POLICE CAR BATTERY LOAD MANAGEMENT

PROJECT PROPOSAL

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To Dr. Michael Schafer

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1 Introduction

Last year, the South Bend police department approached Notre Dame's electrical engineers with a problem concerning power consumption in their patrolling vehicles. The department was replacing car batteries at an unexpectedly high rate, and the members of the force and the garage crew could not agree on a specific cause. The problem became a senior design project, and four students completed a prototype system in the summer of 2007. The unit solved some of the initial design problems, but more design work is needed to reach a usable and marketable solution. In this proposal, we describe some revisions and improvements to the prototype that we will complete by May 2008 in order to bring the product design closer to a useable implementation.

2 Problem Description

2.1 Why are the batteries dying? Though last year's design team produced a hardware prototype capable of monitoring loads, collecting data, and shedding loads in a prioritized manner, they never answered the police department's primary question – why are the car batteries dying so quickly? Police officers have shared stories of batteries draining while the equipment is shut off and of car video systems continually fast forwarding through VHS tapes. The garage crew just blames the officers for needlessly leaving equipment power on. Answering this question is important for the satisfaction of our customer. It may also expose a lack or excess of features in our design.

2.2 The prototype is bulky. The type of vehicle that needs a power management system is probably packed with numerous after-market devices already. Space is a concern, and the current dimensions of the prototype should be reduced to a size that the customer can fit comfortably into his or her vehicle.

2.3 The user interface is unwieldy. It currently consists of a two-line LCD display and four buttons: menu, up, down, and set. There is more information to display at once than can be displayed in two lines. This results in overuse of the up and down buttons, which give no tactile satisfaction when pressed.

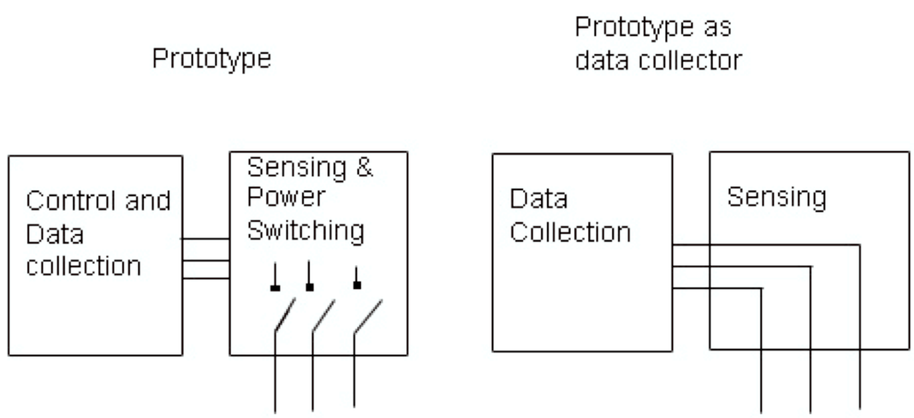
2.4 The serial port connection interface is not convenient. Serial ports are located on the back of computers and may require annoying detection routines when the device is plugged in. Many laptops have ditched the use of serial ports altogether. A more convenient connection interface should be used.

2.5 The power and control sections are on a single PC board in a single case. Power switching circuits and control circuits perform very different functions that require components of a different size and character. It is difficult to design a single board and case that is optimal for both. This also creates a problem when placing the unit in a vehicle. Do you put it near the battery for easy hookup to the power section? Or do you put it where the driver can easily access the controls? You can't have both.

2.6 The battery current sensor is not the best solution. The LEM current transducer connected to the battery line has a fixed hole size that makes it difficult to install when using large-diameter wire.

3 Proposed Solutions

3.1 Collect data with the prototype. Since last year's prototype is capable of both monitoring and recording current data, we could install this unit in a vehicle with its current switches set to "always on." This removes the automatic switching capability of the unit and avoids any problems that may arise from the present state of the control code and circuit. We can use it simply for data collection this semester as we start designing our revisions to the unit as a whole. The data will hopefully shed light on the primary question of the project and aid us in our design decisions. We will also save time and money while taking full advantage of the progress made last year.



3.2a Use surface mounted components. Though they are more difficult to solder, they are smaller and will thus allow for a smaller PCB. There won't be any IC sockets.

3.2b Reduce the size of the hardware mode switches. On the prototype, three-way switching is used to turn each of the 6 devices (GPS, camera, radio, siren, cpu/floods, and auxiliary) to on, off, or auto mode. The switches themselves, which also include a light source, are bulky and require many wires for use. The 'off mode' seems redundant and unneeded. The officer may turn any device off at the actual device. If he is not certain that the device is really turned off, he can switch to 'auto mode' and let the microcontroller switch it off as requested. We anticipate problems if the user forgets that he has switched a device to 'off mode' on the power management block and is trying to switch on his device locally without success. By eliminating the 'off mode,' we can use two-way switches to reduce the wiring needed and perhaps switch size as well. The "on mode" can be implemented more easily by shorting the switching FET.

3.2c Reduce the size of the user interface buttons. The Judco buttons on the prototype are large and unsuitable for a UI application. A set of membrane buttons would take up less space.

3.2d Separate the control and the power circuits. Separating the sections would allow for two small boxes rather than one large box. More placement options are available with this design. It facilitates using surface mounted components in the control circuit. It also decreases the length of large-diameter wire used by placing the power section near the battery.

3.3 Use membrane buttons and a better viewing screen. Membrane buttons are better suited for UI applications. They provide a familiar tactile response when browsing through menus and changing settings. A four-line LCD screen would better display the options available at the UI. If cost allows, we could even use a color cell-phone display.

3.4 Use a USB interface. USB provides plug-and-play functionality. USB inputs are often conveniently located on a computer and are more common than serial ports on a laptop. We will switch to a microcontroller that has built-in compatibility with USB as well.

3.5 Put the power and control sections on separate PCBs in separate cases. As mentioned in **3.2d**, this provides better placement choices in the vehicle. The power circuit can be close to the battery, while the control circuit and UI can be near the user. It will further simplify installation by reducing the need for large-diameter power wire. This also frees us to optimize the PCBs used for the components used in each circuit. We can use a thinner surface-mount PCB for the control circuit and a thicker power-application PCB for the power circuit. The prototype PCB layout reflects the design problems caused by having both circuits on one board as the 12V battery wire termination was placed in the middle of the PCB instead of the middle of the power section, which makes more sense.

3.6 Use a clamp on current sensor. Current transducers with hinged sections for clamping action are available. This simplifies installation for large-diameter wire.

4 Demonstrated Features

Our revision will include the features from the prototype along with the abovementioned improvements. We will demonstrate:

- Prioritized and automated load shedding as the battery loses power.
- An improved UI on the control hardware.
- The ability to set priorities for load shedding via the hardware UI or a software update
- The ability to disable permission to set priorities for load shedding via the hardware UI

- The ability to set loads to "on mode" or "auto mode" via hardware switches that override the software.
- The ability to record data.
- The ability to access the data and update software via a USB interface.
- The system's failure mode of "fail on."
- How we used the prototype to collect data when solving the project's primary question.

5 Available Technologies

As we build upon the prototype design, we will use many of the technologies deemed successful in the first iteration of the design. We will, however, be making some changes or modifications to implement the abovementioned improvements. We will use:

- Surface mounted components
- Two-way switches
- Membrane buttons
- 4-line LCD display or cell phone display
- USB compatible microcontroller
- USB interface
- Current transducers with hinged sections for clamping action

6 Engineering Content

Though our project differs from those that begin solely with an idea, our experience will more accurately reflect an engineer's experience in industry. We are improving an existing product, and we have a real customer in the South Bend police department. We will:

- Investigate the problem further in order to fulfill the requests of a real customer.
- Modify and design power and control circuits to implement proposed features.
- Design printed circuit boards.
- Program a microcontroller.
- Set up a USB interface.
- Design an elegant user interface.
- Select components that suit the product design.
- Acquire casing for the device and design the case layout.

7 Conclusions

The collaboration between Notre Dame and the South Bend police department excited the community, and the project was picked up by the local news media. This coverage exposed the project to a wider audience and the design team garnered interest from other public service departments and even a television camera crew. As the scope of the problem, and thus the number of potential customers, grows, motivation for continuing and advancing the project increases. In May 2008, this project should look like a second iteration of a product design; that is, it should do everything the first iteration does and more. We will be closer to our goal – a usable and marketable product.