The LiPo Crew
Dataforth Battery Charger

Requirements & Specifications

October 19, 2020

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Requirements

1. Abide by IEC safety standards, efficiency rating of 90-95% charger/monitor for a multi-cell LiPo battery

   A safe circuit design is paramount in the development of our battery charger. With safety in mind, LiPo batteries are inherently hazardous and require precise measurements to verify proper working conditions. This notion constitutes our team's implementation of industry leading safety standards along with additional safeguards to further ensure user safety and reliability of our product.

   1.1. State of charge monitoring
      1.1.1. Presets must be predetermined for the LiPo battery being charged, this will automatically set the voltage and current inputs to the LiPo battery charger to reduce overall user input error
      1.1.2. Must display to LCD
   1.2. PCB thermals and components must not exceed 85°C, battery cells thermals must not exceed 70°C while discharging, and 45°C while charging
   1.3. Display thermals of individual cells and the overall average of the six cells to LCD.
      1.3.1. Requires sufficient active cooling for MOSFETs in the form of an individual 40mm fan
   1.4. Cell balancing
      1.4.1. Ensures all battery cells are equally charged and balanced during charging
         1.4.1.1. This includes voltage and current charge balancing so that no individual cell exceeds 100mV difference with respect to other cells
   1.5. User settable alarms limits via physical buttons and/or bluetooth for fault conditions detection for defective cells within the battery pack
      1.5.1. User ability to set fault conditions
         1.5.1.1. Fault conditions: Battery over or under charging(±100mV), battery reached one hundred percent charge capacity, faulty battery connection, wrong user input for battery type, battery over or under current(±50mA), faulty cells(disconnected cells, chemically unstable cells, abnormal temperature variance of cells)
      1.5.2. Fault detection alarms

1.5.2.1. Voltage fault detection: If one cell is receiving more voltage than another cell, detected at ±100mV

1.5.2.2. Current fault detection: If one cell is receiving more current than another cell, detected at ±50mA

1.5.2.3. Faulty battery connection or individual cell connection

1.5.2.3.1. Misconnection between battery and battery charger

1.5.2.3.2. Misconnection between battery cells

1.5.2.4. Wrong user input for battery charging: If user selects the wrong battery type for battery charging through a verification process to determine if the correct battery type is chosen

2. Efficient/ Robust PCB layout and analog circuit design

Battery chargers are becoming more technologically advanced with very robust and aesthetic designs. As a more competitive market for battery chargers grows, it would be crucial to design a charger that can compete with top and mid level battery charging designs.

2.1. Compact design

2.1.1. Ensure at least .01” between traces along to reduce the potential for cross talk between different traces

2.2. Power and ground planes will be kept within the PCB, to be centered and symmetrical

2.3. Design will be encapsulated in a fully plastic shell that will be 3D printed in order to pull our entire design together in a singular, functional battery charger. This will include 3-6 buttons for navigation, 1-2 LCD screen(s) for display and status, a generic plug for battery charging, an input for the 115V AC power supply, and 1 sound emitter(buzzer) to indicate fault detection

2.4. To maximize productivity the battery charger will need to incorporate a preset in terms of voltage and current as well as an overall “time of charge” in present time to allow users to effectively charge a LiPo battery with minimal wasted effort

2.4.1. This charger will also incorporate a function to shut the battery off once each cell(s) have completely charged at a voltage of 4.2V (fully charged) or 2.7V (fully discharged)

2.5. Analog circuit design

2.5.1. Keep power ground and control ground separated to minimize interference

2.5.2. Parallel traces will be avoided to ensure signal integrity

2.5.3. If necessary, crossing of traces will be executed at a ninety degree angle to prevent signal integrity issues

2.5.4. The use of thermally conductive planes for increased heat dissipation

2.5.5. Design validation which will verify tolerances, compatibility, signal integrity, etc

3. Utilize parts from Dataforth raw inventory for dataforth

Since Dataforth is sponsoring this project, they would like the final product to showcase a number of components and parts found in their own inventory. This allows for the presentation of our project to better reflect on Dataforth at the automotive expo where they will be promoting their company.

3.1. Must use BMS chips from Dataforth inventory

3.2. Must use any/all parts that are attainable through Dataforth inventory for the working prototype

4. Simple controls and display for the user input

Simplicity means that the user will have an easy and enjoyable experience with our product. The simpler the design the less the user needs to worry about damaging the product and wasting their time and money.

4.1. Display will provide exact data in real time

4.1.1. Display will show the battery charging bar and percentage during the charging process and while connected.

4.2. Limit number of physical buttons to 3-6 buttons for simple controls

4.2.1. Power button to turn the system on and off

4.2.2. Confirmation button to select and confirm options displayed on the screen

4.2.3. 1-2 buttons to control scrolling options through the user interface

4.2.4. Include an options and/or menu button for easier usability

4.3. All buttons and displayed values will be labeled for the user in form of an inscribed label

4.3.1. Any labels that are not included on the charger will be included in the user manual

5. User manual required to ensure proper operation of battery charger

LiPo battery chargers can be extremely difficult to use especially for first time users. Therefore, a user manual must be provided in order to ensure correct user-ability to avoid errors that could potentially be harmful to the user, the battery, or the battery charger.

5.1. User manual will include visual diagrams on proper battery connection as well as the location of features such as buttons, the LCD display, bluetooth activation, fault detection alarms, and all the ports
5.2. Charger safety features as well as proper handling of the product
5.3. Specification of the charger: including dimensions of the product, C and S rating for each battery type, amount of charging types, specifications for each battery type that can be charged, their preset conditions, and the type of input and output plugs
5.4. Estimated charge times for compatible battery types
5.5. Will instruct the user on how to switch between different battery types
5.6. Will instruct the user how to set/disable fault conditions
5.7. Warning and error messages on LCD
5.8. Operating environment
5.9. Proper disposal of the product in case of any (unfixable or permanent) damage or the need to dispose of the product
5.10. A list of hazardous information regarding the chemical makeup of compatible battery packs

6. Must include basic BMS functions to be integrated into the system

Battery Management Systems tolerate a maximum margin of error of ±1-2% further guaranteeing a safe battery charging system. The BMS allows for regulation of the current and voltage in order to control the constant current and constant voltage stages for maximum life expectancy of the battery.

6.1. Features must include but are not limited to data acquisition, state of charge (SOC), state of health (SOH), charge control, cell equalization and thermal management

7. 115V AC power source

Our battery charger will utilize the power provided by the grid infrastructure that is already in place. In order for this to work the charger must be able to plug in to the outlets that are commonly found in buildings and homes.

7.1. Use of a three-pronged connector to ensure the power is grounded

8. Full documentation

    Full documentation of items pertaining to the manufacturing process, full design layouts, finances and receipts, as well as all drafts. These documents are useful for problem solving, debugging, and manufacturability.

    8.1. Fully integrated drafts and final design
    8.2. Design architecture
    8.3. Software coding and design
    8.4. PCB design and layout
    8.5. Hardware components utilized
    8.6. Financial documentation/receipts
    8.7. User manual/guide

Constraints

1. Use of a MSP430 microcontroller for charging algorithms
    1.1. Program the MSP430 to control the charging of the LiPo battery cells

2. Present final product at Automotive Testing Expo in Novi, Michigan on October 26, 27, 28, 2021
    2.1 Showcase style display suitable for large format video screen in a trade show booth