Load Switch Circuit Module

The load switch circuit has seen significant improvements over the previous version. Version 2.0 retains the core design of back-to-back N-channel MOSFETs forming an AC switch but replaces the single-channel configuration and rotary switch for load selection [old schematic figure] with eight parallel switching channels [new schematic figure]. This upgrade allows for a much wider range of load resistances, as each channel can be independently controlled [resistance range figure]. The previous design faced reliability issues due to the rotary switch, a problem now eliminated with the solid-state implementation. Additionally, the new load switch integrates a microcontroller that reads an onboard Hall effect current sensor, providing over-current protection. The board maintains full compatibility with the previous version, supporting a single pulse-width modulation (PWM) input while also allowing up to eight PWM inputs for independent channel control. Each of the switching channels features galvanically isolated gate drivers with a working isolation voltage of 3.75 kVrms. The board logic side is powered by 5 VDC and the gate drivers are powered by an isolated 15-20 VDC supply. The onboard microcontroller provides either a simple GPIO interface, or UART.

Power Supply Module

The power supply module (PSM) has two primary functions: generating voltage rails and charging the battery. It utilizes two buck-boost converters to produce 5 VDC and 15 VDC power rails, with the 15 VDC rail isolated via a flyback converter. Texas Instruments TPS552872 buck-boost converters were selected for their wide input voltage range, enabling compatibility with various battery configurations. These converters also feature built-in protections, including output overvoltage protection, output short-circuit protection, and thermal shutdown. Designed to support 1–3 cell lithium-ion batteries, the PSM integrates a switch-mode battery charger from Monolithic Power Systems, offering configurable charge current and end-voltage settings. An onboard STM32U5 microcontroller negotiates power from any USB-C Power Delivery-compatible supply for charging. [schematic figure]

Battery Management System Module

Haven't figured this part out yet, not sure if it should be included.

Microcontroller Unit

The microcontroller unit is built around an STM32U5, handling user input, display control, load switching, and USB communication. Menu navigation is achieved using three rotary encoders, allowing precise control of settings displayed on a 3.5-inch capacitive touch screen. The display operates over an SPI interface, while touch inputs are processed separately via an I2C bus to ensure smooth and responsive interaction.

To control the load switch, the microcontroller generates PWM signals with adjustable frequency and duty cycle. Additionally, USB functionality supports firmware updates, allowing end-users to upgrade the system without requiring specialized programming tools. This ensures long-term maintainability and easy deployment of software improvements or feature enhancements. [controller figure]

Comments/Questions

- How in-depth should I be going on the design process?
  - I could expand a ton on part selection, design tools, software, etc
- Keep power supply and microcontroller unit split up?
  - The initial design had separate boards, but now I've combined the functionally
- Talk about BMS?
  - This is going to be a store-bought item so idk if it needs it's own section

Next Steps

- Finish up 'module' sections
  - Need schematics/other figures
- Add Version 1.0 sections
- Get into lab next week to do functional testing and collect data
- Order controller parts by next week or it won't get done