B-Van Lithium Operation Manual

V7R 11/6/2023

Table of Contents

The B-Van is equipped with a 51.2V house battery, an alternator, alternator regulator, 3500W Inverter solar charger, and 200W of solar panels. These instructions will lay out the components and how to operate and maintain them.

Must Read Before Operating

- These instructions are for reference only, please refer to the individual product manuals for detailed instructions and data.
- Do not modify or alter the components in any way.
- Do not connect an external charger to the Lithium Battery.
- Do not alter the solar array in any way.
- Do not connect anything other than the Renogy solar blanket (optional) to the external solar connection.
- Do not attempt to charge the battery with the following conditions:
    - If the voltage difference between the min and max cell voltage is greater than 800mv.
    - If the battery total voltage is less than 32V.
    - If the max cell reads 8,000mV or similar.
    - If the min cell is under 2,000mV.
- When completing service, do not connect or disconnect any 48V DC system components while the system is ON. Verify the Lithium Battery is OFF and all charging sources:
    A. Alternator
    B. Shore Power
    C. Rooftop Solar – disconnect near battery in the 'OFF' position
    D. Side Solar
- For technical assistance please call Patrick Distribution Inc., 1-800-621-2278 or email renogy-oem@patrickind.com

Quick Startup

- It is highly recommended that all charging sources are OFF when powering up and powering down the lithium system. (See Getting Started and Powering Down – Storage and Service sections)
- The Samkoon battery screen should be the primary screen to gather lithium battery information as it provides information directly from the battery BMS.
- If the battery reaches 20% SOC, Total Voltage ≥ 50.0V and/or Minimum Cell Voltage ≥3100mV. The unit will need to start receiving a charge.
- When the unit is depleted below 10% SOC, this can cause the SOC% and voltage levels to be out of calibration. Recalibrate the BMS by changing the inverter parameter #9 to 54.4 and charge the unit to 100% SOC.
- It is imperative to try to recharge the battery to 100% SOC, as this also recalibrates the BMS and balances cells.
- The 12V Master Disconnect (Main Power) Switch must be in 'ON' for the unit to charge with the Alternator.
- When charging with shore power, do NOT start the vehicle.

Renogy System YouTube Video

SCAN ME

Getting Started

1. Verify all charging sources are disconnected:
    A. Alternator
    B. Shore Power
    C. Rooftop Solar – disconnect near battery in the 'OFF' position
    D. Side Solar

2. Turning on the lithium battery: Turn battery on with the self-locking switch and self-resetting switch
    A. Press and release the self-locking switch (typically installed behind an access panel near the lithium battery)

    NOTE: Self-locking switch should be 'ON' at all times except for long periods of storage or service.

    B. Next press and hold the self-resetting switch (typically installed overhead cabinet near Firefly touchscreen) for approximately 5-10 seconds to turn on the battery. There will be a series of clicks count to 5 after the last one.

3. Turn on Inverter by pushing button on Inverter remote switch. Green light will turn on the remote switch when inverter is on. Turn off inverter when not charging by shore power or using 120V outputs (outlets and Timberline Heater) for short storage to preserve battery SOC%. Leaving the inverter ON when the system is not in use can result in a 15-20% loss in SOC per day.

4. To turn on 12V power, press and release the momentary switch located near the rear of the sliding door. Note that the red light by switch is illuminated when the 12V power is active. To turn off the 12V power, press and release the switch again and the red light by switch will turn off.

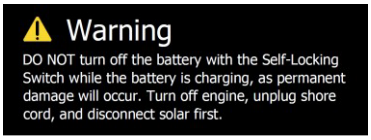
5. Verify the Samkoon Battery Screen is operating and review:
    A. Total Voltage
    B. Minimum and Maximum Cell Voltages
    C. State of Charge
    D. Battery Temperatures
    E. Battery Operation Status

Powering Down – Storage and Service

1. Verify all charging sources have been disconnected:
    A. Alternator
    B. Shore Power
    C. Rooftop Solar – disconnect near battery in the 'OFF' position
    D. Side Solar

WARNING: When turning off battery, press Self-Locking Switch and release. See warning label "DO NOT turn off battery when charge is present…"

NOTE: <u>"ALL CHARGERS" need to be off or disconnected including Engine, Shore Power, and both Rooftop and External Solar. Turn off the 12V disconnect switch and ensure that the "Total Current on the Renogy Monitor = 0A.</u>



2. Turn off the 12V Master Disconnect (Main Power) located near the rear of the sliding door.
3. Turn off the Inverter by pushing button on Inverter remote switch.
4. Press and release the Self-Locking Battery Switch. The button will be flush in the 'OFF' position.
5. Review the Samkoon Battery Screen to ensure that there is not any voltage present.

Storage and Cold Weather Recovery

When storing the unit during the winter months or an undetermined length of time, the BMS should be recalibrated before storage to ensure the SOC is correct and **<u>the system should be shut down following the "Powering Down – Long Storage" section</u>**. There are three different storage terms listed below, and each have their own unique specific criteria. The important part is to determine which storage method, or combination of methods suit the intended storage.

- **Short Term Storage** is defined as storage in which the battery is <u>shut down</u>, unused for up to one month, 30 continuous days. It is important to note that the temperature and humidity range for short term storage is greater than medium or long term storage. This is important to pay close attention to this detail because the aforementioned environmental criteria will define the maximum length of time the battery can be stored.
    1. Short Term Storage: up to 1 month, 30 continuous days
    2. Storage temperature and humidity range: -20°C to 35°C / -4°F to 95°F, 45% to 75% Relative Humidity
    3. Charge the battery to 100% SOC before putting it in storage mode

  To prepare the battery for short term storage, you can charge the battery up to up to 100% SOC, and not lower than 50% before putting it in storage mode. If the storage temperature is less than 10°C or 51°F, then it important to charge the battery to, or as close to 100% SOC.
- **Medium Term Storage** is defined as storage in which the battery is <u>shut down</u>, unused for a length of time greater than one month, 30 continuous days, and up to three months, or 90 continuous days. This is important to pay close attention to this detail because the aforementioned environmental criteria will define the maximum length of time the battery can be stored.
    1. Medium term storage: Greater than 1 month, 30 continuous days, and less than 3 months, 90 continuous days
    2. Storage temperature and humidity range: -10°C to 30°C / 14°F to 86°F, 45% to 75% Relative Humidity
    3. Charge the battery to 70% SOC before putting it in storage mode

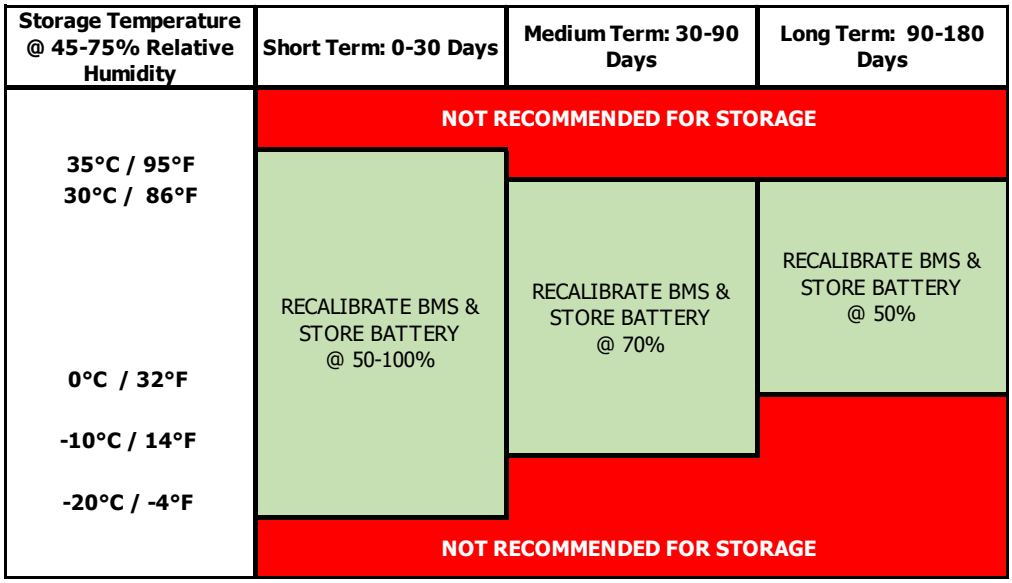
  To prepare the battery for medium term storage, you can charge the battery up to 70% before putting it in storage mode. It is important to note that the environmental criteria is more stringent than the short term storage, and if this criteria is not able to be met, then you cannot store the unit for the extended length of time.
- **Long Term Storage** is defined as storage in which the battery is <u>shut down</u>, unused for a length of time greater than three months, 90 continuous days, and no longer than six months, or 180 continuous days. The suggested SOC before storage is 50%. Storing battery at full charge will cause more capacity loss (permanent) overtime comparing to 40% to 50% SOC. This is important to pay close attention to this detail because the aforementioned environmental criteria will define the maximum

length of time the battery can be stored.

1. Long term storage: Greater than 3 months, 90 continuous days, and less than 6 months, 180 continuous days
2. Storage temperature and humidity range: 0°C to 30°C / 32°F to 86°F, 45% to 75% Relative Humidity
3. Charge the battery to 50% SOC before putting it in storage mode

To prepare the battery for long term storage, you can charge the battery up to up to 50% before putting it in storage mode. It is important to note that the environmental criteria is more stringent than the short term storage, and if this criteria is not able to be met, then you cannot store the unit for the extended length of time.

Following Long Term Storage, the lithium battery will need be cycled and calibrated to reflect the correct SOC% and to ensure optimal performance.



Important Notes:

1. In order to avoid a cold and dead battery, it is highly recommended to utilize the Short Term Storage method. Once a month, operate the battery system including discharging/charging the system and verifying the battery SOC is between 50 to 100%.
2. At the lowest allowed storage temperature -20°C/-4°F, the dischargeable capacity is about 70% of the rated capacity of the battery. Essentially, you are losing 30% of the amp hours. Instead of 210aH, it will be closer to 147aH.
3. With the battery shut down and below 0°C /32°F in storage mode, the self-consumption rate of the lithium cell is about 3% per month.
4. The maximum storage duration is 6 months.
5. Long Term storage is NOT RECOMMENDED when:
    a. Below freezing temperature. This will minimize the lithium battery voltage loss during storage and increase the recovery time caused by lower temperatures.
    b. Temperatures are extreme over 60°C /140°F.

- Storing the battery outside of these environmental parameters: (-20°C to 35°C / -4°F to 95°F, 45% to 75% Relative Humidity) will trigger the low temperature cut off and the battery will be un-usable, and can cause permanent damage. If exposure to environmental criteria outside of the aforementioned parameters is needed please contact RENOGY at: renogy-oem@patrickind.com

System Flow Chart (MY24)

120VAC 3500 Watt inverter powered from the 48V high voltage DC connection, and also charges the 51.2VDC 210 aH Lithium Ion battery with up to 40A when the unit is connected to 120VAC 30A shore connection.

120VAC 30A max shore connection

HIGH VOLTAGE AC Output
Converts 48VDC to 120AC
- Distribution Panel
  - Timberline Electric Heating Element
  - Outlets
  - Microwave

74.4VDC 200W Solar Array (roof mounted) There are 4 50W solar panels mounted on the roof, wired in series to create a 74.4VDC 200W solar array connected to a Victron 150V 35A Solar charger to recharge the 51.2VDC 210 aH Lithium Ion battery.

LOW VOLTAGE DC (12V)
- Firefly Interface
- Refrigerator
- Lights (Interior/Exterior)
- Water Pump
- Awning
- Bed

HIGH VOLTAGE DC (48V)
- Air Conditioner

48VDC Engine driver alternator / generator which charges the 51.2VDC 210 Ah Lithium Ion battery as the engine is running and the engine RPM's are greater than 1500.

39.5VDC 300W external solar blanket array (optional). There is a factory installed RCC10RVRB Rover Boost DC to DC charge controller connected to the factory installed external solar port to recharge the 51.2VDC 210 aH Lithium Ion battery.

System Flow Chart (Pre-MY24)

120VAC 3500 Watt inverter powered from the 48V high voltage DC connection, and also charges the 51.2VDC 210 aH Lithium Ion battery with up to 40A when the unit is connected to 120VAC 30A shore connection.

120VAC 30A max shore connection

74.4VDC 200W Solar Array (roof mounted) There are 4 50W solar panels mounted on the roof, wired in series to create a 74.4VDC 200W solar array that is connected to the 3500W 48V MPPT inverter / charger, to recharge the 51.2VDC 210 aH Lithium Ion battery.

HIGH VOLTAGE AC Output
Converts 48VDC to 120AC
- Distribution Panel
  - Timberline Electric Heating Element
  - Outlets
  - Microwave

LOW VOLTAGE DC (12V)
- Firefly Interface
- Refrigerator
- Lights (Interior/Exterior)
- Water Pump
- Awning
- Bed

HIGH VOLTAGE DC (48V)
- Air Conditioner

48VDC Engine driver alternator / generator which charges the 51.2VDC 210 Ah Lithium Ion battery as the engine is running and the engine RPM's are greater than 1500.

39.5VDC 400W external solar blanket array (optional). There is a factory installed RCC10RVRB Rover Boost DC to DC charge controller connected to the factory installed external solar port to recharge the 51.2VDC 210 aH Lithium Ion battery.

51.2V 210Ah Lithium Battery

- **DO NOT over-charge or over-discharge the battery.**
- **DO NOT discharge the battery at high temperatures above 140°F (60°C).**

- **Battery Operational Parameters:**

Operation Parameter	
Charge Voltage	54.7V
Charge Cut-Off Voltage	58.4V
Discharge Cut-Off Voltage	41.6V (Firmware 137.3.1) 48V (Firmware 137.3.13)
Maximum Continuous Charge Current	105A
Maximum Continuous Discharge Current	200A
Charge Temperature Range	32°F~131°F / 0°C~55°C
Discharge Temperature Range	-4°F~140°F / -20°C~60°C
Storage Temperature Range	-4°F~95°F / -20°C~35°C
Operation Relative Humidity	5%~95%

- **Switch Operation:**
  - The battery can be turned on or off with the Self-Locking Switch and Self-Resetting Switch. For the first time use, press down the Self-Locking Switch and long press the Self-Resetting Switch for approximately 5-10 seconds to turn on the battery. There will be a series of clicks which are completing self-checks on the battery. After the last click, the COM light should begin to flash Orange and the Self-Resetting Switch can be released.
  - Prior to long periods of storage, press the Self-Locking Switch again to turn off the battery. When the battery is off, it has a low self-discharge rate and can hold the charge for a longer period of time.
  - If the battery is in protection mode, it can be restarted by long pressing the Self-Resetting Switch for 3~5 seconds. After restarting, the battery will automatically run the self-check program and release the protection mode if the recovery conditions have been reached.
- **Heating Function Operation**
  - The normal operation of the heating function requires a stable charge current greater than 8A. The heating function will start operating automatically once the battery temperature drops below 41°F (5°C) and stop operating automatically once the battery temperature rises above 50°F (10°C).

    NOTE: The heating function will not be able to operate normally if the unit is not connected to shore power, and the charger setting #28 is not greater than 5A. The solar array is not large enough to preheat the battery.
- **Charging Battery**

  During the standard charging process, the battery is first charged at a constant current via the 51.2V Input/Output Terminals until the battery voltage reaches between 53.6V and 54.8V. The standard charging process is considered complete when the charge current is less than 4.2A. However, leaving the battery on float will continue to balance the battery cells and will not damage the battery. The standard charging process normally takes 7 hours. The battery should be charged to 54.4V to recalibrate the BMS which adjusts the SOC meter, and keeps it close to specifications. This should be done periodically, or as needed. Setting number 9 on the inverter charger may be adjusted between 53.6V and 54.8V to accomplish your specific usage, and then to recalibrate the BMS when needed. Safe charging requires battery temperatures within normal operating temperatures. If the heating function is unable to work normally, battery temperatures above 32°F (0°C) is also required for the

safe charging.

- **Discharging Battery**
  During the standard discharging process, the battery is discharged via the 51.2V Input/Output Terminals until the battery voltage reaches 48.0V. Safe discharging requires battery temperatures between -4°F (-20°C) and 140°F (60°C). **In order to keep all charging options available, the battery should be charged once it reaches 20% SOC, Total Voltage ≥ 50.0V and/or Minimum Cell Voltage ≥3100mV**. Discharging the battery below the Total Voltage or Minimum Cell Voltage can lead to an under voltage fault, which will require the battery to be recovered and limits the charging options to shore power only.

- **Recovery Process**
  To begin the recovery process, connect the RV to an external 120VAC (up to 30A) power source and ensure that the inverter/charger power switch is in the "ON" position. The battery will begin "clicking". The Total Voltage, Cell Voltages and SOC will slowly increase. The Warning or Protection Recovery points will need to be reached to clear (see the BMS Warnings & Protections).

- **Battery Maintenance**
  The battery needs to be maintained above 20% SOC, Total Voltage ≥ 50.0V and/or Minimum Cell Voltage ≥3100mV. When any of the parameters are met, a recharge cycle needs to take place. This can be completed by either connection to 120VAC 30A source or starting the engine to allow the engine driven alternator/generator to recharge the battery.
    - If the battery is not recharged, under-voltage disconnects will take place. The high voltage (51.2V circuit - inverter/charger, engine driven alternator and cabin A/C) and the low voltage (12V circuit - Firefly, interior/exterior lighting, and water pump) will stop functioning when the protection level is achieved (see the BMS Warnings & Protections below).
    - If the lithium battery is disconnected for under-voltage protections, recharging with the engine driven alternator/generator cannot take place. It is vital to always keep the battery above 20% SOC, Total Voltage ≥ 50.0V and/or Minimum Cell Voltage ≥3100mV to avoid the loss of functionality and recharging options.

- **Cold Weather Recovery**
  Note that in cold weather, when the cell temperature drops below 10°C (50°F), the unit will need connected to shore power. The self-heat process may take 15-20 minutes to activate and begin warming the cell temperature enough to re-charge the battery bank. The warming process could take up to one hour or longer. The inverter/charger will charge at 8A to heat the battery, and once the minimum cell temperature reaches 5°C the charging contactor will close, and full charging will begin.

- **Cycling the Battery**
  On batteries which have been in storage for longer than (6) months, the state of charge percentage (SOC%) may read 100% by default. It is recommended to cycle and calibrate the battery to reflect the correct SOC% and to ensure optimal performance.
    1. Power on the battery.
    2. Use the solar inverter to discharge the battery until it disconnects. Large loads will help you achieve this faster such as turning on the air conditioner.
        a. Battery with 137.3.1 Firmware = 2600mV on the lowest cell or 41.6V
        b. Battery with 137.3.13 Firmware – 3000mV on the lowest cell or 48V
    3. Once the battery reaches this point, the Samkoon will power off and the battery will disconnect from the circuit.

4. To begin the recovery process, connect the RV to an external 120VAC (up to 30A) power source, and ensure that the inverter/charger power switch is in the "ON" position. The battery will begin "clicking" and the Samkoon will turn back on. The SOC% will slowly increase. It is imperative to try to recharge the battery completely so that it undergoes a complete cycle. NOTE: It is recommended to shut down any non-critical loads to allow the battery to recharge quicker.

- **Calibrating New or Replaced Batteries**

When the unit is depleted below 10% SOC, this can cause the SOC% and voltage levels to be out of calibration. If the SOC% is incorrect or out of sync, then it is important to charge the battery completely to resynchronize calibration.

1. Ensure the battery is ON.
2. Ensure that the remote inverter/charger power switch is in the "ON" position. The button should be pushed in to power and green light showing.
3. Change the inverter setting #9 to 54.4V.
4. Connect the unit to an external 120VAC (up to 30A) power source.
5. The battery will begin "clicking" and the Samkoon will turn on. It is imperative to charge the battery to 100% completely.
6. Change the inverter setting #9 to 53.6V.

- **Cell Imbalance**

Cell imbalance refers to a condition in which individual cells within a battery module have variations in their electrical characteristics, such as voltage, capacity, or internal resistance. These variations can lead to unequal performance among cells, potentially impacting the overall performance, safety, and longevity of the battery system.

To catch cell imbalances, we need to observe them at a different reference point and not when the batteries are fully charged. Fully charged LFP cells have an acceptable cell voltage differential that can grow due to chemical variability, aging of the cell, and balancing, and be perceived as widest in the fully charged process but not necessarily indicative of a cell imbalance. Therefore, you also won't find balancing occurring during the end charge process. Balancing occurs in the recharging process.

When reviewing the Samkoon screen, there are several parameters which will require a mandatory stoppage of this inspection and repair procedure. Immediately contact Patrick Distribution (1-800-621-2278 or email renogy-oem@patrickind.com) for approval to replace the lithium battery.

WARNING: Do not attempt to charge the battery with the following conditions:

- If the voltage difference between the min and max cell voltage is greater than 800mv.
- If the battery total voltage is less than 32V.
- If the max cell reads 8,000mV or similar.
- If the min cell is under 2,000mV.

When determining cell imbalance, the charge source should be disconnected and the battery idle to observe the actual voltage difference gap between the maximum volt cell and the minimum volt cell. Cell imbalance is determined when the differential has grown beyond 300mV.

Note: At 500mv cell differential the Samkoon will report a Level 1 warning and at 800mv cell differential the Samkoon will report a Level 2 protection. Only when the cell differential has been closed to below 300mv will the error on the Samkoon clear.

If the Max Cell is above 8000mV or the Min Cell is below 2000mV, the battery is likely compromised and will require replacement.

- **<u>Clearing Cell Imbalance</u>**
  Clearing cell balancing requires having a stable charge source and prolonging the charge process so that balancing may take effect. Balancing cannot be carried out if there are any overvoltage warnings and will also not be carried out if the total charging current reaches 0, indicating the battery is fully charged.

  The balancing algorithm is only carried out during charging, triggered when both the following conditions are met:
  1. Single cell voltage reaches 3.4V
  2. The voltage difference between cells is above 60mV.

  When the balancing starts, the cell(s) with high voltage will be discharged at 50mA. The balancing will be ON for 1 sec, then OFF for 1 sec. As long as both the above conditions are met, the balancing cycle will be carried out intermittently. It can't be a continuous process, to avoid overheating of the resistor in balancing circuit.

  Cells can be balanced by the following method:
  1. Review the Samkoon screen to verify the system is not any alarm state – warning or protections.

Displays Charging or Discharging

Normal/Fault

Battery Operation

  2. With the lithium system operational and clear of any faults:
     A. Discharge the system to below 53.0V.
     B. Let the battery sit idle for 10-15 minutes.
     C. Observe and note the Total Voltage, Max_Volt and Min_Volt.

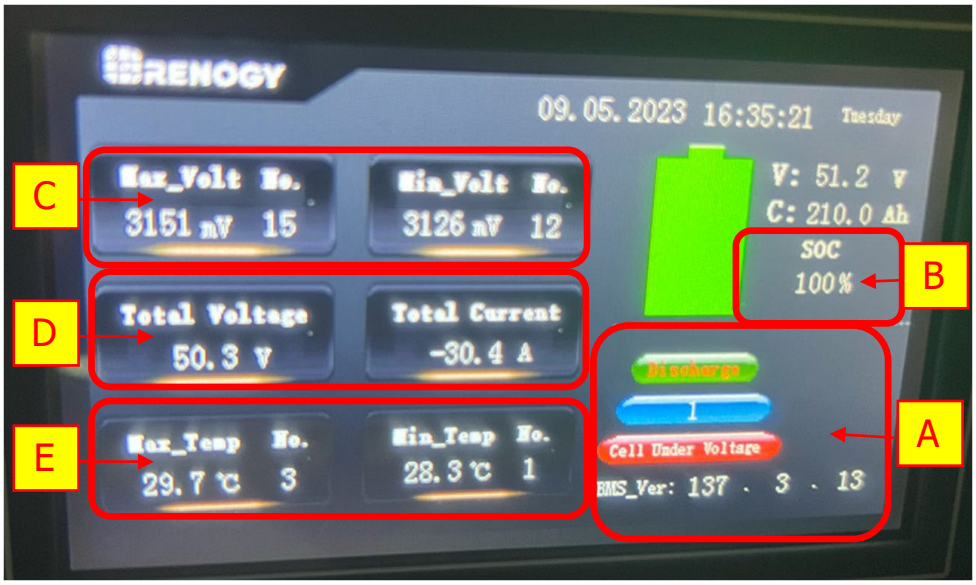
3. Change inverter settings:
    A. Press SET button on Inverter to open parameter settings
    B. Press UP or DOWN and go to Parameter #9 and then press ENT button
    C. Parameter setting will begin to flash, then change to 53.6V.
    D. Press ENT button to save setting
    E. Press UP or DOWN and go to Parameter #28 and then press ENT button
    F. Parameter setting will begin to flash, then change to 5A.
    G. Press SET button to exit setting menu
4. Connect the unit to an external 120VAC (up to 30A) power source.
5. Continue to charge with shore power for an extended amount of time.
    NOTE: Dependent on the lithium battery condition, balancing may take 1-2 days.
6. To observe the cell imbalance differential gap closing, discharge the battery to the same Total Voltage in Step 2 and compare the cell differential. It should be observed that the cell differential should be closer as this cannot be seen when the battery is fully charged.
    NOTE: Repeat Steps 2-5 until the cell differential has closed completely and/or until the Cell Imbalance error has cleared.

Battery Monitor

Typically, the battery monitor is mounted in the overhead cabinet or near the Firefly Touchscreen.
Display features include:

- Lights: Power (PWR), Run and Communication (COM)

Status	PWR	RUN	COM
No Power	Off	Off	Off
Power Connected	On		
CPU Works Normally	On	On	
Communicates Normally	On	On	Flash



A: Battery Operation Status

- Status = this refers to state, whether it is charging or discharging
- Charger Operating Status = this is for the engine driven alternator/generator only, not the solar or inverter / charger
- Faults = this refers to any faults from the battery

- The battery contains a battery management system (BMS) that warns you and protects the battery from over-voltage, under-voltage, over-current, short circuit, high temperature, low temperature, uneven temperature, uneven voltage, and insulation fault. At the Battery Operation Status, you will find a number between 0-3.
  - 0 = Normal (NO faults and all operating values are within normal range)
  - 1 = Warning – message will clear when the system recovery value is reached
  - 2 = Alarm – requires a battery restart when the system recovery value is reached
  - 3 = Protection – requires a battery restart when the system recovery value is reached

B: State of Charge (SOC%)

- SOC Percentage = the current amount of capacity the battery has in SOC%
  - **Depending on the firmware installed, a State of Charge (SOC) Warning will occur. (See the BMS Warnings & Protections chart below)**

C: Cell Voltages

- Max_Volt = the cell number (No.) with the largest mV
- Min_Volt = the cell number (No.) with the smalles mV
  - **These values will be utilized in determining the cell under-voltage or cell over-voltage BMS warnings and protections. (See the BMS Warnings & Protections chart below)**

D: System Voltage and Total Current

- Total Voltage = current battery voltage
  - **The total voltage will be utilized in determining the system under-voltage or system over-voltage BMS warnings and protections.**
- Total Current = net current of the system (Negative Current means the system is discharging and positive current means charging.
- When charging, with minimal discharge:
  - Alternator: Depending on total voltage and other circumstances, the typical total current can range from 0-100A.
  - Shore Cord: Depending on total voltage and other circumstances, the typical total current can range from 0-40A.
  - Solar Power: Depending on total voltage and other circumstances, the typical total current can range from 0-4A.

E: Cell Temperatures

- Max_Temp = the cell number (No.) with the highest cell temperature
- Min_Temp = the cell number (No.) with the lowest cell temperature
  - **These values will be utilized in determining charge high temperature, charge low temperature, discharge high temperature, discharge low temperature and uneven temperature BMS warnings and protections. (See the BMS Warnings & Protections chart below)**

- **Battery Management System**
  - The battery contains a battery management system (BMS) that warns you and protects the battery.

BMS Warnings & Protections

Battery Operation Status	137.3.1 Firmware	137.4.1 Firmware or Higher	Notes
Battery Overvoltage Warning	56.8V	56.8V	If the voltage is greater than the warning voltage for 10s, a warning will be triggered and a warning message will be sent out immediately
Battery Overvoltage Warning Recovery	56V	56V	If the voltage is less than the warning recovery voltage for 10s, the warning will be cleared.
Battery Overvoltage Protection	58.4V 51.2V circuit	58.4V 51.2V circuit	**51.2V Circuit:** If the voltage is greater than the protection voltage for 2s, the protection will be triggered, a pre-alarm message will be sent out immediately, and the relay will be opened after a delay of 3s **12V Circuit:** The 12V circuit is not affected and is allowed to continue discharging
Battery Overvoltage Protection Recovery	56V 51.2V circuit	56V 51.2V circuit	1. If the voltage is less than the protection recovery voltage for 10s, the protection will be released and the relay will be closed 2. The self-check will start after the battery voltage drops below 57.6V with a duration of 2s and an interval of 10s. If the discharge current is greater than 2A for 2s, the protection will be released and the relay will be closed
Cell Overvoltage Warning	3550mV	3550mV	If the voltage is greater than the warning voltage for 10s, a warning will be triggered and a warning message will be sent out immediately
Cell Overvoltage Warning Recovery	3500mV	3400mV	If the voltage is less than the warning recovery voltage for 10s, the warning will be cleared
Cell Overvoltage Protection	3650mV 51.2V Circuit	3650mV 51.2V Circuit	**51.2V Circuit:** If the voltage is greater than the protection voltage for 2s, the protection will be triggered, a pre-alarm message will be sent out immediately, and the relay will be opened after a delay of 3s **12V Circuit:** The 12V circuit is not affected and is allowed to continue discharging
Cell Overvoltage Protection Recovery	3500mV 51.2V Circuit	3400mV 51.2V Circuit	1. If the voltage is less than the protection recovery voltage for 10s, the protection will be released and the relay will be closed. 2. The self-check will start after the cell voltage drops below 3.6V with a duration of 2s and an interval of 10s. If the discharge current is greater than 2A for 2s, the protection will be released and the relay will be closed.

<table>
<tr><td>Battery Under-voltage Warning</td><td>48V</td><td>49.6V</td><td>If the voltage is less than the warning voltage for 10s, a warning will be triggered and a warning message will be sent out immediately</td></tr>
<tr><td>Battery Under-voltage Warning Recovery</td><td>48.8V</td><td>50.4V</td><td>If the voltage is greater than the warning recovery voltage for 10s, the warning will be cleared</td></tr>
<tr><td rowspan="4">Battery Under-voltage Protection</td><td rowspan="2">44.8V
51.2V circuit</td><td rowspan="4">48.0V
51.2V circuit
& 12V circuit</td><td>51.2V Circuit</td></tr>
<tr><td>If the voltage is less than the protection voltage of 51.2V circuit for 5s, the protection will be triggered, a pre-alarm message will be sent out immediately, and the relay will be opened after a delay of 10s</td></tr>
<tr><td rowspan="2">41.6V
12V circuit</td><td>12V Circuit:</td></tr>
<tr><td>If the voltage is less than the protection voltage of 12V circuit for 5s, the protection will be triggered, the switch of 12V circuit will be opened and the power will be cut off after a delay of 5s</td></tr>
<tr><td rowspan="4">Battery Under-voltage Recovery</td><td rowspan="2">48.8V
51.2V circuit</td><td rowspan="4">50.4V
51.2V circuit
& 12V circuit</td><td>51.2V Circuit ：</td></tr>
<tr><td>1. If the charge voltage is greater than 49.2V & PACK+2V for 10s, the relay will be closed and engage charging.
2. After activation, during the charging and recovery, it has a continuous self-check procedure. If it detects the charge power is smaller than the load consumption (total current is negative), it will open the relay and disconnect charging;
* If this happens, there is a 5-min interval before it restarts the charge voltage detection;
* If this happens 3 consecutive times, the interval increases to 1 hour; If it happens another 5 consecutive times, it will be locked for 18 hours before it restarts the charge voltage detection.
* During the above process, the interval and lockout can be cleared immediately by restarting the battery.</td></tr>
<tr><td rowspan="2">44.8V
12V circuit</td><td>12V Circuit ：</td></tr>
<tr><td>The 12V under-voltage protection will be released with the relay closed if both the following recovery conditions are met:
1. The voltage is greater than the recovery voltage (50.4V) for 10s.
2. The SOC is greater than 20% for 10s.</td></tr>
<tr><td>Cell Under-voltage Warning</td><td>3000mV</td><td>3100mV</td><td>If the voltage is less than the warning voltage for 10s, a warning will be triggered and a warning message will be sent out immediately</td></tr>
<tr><td>Cell Under-voltage Warning Recovery</td><td>3050mV</td><td>3250mV</td><td>If the voltage is greater than the warning recovery voltage for 10s, the warning will be cleared</td></tr>
</table>

<table>
<tr><td rowspan="3">Cell Under-voltage Protection</td><td rowspan="2">2800mV
51.2V Circuit</td><td rowspan="3">3000mV
51.2V circuit
& 12V circuit</td><td>51.2V Circuit</td></tr>
<tr><td>If the voltage is less than the protection voltage of 51.2V circuit for 5s, the protection will be triggered, a pre-alarm message will be sent out immediately, and the relay will be opened after a delay of 10s</td></tr>
<tr><td>2600mV
12V Circuit</td><td>12V Circuit:
If the voltage is less than the protection voltage of 12V circuit for 5s, the protection will be triggered, the switch of 12V circuit will be opened and the power will be cut off after a delay of 5s</td></tr>
<tr><td rowspan="3">Cell Under-voltage Protection Recovery</td><td rowspan="2">3050mV
51.2V Circuit</td><td rowspan="3">3250mV
51.2V circuit
& 12V circuit

SOC% ≥ 20%</td><td>51.2V Circuit ：
1. If the charge voltage is greater than 49.2V & PACK+2V for 10s, the relay will be closed and engage charging.
2. After activation, during the charging and recovery, it has a continuous self-check procedure. If it detects the charge power is smaller than the load consumption (total current is negative), it will open the relay and disconnect charging;
* If this happens, there is a 5-min interval before it restarts the charge voltage detection;
* If this happens 3 consecutive times, the interval increases to 1 hour; If it happens another 5 consecutive times, it will be locked for 18 hours it restarts the charge voltage detection.
* During the above process, the interval and lockout can be cleared immediately by restarting the battery.</td></tr>
<tr><td>12V Circuit ：</td></tr>
<tr><td>2800mV
12V Circuit</td><td>The 12V under-voltage protection will be released with the relay closed if both the following recovery conditions are met:
1. The voltage is greater than the recovery voltage (50.4V) for 10s.
2. The SOC is greater than 20% for 10s.</td></tr>
<tr><td>SOC Warning</td><td>20%</td><td>15%</td><td>Remind customers to charge the battery and reduce the loads</td></tr>
<tr><td>SOC Protection Recovery</td><td>20%</td><td>20%</td><td>If the SOC is greater than 20% for 10s, the under voltage protection will be cleared, and the 12V circuit relay will be closed</td></tr>
<tr><td>Charge High Temperature Warning</td><td>50℃</td><td>50℃</td><td>If the temperature is higher than the warning temperature for 10s, a warning will be triggered and a warning message will be sent out immediately</td></tr>
<tr><td>Charge High Temperature Warning Recovery</td><td>45℃</td><td>45℃</td><td>If the temperature is lower than the warning recovery temperature for 10s, the warning will be cleared</td></tr>
</table>

Charge High Temperature Protection	55℃ (51.2V Circuit)	55℃ (51.2V Circuit)	**51.2V Circuit:** If the temperature is higher than the protection temperature of 51.2V circuit for 5s, the protection will be triggered, a pre-alarm message will be sent out immediately, and the relay will be opened after a delay of 5s
	57℃ (12V Circuit)	57℃ (12V Circuit)	**12V Circuit:** If the temperature is higher than the protection temperature of 12V circuit for 3s, the protection will be triggered, the switch of 12V circuit will be opened, and the BMS power will be cut off immediately
Charge High Temperature Protection Recovery	50℃ 51.2V Circuit & 12V Circuit	50℃ 51.2V Circuit & 12V Circuit	**51.2V Circuit:** If the temperature is lower than the protection recovery temperature for 10s, the protection will be released and the relay will be closed **12V Circuit:** If the battery is restarted or activated by PV charging after the battery temperature drops below the protection recovery temperature, the protection will be released, the switch of 12V circuit will be closed, and the BMS will restore power immediately
Discharge High Temperature Warning	55℃	55℃	If the temperature is higher than the warning temperature for 10s, a warning will be triggered and a warning message will be sent out immediately
Discharge High Temperature Warning Recovery	50℃	50℃	If the temperature is lower than the warning recovery temperature for 10s, the warning will be cleared
Discharge High Temperature Protection	60℃ 51.2V Circuit	60℃ 51.2V Circuit	**51.2V Circuit:** If the temperature is higher than the protection temperature of 51.2V circuit for 5s, the protection will be triggered, a pre-alarm message will be sent out immediately, and the relay will be opened after a delay of 5s
	62℃ 12V Circuit	62℃ 12V Circuit	**12V Circuit:** If the temperature is higher than the protection temperature of 12V circuit for 3s, the protection will be triggered, the switch of 12V circuit will be opened, and the BMS power will be cut off immediately
Discharge High Temperature Protection Recovery	55℃ 51.2V Circuit & 12V Circuit	55℃ 51.2V Circuit & 12V Circuit	**51.2V Circuit:** If the temperature is lower than the protection recovery temperature for 10s, the protection will be released and the relay will be closed

			12V Circuit: If the battery is restarted or activated by PV charging after the battery temperature drops below the protection recovery temperature, the protection will be released, the switch of 12V circuit will be closed, and the BMS will restore power immediately
Charge Low Temperature Warning	5℃	5℃	If the temperature is lower than the warning temperature for 10s, a warning will be triggered, a warning message will be sent out immediately, the heating pad will start working, and the BMS will request 20A charge current. If the actual charge current is greater than 25A, the BMS will need to request lowering the charge current
Charge Low Temperature Warning Recovery	10℃	10℃	If the temperature is higher than the warning temperature for 10s, the warning will be cleared, the heating pad will stop working, and the BMS will request 105A charge current. If the actual charge current is greater than 110A, the BMS will need to request lowering the charge current
Charge Low Temperature Protection	0℃ 51.2V Circuit	0℃ 51.2V Circuit	**51.2V Circuit:** If the temperature is lower than the protection temperature for 5s, the protection will be triggered, a pre-alarm message will be sent out, the relay will be opened with a delay of 5s, and the BMS will request 8A charge current. If the actual charge current is greater than 10A, the BMS will need to request lowering the charge current **12V Circuit:** The 12V circuit is not affected and is allowed to continue discharging
Charge Low Temperature Protection Recovery	5℃ 51.2V Circuit	5℃ 51.2V Circuit	If the temperature is greater than the protection recovery temperature for 10s, the protection will be released, the relay will be closed, and the BMS will request 40A charge current. If the actual charge current is greater than 45A, the BMS will need to request lowering charge current
Discharge Low Temperature Warning	-10℃	-10℃	If the temperature is lower than the warning temperature for 10s, a warning will be triggered, a warning message will be sent out, and the BMS will request lowering the discharge current by 50%
Discharge Low Temperature Warning Recovery	-5℃	-5℃	If the temperature is higher than the warning recovery temperature for 10s, the warning will be cleared
Discharge Low Temperature Protection	-20℃ 51.2V Circuit	-20℃ 51.2V Circuit	**51.2V Circuit:** If the temperature is lower than the protection temperature for 5s, the protection will be triggered, a pre-alarm message will be sent out immediately, and the relay will be opened after a delay of 5s

	-22℃（12V Circuit）	-22℃（12V Circuit）	**12V Circuit:** If the temperature is lower than the protection temperature for 20s, the protection will be triggered, the switch of 12V circuit will be opened, and the BMS power will be cut off immediately
Discharge Low Temperature Protection Recovery	-15℃ 51.2V Circuit & 12V Circuit	-15℃ 51.2V Circuit & 12V Circuit	**51.2V Circuit:** If the temperature is higher than the protection recovery temperature for 10s, the protection will be released and the relay will be closed **12V Circuit:** If the battery is restarted or activated by PV charging after the battery temperature rises above the protection recovery temperature, the protection will be released, the switch of 12V circuit will be closed, and the BMS will restore power immediately
Short Circuit Protection Delay	100ms	100ms	
Short Circuit Protection Current	1920A	1920A	Fuse I2t=1575000
Short Circuit Protection Recovery			Remove the short circuit and restart the battery
Uneven Temperature Primary Warning	15℃	15℃	If the temperature is higher than the primary warning temperature for 10s, a warning will be triggered and a primary warning message will be sent out
Uneven Temperature Secondary Warning	20℃	20℃	If the temperature is higher than the secondary warning temperature for 10s, a warning will be triggered and a secondary warning message will be sent out
Uneven Temperature Warning Recovery	10℃	10℃	If the temperature is lower than the warning recovery temperature for 10s, the warning will be cleared
Uneven Voltage Primary Warning	500mV	500mV	If the voltage is higher than the primary warning voltage for 10s, a warning will be triggered and a primary warning message will be sent out
Uneven Voltage Secondary Warning	800mV	800mV	If the voltage is higher than the secondary warning voltage for 10s, a warning will be triggered and a secondary warning message will be sent out
Uneven Voltage Warning Recovery	300mV	300mV	If the voltage is lower than the warning recovery voltage for 10s, the warning will be cleared

- **Battery 101**
  How to quickly calculate power for consumption, and recharge. There is a physical limit to the amount of stored energy, so energy must be budgeted. You can determine what each activity, or load will "cost you" in watt-hours. This will help you understand energy usage, and how to make your reserve last when a charging source in not available.

  To be able to manage energy, there needs to be a basic understanding of a few mathematic equations to convert energy from one source to the same source as the battery. The first step is a basic understanding

of electrical terms.

The battery is rated at 51.2VDC at 210Ah. An "Ah" is amp-hour, or a rating for battery capacity (electric charge) which means that it will supply 210 amps of current for one hour. This means that to determine the capacity that a load will consume we will need to use a few calculations to move the loads of various power sources to one value.

To make calculations easy, we will use watt-hours or Wh. Watts is a measure of power, and it's the product of the current and voltage of a specific load or device, and to determine power, simply multiply the wattage (in watts) by the time it's used (in hours). Example:

Coffee pot consumes 12.5A and it connects to the 120VAC outlet. (12.5A) x (120V) = 1500W

To determine the energy use (watt-hours) of the activity, first determine the load in watts and multiply by the time it's used (in hours). Example:

Making coffee for breakfast and the coffee pot was on for 30 minutes:
Wh = (1500W) x (.5 Hours) = 750Wh

The battery has 210 Ampere Hours at 51.2VDC, or 10,752Wh of energy available at 100% SOC. Each 1% of SOC (state of charge) is equal to 2.1A at 51.2VDC, or 107.52Wh (51.2V x 2.1A). To determine current reserve capacity, in SOC% left after the usage, divide the Wh's of usage by 107.52Wh to determine the SOC % that the activity would cost. Then you can compare that SOC percentage from the current SOC percentage to determine if you want to perform that activity. Continuing our example from above:

Making coffee for breakfast and the coffee pot was on for 30 minutes:
Wh = (1500W) x (.5 Hours) = 750Wh
SOC% = 750Wh/107.52Wh = 6.98%
SOC% Cost for 30 minutes of coffee is approximately 7% SOC

The display will give you current SOC%, and the aforementioned calculations can be used to determine what loads will cost in SOC, to help determine how long the current capacity can last before recharging. Recharging uses the same calculations so you simply convert the amps of charging to watt hours, then SOC%. The only difference is you add from current SOC% instead of subtract. To simplify this, a chart was comprised of typical loads and charge values, with corresponding Wh and SOC percentage are.

- **SOC Quick Reference for discharge:** Use the chart below as a quick reference for typical load SOC percentages to subtract from current SOC percentage for discharge times, see below:

USAGE (LOADS)(IN Wh)					*USAGE (LOADS)(SUBTRACT FROM SOC%*			
LOAD NAME	*WATT HOURS*				*AMP HOURS*			
	FOR 15 MIN.	*FOR 30 MIN.*	*FOR 45 MIN.*	*FOR 1 HOUR*	*FOR 15 MIN.*	*FOR 30 MIN.*	*FOR 45 MIN.*	*FOR 1 HOUR*
INTERIOR LIGHTS	10	20	30	40	0.09%	0.19%	0.28%	0.37%
EXTERIOR LIGHTS	12.5	25	37.5	50	0.12%	0.23%	0.35%	0.47%
WATER PUMP	15.6	31.3	46.9	62.5	0.15%	0.29%	0.44%	0.58%
AIR PUMP	45	90	135	180	0.42%	0.84%	1.26%	1.67%
ELWELL HEATING	448	896	1344	1792	4.17%	8.33%	12.50%	16.67%
CABIN AIR CONDITIONER	384	768	1152	1536	3.57%	7.14%	10.71%	14.29%
COOKTOP	375	750	1125	1500	3.49%	6.98%	10.46%	13.95%
COFFE MAKER	375	750	1125	1500	3.49%	6.98%	10.46%	13.95%
KEURIG (HEATING)	375	750	1125	1500	3.49%	6.98%	10.46%	13.95%
KEURIG (ON AFTER WARM)	100	200	300	400	0.93%	1.86%	2.79%	3.72%
MR COFFEE COFFEE POT	375	750	1125	1500	3.49%	6.98%	10.46%	13.95%
AIR FRYER	425	850	1275	1700	3.95%	7.91%	11.86%	15.81%

ELECTRIC GRILL	400	800	1200	1600	3.72%	7.44%	11.16%	14.88%
WAFFLE IRON	375	750	1125	1500	3.49%	6.98%	10.46%	13.95%
SPACE HEATER	375	750	1125	1500	3.49%	6.98%	10.46%	13.95%
1 HP VACCUM CLEANER	186.5	373.1	559.6	746.2	1.73%	3.47%	5.20%	6.94%
1/2 HP VACCUM CLEANER	93.3	186.5	279.8	373.1	0.87%	1.73%	2.60%	3.47%
TRAVEL HAIR DRYER LOW	225	450	675	900	2.09%	4.19%	6.28%	8.37%
TRAVEL HAIR DRYER MED	300	600	900	1200	2.79%	5.58%	8.37%	11.16%
TRAVEL HAIR DRYER HIGH	375	750	1125	1500	3.49%	6.98%	10.46%	13.95%

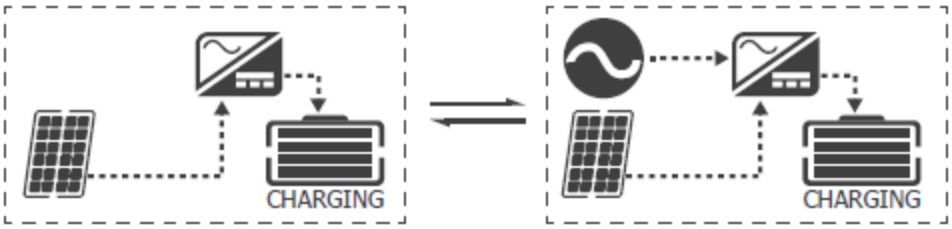
- **SOC Quick Reference for re-charge:** Use the chart below as a quick reference for typical load SOC percentages to add to current SOC percentage for recharge times, see below:

CHARGING (REPLENSHMENT) (IN Wh)					***CHARGING (REPLENSHMENT) (ADD TO SOC %)***			
SOURCE NAME	***WATT HOURS***				***WATT HOURS***			
	FOR 15 MIN.	***FOR 30 MIN.***	***FOR 45 MIN.***	***FOR 1 HOUR***	***FOR 15 MIN.***	***FOR 30 MIN.***	***FOR 45 MIN.***	***FOR 1 HOUR***
ALTERNATOR 1000 RPM	408.8	817.5	1226.3	1635	3.80%	7.60%	11.40%	15.21%
ALTERNATOR 1250 RPM	885.6	1771.3	2656.9	3542.5	8.24%	16.47%	24.71%	32.95%
ALTERNATOR 1400 RPM	1090	2180	3270	4360	10.14%	20.28%	30.41%	40.55%
ALTERNATOR 1600 RPM	1226.3	2452.5	3678.8	4905	11.40%	22.81%	34.21%	45.62%
ALTERNATOR 1700 RPM	1294.4	2588.8	3883.1	5177.5	12.04%	24.08%	36.12%	48.15%
ALTERNATOR 1800 RPM	1362.5	2725	4087.5	5450	12.67%	25.34%	38.02%	50.69%
ALTERNATOR 2150 RPM	1430.6	2861.3	4291.9	5722.5	13.31%	26.61%	39.92%	53.22%
ALTERNATOR 2500 RPM	1498.8	2997.5	4496.3	5995	13.94%	27.88%	41.82%	55.76%
ALTERNATOR 3000 RPM	1566.9	3133.8	4700.6	6267.5	14.57%	29.15%	43.72%	58.29%
INVERTER CHARGER FULL	545	1090	1635	2180	5.07%	10.14%	15.21%	20.28%
INVERTER CHARGER 75%	408.8	817.5	1226.3	1635	3.80%	7.60%	11.40%	15.21%
INVERTER CHARGER 50%	272.5	545	817.5	1090	2.53%	5.07%	7.60%	10.14%
INVERTER CHARGER 25%	100	200	300	400	0.93%	1.86%	2.79%	3.72%
SOLAR BANK ROOF (FULL)	50	100.1	150.1	200.1	0.47%	0.93%	1.40%	1.86%
SOLAR BANK ROOF (50%)	25	50	75.1	100.1	0.23%	0.47%	0.70%	0.93%
SOLAR BLANKET EXT. (FULL)	75.1	150.1	225.2	300.2	0.70%	1.40%	2.09%	2.79%
SOLAR BLANKET EXT. (50%)	37.5	75.1	112.6	150.1	0.35%	0.70%	1.05%	1.40%

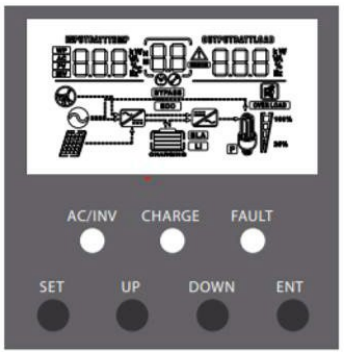
Inverter Charger

The Renogy Solar Inverter Charger is an advanced hybrid system combining the advanced charging algorithm of solar and industrial reliability and electrical energy of pure sine wave inverters to give you a complete power system. The unit features 4 charging modes and 3 output modes to meet an array of application needs. The recommended charging mode is:

- **Hybrid Charging:** In Hybrid Charging, PV and Utility will work together to charge the battery bank at the same time. Priority will be given to PV and utilize MPPT charging. Upon PV charging being insufficient, the power supply replenishes with Utility power. This method is the fastest to charge and suitable for unstable areas of the grid, ready to provide adequate backup power supply.



- **Renogy BT-2 Bluetooth Module:** The BT-2 Bluetooth module used to pair charge controllers with the Renogy BT App. After pairing is done you can monitor your system and change parameters directly from you cell phone or tablet. You can see performance in real time without the need of checking on the controller's LCD.



- **Inverter Settings:** Process for updating/changing the inverter parameters includes:
  A. Remove access cover to access the 48V Solar Inverter.
  B. Review the option numbers before starting to reset inverter parameters. When reviewing and updating the Inverter Settings, it is recommended to start with option #8. It must be set for LF16. With option #8 changed, it will set many of the options (green highlighted). Yellow highlighted items are those which should have be manually set.
  C. Change all necessary parameters:
     1. Select the 'SET' button
     2. With the double '00' flashing, press the 'UP' button until parameter number desired to change.
     3. Press the 'ENT' button
     4. With the parameter value flashing, press the 'UP' or 'DOWN' button until desired value is selected.
     5. Press the 'ENT' button
     6. Press the 'SET' button to close out the settings.

- **Power Shore Settings:** In order to change the AC Charging Current where the connection is less than 120VAC 30A. The inverter/charger rate may need to be reduced. Utilizing the inverter setting process above, change parameter 28 'AC Charging Current' from 0-40A by intervals of 5A to desired charging current. For reference, here are the recommendations for setting #28:
  - 15A shore: 20A DC
  - 20A shore: 25A DC
  - 30A shore: 40A DC

Inverter Settings

OPTION #	DESCRIPTION	SETTING	DEFAULT OR CUSTOM
00	EXIT	N/A	
01	LOAD WORKING MODE	UTILITY	DEFAULT
02	OUTPUT FREQUENCY	60	DEFAULT
03	AC INPUT VOLTAGE RANGE	UPS	DEFAULT
04	BATTERY POWER UTILITY SETPOINT	44.0V	DEFAULT

05	UTILITY TO BATTERY POWER SETPOINT	58.8V	DEFAULT
06	BATTERY CHARGING MODE	SnU	DEFAULT
07	MAXIMUM CHARGING CURRENT	80A	DEFAULT
08	BATTERY TYPE	L16	CUSTOM SET POINT
09	BOOST CHARGE VOLTAGE	53.6V	CUSTOM SET POINT
10	BOOST CHARGE DURATION	VARIABLE UNTIL FULL	DEFAULT
11	FLOAT CHARGE VOLTAGE	N/A	DEFAULT
12	LOW VOLTAGE LOAD DISCONNECT	50.0V	CUSTOM SET POINT
13	BATTERY OVER DISCHARGED DELAY TIME	30 s	CUSTOM SET POINT
14	BATTERY UNDERVOLTAGE ALARM	50.4V	CUSTOM SET POINT
15	BATTERY DISCHARGE LIMIT VOLTAGE	49.6V	CUSTOM SET POINT
16	SET EQUALIZATION CHARGING	N/A	DEFAULT
17	BATTERY EQUALIZATION VOLTAGE	N/A	DEFAULT
18	BATTERY EQUALIZATION DURATION	N/A	DEFAULT
19	BATTERY EQUALIZATION TIME DELAY	N/A	DEFAULT
20	EQUALIZATION INTERVAL	N/A	DEFAULT
21	ENABLE EQUALIZATION IMMEDIATELY	N/A	DEFAULT
22	POWER SAVING MODE	DIS	DEFAULT
23	OVERLOAD AUTOSTART	ENA	DEFAULT
24	OVERTEMPERATURE AUTOSTART	ENA	DEFAULT
25	BUZZER ALARM	ENA	DEFAULT
26	ALARM	DIS	CUSTOM SET POINT
27	OVERLOAD BYPASS	ENA	DEFAULT
28	MAXIMUM D/C CHARGING CURRENT	40A	DEFAULT
29	SPLIT PHASE	DIS	DEFAULT
30	N/A	N/A	N/A
31	N/A	N/A	N/A
32	N/A	N/A	N/A
33	N/A	N/A	N/A
34	N/A	N/A	N/A
35	LOW VOLTAGE DISCONNECT RECOVER	51.6V	CUSTOM SET POINT
36	PV CHARGING CURRENT	80A	DEFAULT
37	BATTERY CHARGING BOOST RETURN SETPOINT	52V	DEFAULT
38	AC OUTPUT VOLTAGE SETTING	120	DEFAULT
39	MAX AC INPUT CURRENT	30A	CUSTOM SET POINT

Inverter Fault Codes

Fault code	Fault name	Description
【01】	BatVoltLow	Battery under-voltage alert
【02】	BatOverCurrSw	Battery discharge current software protection
【03】	BatOpen	Battery not detected
【04】	BatLowEod	Battery under voltage stop discharge alarm
【05】	BatOverCurrHw	Battery overcurrent hardware protection

【06】	BatOverVolt	Charge overvoltage protection
【07】	BusOverVoltHw	Bus overvoltage hardware protection
【08】	BusOverVoltSw	Bus overvoltage software protection
【09】	PvVoltHigh	PV overvoltage protection
【10】	PvBuckOCSw	Buck Overcurrent Software Protection
【11】	PvBuckOCHw	Buck Overcurrent Hardware Protection
【12】	bLineLoss	utility power down
【13】	OverloadBypass	Side-by-side load protection
【14】	OverloadInverter	inverter overload protection
【15】	AcOverCurrHw	Inverted overcurrent hardware protection
【17】	InvShort	Inverter short-circuit protection
【19】	OverTemperMppt	Controller over-temperature protection
【20】	OverTemperInv	inverter over temperature protection
【21】	FanFail	Fan failure
【22】	EEPROM	Memory failure
【23】	ModelNumErr	Model settings are wrong
【26】	RlyShort	Error between AC output and bypass
【29】	BusVoltLow	Internal battery boost circuit failure

Rooftop Solar Array

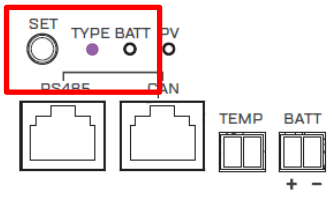
There are two (2) DC disconnect switches installed in the rooftop solar array. One is located on top of the roof and one is located inside the unit near the inverter location. It is important that both switches are in the "ON" position when rooftop solar is needed.

Rover Boost Charge Controller (Exterior Solar Blanket)

The Rover Boost controller is a 10Amp Maximum Power Point Tracking (MPPT) charge controller engineered to charge the 48V battery bank. Featuring multi-stage battery charging (Bulk, Boost, Float, and Equalization), the Rover Boost is pre-set to be compatible with Lithium batteries, and even includes custom battery settings. The Rover Boost is packed with numerous battery bank, controller, and solar electronic protections for an optimized system. Key features include:

- Self-adaptable to a wide solar panel input voltage for appropriate battery charging.
- Multi-Function LEDs displaying system information and identifying any errors.
- 4 Pre-set battery charge profiles includes Lithium batteries.
- Multiple battery bank, controller, and solar electronic protections including over-charge protection, reverse polarity protection, and more.
- RS485 communication port for monitoring using the Bluetooth module and Renogy DC Home App.

Battery Setup: Your unit should be pre-set with the correct battery type. The LED Indicators and SET button are found on the OUTPUT side of the Rover Boost.



- Programming: Set Battery Type to Purple LED - To change or set the battery type, long press the SET button for approximately 8 seconds. The Type Indicator will flash a color depending on the battery type indicated below. Tap the SET button to change between battery types until color PURPLE is showing.

LED Indicators: The Rover Boost LED indicators work to provide battery type information, battery status information, and solar charging information.

BATT LED	Color	Behavior	Charge State
●	Green	***Always on*** Bright, always on	Battery is fully charged
●	Yellow	***Always on*** Bright, always on	Battery voltage is normal
●	Red	***Always on*** Bright, always on	Battery undervoltage warning
●	Red	***Slow Flashing*** ON 1 second, OFF 1 second, cycle is 2 seconds	Battery over discharged disconnected
●	Red	***Quick Flashing*** ON 0.1 second, OFF 0.1 second, cycle is 0.2 seconds	Battery Overvoltage or Over temperature
○	---	***OFF***	Battery is not detected

PV LED	Color	Behavior	Charge State
●	Green	***Always on*** Bright, always on	MPPT Bulk Charging
●	Green	***Slow Flashing*** ON 1 second, OFF 1 second, cycle is 2 seconds	Boost Stage
●	Green	***Single Flash*** ON 0.1 second, OFF 1.9 seconds, cycle is 2 seconds	Float Stage
●	Green	***Quick Flashing*** ON 0.1 second, OFF 0.1 second, cycle is 0.2 seconds	Equalization Charge
●	Green	***Double Flashing*** ON 0.1 seconds, OFF 0.1 second, ON 0.1 seconds OFF 1.7 seconds	Lithium Activation or Power Limiting
○	---	***OFF***	PV is not charging or not detected

Renogy BT-2 Bluetooth Module: Pair the controller to the Renogy DC Home App to monitor your system using a smart device like a cell phone or tablet. Set custom charging parameters using User Mode and monitor your system in real time.

APS-500 Alternator Regulator

The APS-500 provides control over alternator-based charging by utilizing system voltage, current monitoring and alternator and battery temperature to ensure safe and powerful charging. The APS-500 Alternator Regulator is equipped with a multi-color LED which provides a range of operational and advisory codes. The LED is visible via a waterproof bezel located on near the lower left corner of the label on the regulator's cover.

WARNING: Turn off switches and disconnect your batteries prior to installing your APS-500 Alternator Regulator or other electrical system components. Failure to do so may cause damage or injury. Do not reconnect batteries until wiring is complete, and ensure wires are connected correctly.

There are three modes of information provided:

- Orange (Flashing) = Synced with the battery BMS
- Green = Lost communication with the battery BMS
- Red (Flashing) = Error/Advisory mode

Should the APS-500 determine that a condition is outside of normal limits, it will display a red flashing LED pattern, followed by a series of flashes indicating the type of fault occurring. Most errors are hard-faults, indicating a condition which the APS-500 Alternator Regulator is unable to decipher and as such will shut down until corrected, in order to prevent any potential systems or battery damage. A few errors will attempt to auto-restart to see if the failing condition clears (example, error low battery voltage). When a fault is detected, the APS-500 will flash the "Error" code twice, followed by a series of flashes indicating the fault/error number. Note: the LED will only indicate the most recent fault detected.

- Ignore the fast flashes.
- Start counting the number of flashes to provide you the first digit of the error code.
- There will be a short pause.
- Start counting the number of flashes to provide you the second digit of the error code.

In some models, the APS-500 is not easily accessible via an access panel. In these vehicles, a secondary light has been added.

APS-500 Alternator Regulator Codes

Error Code	Description
12	Battery temperature exceeded limit
13	Battery voltage exceeded upper limit
14	Battery voltage below lower limit
21	Alternator temperature exceeded limit
22	Alternator rpms above expected value
23	Alternator #2 temperature exceeded limit

24	Alternator temperature exceeded limit during ramp
31	Global Variable charging state has some unsupported value in check for faults
32	Global Variable charging state has some unsupported value in manage alt
33	Global Variable cpIndex has some unsupported value in calculate alt targets
34	Global Variable cpIndex has some unsupported value in check for faults
35	Global Variable SystemAmpMult has some unsupported value in check for faults
41	Internal Field FET temperature exceed limit.
42	A 'Required' sensor is missing, and WS500 is configured to FAULT out
51	A CAN message was received that the battery charging bus has been disconnected
52	We have noted that a command has been sent asking for the battery bus to be disconnected
53	Battery Instance number is out of range (needs to be from 1..100)
54	Too many different BMS's are asking to be aggregated
57	A CAN command has been received asking for the battery but to be disconnected due to Low Voltage
58	A CAN command has been received asking for the battery but to be disconnected due to High Current
59	A CAN command has been received asking for the battery but to be disconnected due to High Battery Temperature
61	A CAN command has been received asking for the battery but to be disconnected due to Low Battery Temperature
62	A CAN command has been received that the battery has reached its upper limit, but not yet disconnecting. Charging should stop.

Frequently Asked Questions (FAQ)

How long does it take to fully charge the Lithium Battery?

- There are a number of variables surrounding the length of time to fully charge the Lithium Battery.
- The Inverter Boost Charge Voltage (setting #9) should be set to 53.6V most of the time. The system can be charged utilizing alternator, shore power and/or solar.
- The battery needs to be maintained above 20% SOC, Total Voltage ≥ 50.0V and/or Minimum Cell Voltage ≥3100mV. When any of the parameters are met, a recharge cycle needs to take place. This can be completed by either connection to 120VAC 30A source or starting the engine to allow the engine driven alternator/generator to recharge the battery.

What is my Battery Operation Status?

- The battery contains a battery management system (BMS) that warns you and protects the battery from over-voltage, under-voltage, over-current, short circuit, high temperature, low temperature, uneven temperature, uneven voltage, and insulation fault. At the Battery Operation Status, you will find a number between 0-3.
  0 = Normal (NO faults and all operating values are within normal range)
  1 = Warning – message will clear when the system recovery value is reached
  2 = Alarm – requires a battery restart when the system recovery value is reached
  3 = Protection – requires a battery restart when the system recovery value is reached
- It is important to note that a lithium battery fault may affect multiple components. By first looking at the battery monitor screen (Renogy Samkoon), it will help diagnose the root cause of the fault and allow for the fault to be corrected. Once the battery fault is corrected, all other erroneous faults will be cleared from alternator regulator. The most common faults are under-voltage, over-voltage and under-temperature. It is important to know that the severity number of the fault, which is indicated in the second bubble below the battery is a 1 (warning), 2(alarm), 3(protection). Any condition with the fault level of 1 or warning is self-recoverable, and will correct itself once the level of the waring is reduced.

How do I verify that the Lithium Battery is charging?

- On the Samkoon Screen:
  - Review the Top Bubble which states Charge or Discharge.
  - Review the Total Current - Negative Current means the system is discharging and positive current means charging.
    - Alternator: Depending on total voltage and other circumstances, the typical total current can range from 0-100A.
    - Shore Cord: Depending on total voltage and other circumstances, the typical total current can range from 0-40A.
    - Solar Power: Depending on total voltage and other circumstances, the typical total current can range from 0-4A.

- On the Inverter Screen, review to ensure that the inverter is showing the solar and/or utility charging:

If my Lithium Battery has a fault, what do I need to do?

Refer to the BMS Warnings & Protections chart in the 51.2V 210Ah Lithium Battery section (above) for the triggering and recovery condition of each warning and protection.

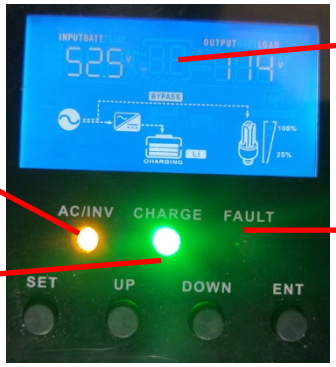
- Most common faults are Battery Under-Voltage, Battery Cell Over-Voltage and Charge Low Temperature.
  - **Battery Under-Voltage or Cell Under-Voltage**: plug in the shore cord to charge the lithium battery to the recovery condition.
  - **Battery Over-Voltage or Cell Over-Voltage**: remove any charging sources and utilize the 12V or 48V system to draw down the battery to the recovery condition.
  - **Charge Low Temperature**: Bring the unit inside to allow the unit to warm or warm the unit with the internal heaters by connecting the shore power, it will provide a stable charge current greater than 8A required for the self-heating function to operate normally.
- NOTE: Warnings will automatically disappear and Protections will require restarting the Lithium Battery.

How do I verify my shore power is charging on the inverter?

Orange light will flash while inverting.

Orange light will be solid when shore power is connected.

Green light will flash while charging.



Fault Code Display

Red light will be solid during a fault with a buzzing alarm

Inverter Charger On/Off Remote
Green Light = Inverter Powered

Inverter Charger On/Off Remote
Red Light = Inverter Fault

- The Inverter remote switch must be in the ON position and the AC/INV light on the Inverter Screen must be a solid Orange light indicating the shore power is connected.
- On the Renogy Inverter Remote Switch, verify that the Red light is off and/or review the Inverter Screen to see if any Inverter Faults are present. The most common faults are 03 (Battery Not Detected) and 04 (Battery Under-voltage).

How do I verify my rooftop solar power is charging?

- There two different solar options for the Lithium System:
  - There are 4 50W solar panels mounted on the roof, wired in series to create a 74.4VDC 200W solar array that is connected to the 3500W 48V MPPT inverter / charger, to recharge the 51.2VDC 210 aH Lithium Ion battery.
  - There is a factory installed Rover Boost DC to DC charge controller connected to the factory installed external solar port to recharge the 51.2VDC 210 aH Lithium Ion battery.
- The rooftop solar panels are connected to an emergency disconnect switch on the roof and a secondary disconnect switch near the inverter. There are multiple solar connections dependent on production build:
- Units prior to MY2024, the solar routes through the inverter to the lithium battery.
  - On the inverter LCD screen, press the down button to cycle through the screens until they get to the one that shows PV Input Voltage on the left side of the screen and PV Output Current on the right side of the screen.
  - The PV Input Voltage must be over 60V for solar to charge from the 200W solar array on the roof. The PV Output Amps (A) charge output displays how many Amps the solar is charging.

Inverter Display Screen

Press the DOWN button twice to get to the PV Screen from Main Screen

- Units built after MY2024, the solar routes through the Victron Solar Controller to the lithium battery.
  - Use the Victron Connect APP. The PV Input Voltage must be over 60V for solar to charge from the 200W solar array on the roof. The PV Output Amps (A) charge output displays how many Amps the solar is charging. Solar will produce about 3-5A on sunny day

Why is my Alternator not charging the battery?

- The APS-500 Voltage Regulator is the component that regulates the alternator charging by getting messages from the battery BMS. There is a light on the voltage regulator:
  - Orange (Flashing) = Synced with the battery BMS
  - Green = Lost communication with the battery BMS
  - Red (Flashing) = Error/Advisory mode
- Should the APS-500 determine that a condition is outside of normal limits, it will display a red flashing LED pattern, followed by a series of flashes indicating the type of fault occurring. Most errors are hard-faults, indicating a condition which the APS-500 Alternator Regulator is unable to decipher and as such will shut down until corrected, in order to prevent any potential systems or battery damage.
- A few errors will attempt to auto-restart to see if the failing condition clears (example, error low battery voltage). When a fault is detected, the APS-500 will flash the "Error" code twice, followed by a series of flashes indicating the fault/error number.
  Note: the LED will only indicate the most recent fault detected.

What needs to be done to clear Charge Low Temperature Warning and/or Protection?

- With the system shut down for long periods of storage, it is not necessary to keep the unit connected to shore power. However, shore power will need to be connected if the temperature drops below 10°C (50°F) for charging
- The heat process may take 15-20 minutes to activate and begin warming the cell temperature enough to re-charge the battery bank. The warming process could take up to one hour or longer.
- The inverter/charger will charge at 8A to heat the battery, and once the minimum cell temperature reaches 5° the charging contactor will close, and full charging will begin.
  NOTE: With the shore power connected, it is common to hear clicking and to see the shore power to connect and disconnect on the inverter. Leave the shore power connected and allow time to complete the warming process.
  NOTE: Once the warming process is completed, it will take additional time to charge completely.

Does my battery draw power to heat the battery in cold weather?

- The normal operation of the heating function requires a stable charge current greater than 8A. The self-heating function will start operating automatically once the battery temperature drops below 41°F (5°C) and stop operating automatically once the battery temperature rises above 50°F (10°C).
- The self-heating function will not be able to operate normally if the unit is not connected to shore power, and the Inverter Maximum A/C Charging Current (setting #28) is not greater than 5A. The solar array is not large enough to preheat the battery.

What do I need to do if my battery goes into Battery Over-Voltage or Cell Over-Voltage Protection Mode?

- To begin the recovery process, disconnect any external 120VAC (up to 30A) power source and turn off the secondary solar switch. Ensure that the inverter/charger power switch is in the "ON" position.
  - If a Warning occurs, the message will automatically clear itself once the recovery threshold is met.
  - For a Protection (hard fault), the protection mode will need to be cleared by allowing the cell voltage to reach the recovery and restarting the battery.

  NOTE: With the new lithium battery firmware 137.3.13, the 48V side will stop operating but the 12V side will continue to work as an attempt to lower the cell voltage.

What do I need to do if my battery goes into Battery Under-Voltage or Cell Under-Voltage Protection Mode?

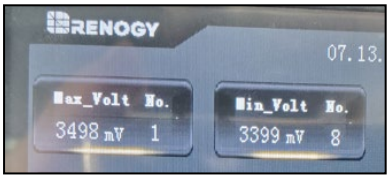
- To begin the recovery process, connect the RV to an external 120VAC (up to 30A) power source, and ensure that the inverter/charger power switch is in the "ON" position.
    - For a Protection (hard fault), the protection mode will need to be cleared by allowing the cell voltage to reach the recovery and restarting the battery.
- When the unit is depleted below 10% SOC, this can cause the SOC% and voltage levels to be out of calibration, the only way to recalibrate the BMS is to charge the unit to 54.4V which will re-calibrate the SOC to 100%.
  NOTE: If a battery is allowed to let the minimum cell voltage to be lower than 2000mV, it is unlikely that the lithium battery can be recovered.

Why is the SOC% (State of Charge) not showing on the Firefly Screen?

- When the unit is depleted below 10% SOC, this can cause the SOC% and voltage levels to be out of calibration.
- There are times when you will see that this system's total voltage is either increasing or decreasing but the SOC% may appear to be locked on a certain percentage. The BMS (Battery Management System) can fall out of calibration over time.
- When this occurs, change the inverter #9 setting to 54.4 and fully charging the battery with shore power. It will recalibrate the battery BMS.
  NOTE: After calibration, it is recommended to re-set Inverter setting #9 back to 53.6V.

Troubleshooting Guide

Lithium Battery		
Problem/symptom	**Possible causes**	**Solution**
Attempt to turn on battery, but reset button doesn't initiate startup sequence - nothing happens	The reset switch may be installed backwards	Unplug the switch and verify the tab lines up with the latch, and the terminals of the switch line up with the terminals in the connector
	Battery or Cell under-voltage protection	* Connect the unit to an external 120VAC power source, and ensure that the inverter/charger power switch is in the "ON" position.
Attempt to turn on battery, but screen turns off when let go of reset switch or all information reads (0)	Battery internal fuse may have blown	Replace internal fuse - contact Dehco (See Must Read Before Operating section on page 2)
The battery turns on, but there is no 48V power	Fuse in the battery may be blown	Replace fuse/BDU - contact Dehco (See Must Read Before Operating section on page 2)
	The contactor in the battery may be stuck open	Replace BDU - contact Dehco (See Must Read Before Operating section on page 2)
The battery turns on, but there is no 12V power	Fuse in the battery may be blown	Replace fuse/BDU - contact Dehco (See Must Read Before Operating section on page 2)
	The contactor in the battery may be stuck open	Replace BDU - contact Dehco (See Must Read Before Operating section on page 2)
	The DCDC converter may be defective	Replace BDU - contact Dehco (See Must Read Before Operating section on page 2)

The battery doesn't turn off (12V or 48V)	The contactor in the battery may be stuck closed	Replace BDU - contact Dehco (See Must Read Before Operating section on page 2)
The battery charge doesn't last as long as expected	The battery may be too cold (reduces capacity)	Maintain the battery temperature above 23°F (-5°C) during discharge.
	The water heater may be on (high power draw)	Turn off the water heater, if not needed
	The battery cells may be excessively imbalanced	Contact Dehco (See Must Read Before Operating section on page 2)
The battery will not charge	Battery voltage may be too high	Inverter setting #37 is 52V - The unit will need to discharge before charging
Cell imbalance	If the max cell reads 8,000mV or similar, the cell is likely compromised and the battery should be replaced	Contact Dehco (See Must Read Before Operating section on page 2)
	If the min cell is under 2,000mV, the cell is likely compromised and the battery should be replaced	Contact Dehco (See Must Read Before Operating section on page 2)
	Cell Imbalance is determined when: 1. A single cell (max voltage cell) reaches 3400mV and 2. The voltage difference between the max voltage cell and min voltage cell is above 60mV. 	1. Review the Samkoon screen to verify the system is not any alarm state – warning or protections. 2. With the lithium system operational and clear of any faults, discharge the system to below 53.0V and/or 90% SOC. 3. Change inverter settings: A. Setting #9 Boost Charge Voltage = 53.6V B. Setting #28 Maximum AC Charging Current = 5A 4. Connect the unit to an external 120VAC (up to 30A) power source. 5. Continue to charge with shore power until the unit's cell imbalance has cleared or the Total Current reaches a consistent 0.0A. If the unit is left in the charging stage for an extended period, it should be observed that the voltage difference reduces to under 60mV. **NOTE: Dependent on the lithium battery condition, balancing may take 1-2 days.**
Battery/Cell under-voltage Warning on Samkoon	Unit was allowed to continue to discharge below the warning/protection thresholds	* Connect the unit to an external 120VAC power source, and ensure that the inverter/charger power switch is in the "ON" position * If the unit exceeded the warning or protection threshold, allow the unit to charge above 50.4V and/or 3250mV. * If the unit exceeded the protection threshold, the unit will need to reach the recover set point and re-start the lithium battery system.

Battery/Cell over-voltage Warning on Samkoon	Inverter Setting #9 set higher than 53.6V.	* Verify and change the inverter setting to 53.6V * If the unit exceeded the warning or protection threshold, allow the unit to discharge below 56.0V and/or 3400mV. * If the unit exceeded the protection threshold, the unit will need to reach the recover set point and a manual re-start of the lithium battery system. 1. Disengage self-locking switch 2. Re-engage self-locking switch 3. Press and Hold self-reset switch until battery and Samkoon powers back ON.
Charge Low Temperature Warning on Samkoon	If the battery is lower than 32°F (0°C) for more than 10 seconds, the battery protection mode will engage.	* Warm the interior of the vehicle to a minimum of 41°F (5°C) * The inverter/charger will charge at 8A to heat the battery, and once the minimum cell temperature reaches 5° the charging contactor will close, and full charging will begin.

Inverter/charger

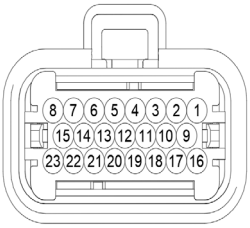
Problem/symptom	Possible causes	Solution
The inverter won't turn ON	The battery is OFF	Turn the battery ON
	The inverter remote switch is OFF	Turn the inverter remote switch ON
	The inverter main switch is OFF	Locate the switch on the inverter and set to "REM" so it will work with the remote switch 
	The inverter has a fault of some kind (Low battery, over temp, etc.)	Observe the inverter screen, note any fault codes, compare to the inverter fault table
The inverter stays on even though the remote switch is turned off	The inverter main switch is ON	Locate the switch on the inverter and set to "REM" so it will work with the remote switch.
The charger doesn't charge the battery	There is no AC power to the inverter/charger	* Verify the power shore cord and the circuit breaker is ON * Check for loose wiring connection Check the inverter screen to see if it indicates incoming AC power
	Charge rate set too low or 0A	Check inverter setting #28, it should be in the range of 5-40A, depending on shore power available
The inverter beeps randomly through the day	Output from the rooftop solar panels is on the threshold of operating the inverter	* Eliminate any shade/shadows from the solar panels * Turn off the beep feature in the inverter settings (this will also silence any other faults)

Screen not displaying	Inverter in sleep mode	Click any button on the screen to exit screen sleep mode.
	Battery connections	Verify the battery is properly connected and charged to be able to recognize the solar inverter.
Battery over-voltage protection	Battery over-voltage	Measure whether the battery voltage exceeds 60Vand disconnect the photovoltaic array from and the power-on.
Battery under-voltage protection	Battery under-voltage	Wait until the battery is charged to return to above the low voltage recovery voltage.
Fan failure	Check that the fan is not turning or is blocked by something else.	If fan failure, contact Dehco. (See Must Read Before Operating section on page 2)
Over-temperature Protection	internal temperature of the unit is too high and causes the unit to stop charging and discharging (131°F/55°C)	Normal charge and discharge control is restored when the temperature of the equipment cools.
Overload Protection	Too much load	* Reduce the use of electrical equipment * Restart the solar inverter charger and load recovery output
Inverter short-circuit protection	Inverter protects and stops when the external battery port is shorted while the PV or AC is charging stop the output current.	* Disconnect or reduce any loads from the unit. * Shut down the solar inverter charger and turn on again to clear the error.
PV overvoltage	Check with the meter if the PV input voltage is above the maximum allowable input voltage of 145 V operating voltage.	Reduce the PV input voltage below the maximum allowable input voltage of 145 V operating voltage.

Firefly multiplex control system

Problem/symptom	Possible causes	Solution
No battery data on Firefly screen / 0% SOC	The battery has a fault	* Observe the battery screen (Samkoon) for any fault information * Correct any faults
	The alternator regulator has a fault	* The LED on the regulator is red or flashing red Count the flashes and compare to the fault table locate in the APS-500 Alternator Regulator section. * Correct any faults
	The Firefly system isn't communicating with the regulator	Check RV-C wiring connections and verify network termination resistance is ~60Ω
The screen flickers excessively, continuously	The DCDC converter may be defective - low voltage or noisy DC	Replace BDU - contact Dehco (See Must Read Before Operating section on page 2)

Alternator charging system

Problem/symptom	Possible causes	Solution
Alternator doesn't charge the battery	RPM at idle (too low)	RPM should be approximately 1000 or greater
	The battery is turned off	Turn on the battery
	The house disconnect is turned off	Turn on the house disconnect
	Blown fuses	Verify the 10A and 3A fuses are not blown and seated correctly. NOTE: some units may be built with the 3A fuse as part of the fuse panel.
	The alternator regulator has a fault	* The LED on the regulator is red or flashing red Count the flashes and compare to the fault table located in the APS-500 Alternator Regulator section. * Correct any faults
	The battery has a fault	* Observe the battery screen (Samkoon) for any fault information * Correct any faults
	The regulator isn't communicating with the battery	The LED on the regulator may be green in color Check RV-C wiring connections and verify network termination resistance is ~60Ω
	No 12V power supply to the regulator	* Measure voltage from pin 20 to pin 4, should be ~12V * No voltage indicates a blown fuse or battery disconnect turned off
	No 48V power supply to the regulator	* Measure voltage from pin 8 to pin 4, should be ~48-54V * No voltage indicates a blown fuse
	Field circuit to alternator shorted to ground or open	Measure resistance from pin 6 to pin 4, should be ~45Ω; lower is a short circuit, higher is an open circuit
	The regulator may be defective	* Likely caused by R&R regulator while 48V battery power is ON. * Indicated by the LED on the regulator never turning ON. * Replace the regulator
		

48V Air Conditioner

Problem/symptom	Possible causes	Solution
The A/C doesn't work at all	Problem with 48V wiring at the A/C	* Check connections at the A/C, ensure it has blue twist caps or gray Anderson connector * Perform TSB 22-075, if not done already

	No 48V power supply to the A/C	Remove the inside cover and measure voltage at the A/C, should have battery voltage (~48-54V) Inspect fuse If fuse is blown measure resistance of power wire to ground to ensure no short circuit, then replace fuse
	No 12V power supply to the A/C control circuits	Remove the inside cover and inspect the wiring connections Measure voltage on the compressor and fan wires to see if getting expected voltage
When calling for cooling, the compressor and outside fan turn on, but the inside fan doesn't turn on	No 12V power supply to the A/C control circuits	Remove the inside cover and inspect the wiring connections Measure voltage on the fan wire to see if getting expected voltage
	Wiring issue at the A/C connection	Remove the inside cover and inspect the wiring connections Verify the wires are connected to the A/C wires correctly Measure voltage on the fan wire to see if getting expected voltage
	Wiring issue inside the A/C	The wiring inside the A/C may be connected incorrectly, in which case the A/C should be repaired, but alternatively the wiring connection could be re-pinned to align the circuits accordingly
When calling for cooling, the inside fan turns on, but the outside fan and compressor don't run/air doesn't get cold	Delay currently in effect	The control system will impose a delay (2-5imn) if the A/C was recently turned off, to allow residual pressure in the refrigerant system to dissipate before restarting the compressor
	No 12V power supply to the A/C control circuits	Remove the inside cover and inspect the wiring connections Measure voltage on the compressor request wire to see if getting expected voltage
	Wiring issue at the A/C connection	Remove the inside cover and inspect the wiring connections Verify the wires are connected to the A/C wires correctly Measure voltage on the compressor wire to see if getting expected voltage
	Wiring issue inside the A/C	The wiring inside the A/C may be connected incorrectly, in which case the A/C should be repaired, but alternatively the wiring connection could be re-pinned to align the circuits accordingly

Rover Boost Charge Controller (Optional Solar Blanket)

Problem/symptom	Possible causes	Solution
Solar Blanket isn't charging the battery	Too much shade on the solar panels	Move the vehicle to a better location, or wait for better conditions
	Rover Boost Charge Controller	Review the electronic protections

The system is dead; no LEDs	No battery Power	The battery may be experiencing an electronic protection, see disconnected, over-discharged, reverse polarity, over/under temperature in BATT chart above for individual fixes.
PV will not display or charge	PV Reverse Polarity	The panels are connected to the controller but not charging or not detected. 1. Use a multi-meter to verify a PV voltage as well as the voltage being within 15 – 40VDC 2. Use a multi-meter to verify the correct positive and negative polarity matches the polarity seen on the OUTPUT port.
	PV Over-Voltage	The panel's voltage is higher than the controller's maximum input. 1. Use a multi-meter to verify a PV voltage as well as the voltage being within 15 – 40 VDC. 2. Check your solar panel input against your battery system voltage. Use a multi-meter to check that the incoming voltage is within 15 ~ 40VDC for 48V systems. If this is a 36V system, the PV voltage should not exceed 15 ~ 25VDC.
Charging current is lower than expected; PV current may also be low	Float mode	The controller is normally operating in a Float mode, where the current is reduced to control and maintain the battery.
	Shaded Panels	Inspect the solar panels for any dust or debris on the surface. Clear anything creating shade to resume normal operation
	Low Insolation	Atmospheric conditions such as low clouds, haze, sun setting will reduce the panel output as the insolation conditions also drop attributing the lower power output. Clearer conditions will increase performance.
	High Temperature	While not outside of operating conditions, higher temperature reduce the efficiency of the solar panels with excess heat, where the maximum power voltage is not much higher than the battery voltage, leaving little to Boost.
	Improper Wiring	The panels are experiencing higher voltage drop due to undersized wiring, poor connections, or perhaps higher environmental conditions. Double check and secure all connections and verify correct gauges.
Rover Boost was Charging but then stopped	High ambient temperature	High temperature or residual temperature may prevent the controller from resuming charge. Ventilate the charge controller location or reduce PV power to lower heat.
Rover Boost not charging properly	Incorrect Battery Type	If you have a 48V Battery, make sure to press the SET button to toggle the controller to a 48V battery system.
Solar (Rooftop Panels)		
Problem/symptom	**Possible causes**	**Solution**

Solar isn't charging the battery	One of the disconnect switches is turned off	Turn on both disconnect switches
	Too much shade on the solar panels	Move the vehicle to a better location, or wait for better conditions

System History: Lithium System Component Configurations

System Component	Versions:	Updates included:
Lithium Battery	Version 1: Firmware = 137.3.1 Version 2: Firmware = 137.3.13 (Changed 7/2023)	Version 2: Firmware updates include raising the low-voltage cutoff. Decreases the opportunity to over-discharge the battery beyond recovery.
G4 Tap	Version 1: Battery built with a RV-C Terminator Resistor requiring a Common G4 Tap at the Spyder communication wires outside the battery. (Units M1SY8051 to M1SY8092) Version 2: Battery changed to a Terminator Tap causing Over-Termination Communication Errors.	Version 1: * If the lithium battery is updated to a newer battery, a jumper harness and G4 Terminator Tap will be required. Version 2: * TSB 22-076 was provided to replace Common G4 Tap with a Terminator.
Alternator Regulator	Version 1: Firmware = 2.4.7 Version 2: Firmware = 2.4.7 Version 3: Firmware = 2.5.0	Version 1: * All warnings/protections shut down the regulator and causes 0% SOC & Faults on Firefly Monitor. * Regulator Harness - Brown Wire to 3A inline fuse at the lithium battery and Orange Wire was not used. * Re-setting the regulator had to be done by utilizing the battery Self-Reset Button. Version 2: * All warnings/protections shut down the regulator and causes 0% SOC & Faults on Firefly Monitor. * Regulator Harness - Brown Wire to 3A inside the 12V Fuse Panel and Orange Wire connected to APS Fault Light wire when Regulator is not visible (SY Fault Light is mountied in rear access near inverter) * Re-setting the regulator had to be done by utilizing the House Disconnect Switch. * Started with MY23 units. Version 3: * Only protection errors shut down the regulator and causes 0% SOC & Faults * Regulator Harness - Brown Wire to 3A inside the 12V Fuse Panel and Orange Wire connected to APS Fault Light wire when Regulator is not visible (SY Fault Light is mounted in rear access near inverter).

		* Fault Codes appear on the Renogy Tab of the Firefly Touchscreen.
Alternator	48V	Belt Changes by Chassis Model Year
Inverter	Version 1: Inverter w/Remote Switch Version 2: Inverter w/Remote Switch	<u>Version 1:</u> * Transfer switch required for GFCI functionality * Recommended Inverter Settings: 08 - Battery Type = L16 09 - Boost Charge Voltage = 54.8V 26 - Alarm = DIS 35 - Low Voltage Disconnect Recover = 50.8V <u>Version 2:</u> * Transfer switch required for GFCI functionality * Added 2030664 Bluetooth Module with MY23. * Recommended Inverter Settings: 08 - Battery Type = L16 09 - Boost Charge Voltage = 54.0V 26 - Alarm = DIS 35 - Low Voltage Disconnect Recover = 50.8V <u>Version 3:</u> * Transfer switch required for GFCI functionality * Recommended Inverter Settings: 08 - Battery Type = L16 09 - Boost Charge Voltage = 53.6V 12 - Low Voltage Load Disconnect = 50.0V 13 - Battery Over Discharged Delay Alarm = 30s 14 - Battery Over Under-Voltage Alarm = 50.4V 15 - Battery Discharge Limit Voltage = 49.6V 26 - Alarm = DIS 35 - Low Voltage Disconnect Recover = 51.6V 39 - Max AC Input Current = 30A
Victron Solar Charger	Version 1: Solar Power through inverter Version 2: Solar Power through solar charger	<u>Version 1:</u> * Rooftop solar routed from solar panels to disconnect switches to inverter to lithium battery. <u>Version 2:</u> * Rooftop solar routed from solar panels to disconnect switches to solar charger to lithium battery.
High Idle Start Stop (HISS	Version 1: No High Idle Start Stop (HISS) Version 2: High Idle Start Stop installed on Ford Transit and Dodge Promaster units. Prep package is provided	Version 1: No High Idle (only after-market) <u>Version 2:</u> * Starting with MY24 units, High Idle Start Stop is standard on the Dodge Promaster and Ford Transit units. Auto Engine Start is available through the Firefly Touchscreen. * High Idle Start Stop Prep is available on the Mercedes Sprinter.
Rover Boost Solar Charger	Version 1: Battery Type set to Purple (48V Lithium-iron Phosphate (LFP) - 15 Strings	Version 1: Bluetooth module provided