Battery Monitoring for Electric Vehicle Battery Packs

Analysis of Senior Project Design

# Functional Requirements

1. The system must be capable of measuring the individual voltages of eighteen 12V batteries in series.
2. The system must be capable of measuring all batteries at least once per minute.
3. The system must be capable of measuring the voltage of the battery to within 2% of the true voltage (within 240mV).
4. The system must electrically isolate batteries from each other in order to prevent short circuits.
5. The system must never draw more than 1mA of current from the battery pack.

# Primary Constraints

The primary challenge with designing this system was choosing a mechanism by which to measure the voltage of a relatively high voltage (216V) battery pack using a low voltage (3.3V or 5V) system (microcontroller and peripherals). The two aspects of this challenge were designing a mechanism to measure the voltage of the battery pack, and designing a mechanism to power the system. There are existing SOCs designed to measure battery voltages, but few of them can withstand such high voltages, and the ones that do exist are prohibitively costly. Another option (the option that was used) is to use a voltage divider to produce a smaller, measureable voltage (0-5V). In this system, however, resistances must be chosen carefully to ensure that a minimal amount of power is drawn (and wasted) from the battery pack in the process of measuring, but also that the equivalent resistance of the voltage divider is much, much lower than that of the measuring circuit (so that the measurement circuit does not significantly affect the current flowing through the voltage divider. It is also possible to use a DC/DC converter to power the system from the main battery pack, but the availability of such devices is limited, and costs can be prohibitively high. Another solution (the solution that was used) is to power the system from its own battery, while connecting the grounds from the system and the battery pack in order to take accurate measurements. Other challenges included designing a mechanism to electronically isolate batteries from one another, as well as developing a system to select which battery is being tested at any given time.

# Economic

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Planned cost at project inception | $70.00 | | | |
| Final cost of completed system | $42.97 | | | |
| Bill of materials | See Table 1: Bill of Materials | | | |
| Additional equipment cost | **Item** | **Quantity** | **Unit Cost** | **Total Cost** |
| Solderless Breadboard | 3 | $16.59 | $49.77 |
| Power supply | 1 | $50.00 | $50.00 |
| Multimeter | 1 | $25.00 | $25.00 |
| Battery Pack | 1 | $1,500.00 | $1,500.00 |
| **Total** |  |  | **$1,624.77** |
| Planned development time at project inception | 10 Weeks | | | |
| Actual development time | 7 Weeks | | | |

Table : Bill of Materials

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Part Description | Reference Designator(s) | Distributor | Distributor Part Number | Quantity Required | Unit Price | Total Price |
| Atmega32u4 Breakout Board | X4 | adafruit | 296 | 1 | $19.90 | $19.90 |
| 249kΩ Resistor (CMF55249K00BEEB) | R19 | Digi-Key | CMF249KHBCT-ND | 1 | $0.93 | $0.93 |
| 4.7kΩ Resistor (MFP-25BRD52-4K7) | R20 | Digi-Key | 4.7KADCT-ND | 1 | $0.46 | $0.46 |
| Optocoupler (TLP222G(F)) | U1-U18 | Digi-Key | TLP222GF-ND | 18 | $1.013 (quantities of 10 or more) | $18.24 |
| Analog to Digital Converter (MCP3301-CI/P) | X6 | Digi-Key | MCP3301-CI/P-ND | 1 | $2.27 | $2.27 |
| 3:8 Decoder (SN74AHCT138N) | X1-X3 | Digi-Key | 296-4666-5-ND | 3 | $0.39 | $1.17 |
| Total |  |  |  |  |  | **$42.97** |

# Manufacturing

|  |  |
| --- | --- |
| Estimated units sold per year | 25,000 |
| Estimated manufacturing cost per unit | $40.00 |
| Estimated purchase price | $50.00 |
| Estimated profit per year | $250,000 |
| Estimated cost of operation per year | $10.00 |

# Environmental

Manufacturing of this system would have many of the same environmental factors as most other electronic systems. The use of integrated circuits and printed circuit boards means that some heavy metals and uncommon elements would be used. Like all electronics, improper disposal of this system could release toxins into ecosystems or the water tables. Also like other electronics, however, the majority of this system could be recycled and made into other electronics at a future time.

Use of the system would also have a minor negative effect on the environment, as the system uses a battery, which would need to be disposed of. This effect would be minor because the battery only needs to be replaced occasionally.

Use of the system could also have an indirect positive effect on the environment. This system could enable greater adoption of electric vehicles, as well as better management of those vehicles’ batteries. Greater adoption of electric vehicles reduces greenhouse gas emissions from vehicles, and would allow some of the energy used to power those vehicles to come from renewable resources. Furthermore, this system can help prolong the life of the batteries electric vehicles use, reducing how frequently they must be replaced. Because the batteries are by far the most toxic component in electric vehicles, reducing the frequency with which they must be replaced could have a very positive outcome on the environmental effects of the vehicles as a whole.