Digital Dash for an Electric Race Car

Design requirements

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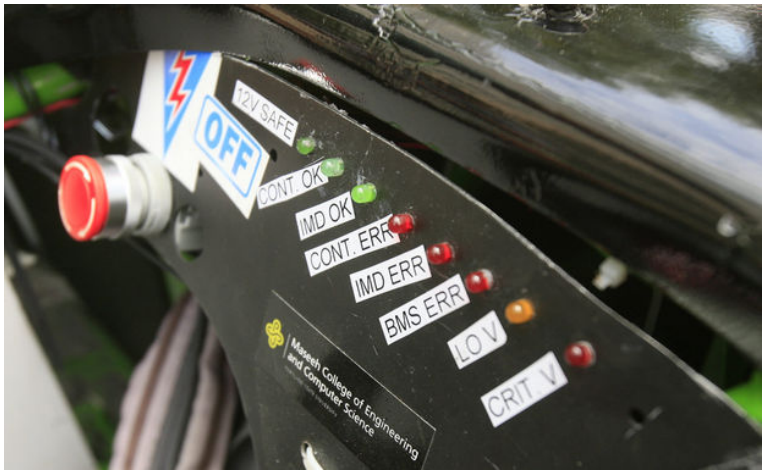
This document summarized the customer requirements as presented on the first capstone group meeting. The document contains original capstone proposal, design requirements, timeline, expected deliverables and estimated budget.

Original Capstone Proposal

budget: ~$500
complete by: March 2015
customer: Viking Motorsports, http://vms.groups.pdx.edu/



Traditional dash in race cars is very rudimentary and shows only the absolute minimum, i.e. Neutral indicator and overtemperature warning lights in gas powered cars, or status (OK/FAULT) of motor controller, battery management system (BMS), and safety subsystems. The status is indicated by either different light color, or by blinking light. Because electric race car is more complex than its gas powered counterpart, a traditional dash isn't sufficient.

The driver of the electric car has to know the status of all important subsystems, he/she has to be able to clearly see indicated faults and their nature and also the estimated remaining charge, so they can adapt their driving style (important especially for endurance competitions).

The solution is a small sunlight-readable LCD display (for example 2.7" or similar). The display will connect into the car CAN-bus and will grab necessary information from there. Other means of communication are possible (i.e. bluetooth/wifi/serial connection with the Vehicle Control Unit - VCU). A simple Graphical User Interface (GUI) has to be developed, as well as simple heuristics to determine which information to display.

The student/team will be expected to choose most suitable LCD display, design the communication interface with the VCU and develop GUI and waterproof casing for the display. The solution will be tested in test-drives and during international races.

Introduction

“Viking Motorsports is preparing a new electric car for international Formula SAE competition in Nebraska, June 2015. Over 20 university teams from around the world are competing in the electric vehicle (EV) category. Digital Dash is an important part of the vehicle design, because it replaces the current dash with LEDs and conveys more information to the driver. Digital Dash is an open source project (both hardware and software). Depending on the success of Viking Motorsports car, other teams might decide to use Digital Dash too and leverage its functionality.

While driver is driving, there is very little time to look at the dash. Therefore any information shown must be very clear, simple and comprehensive. Most important during longer endurance runs is remaining battery capacity, and temperature of batteries and motor controller. In pits the most important for driver is to have an overview of the vehicle state (is it in ready-to-drive-mode) and possible faults that might occur (over/under voltage, over temperature...).”

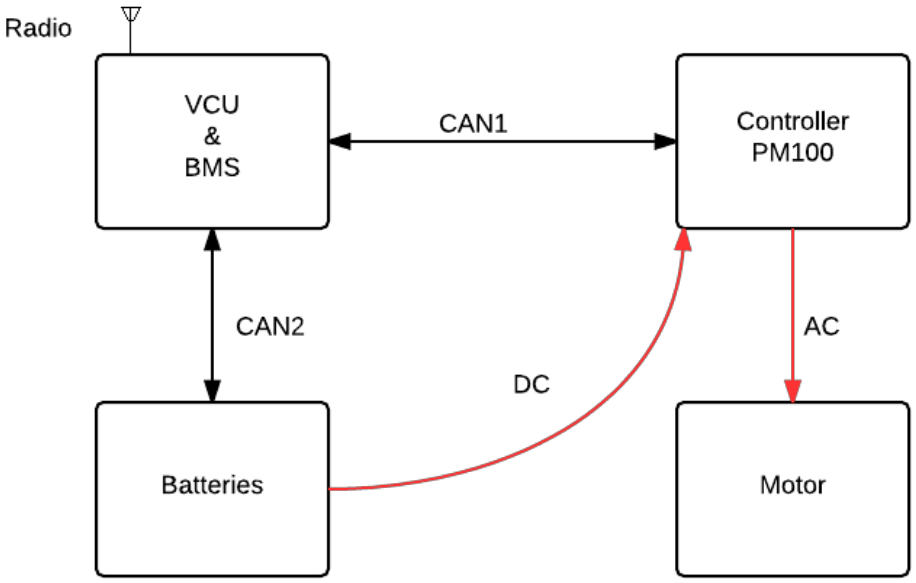
Requirements and Grading

All mentioned requirements and features have to be fulfilled, unless they are marked as **Nice to have**. In other words, full customer satisfaction (and hence highest grade) is achieved if all requirements are fulfilled. Nice-to-have features don’t necessarily give you better grade, but will definitely impress and show that you provided something extra.

Sometimes a short comment on a given requirement is added for clarity.

Vehicle Diagram

Battery Management System (BMS) monitors batteries (temperature, cell voltages) over a separate CAN bus. Vehicle Control Unit (VCU) logs all vehicle data, sends telemetry over radio link, and reads/sends data from/to Motor Controller (PM100) over another CAN bus. A simple car diagram is shown below. BMS and VCU is in fact one system (runs on the same microcontroller).



Mechanical Requirements

Digital Dash is essentially a bright LCD display (plus necessary electronics and connectors), in a waterproof enclosure. The dash space is limited, thus is not reasonable to use a larger than 5”. The current car dash can be adjusted (i.e. switches moved around etc.) to accommodate Digital Dash.

Requirements:

- Sunlight readable (or equivalently bright) LCD - sun shade or similar is allowed, must be easily readable in direct sunlight[1]
- Driver has to have a clear view of the Digital Dash
- Larger displays are not necessarily better, if a smaller display (i.e. 2.7” from http://www.ebay.com/itm/Brand-New-Earth-Lcd-83-13319-2-7-Lcd-Outdoor-Sunlight-Readable-/251617027047?pt=LH_DefaultDomain_0&hash=item3a958b23e7) can convey all necessary information, it is preferred over a larger one
- Digital Dash has to be in a waterproof enclosure, so it can be used in rain, while maintaining its visibility
- Digital Dash has to be designed to be reasonably robust[2]
- It has to be possible to remove and mount Dash reasonably easily

[1] e-ink or similar technology is allowed
[2] i.e. will survive rough driving for at least one season (12 months)

Electrical Requirements

Provided is 12V power from main car battery (no limit on current consumption, although it should be in a reasonable range). Suggested connectors are Deutsch ™ or similar.

Requirements:

- It must be possible to use the vehicle either with or without the Digital Dash[3]
- Reasonably robust against electrical noise
- The start-up time should be reasonably short (definitely less than 30 seconds)
- *[Nice to have] Driver can change interactively vehicle mode between sport and endurance (equivalent to dry/wet track mode)*

Software Requirements

Digital Dash should be reasonably simple to reconfigure and add/remove variable/message to display.

Displaying information

The information have to be displayed in an easily readable form (large enough font, color coding, etc.). It might be necessary to adjust the display layout depending on system state (i.e. if there are more faults to be displayed, then it might not be useful to show motor RPM in large font).

Highest priority in displaying have errors, they have to be visible at all times as long the error is present. Warnings have informative meaning, and lower priority and they are basically telling to the driver that some variables are outside their normal values. Variables should be displayed unless there is more important error or warning.

Variables

- Main battery voltage (typically 120-200V) - send over CAN from PM100
- PM100 temperature (typically 0 - 100 C) - send over CAN from PM100
- Max cell temperature (0-60C)- must be requested from BMS
- *[nice to have] sport/endurance mode - must be requested from VCU*
- *[nice to have] datalogging status (RUNNING/STOPPED) - must be requested from VCU*

Warnings

- Main Battery voltage low (below threshold)
- PM100 temperature high (above threshold)

[3]e.g. in case of CAN bus, termination resistors might have to be added to the connectors

- Max cell temperature high (above threshold)

Required errors

- Battery voltage below limit
- PM100 temperature above limit
- Max cell temperature above high
- Battery Management System error - must be requested from BMS
- Insulation Monitoring Device error - must be requested from VCU
- PM100 error - send over CAN from PM100

Expected Timeline

- January 2015 - the team should prepare Preliminary Design Review (PDR) showing their intended solution.
- February - April 2015 - building the prototype, HW and SW development
- May 2015 - first prototype delivered and installed into the car for testing[4]
- June 2015 - final version based on the feedback from customer is delivered, project files are posted online to adhere to the open source nature of the project (preferred if you use github for code and hw design, plus make a little webpage with some short howto and examples)

Preliminary Design Review

PDR should cover the research of the available LCD displays, research of possible communication solutions (CAN, Serial, USB, Zigbee etc), and selected hardware and software solution.

Deliverables

- One functional unit.
- Professional project documentation and source files (SW/HW)
- Well commented code
- A user manual (so Viking Motorsports can produce and use more units)

[4] Allow at least two weeks for testing