AquaSol SOLUTIONS

Solar Powered Battery Charger for Offshore Applications

System Test Plan

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GLOSSARY

BMS	Battery Management System
CEC	Canadian Electric Code
CSA	Canadian Standards Association
DC	Direct Current; DC loads require a constant voltage to power them
DFO	Department of Fisheries and Oceans
GPIO	General Purpose Input/Output
GSM	Global System for Mobile Communications
IC	Integrated Circuit
IO	Input/Output
ISM	Industrial, Scientific, and Medical – usually refers to the 2.4-2.5 GHz frequency band for transmitting information
MCU	Microcontroller Unit
MPP	Maximum Power Point
MPPT	Maximum Power Point Tracking

OCP	Over Current Protection
OCPD	Over Current Protection Device
PCB	Printed Circuit Board
PMU	Power Management System
RH	Relative Humidity
SOC	State of Charge
STC	Standard Test Conditions

1. CHARGING MODULE

1.1. Over current protection device (OCPD) functionality	
Procedure Replace the solar panels with a power supply to source 9 A through the OCPD (9 A circuit breaker). **Required outcome(s)** • OCPD trips.	**Result** ☐ Pass ☐ Fail **Comments**

1.2. Solar panel open-circuit voltage and short-circuit current	
Procedure Connect the solar panels in series. Measure the open-circuit voltage and short-circuit current. **Required outcome(s)** • The open-circuit voltage is close to 44.6 V (since the open-circuit voltage of each panel is 22.3 V). • The short-circuit current is close to 5.28 A (the short-circuit current of each solar panel). • Note: Video will be provided showing required outcomes.	**Result** ☐ Pass ☐ Fail **Comments**

2. Power Management Unit (PMU) Hardware/Electronics

2.1. Backup battery charger functionality	
Procedure Connect the backup batteries to a dummy load resistor to drain some of their capacity, and then reconnect to PMU electronics. Connect an ammeter in series between the backup battery charge controller IC and the backup battery pack. Connect a voltmeter across the backup battery terminals. See Figure 1 in appendix. **Required outcome(s)** • The ammeter initially reads no more than 2 A, indicating the IC is charging the backup batteries. • The voltmeter initially reads under 8.2 V, indicating the batteries are not at 100% state-of-charge (SOC). • When the backup battery voltage reaches close to 8.2 V, the ammeter reads zero amps, indicating no more charging.	**Result** ☐ Pass ☐ Fail **Comments**
2.2. Source Select Circuit Functionality	
Procedure Place a voltmeter across the input and output of the 5 V regulator. Then, disconnect the main battery pack from the source select circuit. **Required outcome(s)** • Before disconnecting, the input voltmeter reads 20-29.2 V, indicating the main battery pack is in use. • After disconnecting, the input voltmeter reads	**Result** ☐ Pass ☐ Fail **Comments**

7-8.2 V, indicating the backup batteries are used. • Check that the regulator output is 5 V in both cases.	

3. MICROCONTROLLER (MCU) POWER CONTROL

3.1. CAN communication	
Procedure Connect a logic analyzer between the off-the-shelf BMS and the PMU.	**Result** ☐ Pass ☐ Fail
Required outcome(s) • The PMU sends a remote CAN frame to the BMS, requesting battery status information. • The BMS sends the requested CAN data frame to the PMU with the SOC, temperature, voltage, and current data for all connected battery modules.	**Comments**
3.2. I2C communication	
Procedure Connect a logic analyzer between the humidity sensor and the MCU.	**Result** ☐ Pass ☐ Fail
Required outcome(s) • An I2C start condition and data request is initiated by the MCU. • After roughly 50 ms, the MCU sends a read request. • The sensor replies with two bytes; the MCU then creates a stop condition.	**Comments**

3.3. Unsafe battery conditions	
Procedure Under voltage condition is triggered by critically discharging the battery module. **Required outcome(s)** • The BMS sends a warning message to the PMU via the CAN interface when cell voltage is below 2.8 V. • The PMU disconnects the relay connecting the loads to the batteries and sends an Ethernet warning message to the webserver. • The source select should switch to the backup battery. • Note: This is the only unsafe battery condition that can be feasibly tested.	**Result** ☐ Pass ☐ Fail **Comments**
3.5. High humidity safety shutoff	
Procedure Place a wet sponge directly on the humidity sensor to simulate excessive moisture in the enclosure. **Required outcome(s)** • The PMU sends an immediate Ethernet message to the webserver, indicating that the system will shut down. • The system then shuts down the peripherals and the CPU, and disconnects the relay switch connecting the loads to the batteries.	**Result** ☐ Pass ☐ Fail **Comments**

4. WEB APPLICATION

4.1. Display status of active sites	
Procedure Connect an Ethernet cable between the MCU and a computer with access to internet. **Required outcome(s)** • The application automatically displays active site information, including battery status and any warnings.	**Result** ☐ Pass ☐ Fail **Comments**
4.2. Battery charge history	
Procedure Click on a battery icon in the application, and select 'History'. **Required outcome(s)** • The application shows the battery charge history for that battery.	**Result** ☐ Pass ☐ Fail **Comments**
4.3. Operating cycle configuration	
Procedure Click on a battery icon in the application, and select 'Settings'. Alter the operating cycle. **Required outcome(s)** • The webserver sends an Ethernet message to the PMU for changing the power mode and duty cycle. • The PMU will change the power mode and duty cycle to the required setting. • The PMU will send a confirmation Ethernet message to the webserver, which will display	**Result** ☐ Pass ☐ Fail **Comments**

the confirmation message to the user.	

REFERENCES

APPENDIX

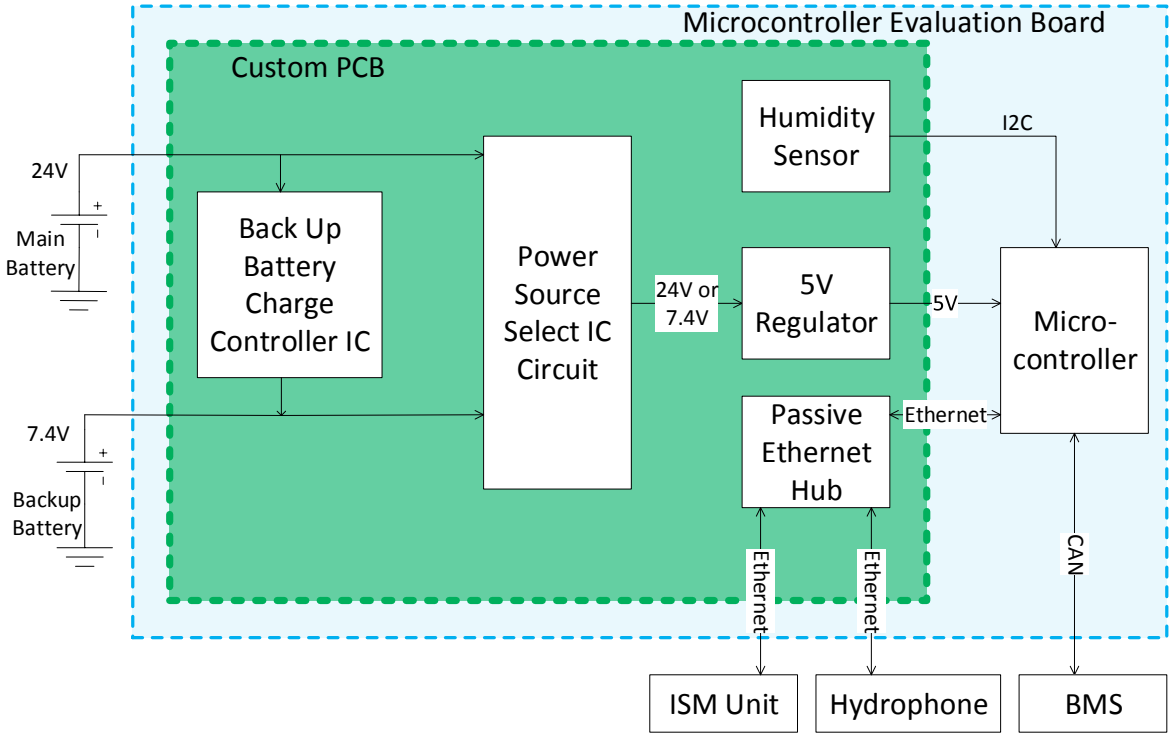

Figure 1: High level block diagram of PMU and MCU evaluation board