PROPOSAL

FOR

PROGRAMMABLE PULSE CHARGER

TK BATTERY TECHNOLOGY

BY

PH ENGINEERING

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1 INTRODUCTION

TK Battery Technology (TBT) is developing advanced charging technology for lithium batteries, and needs flexible tools to test and verify its charging algorithm, which charges the batteries in pulses. Currently there are no commercially available off-the-shelf equipment that satisfies TBT's unique requirements, therefore a custom designed charger is needed.

PH Engineering (PH) specializes in custom hardware and software design for over 25 years, with in-depth technical expertise and extensive industrial experience. TBT contacted PH for a custom design of the special charger.

2 OVERVIEW

TBT needs to experiment with various charging parameters to identify the optimal pulse charging algorithm for certain lithium batteries. This laboratory charger needs to be designed with flexibility in mind, with the parameters programmable from a host laptop computer, so TBT can easily adjust the parameters, conduct the test, analyze the result, modify the parameters, test again repeatedly, to find the optimal set of parameters.

The application is limited to lithium batteries. So the charger needs to charge batteries from 3.5 to 4.2 V, with charging current up to 10 A. TBT also likes to conduct tests on multiple batteries simultaneously. Each test needs to be individually remote programmable, and can be started and terminated independently. In addition, TBT needs to discharge the batteries after fully discharging them, to measure their capacity.

3 PROPOSED APPROACH

The proposed approach consists of the following tasks:

1. Discovery
    - Define requirements
    - Detailed specifications
    - Research
2. Hardware Design
    - Components selection
    - Circuits design
    - Tolerance analysis
    - Thermal analysis
    - Schematics
3. Firmware Design

- Framework architecture
- Microprocessor selection
- Hardware drivers
- Device drivers
- Interrupt routines
- Command parsing and execution
- Charging algorithm

4. Hardware Construction
    - Bill of materials
    - Parts sourcing
    - PCB layout
    - PCB fabrication
    - PCB assembly
5. Firmware Implementation
    - Development environment setup
    - Code writing
    - Programming
6. Testing
    - Test environment set up
    - Tools set up
    - Functional verification
    - Specification validation
7. Project communication
    - Progress update
    - User manual

4 TECHNICAL DETAILS

The specifications described below are based on initial discussions between TBT and PH and are subject to further modification. They nevertheless define the basic depth and scope of the design work.

4.1 Electrical

- Input voltage: DC 12 V to 30V
- Input current: 5A each @12V supply; 2.5A @24V supply
- Output voltage: up to 4.3 V DC to charge lithium batteries
- Output current: up to 10 A each channel
- Discharge current: up to 10A each channel
- Operating ambient temperature: 0 to 30 ºC.

4.2 Physical

- Estimated board size: 5 x 8 x 2 inch for each channel
- Each charger channel occupies its own individual circuit board
- Each circuit board has 4 mounting holes at the corners

4.3 External Connections

- Input power: 2 wires
- Output to battery: 5 wires; 2 charging, 2 monitor, 1 temperature sensor
- Communication: 2 wires, shielded
- Test points will be provided

4.4 Pulse Charging Algorithm

- The charging algorithm uses proprietary pulse sequence. The exact details will be provided by TBT.
- Each pulse train consists of up to 8 pulses, followed by 1 or 2 optional negative (discharge) pulse.
- The charging terminates when any of the following occurs:
  - The battery voltage reaches desired level
  - The charging current falls below a preset level
  - The battery temperature reaches safety value
  - A preset maximum time has elapsed

4.5 Programmable Parameters

The charging algorithm parameters can be controlled by user via external communication links. The controllable parameters include:

- Pulse time width in and pulse current amplitude
- Rest time width between pulses
- Number of such pulses
- Reverse pulse amplitude and width, if any
- Rest time between pulse trains
- Termination conditions

The above parameters can be altered on the fly during the charging process. User can thus adjust the charging algorithm based on the status of the charging process. The circuit board firmware only acts according to user command, and doesn't have any built-in intelligence of what the algorithm is or how it'll be adjusted.

In addition, user can send commands to each board:

- Start / Stop
- Assign ID address
- Identification
- Report charging status
- Report errors

4.6 User Interface

User can specify parameters and observe the charging process in the following manner:

- The charger can communicate with a host laptop computer via external serial link. The exact hardware interface has not been decided, but likely will be in one of the following format: RS-232, I^2C, or USB.
- The circuits will have on-board LED indicators for charging status and error conditions
- The circuit board will have test points for testing and diagnosis purposes.
- No data will be stored onboard since real-time data is transmitted to user.

4.7 Fault Protections:

The charger will be protected against the following: fault conditions

- Output short circuit
- Reversed output connection
- Reversed input connection
- High temperature at battery
- High temperature in internal circuits

5 DELIVERABLE

Total 3 charger boards will be delivered to TBT. The design allows up to 8 boards to be controlled by computer.

When the first board is completed, PH will send it for TBT evaluation. Upon approval by TBT, PH will finish and deliver the remaining boards.

PH will also write a user manual to describe features of the charger, operating procedures, and safety precautions.

TBT will be responsible to develop the user interface and control program that runs on the computer. TBT will also loan PH batteries needed, or a battery simulator, for testing the charger.

6 SCHEDULE AND BUDGET

The project is estimated to take 3 months to complete. The total cost to TBT is $35,000. PH requests payments as following:

- $10,000 to start work
- $15,000 upon delivery of the first circuit board
- The remaining due upon completion of all work

PH will keep TBT informed of the work progress through emails and phone calls on regularly basis. PH will provide TBT a user manual to outline the command protocol and other technical details.