PacMan BoB QA Test Plan

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Abstract

This document covers the plan of testing to ensure the Pack Manager Breakout Board (PacMan BoB) will operate as intended as a unit before full system integration. Procedure for each test and criteria for passing will also be described in detail by this document.

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Executive Summary

PacMan BoB Introduction

The Pack Manager (PacMan or PM) is responsible for monitoring the state of all battery cells, handling automatic charging routines, and taking necessary safety measures in the event of a system fault. The PM consists of two major components: the TS-8160-4200 Single Board Computer and the Pack Manager Breakout Board (PacMan BoB). The TS-8160-4200 is an ARM-based processor running linux. It handles most of the calculations and state transitions of the battery pack system. The second major component of the PM is the PacMan BoB. The PacMan BoB acts as the medium between the computer and the other components in the pack. The PacMan BoB will condition the 3.3V DIO pins from the TS-8160-4200 in order to allow the TS-8160-4200 to control both charging and safety loop relays. The PacMan BoB also handles the gathering of system-level data, such as temperatures within the pack fuses or AIRs, overall battery pack voltage, and pack current. In addition, the PacMan BoB contains hardware which galvanically isolates communication lines between the battery pack and the outside world. This test plan is intended to be used with the PacMan BoB only and all TS-8160-4200 signals will be simulated by the tester.

PacMan BoB Assembly and Test Plan

T000: 5V Switching Power Regulator Verification

This test will verify that the switching power regulator on the PacMan BoB will provide a constant 5V output under normal battery pack operating voltages. It will also check for any unforeseen short circuits between the positive and negative terminals of the battery pack.

Assembly:

Place and solder the following components on the PacMan BoB PCB:

-U4: MIC4680 SM 5V Switching Voltage Regulator
-L1: 68uH SM Inductor
-C1: 22uF SM Ceramic
-C2: 220uF SM Electrolytic Cap
-D2: B260A Schottky Diode
-M1: P-Channel Mosfet
-J9, J10, J14 – 0.1" pitch 2 pin screw terminal block

Additional Test Materials:

-Power Supply Capable of supplying up to 30V.
-Voltage meter or multimeter.

Test Procedure:

1. Perform test for passing criteria 1-2
2. Connect the power supply's positive terminal to the Pack POS screw terminal (J10) and connect the power supply's negative terminal to the Pack NEG screw terminal (J14)
3. Turn on the power supply and adjust the voltage to 5VDC
4. Perform tests for passing criteria 3 – 8.
5. Turn the power supply output off and connect the power supply's positive terminal to the Pack NEG screw terminal and connect the power supply's positive terminal to the Pack POS screw terminal.
6. Perform test for passing criteria 9-11.
7. Turn the power supply output off and disconnect its terminals from Pack POS and Pack NEG.

Passing Criteria

Criteria	Description	Pass
	Passing Criteria	
1	There is no electrical continuity between the Pack POS and Pack NEG screw terminals.	
2	There is no electrical continuity between pin 1 and pin 3 of component M1.	
3	The voltage at the 5V terminal on J9 is 5V ± 5% when the power supply is set to 5VDC.	
4	The voltage at the 5V terminal on J9 is 5V ± 5% when the power supply is set to 10VDC.	
5	The voltage at the 5V terminal on J9 is 5V ± 5% when the power supply is set to 15VDC.	
6	The voltage at the 5V terminal on J9 is 5V ± 5% when the power supply is set to 20VDC.	
7	The voltage at the 5V terminal on J9 is 5V ± 5% when the power supply is set to 25VDC.	
8	The voltage at the 5V terminal on J9 is 5V ± 5% when the power supply is set to 30VDC.	
9	No current is allowed to flow from the power supply into the PacMan BoB when the positive and negative terminals are connected backward.	
10	The voltage at the 5V terminal on J9 is 0V ± 0.25V	
11	No smoke or excessive heat is being dissipated by circuit components.	

_____ _____ _____

Witness/Examiner Signature Date Pass/Fail

T001: Sensor Array Verification

This test will verify that the temperature, current, and overall pack voltages can be successfully measured.

Assembly:

Place and solder the following components on the PacMan BoB PCB:

-U1 and U9: LTC4151 High Side Voltage Sensor
-U2, U3, U6: MCP6242 Rail to Rail Op Amp
-C3 and C4: 0.1uF Ceramic SM Capacitor
-R3: 100K SM Resistor
-R22 and R23: 2K SM Resistor
-R24: 1.5M SM Resistor
-J1, J2, J3, J4: 3 pin header
-J21: 6 pin locking header
-J11, J12, J13, J15, J16, J17, J19, J20: 2 8-pin 0.1" pitch screw terminal or 1 16-pin terminal

Additional Test Materials:

- 2 Power Supplies capable of supplying up to 30V.
-Voltage meter or multimeter

Test Procedure:

1. Connect the power supply's positive terminal to the PACK POS screw terminal (J10) and connect the power supply's negative terminal to the PACK NEG screw terminal (J14)
2. Turn on the power supply and adjust the voltage to 10VDC
3. Connect power supply two's positive terminal to pin 2 of sensor 1's junction (J1) and its negative terminal to the pack negative terminal.
4. Turn on power supply two and adjust the voltage to 1VDC
5. Perform tests for passing criteria 1-12.
6. Connect power supply two's positive terminal to SHUNT+ and its negative terminal to SHUNT-.
7. Turn on power supply two and adjust the voltage to 40mVDC.
8. Connect the I2C port on the board to the I2C adapter and send the command ___ to address 0x68 to receive the discharging current
9. Perform test for passing criteria 13.
10. Send command ____ to address 0x68 to receive the total pack voltage via I2C
11. Perform test for passing criteria 14.
12. Switch the SHUNT+ and SHUNT- connections and send command ____ to address 0x69 to receive the charging current
13. Perform test for passing criteria 15.

Passing Criteria

Criteria	Description	Pass
	Passing Criteria	
1	The voltage at PIN 7 of the ADC header is 1V ± 5% when 1V is applied at pin 2 of J1	
2	The voltage at PIN 7 of the ADC header is 3V ± 5% when 3V is applied at pin 2 of J1	
3	The voltage between pin 1 and pin 3 of sensor 1 (J1) is 5V ± 5%	
4	The voltage at PIN 5 of the ADC header is 1V ± 5% when 1V is applied at pin 2 of J2	
5	The voltage at PIN 5 of the ADC header is 3V ± 5% when 3V is applied at pin 2 of J2	
6	The voltage between pin 1 and pin 3 of sensor 1 (J2) is 5V ± 5%	
7	The voltage at PIN 3 of the ADC header is 1V ± 5% when 1V is applied at pin 2 of J3	
8	The voltage at PIN 3 of the ADC header is 3V ± 5% when 3V is applied at pin 2 of J3	
9	The voltage between pin 1 and pin 3 of sensor 1 (J3) is 5V ± 5%	
10	The voltage at PIN 1 of the ADC header is 1V ± 5% when 1V is applied at pin 2 of J4	
11	The voltage at PIN 1 of the ADC header is 3V ± 5% when 3V is applied at pin 2 of J4	
12	The voltage between pin 1 and pin 3 of sensor 1 (J4) is 5V ± 5%	
13	The value received via I2C in the terminal window is _____ ± 5%	
14	The value received via I2C in the terminal window is _____ ± 5%	
15	The value received via I2C in the terminal window is _____ ± 5%	

_____ _____ _____

Witness/Examiner Signature Date Pass/Fail

T002: Relay Control Verification

This test will verify that relays can be triggered on and off using the TS-8160-4200 DIO pins.

Assembly:

Place and solder the following components on the PacMan BoB PCB:

-U5: M74HC07 Hex Open-Drain Buffer
-U7: 5V PCB mount SPST-NO Relay
-U13: Dual 4-input NOR gate
-U14: LTV-357T SM Optoisolator
-U15: LDA210 dual SM Darlington Optoisolator
-C5, C9: 0.1uF SM capacitor
-R1, R4, R7, R8: 10K SM Resistor
-R2, R10, R11: 1K SM Resistor
-R5: 100K SM Resistor
-R6: 6.2K SM Resistor
-R9: 5.6K SM Resistor
-Q5, Q6: 2N2222 NPN Transistor
-D5, D6, D7: D1N4148 Through-Hole Diode
-D4: 1N4001 Through-Hole Diode

Additional Test Materials:

- 3 Power Supplies capable of supplying up to 30V.
-Voltage meter or multimeter
-2 Gigavac 24V-NO Charging relays
-1 24VDC 210mA fan

Test Procedure:

1. Connect the power supply's positive terminal to the PACK POS screw terminal (J10) and connect the power supply's negative terminal to the PACK NEG screw terminal (J14)
2. Turn on the power supply and adjust the voltage to 10VDC
3. Connect the fan's positive wire to FAN+ and its negative wire to FAN-
4. Connect charge relay 1's positive control terminal to C RLY1+ and its negative control terminal to C RLY1-
5. Connect charge relay 1's positive control terminal to C RLY2+ and its negative control terminal to C RLY2-
6. Connect power supply two's positive terminal to CHRG POS and its negative terminal to CHRG NEG
7. Turn on power supply two and adjust the voltage to 24VDC
8. Perform tests for passing criteria 1-3
9. Connect power supply three's negative terminal to Pack NEG and its positive terminal to PIN 1 of the DIO header

10. Turn on power supply three and adjust its voltage to 3.3VDC
11. Perform test for passing criteria 4-5
12. Turn off power supply three.
13. Perform test for passing criteria 6-8
14. Connect power supply three's positive terminal to PIN 5 of the DIO Header, turn on its output, and adjust the voltage to 3.3V.
15. Perform test for passing criteria 9.
16. Turn off power supply three
17. Perform test for passing criteria 10.
18. Connect a wire between DET1 and DET2
19. Perform test for passing criteria 11-12.
20. Turn off power supply two and one.
21. Perform test for passing criteria 13-15.

Passing Criteria

Criteria	Description	Pass
	Passing Criteria	
1	The fan spins in a controlled manner when 24VDC is applied.	
2	Charge relay 1's contacts are open.	
3	Charge relay 2's contacts are open.	
4	Charge relay 1's contacts are closed.	
5	Charge relay 1's contacts are closed.	
6	Charge relay 1's contacts are open.	
7	Charge relay 2's contacts are open.	
8	SLoop_Out and SLoop_In have continuity	
9	There is no continuity between SLoop_Out and SLoop_In	
10	SLoop_Out and SLoop_In have continuity	
11	There is no continuity between SLoop_Out and SLoop_In	
12	The voltage at PIN 13 of the DIO header is 3.3V ± 5%	
13	Charge relay 1's contacts are open.	
14	Charge relay 2's contacts are open.	
15	There is no continuity between SLoop_Out and SLoop_In	

_____ _____ _____

Witness/Examiner Signature Date Pass/Fail

T003: Watchdog Timer Verification

This test will verify the watchdog timer IC will successfully open the safety loop relay if it detects a software issue

Assembly:

Place and solder the following components on the PacMan BoB PCB:

-U8: ADM1232 Watchdog Timer
-C6, C11: 0.1uF SM capacitor

Additional Test Materials:

- 1 Power Supply capable of supplying up to 30V.
-Voltage meter or multimeter
- Function Generator capable of providing a 3.3Vpp >1Hz square wave

Test Procedure:

1. Connect the power supply's positive terminal to the PACK POS screw terminal (J10) and connect the power supply's negative terminal to the PACK NEG screw terminal (J14)
2. Turn on the power supply and adjust the voltage to 10VDC
3. Perform test for passing criteria 1
4. Connect the function generator's positive output terminal to PIN 7 of the DIO header and its negative output terminal to Pack NEG.
5. Provide a 3.3Vpp square wave running at 5Hz from the function generator with the waveform oscillating between a low voltage of 0V and a high voltage of 3.3V
6. Perform test for passing criteria 2
7. Turn off the output to the function generator
8. Perform test for passing criteria 3

Passing Criteria

Criteria	Description	Pass
	Passing Criteria	
1	There is no continuity between SLoop_Out and SLoop_In	
2	There is continuity between SLoop_Out and SLoop_In	
3	There is no continuity between SLoop_Out and SLoop_In	

_____ _____ _____

Witness/Examiner Signature Date Pass/Fail

T004: RS-485 Communication Link Verification

This test will verify the RS-485 serial communication link works correctly.

Assembly:

Place and solder the following components on the PacMan BoB PCB:

-U12: ADM2483 RS-232 to RS485 Isolated Transceiver
-C7, C8: 0.1uF SM capacitor

Additional Test Materials:

- 4 Power Supplies capable of supplying up to 30V.
-Voltage meter or multimeter
- Function Generator capable of providing a 3.3Vpp >1Hz square wave

Test Procedure:

1. Connect the power supply's positive terminal to the PACK POS screw terminal (J10) and connect the power supply's negative terminal to the PACK NEG screw terminal (J14)
2. Turn on the power supply and adjust the voltage to 10VDC
3. Connect power supply two's positive terminal to PIN 11 on the DIO Header and its negative terminal to Pack NEG
4. Connect power supply three's positive terminal to PIN 7 on the COM1 Header and its negative terminal to Pack NEG
5. Connect power supply four's positive terminal to GLV_5V and its negative terminal to GLV_GND.
6. Turn on power supply two and four and adjust their voltages to 5VDC.
7. Perform test for passing criteria 1.
8. Turn on power supply three and adjust its voltage to 5VDC
9. Perform test for passing criteria 2.
10. Turn off power supply two and three. Disconnect power supply three's positive terminal from PIN 7 of the COM1 Header and attach it to RS-485+. Disconnect power supply three's negative terminal from Pack NEG and attach it to RS-485-
11. Turn on power supply three and adjust its voltage to 5VDC
12. Perform test for passing criteria 3.
13. Switch the positive and negative terminal connections of power supply three. Turn on power supply three and adjust its voltage to 5VDC
14. Perform test for passing criteria 4.

Passing Criteria

Criteria	Description	Pass
	Passing Criteria	
1	The voltage between RS-485- and RS-485+ is -5V ± 5%	
2	The voltage between RS-485- and RS-485+ is 5V ± 5%	
3	The voltage at PIN 8 of the COM1 Header is 5V ± 5%	
4	The voltage at PIN 8 of the COM1 Header is 0 ± 0.25V	

Witness/Examiner Signature	Date	Pass/Fail