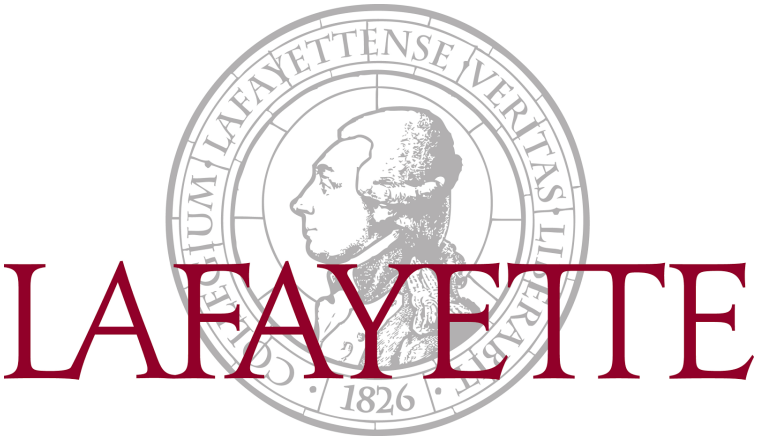
VSCADA

Vehicle Supervisory Control and Data Acquisition



Final Report

Lafayette College

Lafayette Formula Electric Vehicle
Electrical and Computer Engineering

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Abstract

The following document summarizes the work done by the Vehicle Supervisory Control and Data Acquisition team (VSCADA) in the Spring 2015 semester for Lafayette Formula Electric Vehicle (LFEV) project. This document is intended to serve as a high-level overview of the VSCADA system requirements, design and integration. Links to additional system deliverables are provided for further reference.

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Introduction

The Lafayette Formula Electric Vehicle (LFEV) is a complex, open-ended, multi-year project with the end goal of producing a fully compliant, integrated and tested electric vehicle to compete in the Electric Vehicle (EV) category of the Formula Hybrid competition. The project began at Lafayette College in 2013 and was continued in 2014. In 2015 there were five overarching goals as follows:

- A competition-ready, fully compliant accumulator to provide the vehicle's Tractive System Voltage (TSV).
- A new Grounded Low Voltage (GLV) system to power all vehicle subsystems other than the tractive system along with a fully integrated, packageable Safety Loop and TSV Load Controller (now known as Tractive System Interface or TSI)
- A fully assembled Motor Controller System (MCS) test stand, consisting of a motor, motor controller system, dynamometer and data acquisition box to operate and characterize the motor to be used in the final vehicle (known as the DYNO system).
- A combined hardware and software system collectively known as Vehicle Supervisory Control and Data Acquisition (VSCADA) to interface with GLV, TSV and DYNO to acquire data from these other subsystems and control the vehicle system state.

The VSCADA subsystem of the LFEV is the among the most challenging to design and integrate for two reasons: first, it must interface with several different subsystems, each with varying hardware, and second, it must act as the brains of the overall integrated system and use the data acquired from all subsystems to make an informed decision on the system state as well as set control signals (i.e. flip relays).

The LFEV-Y3-2015 team consisted of 20 members, while the VSCADA team consisted of six members: Yiming Chen (team leader), John Gehrig, Bikram Shrestha, Sam Cesario, Rameel Sethi and Adam Cornwell.

VSCADA System Requirements

The VSCADA subsystem of the LFEV was to be designed subject to a number of VSCADA-specific as well as project-wide and general-purpose requirements.

The main VSCADA-specific requirements included:

- Provision of several different physical interfaces for the user to access the VSCADA software, including an on-car dashboard display, a remote PC interface and a cell phone app.
- Development of different operational modes for VSCADA software: a drive mode to assist the driver in operation of the vehicle while performing all needed safety checking; a drive mode demo to be used in Acopian Engineering Center for both visitors and for testing purposes which does not require physical hardware; and a Maintenance mode which can be used to monitor and change as many low-level parameters, states, outputs, and configuration settings of the car as possible.
- Data acquisition from all other subsystems of the LFEV including TSV, GLV and DYNO, with real-time plotting of data, monitoring and storing of all measurands at programmable sampling rates, and calibration of stored data by addition and/or calculation of calibration factors through data analysis.
- Control of system state, including the ability to shut down LFEV subsystems in case of an unsafe condition, addition and modification of system rules and alarms, logging of all events and exceptions, through closed-loop control of motor and motor controller, communication with TSV accumulator, and control signals to GLV.

The team originally intended to address most of the above requirements, with the exception of the cell phone app and closed-loop motor control. Please see the Traceability Matrix of the Acceptance Test Plan (deliverable D004) for a complete list of VSCADA system requirements.

System Design Overview

The first and most important design decision faced by the VSCADA team was to choose a unified protocol to be able to communicate with all other LFEV subsystems. There were various choices such as RS-485 and I2C, but the team decided on using the CAN (Controller Area Network) protocol this year. There were several reasons for choosing CAN, including the fact that CAN is a protocol designed specifically for usage in vehicles, and it is well-established since nowadays all vehicles are required to use CAN for in-vehicle communication. Another reason was that the motor controller purchased last year also supports CAN communication.

Having chosen a communication protocol, it was necessary to design and fabricate PCBs that would allow CAN communication between the VSCADA software and other hardware. Since CAN is a broadcast protocol (meaning all nodes on the network receive a CAN frame sent out), one board would need to be provided for each node and each baord would need to be assigned a CAN address. A CAN Communications Board (also known as JGB) was designed using an ATMEL ATmega 16M1 Automotive AVR microcontroller and CAN transceiver. The JGB is capable of A/D and D/A conversion, PWM, isolated relays, digital I/O and RS-232 communication.

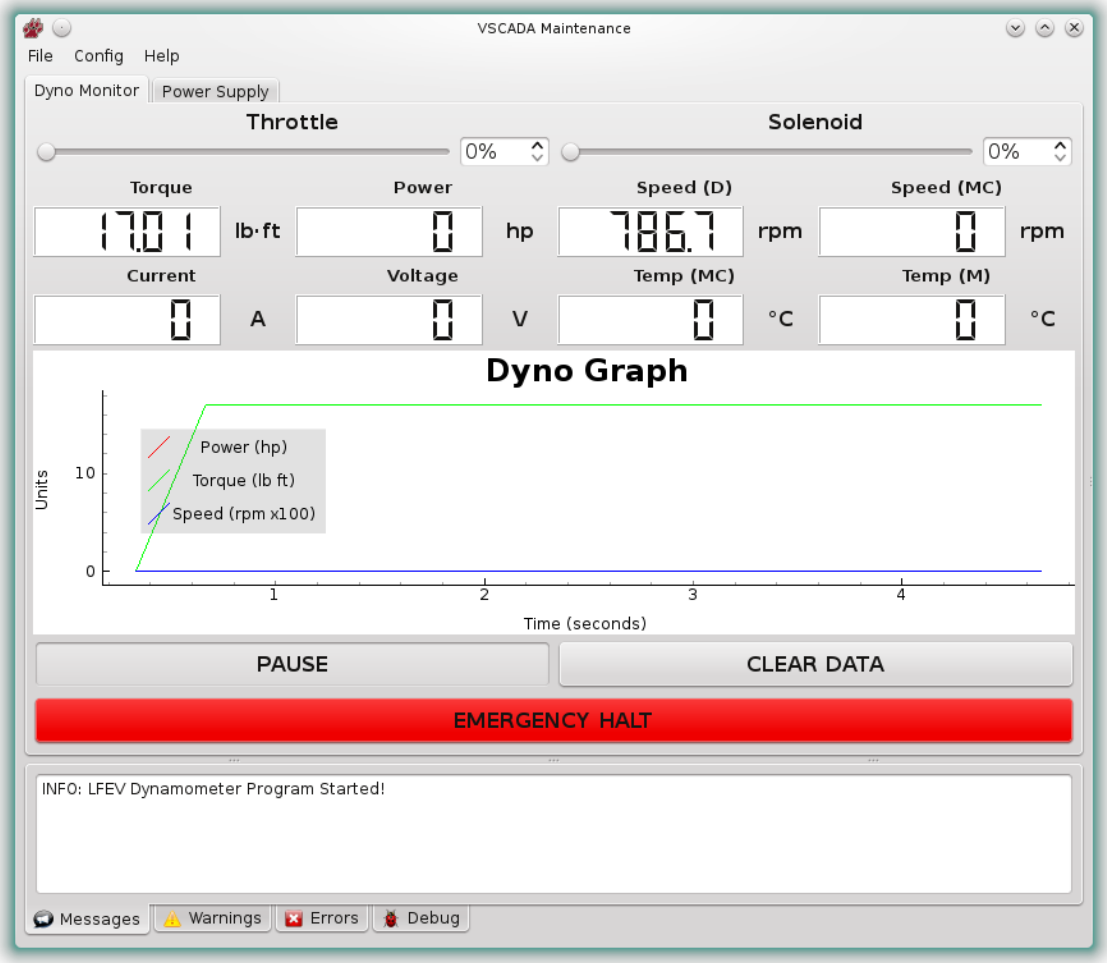
Although data from the dynamometer can be acquired from the provided Huff box over USB, the same task was undertaken using CAN since VSCADA needed to communicate with the rest of the subsystems (TSV and GLV) over CAN as well, and we desired a unified communication protocol. A frame format for the motor controller was decided on. Nevertheless, we utilized an open-source Python library called PyDAQFlex to acquire data from the Huff box. Python code was written to communicate with the Magna power supply as well.

Regarding the VSCADA software design, a Dyno data acquisition program API was designed to acquire data from the dynamometer and motor controller, control the throttle input, and produce plots of the data. The program is also capable of performing an emergency stop on the motor should it be deemed unsafe to continue operation, as well as exporting stored data to a portable CSV format. In addition to the Dyno, it is able to read current and voltage from the Magna power supply.

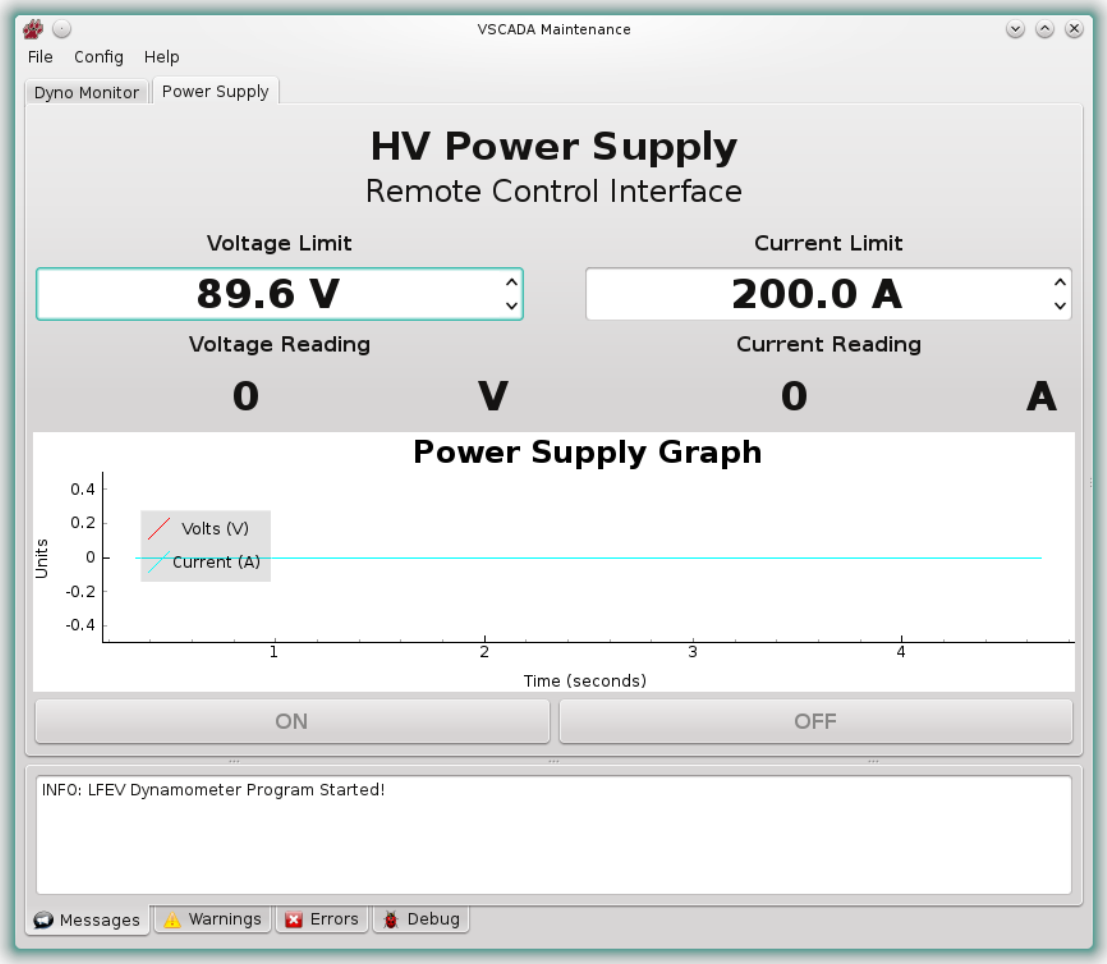
Please consult the Maintenance Manual (deliverable D003) for a complete software API as well as JGB schematic.

Final System Integration

The final delivered VSCADA system consists of the Dyno data acquisition program, which can be installed on a computer and connected to the computer in the Motor Controller System (MCS) Test Stand in AEC 401 over a remote desktop client (to remain in compliance with the LFEV Safety Plan). Below are screenshots of the Dyno and Power Supply tabs of the VSCADA application.



Dyno Monitor



Power Supply

Please consult the User's Manual (deliverable D002) for further information on how to use the VSCADA Maintenance App.

Errata and Future Work

Although VSCADA integration with the DYNO subsystem of the LFEV was achieved, much work needs to be done before the VSCADA system can be considered complete. Although integration with DYNO was achieved, it was done so through the Huff box rather than through the motor controller via CAN due to a buffer overflow bug in the CAN handler code. There needs to be a unified communication protocol for all subsystems, therefore it is imperative that this bug be fixed. Integration with GLV and TSV was not achieved (although VSCADA software was able to control GLV relays through CAN), which needs to be achieved in order for the VSCADA system to be considered complete.

There is much left to be desired on the software side. Calibration parameters and system shutdown rules are hardcoded and cannot be changed without software recompilation. A configuration manager maintenance app was developed to allow more dynamic control over all measurands and rules/alarms, but it was not integrated into the final system due to time constraints. Future teams would find it useful to extend the capabilities of this app and integrate with the JGB.

Please read the VSCADA Errata Memo for a complete list of issues that need to be addressed by future VSCADA teams.

Appendix: List of Deliverables

Item No.	Description	Link (if applicable)
D000	PDR Materials	http://sites.lafayette.edu/ece492-sp15/files/2015/02/2015-02-08-PDR-Presentation.pdf
D001	CDR Materials	http://sites.lafayette.edu/ece492-sp15/files/2015/02/Afternoon-Follow-Up.pdf
D002	Users Manual	
D003	Maintenance Manual and Final Report	
D004	Acceptance Test Plan	http://sites.lafayette.edu/ece492-sp15/files/2015/02/D004-AcceptanceTestPlanFinalDraft2.pdf
D005	Acceptance Test Report	http://sites.lafayette.edu/ece492-sp15/files/2015/02/D004-AcceptanceTestReport.pdf
D006	QA Audit Report	N/A (No QA testing performed)
D007	Project Web Site	http://sites.lafayette.edu/ece492-sp15
D008	LFEV-Y3-2015 Integrated System and Presentation	http://sites.lafayette.edu/ece492-sp15/files/2015/02/FDD.pdf
D009	Conference Paper, Presentation, and Video	N/A (Waived)
D010	Project Poster	http://sites.lafayette.edu/ece492-sp15/files/2015/02/Poster.pdf
D011	Calibration and Accuracy Analysis	N/A (See DYNO D003, D011 instead for information on DYNO calibration)
D012	Software Maintainability Plan	http://sites.lafayette.edu/ece492-sp15/files/2015/02/MaintainabilityPlan1.pdf
D013	Individual Research Report(s)	http://sites.lafayette.edu/ece492-sp15/independent-research/
D014	Project Management and Status Letters	http://sites.lafayette.edu/ece492-sp15/management/
D015	Interface Control Document	http://sites.lafayette.edu/ece492-sp15/files/2015/02/D015-Interface-Control-Document-Draft.pdf
D016	Reliability Report	
D017	Maintainability Report	http://sites.lafayette.edu/ece492-sp15/files/2015/02/MaintainabilityPlan1.pdf
D018	System Bill of Materials	http://sites.lafayette.edu/ece492-sp15/files/2015/02/VSCADA_BOM.pdf