Project Title: **Battery Pod Control 2.0**
Team Name: **Pod People**

**Team Members:**

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**Project Abstract:**

This project is to redesign and improve the SubjuGator’s Battery Pod Control system. This new version of the system will have reduced power consumption by incorporating features such as solid state relays to replace the mechanical ones. Additionally, this system will allow for in-pod charging of the batteries. This will reduce the time it takes to ready battery pods by eliminating the need for pod disassembly and reassembly during charging. A current limiting system and a cell balancing system will be needed to accomplish this goal. Legacy features will include the hall-effect switch control of the relays and low voltage protection of the batteries. The low voltage protection system should also be redesigned to reduce power consumption.
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Introduction

The Battery Pod Control 2.0 project will provide an integrated battery control system. While there are IC’s that provide battery monitoring, this system will combine battery monitoring, charge balancing, and the means to control power distribution through relays. The incorporation of all these different features into one system is what makes this project unique.

Project Features

- **Low Power** – A PIC microprocessor that can go into a sleep or shutdown mode to conserve power will be used. This maintains consistency with the other embedded microcontrollers being used on the SubjuGator. Any other means within the design to conserve power will also be considered.

- **In-Pod Battery Charging** – The system must align the batteries for charging once the pod is disconnected. The ability to charge without disassembling the pods will save time on pod turnaround. Additionally, the batteries and the individual cells must remain balanced during charging.

- **Low Voltage Protection** – The system must be able to monitor the voltage on all batteries and interrupt power if a low voltage condition exists on a battery. This is necessary to prevent permanent damage of the LiPo batteries used.
• **Overcurrent Protection** – A current limiting system in the battery pod will be used to protect the batteries while charging.

• **Merge Board Interface** – The battery pod control system must be able to work with the SubjuGator merge board to provide stable power and alerts if a battery pod has shut down. Also, the systems must not interfere with each other.

• **Hall Effect Switch** – A hall effect switch will be used to allow an operator to use the solid state relays to disconnect the batteries using a magnet on the outside of the hull. This is a legacy system that needs improvement to minimize power consumption.

• **Voltage and Current** - The power rails and associated components and traces should be rated at 60A. The system should be able to take power from the 32V or 16V rail as needed to supply power to the electronics of the battery pod control system.

• **Size** - The system must be designed to the constraints of the battery pod. The PCB must be able to fit underneath the battery tray.

• **Fuses** – Fuses must be used in the battery pod to protect the batteries from damage from high current conditions.
Technology Selection

Microcontroller

The microcontroller being chosen is a PIC featuring XLP (Extreme Low Power). A PIC microcontroller will provide consistency with the other embedded technologies being used in SubjuGator 7.0. Additionally as seen in Figure 1, the PIC can provide a deep sleep mode in the nanoamp range that is superior to that provided by the MSP430. This will help meet the design goal of minimizing power consumption.

![Comparing Sleep Mode Currents MSP430 versus XLP](image)

Figure 1 - Comparison of Sleep Modes
System Power Supply

The competition pods will only have only a 16v or 32v power rail in them. This makes it necessary for the Battery Pod Control System to take power from either rail while maintaining the rails electrically isolated from each other.

Digital isolators will be used to provide the electrical isolation between the rails. The digital isolators consume less power and are more reliable than equivalent optocouplers. Figure 2 below shows a comparison of optocoupler and digital isolator power consumption.

![Figure 2 - Comparing Optoisolator with Digital Isolator]
Finally, Linear Technologies produces a FET IC that simulates an ideal diode. These ideal diodes are more efficient than a standard diode in that they waste less power. This is consistent with the design goal of lowering power consumed. Figure 3 below shows the comparison of the FET IC and a standard diode.

![Power Dissipation vs Load Current](Image)

*Figure 3 - Comparing Diode with FET-based Ideal Diode*
Relays

Solid state relays will be used to replace the mechanical ones currently in the SubjuGator. Solid state relays consume less power, operate faster, are more rugged, and are less susceptible to mechanical shock. These features make them a better choice for use in our system.

Flowcharts and Diagrams

Block Diagram

![System Block Diagram](image-url)
System Power

The system should be able to take power from either the 16V or 32V rail. This will ensure the system can operate in either the practice or competition configurations. The two power rails must remain electrically isolated from each other to ensure the 16V rail remains clean for the sub electronics.

The power will be reduced down to 3.3V or 5V, depending on microcontroller used, by a voltage regulator and then isolation will be provided by a digital isolator. Ideal diodes will provide an OR’ing of the power sources.

Battery Charging

The battery charging system needs to limit current while charging to prevent damage to the battery. Additionally, there needs to be a means to balance the cells while charging. The use of an IC or discrete components needs to be determined. Battery safety is paramount.

System Control

The heart of the system control will be a PIC microcontroller. This is to conform to the standard being used in the new generation Subjugator.

This system will control the solid state relays to remove load from the battery in case of an undervoltage condition or if a signal from the hall effect sensor line is received.

The undervoltage sensing circuitry needs to generate an undervoltage signal if a cell is discharged to 3.1V. Below 3.0V, possible damage could occur. When this signal is received, the solid state relays should open.

Lastly, the microcontroller should align the system for charging when required. The differences in configuration between charging and normal operation needs to be determined.
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Software Flowchart

Figure 5 - Software Flowchart
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Upon receipt of a reset, the system will initialize. This will include sending an open signal to the relays so they start at a known condition. The microcontroller will then go into sleep mode to conserve power.

An interrupt will cause the microcontroller to wake up and perform the required action. If the hall effect switch changes state, the microcontroller will open/shut the relays as required. If a low voltage condition occurs, the relays will open and the hall effect switch will not be allowed to shut the relays. Finally, if a signal is received to align the battery charge system, the necessary alignments will be done and the relays will be shut.

The use of alarms and indicators is yet to be determined.

Division of Labor

Below is a breakdown of the division of labor:

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<tr>
<th></th>
<th>Brian Long</th>
<th>Bryce Unger</th>
</tr>
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<td>Preliminary Research</td>
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<td>Design</td>
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<tr>
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<tr>
<td>Prototyping/Testing</td>
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<tr>
<td>Construction</td>
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<tr>
<td>Final Testing and Integration</td>
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Figure 6 - Division of Labor
Gantt Chart

Below is the Gantt Chart:

![Gantt Chart]

**Figure 7 - Gantt Chart**

Bibliography

