LPRDS-CMS-2011

User Manual

Lafayette Photovoltaic Research and Development System
Cell Management System
ECE492 – Spring 2011
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I. Introduction

Cell Management System (CMS)

The main function of the CMS is to balance and monitor the state of charge of a pack of four Lithium Iron Phosphate Cells. The CMS can be used in automatic mode, and can also be easily monitored and controlled via I²C communication. Each pack of cells contains a single Printed Circuit Board (PCB), which is referred to as the OBPP (One Board Per Pack). The OBPP acts as the brain of the CMS, as well as a visual indicator of the state of the CMS.

Under automatic conditions, a pack of 4 cells can be charged or discharged by the user and the CMS will automatically balance the cells’ state of charge over several cycles, thus improving the lifetime of the cells, and improving the pack performance. The user can visually monitor charge and discharge cycles by observing the LED indicators on the OBPP. For more information about these indicators, see Operating Instructions Section.

In addition to automatic mode, the user can also control and monitor the CMS from a PC terminal. A range of commands allows the user to set cell bypass conditions, change parameters, or read cell voltages, current, or temperature. For more about this command set, see the Operating Instructions Section.
II. Getting Started

A. System Components

1. Batteries - The Cell Management System includes 4 Li-Ion batteries. Specifically, the batteries are Lithium Iron Phosphate (LiFePO4) cells.

   Capacity: 3.2V, C = 10Ah
   Size: 82x27x108 mm (L x W x H).

2. One Board Per Pack (OBPP) - The OBPP is the board responsible for managing and monitoring each cell in a pack of four cells. This board must be mounted in the appropriate orientation onto a pack of four cells. See the Installation Section for instructions.

3. Screws and Spacers - Provided with the CMS are:

   Spacers: Four (4) Aluminum, four (4) copper
   Screws: 8 (5/8" 10-32)
   Lock Washers: 8 (10-32)

4. Cables - Provided with the CMS are:

   Power Cable: 1 to connect to another pack in series
   I²C Cable: 1 for connection to I²C bus

5. PC to I2C Converter: The converter provided with the CMS is necessary for the use of the I2C features. This device is used to convert either RS-232 or USB to I2C.

6. RealTerm: This is free software that is useful for sending basic hex/ascii/binary commands via a PC's USB or RS-232 COM ports. This software is used for sending basic I2C commands.
B. Extras You May Need

1. **Constant Current Power Supply**- For cell charging, it is recommended to use a constant current source. The current source should be limited to no more than 2C (20A). It is recommended to use a constant 10A source, which will charge an empty pack in about 1 hour.

3. **Relay**- It may be convenient to use a relay when charging a pack. A common emitter output on the OBPP provides a logic high output when a pack becomes fully charged, and a logic low when the pack is fully discharged. Connecting a power supply or load to the pack through a relay controlled by this output will prevent the pack from being over charged or over discharged. In the event that a relay is not available, the user can view and LED indicator on the OBPP that will signify when charging or discharging is complete.

4. **Safety Glasses**- Please be cautious when working with high voltage electronics. Particularly when connecting several packs in series, or installing the OBPP, it is important to wear safety glasses.

5. **PicKit Serial Programmer**- The PicKit is a device that is used for In Circuit Serial Programming (ICSP) of PIC u-controllers. This device may be needed if the CMS firmware requires recompiling or software updates.

C. Warnings

1. **DO NOT** short the terminals of any cells. This could result in serious injury or cause the permanent damage to the CMS and/or cells.

2. **DO NOT** touch heat sinks while board is in operation. They, or other components on the board may become extremely hot!
III. Installation

A. Installing the OBPP

1. Screw spacers onto the terminals of four cells. Match Copper spacers with Copper terminals, and Aluminum spacers with Aluminum terminals.

2. Place the OBPP on top of a pack of four cells, as shown below, lining the holes with the top of the spacers.

3. Once aligned, secure the OBPP with the provided screws, being careful not to short any of the cells with a screw or screwdriver.
IV. Operating Instructions

A. Charging

1. If it is the first time using the CMS, or after a system crash, reset the CMS by jumping the reset pins on the OBPP, as shown in *figure 2*.

2. If a relay is unavailable, skip to step 7.

3. If a relay is available, attach the positive terminal of the relay switch to the “Done” pin on the OBPP and the negative terminal of the relay switch to the “GND” pin on the OBPP. Use a 10KOhm Resistor to pull up the “Done” Signal to $V_{DD}$.

4. Attach the positive terminal of the power supply to the positive terminal of the relay.

5. Attach the negative terminal of the power supply to the negative terminal of the pack.

6. Attach the negative terminal of the relay to the positive terminal of the pack. The above configuration will cause the relay to open when the cell becomes fully charged. This will prevent the cells from being over charged.
7. For a setup without a relay, connect the positive terminal of the power supply to the positive terminal of the pack, and the negative terminal of the power supply to the negative terminal of the pack as shown in figure 3.

8. After checking to make sure the relay is closed (on), turn on the power supply so that it is current limited within a range of 5-20A. Once on, the pack will begin to charge. The green LED labeled “CHRG” should blink, as well as the yellow LED labeled “ON.” If this is not the case, perform a system reset, or refer to the maintenance manual for instructions to reprogram the CMS.

*Note: **DO NOT** turn a power supply on before attaching to a pack.
B. Discharging

1. If it is the first time using the CMS, or after a system crash, reset the CMS by jumping the reset pins on the OBPP, as shown in figure 2.

2. If a relay is unavailable, skip to step 7.

3. If a relay is available, attach the positive terminal of the relay switch to the “Done” pin on the OBPP and the negative terminal of the relay switch to the “GND” pin on the OBPP. Use a 10KOhm Resistor to pull up the “Done” Signal to $V_{DD}$.

4. Attach the positive terminal of the load* to the positive terminal of the pack.

5. Attach the negative terminal of the load to the positive terminal of the relay.

6. Attach the negative terminal of the relay to the negative terminal of the pack. The above configuration will cause the relay to open when the cell becomes fully discharged. This will prevent the cells from being over discharged.

7. For a setup without a relay, connect the positive terminal of the load to the positive terminal of the pack, and the negative terminal of the load to the negative terminal of the pack as show in figure 3.

8. Check to make sure the relay is closed (on), once on, the pack will begin to discharge.

* DO NOT use a load that requires more than 20A. Doing so could cause the fuse to give out, or in certain situations cause permanent damage to the CMS.
C. I2C Operation

1. If it is the first time using the CMS, or after a system crash, reset the CMS by jumping the reset pins on the OBPP, as shown below.

2. Open RealTerm I2C. If RealTerm I2C is not installed on your PC, go to:
   http://realterm.sourceforge.net/index.html#downloads_Download
   To download, as well as for RealTerm help.

3. Using either an RS-232 or USB cable, connect the PC to I2C converter to the PC running RealTerm I2C.

4. Connect the provided I2C communication cable between the PC to I2C converter and the OBPP. Be sure to orient the cables as shown below.

5. In RealTerm, under the ‘Port’ tab:
   a. Select ‘Baud’ of 57600
   b. Select ‘Port’ 3, the Port number for the USB port
   c. Set ‘Parity’ to ‘None’
   d. Set ‘Data Bits’ to ‘8’
   e. Set ‘Stop Bits’ to ‘1 bit’
   f. Set ‘Hardware Flow Control’ to ‘RTS/CTS’
   g. Set ‘Software Flow Control’ to ‘Xon Char: 17’ and ‘Xoff Char: 19’. Do not check ‘Receive’ or ‘Transmit’
   h. Click ‘Change’ Button to save settings

6. In RealTerm, under the ‘I2C’ tab:
   a. Set ‘Bus Num’ to ‘1’
   b. Set ‘Address’ to 0x54, which is the default address of an OBPP, or else set to the known address of the board.
   c. Set ‘SubAddr=’ to 0
7. Sending Commands

Read Command Format:

<table>
<thead>
<tr>
<th>Board Address</th>
<th>Command Number</th>
<th>Data Byte High</th>
<th>Data Byte Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default 0x54</td>
<td>(0x00-0x1B)</td>
<td>0xF0</td>
<td>0x00</td>
</tr>
</tbody>
</table>

Write Command Format:

<table>
<thead>
<tr>
<th>Board Address</th>
<th>Command Number</th>
<th>Data Byte High</th>
<th>Data Byte Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default 0x54</td>
<td>(0x00-0x1B)</td>
<td>0x0X</td>
<td>0xXX</td>
</tr>
</tbody>
</table>

8. Pay careful attention to the boundary conditions for command sets. Failure to send correct commands could result in failure of the system.
E. Troubleshooting

1. Common Failures

<table>
<thead>
<tr>
<th>Component</th>
<th>Error</th>
<th>Possible Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batteries</td>
<td>Cell appears to have capacity of less than 10 A-h</td>
<td>Replace Cell</td>
</tr>
<tr>
<td>Any LED</td>
<td>LED never turns on</td>
<td>Replace Green LED</td>
</tr>
<tr>
<td>Any LED</td>
<td>LED acts in an unexpected manner</td>
<td>Reset OBPP</td>
</tr>
<tr>
<td>I2C</td>
<td>I2C Read Returns 0xFFFF or other unexpected value</td>
<td>Reset OBPP</td>
</tr>
<tr>
<td>I2C</td>
<td>I2C Write does not change parameters as expected</td>
<td>Reset OBPP</td>
</tr>
<tr>
<td>Current Sensor</td>
<td>I2C returns invalid data for Current reading</td>
<td>See Maintenance Manual for Instructions to replace Current Sensor</td>
</tr>
<tr>
<td>Temperature Sensor</td>
<td>I2C returns invalid data for Temperature reading</td>
<td>See Maintenance Manual for Instructions to replace Temperature Sensor</td>
</tr>
<tr>
<td>Fuse</td>
<td>CMS unable to be charged/ discharged - I2C not responding as expected</td>
<td>Replace Fuse Reset OBPP</td>
</tr>
</tbody>
</table>

2. Replacing a Fuse

If you find the pack is unable to take a charge or a discharge, or if certain components are not responding properly, the problem may be a blown fuse. A blown fuse will look like the one shown in the figure __. If your fuse looks similar to this, follow the instructions below to replace the fuse.

   a. Remove the broken fuse.
   b. Using the part described below, install the new Fuse. There is no directionality to the part, so orientation does not matter.

| 25 Amp Automotive Blade Fuse | F1018-ND | Blade Fuse | Digikey |

3. Resetting Board

If you find any issues with I2C communication, or if the CMS appears to be stuck in a state, a possible solution is to reset the firmware. This can be done by simply putting a jumper across the reset pins, as shown in **figure 2**.
VII. Appendix

A. Board Components

a. The meaning of the LED’s on the OBPP

The LED’s on the OBPP are visual signals which inform the users and the maintainers about the current status of the CMS. The following figure depicts what LED’s mean:

- Solid – Charged
- Blink – Charging
- Solid – Discharged
- Blink – Discharging
- Solid – Slave
- Blink – Stand-alone
- Solid – Bypassing

Figure 4 - OBPP LEDs
b. Pinouts of all connectors

There are two (2) connectors on the OBPP, which are:
- Anderson connector
- Data connector
Pinout for Anderson Connector (3-pin connector)

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Power (+12V)</td>
</tr>
<tr>
<td>2</td>
<td>No Connection</td>
</tr>
<tr>
<td>3</td>
<td>Ground</td>
</tr>
</tbody>
</table>

Pinout for Data Connector (2x5 connector)

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>External Power (+5V)</td>
</tr>
<tr>
<td>2</td>
<td>External SDA (data for $I^{2}C$)</td>
</tr>
<tr>
<td>3</td>
<td>External SCL (clock for $I^{2}C$)</td>
</tr>
<tr>
<td>4</td>
<td>No Connection</td>
</tr>
<tr>
<td>5</td>
<td>No Connection</td>
</tr>
<tr>
<td>6</td>
<td>External RTSS (Redundant Temperature Sensing System)</td>
</tr>
<tr>
<td>7</td>
<td>External Done</td>
</tr>
<tr>
<td>8</td>
<td>Ground</td>
</tr>
<tr>
<td>9</td>
<td>No Connection</td>
</tr>
<tr>
<td>10</td>
<td>No Connection</td>
</tr>
</tbody>
</table>