I2C TEST

LPRDS-CMS-2011 QA AUDIT TECHNICAL MEMO

TEST: I2C TEST
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WITNESS: PROFESSOR NADOVICH
DATE: 5/5/2011

TEST DESCRIPTION

This test will exhaust every command in the I2C API and verify that each and every command works as specified.

PRE CONDITIONS

- OBPP board must be connected to a 4-cell LiFePO4 pack
- Connect a current meter in series with the OBPP and the MPJA9604PS
- Connect Simulink probes across each cell in order to measure voltage
- USB to I2C interface must be connected to a PC and the OBPP board
- RealTerm must be open and configured to use the USB connection

TEST Using Board: 01, Firmware Version 1.3

I2C Command Format

| 0h54 | Memory Address (8 bits) | Argument (16 bits) |

- Enter the following command to read data from the Board Number register
  - 0x541BF000

- You should receive back a 16-bit response in RealTerm which is the board number

  Board Number: 0001 = 0x0001
• Enter the following command to read data from the Version Number register
  o 0x541AF000

• You should receive back an 16-bit response in RealTerm which is the version number
  Version Number: **0010** = 0x0010

• Enter the following command to read the I²C address from the board. The address will
  be an 16-bit hexadecimal value
  o 0x5410F000
  **I²C Address: 0541** = 0x0054

• Enter the following command to change the I²C address from the board to 0x24. The
  address should be an 8-bit hexadecimal value
  o 0x54100024

• Enter the following command to read the I²C address from the board. The address will
  be an 16-bit hexadecimal value
  o 0x2410F000
  **I²C Address: 0241** = 0x0024

• Enter the following command to change the I²C address from the board to 0x54. The
  address should be an 8-bit hexadecimal value
  o 0x24100054

• Enter the following command to read the System Mode. A 16-bit value will be returned:
  0x0000 is auto mode and 16x00FF is non-auto mode.
  o 0x5412F000
  **System Mode: 0000** = 0x0000
- Enter the following command to read the current sensor
  - 0x5400F000
  - **Hexadecimal Value:**

  Current Reading: \( 0.06 \) = Actual Current Reading: \( 1 \text{ A} \) (+/- 5%)

\[
\left( \frac{849}{EB4} \cdot 50 \right) - 25 = 0.06 \text{ A}
\]

- Enter the following four commands to read the voltages of each of the four cells
  - 0x5401F000
  - **Hexadecimal Value:** \( 0\text{ABE} \)

  Voltage Reading 1: \( 3.339 \) = Actual Voltage Reading 1: \( 3.340 \) (+/- 5%)

  - 0x5402F000
  - **Hexadecimal Value:** \( 0\text{AD6} \)

  Voltage Reading 2: \( 3.369 \) = Actual Voltage Reading 2: \( 3.364 \) (+/- 5%)

  - 0x5403F000
  - **Hexadecimal Value:** \( 0\text{AB5} \)

  Voltage Reading 3: \( 3.378 \) = Actual Voltage Reading 3: \( 3.314 \) (+/- 5%)

  - 0x5404F000
  - **Hexadecimal Value:** \( 0\text{AD4} \)

  Voltage Reading 4: \( 3.367 \) = Actual Voltage Reading 4: \( 3.364 \) (+/- 5%)
• Enter the following four commands to read the temperatures of each of the four sensors
  
  o 0x5405F000
  
  o Hexadecimal Value: \( 0752 \)
  
  Temperature Reading 1: \( 25.1 \degree C \) = Actual Temperature Reading 1: \( 25.55 \degree C \) (+/- 4\degree C)
  
  o 0x5406F000
  
  o Hexadecimal Value: \( 06E9 \)
  
  Temperature Reading 2: \( 25.25 \degree C \) = Actual Temperature Reading 2: \( 25.55 \degree C \) (+/- 4\degree C)
  
  o 0x5407F000
  
  o Hexadecimal Value: \( 0725 \)
  
  Temperature Reading 3: \( 27.3 \degree C \) = Actual Temperature Reading 3: \( 26.6 \degree C \) (+/- 4\degree C)
  
  o 0x5408F000
  
  o Hexadecimal Value: \( 0735 \)
  
  Temperature Reading 4: \( 28.4 \degree C \) = Actual Temperature Reading 4: \( 26.6 \degree C \) (+/- 4\degree C)

• Enter the following command to read the value of current integration
  
  o 0x5409F000
  
  o Hexadecimal Value: \( 0126 \) = 0x012C (50% SOC)

• Enter the following four commands to read the duration/state of bypass for each of the
  four cells (lower 8 bits: Duration (7 bits)/ Bypass Switch (1 bit))
  
  o 0x540BF000
  
  Bypass 1: \( 0000 \) = 0h0000 (0 min/ off)
  
  o 0x540CF000
  
  Bypass 2: \( 0000 \) = 0h0028 (20 min/ off)
- Enter the following command to read the System Mode. A 16-bit value will be returned: 0x0000 is auto mode and 0x00FF is non-auto mode.
  
  o 0x5412F000
  
  **System Mode:**  \[\text{\underline{0000}}\]  = 0x0000

- Enter the following command to disable Automatic Mode.
  
  o 0x541200FF

- Enter the following command to read the System Mode. A 16-bit value will be returned: 0x0000 is auto mode and 0x00FF is non-auto mode.
  
  o 0x5412F000
  
  **System Mode:**  \[\text{\underline{0FF}}\]  = 0x00FF

- Enter the following four commands to write the duration/state of bypass for each of the four cells (lower 8 bits: Duration (7 bits)/ Bypass Switch (1 bit))
  
  o Set bypass duration to 2 minutes and turn on bypass: 0x0005
  
  o Bypass LED's will illuminate for each cell as bypass is enabled and will stay illuminated for approximately 2 minutes
  
  o 0x540B0005
o Enter the following command to read the duration/state of bypass for cell one. It should match the 16-bits above used to set the cells

0x540BF000

**Bypass 1: \[0005\] = 0x0005**  
**Time: 1:50**

0x540C0005

o Enter the following command to read the duration/state of bypass for cell two. It should match the 16-bits above used to set the cells

0x540CF000

**Bypass 2: \[0005\] = 0x0005**  
**Time: 1:42**

0x540D0005

o Enter the following command to read the duration/state of bypass for cell three. It should match the 16-bits above used to set the cells

0x540DF000

**Bypass 3: \[0005\] = 0x0005**  
**Time: 1:41**

0x540E0005

o Enter the following command to read the duration/state of bypass for cell four. It should match the 16-bits above used to set the cells

0x540EF000

**Bypass 4: \[0005\] = 0x0005**  
**Time: 1:30**

- Enter the following command to read the Relay Out. A 16-bit value will be returned: 0x00FF is **on** and 0x0000 is **off**

0x540FF000

**Relay Out: \[0000\] = 0x0000**

- Enter the following command to write the Relay Out. 0x00FF is **off**

0x540F00FF
• Enter the following command to read the Relay Out. A 16-bit value will be returned: 0x00FF is off and 0x0000 is on.
  
  o 0x540FF000

    Relay Out: 0xFF = 0x00FF

• Enter the following command to read the System State. A 16-bit value will be returned: 0x0000 to # of States.
  
  o 0x5411F000

    System State: 0001 = Charging ✓

• Enter the following command to read the Upper Voltage Threshold. A 16-bit value will be returned: 0x0000 to 0x00FF.
  
  o 0x5413F000

    Upper Voltage Threshold: 0xC7 9 = 0x0C29 = 3.8V

• Enter the following command to write the Upper Voltage Threshold. 4.2 Volts: 0x0D70
  
  o 0x54130D70

• Enter the following command to read the Upper Voltage Threshold. A 16-bit value will be returned: 0x0000 to 0x00FF.
  
  o 0x5413F000

    Upper Voltage Threshold: 0xD7 0 = 0x0D70 = 4.2V

• Enter the following command to read the Lower Voltage Threshold. A 16-bit value will be returned: 0x0000 to 0x00FF.
  
  o 0x5414F000

    Lower Voltage Threshold: 0x8F 6 = 0x08F6 = 2.8V

• Enter the following command to write the Lower Voltage Threshold. 3.2 Volts: 0x0A3C
  
  o 0x54140A3C
• Enter the following command to read the Lower Voltage Threshold. A 16-bit value will be returned: 0x0000 to 0x00FF.
  
  o 0x5414F000

  **Lower Voltage Threshold:** \[ \text{0A3C} \] = 0xA3C = 3.2V

• Enter the following command to read the Temperature Threshold. A 16-bit value will be returned: 0x0000 to 0x00FF.
  
  o 0x5415F000

  **Temperature Threshold:** \[ \text{0B0A} \] = 0x0B0A = 60 °C

• Enter the following command to write the Temperature Threshold. 50 degrees: 0x0032
  
  o 0x54150032

• Enter the following command to read the Temperature Threshold. A 16-bit value will be returned: 0x0000 to 0x00FF.
  
  o 0x5415F000

  **Temperature Threshold:** \[ \text{0052} \] = 0x0052 = 50 °C

• Enter the following command to read the Bypass Duration. A 16-bit value will be returned: 0x0000 to 0x00FF.
  
  o 0x5416F000

  **Bypass Duration:** \[ \text{0014} \] = 0x0014 = 20 minutes

• Enter the following command to write the Bypass Duration. 40 minutes: 0x0028
  
  o 0x54160028
• Enter the following command to read the Bypass Duration. A 16-bit value will be returned: 0x0000 to 0xFFF.
  
  o 0x5416F000
  
  Bypass Duration: \underline{0028} = 0x0028 = 40 minutes

• Enter the following command to read the Bypass Threshold. A 16-bit value will be returned: 0x0000 to 0xFFF.
  
  o 0x5417F000
  
  Bypass Threshold: \underline{0029} = 0x0029 = 50 mV

• Enter the following command to write the Bypass Threshold. 150 mV: 007A
  
  o 0x5417007A

• Enter the following command to read the Bypass Threshold. A 16-bit value will be returned: 0x0000 to 0xFFF.
  
  o 0x5417F000
  
  Bypass Threshold: \underline{007A} = 0x007A = 150 mV

• Enter the following command to read the Seconds Counter. A 16-bit value will be returned: 0x0000 corresponds to 0 seconds and 0x003B corresponds to 59 seconds.
  
  o 0x540AF000
  
  Seconds: \underline{0003} = 0x0000 – 0x003B
• Enter the following command to read the Runtime Minutes Counter. A 16-bit value will be returned: 0x0000 corresponds to 0 minutes and 0xFFFF corresponds to 65535 minutes. Time for two minutes. Resend the same command. Difference between results should be 2.
  
  o 0x5418F000

  **Total Minutes:** \( \text{0000} - \text{0000} = T2-T1 = 0x0002 \) ✔

• Enter the following command to read the Cycle Minutes Counter. A 16-bit value will be returned: 0x0000 corresponds to 0 minutes and 0xFFFF corresponds to 65535 minutes. Time for two minutes. Resend the same command. Difference between results should be 2.
  
  o 0x5419F000

  **Cycle Minutes:** \( \text{0000} - \text{0000} = T2-T1 = 0x0002 \) ✔

• Enter the following command to enable Automatic Mode.
  
  o 0x54120000

• Enter the following command to read the System Mode. A 16-bit value will be returned: 0x0000 is auto mode and 0x00FF is non-auto mode.
  
  o 0x5512F000

  **System Mode:** \( \text{0000} = 0x0000 \) ✔
<table>
<thead>
<tr>
<th>Command Test</th>
<th>Actual Measurement</th>
<th>I2C Measurement</th>
<th>Passing Criteria</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read Board ID</td>
<td>N/A</td>
<td>0001</td>
<td>16-bit response from PIC must equal 0x0001</td>
<td>Pass</td>
</tr>
<tr>
<td>Read Version Number</td>
<td>N/A</td>
<td>0010</td>
<td>16-bit response from PIC must equal 0x0010</td>
<td>Pass</td>
</tr>
<tr>
<td>Read I2C Address</td>
<td>N/A</td>
<td>0054</td>
<td>16-bit response from PIC must equal 0x0054</td>
<td>Pass</td>
</tr>
<tr>
<td>Change I2C Address</td>
<td>N/A</td>
<td>0024</td>
<td>16-bit response from PIC must equal 0x0024</td>
<td>Pass</td>
</tr>
<tr>
<td>Read System Mode</td>
<td>0x0000 (Auto Mode)</td>
<td>0000</td>
<td>16-bit response from PIC must equal 0x0000</td>
<td>Pass</td>
</tr>
<tr>
<td>Read Current</td>
<td>3.340 V</td>
<td></td>
<td>Actual current must be within +/- 5% of I2C reading</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td>Read Voltage 1</td>
<td>3.340 V</td>
<td></td>
<td>Actual voltage must be within +/- 5% of I2C reading</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td>Read Voltage 2</td>
<td>3.369 V</td>
<td></td>
<td>Actual voltage</td>
<td>Pass/Fail</td>
</tr>
<tr>
<td>Test Case</td>
<td>Result</td>
<td>Notes</td>
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<td>---------------------------</td>
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<td>--------------------------------------------</td>
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<tr>
<td>Read Voltage 3</td>
<td></td>
<td>Actual voltage must be within +/- 5% of I2C reading</td>
<td></td>
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<tr>
<td>3.314 V</td>
<td></td>
<td>Pass</td>
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<tr>
<td>3.328 V</td>
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<tr>
<td>Read Voltage 4</td>
<td></td>
<td>Actual voltage must be within +/- 5% of I2C reading</td>
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<tr>
<td>3.364 V</td>
<td></td>
<td>Pass</td>
<td></td>
<td></td>
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<tr>
<td>3.367 V</td>
<td></td>
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<tr>
<td>Read Temperature 1</td>
<td></td>
<td>Actual temperature must be within +/- 4°C of I2C reading</td>
<td></td>
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<tr>
<td>25.55°C</td>
<td></td>
<td>Pass</td>
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<tr>
<td>29.4°C</td>
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<tr>
<td>Read Temperature 2</td>
<td></td>
<td>Actual temperature must be within +/- 4°C of I2C reading</td>
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<tr>
<td>25.55°C</td>
<td></td>
<td>Pass</td>
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<tr>
<td>25.35°C</td>
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<tr>
<td>Read Temperature 3</td>
<td></td>
<td>Actual temperature must be within +/- 4°C of I2C reading</td>
<td></td>
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</tr>
<tr>
<td>26.66°C</td>
<td></td>
<td>Pass</td>
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<tr>
<td>27.83°C</td>
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<tr>
<td>Read Temperature 4</td>
<td></td>
<td>Actual temperature must be within +/- 4°C of I2C reading</td>
<td></td>
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<tr>
<td>26.66°C</td>
<td></td>
<td>Pass</td>
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<tr>
<td>28.47°C</td>
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<tr>
<td>Read Current Integration</td>
<td>N/A</td>
<td>16-bit response from PIC</td>
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<tr>
<td>Read Bypass 1</td>
<td></td>
<td>16-bit response from PIC must equal 0x0000</td>
<td></td>
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<tr>
<td>0x0000 (0 min/ off)</td>
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<td>Pass</td>
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<tr>
<td>Read Bypass 2</td>
<td></td>
<td>16-bit response from PIC must equal 0x0000</td>
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<tr>
<td>0x0000 (0 min/ off)</td>
<td></td>
<td>Pass</td>
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<tr>
<td>Read Bypass 3</td>
<td></td>
<td>16-bit response from PIC must equal 0x0000</td>
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<td></td>
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<tr>
<td>0x0000 (0 min/ off)</td>
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<td>Pass</td>
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<tr>
<td>Read Bypass 4</td>
<td></td>
<td>16-bit response from PIC must equal 0x0000</td>
<td></td>
<td></td>
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<tr>
<td>0x0000 (0 min/ off)</td>
<td></td>
<td>Pass</td>
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<tr>
<td>Disable Automatic Mode</td>
<td></td>
<td>16-bit response from PIC must equal 0x0FF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Mode = 0x00FF</td>
<td></td>
<td>Pass</td>
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<tr>
<td>(Non-auto Mode)</td>
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<tr>
<td>Write Bypass 1</td>
<td></td>
<td>16-bit response from PIC must equal 0x0005</td>
<td></td>
<td></td>
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<tr>
<td>0x0005 (2 min/ on)</td>
<td></td>
<td>Pass</td>
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<tr>
<td>Operation</td>
<td>Value</td>
<td>16-bit Response</td>
<td>Result</td>
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<tr>
<td>Write Bypass 2</td>
<td>0x0005 (2 min/ on)</td>
<td>0005</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Write Bypass 3</td>
<td>0x0005 (2 min/ on)</td>
<td>0005</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Write Bypass 4</td>
<td>0x0005 (2 min/ on)</td>
<td>0005</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Read Relay Out</td>
<td>0x0000 (on)</td>
<td>0000</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Write Relay Out</td>
<td>0x00FF (off)</td>
<td>00FF</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Read System State</td>
<td>N/A</td>
<td>0001</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Read Upper Voltage Threshold</td>
<td>0x0C29 (3.8V)</td>
<td>0C29</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Write Upper Voltage Threshold</td>
<td>0x0D70 (4.2V)</td>
<td>0D70</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Read Lower Voltage Threshold</td>
<td>0x08F6 (2.8V)</td>
<td>08F6</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Write Lower Voltage Threshold</td>
<td>0x0A3C (3.2V)</td>
<td>0A3C</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Read Temperature Threshold</td>
<td>0x003C (60 degrees)</td>
<td>0B0A</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Write Temperature Threshold</td>
<td>0x0032 (50 C)</td>
<td>0032</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Read Bypass Duration</td>
<td>0x0014 (20 minutes)</td>
<td>0014</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Write Bypass Duration</td>
<td>0x0028 (40 minutes)</td>
<td>0028</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Read Bypass Threshold</td>
<td>0x0029 (50mV)</td>
<td>0029</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
<td>Value</td>
<td>Notes</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>Write Bypass Threshold</td>
<td>0x007A (150 mV)</td>
<td>007A</td>
<td>16-bit response from PIC must equal 0x007A (Pass)</td>
<td></td>
</tr>
<tr>
<td>Read Seconds</td>
<td></td>
<td>0003</td>
<td>16-bit response from PIC must between 0x00 and 0x3B (Pass)</td>
<td></td>
</tr>
<tr>
<td>Read Total Minutes</td>
<td></td>
<td>0006 - 0006 = 0002</td>
<td>Difference between the two 16-bit responses from PIC must be 0x0002 (Pass)</td>
<td></td>
</tr>
<tr>
<td>Read Cycle Minutes</td>
<td></td>
<td>0008 - 0006 = 0002</td>
<td>Difference between the two 16-bit responses from PIC must be 0x0002 (Pass)</td>
<td></td>
</tr>
<tr>
<td>Enable Automatic Mode</td>
<td>System Mode = 0x0000 (Auto)</td>
<td>0000</td>
<td>16-bit response from PIC must equal 0x0000 (Pass)</td>
<td></td>
</tr>
</tbody>
</table>