAKEHOLDER SIGN-OFF

Meeting Date	Attendees	Comments
03/04/20	Frank, Members of the EV Club, Mr. Heidt, Mr. Amini	Confirmed all the requirements
TBD	Frank, Mr. Roller	TBD Need Approval of Manager

APPENDIX

Appendix A. Definitions, Acronyms, and Abbreviations

SOC - State of Charge of the battery
EV - Electric Vehicle
RMBS - Remote Battery Monitoring System

BMS - Battery Monitoring System
ADC- Analog to Digital Converter
IC - Integrated Circuits
Thermocouple - A thermocouple is an electrical device consisting of two dissimilar electrical conductors forming an electrical junction.
Shunt - A shunt is a device which creates a low-resistance path for electric current, to allow it to pass around another point in the circuit.

Appendix B. References

He, Lei, Bingjun Xiao, and Yiyu Shi. “A Universal State-of-Charge Algorithm for Batteries.” 47th IEEE Design Automation Conference “DAC ‘10”, 2010.