12V & 24V LFP LITHIUM-ION BATTERY OPERATING MANUAL

Rolls

BATTERY ENGINEERING

Recommended safety, installation, operation & troubleshooting procedures for Rolls 12V & 24V Lithium Iron Phosphate ($LFP/LiFePO_4$) batteries.

TABLE OF CONTENTS

ROLLS 12V & 24V LITHIUM IRON PHOSPHATE (LFP) BATTERIES

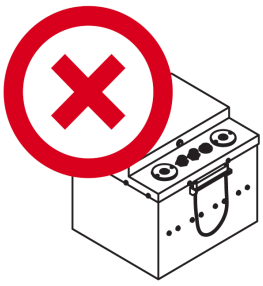
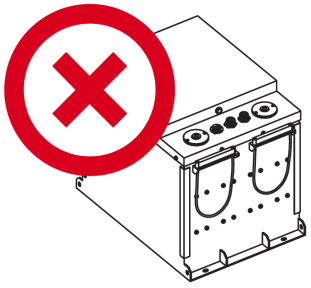
Rolls 12V & 24V Lithium Iron Phosphate (LFP/$LiFePO_4$) batteries are an ideal replacement for traditional lead-acid batteries of equivalent size & capacity and offer the same quality, reliability & performance found in other Rolls Battery products.

This manual provides detailed instructions for safe and proper installation, operation and care of Rolls 12V & 24V LFP battery models. Please read carefully to clearly understand the operating instructions and any potential safety risks prior to installation.

Failure to install or use this battery as instructed may result in damage to the product that may not be covered under the manufacturer warranty. See warranty terms & conditions for full details.

Note: This manual offers installation, charging and troubleshooting guidance for Rolls 12V & 24V LFP lithium batteries.

See **Rolls S24-2800LFP & S48-6650LFP ESS Battery Operating Manual** for usage instructions specific to **Rolls S24-2800LFP ESS** and **S48-6650LFP ESS** (Energy Storage System) models.

This document is **NOT APPLICABLE** to the following models	
S24-2800LFP ESS	S48-6650LFP ESS
	

Nominal voltage of an LFP battery differs from equivalent lead-acid batteries.

LFP Battery	Lead-Acid Battery
Cell = 3.2V	Cell = 2.0V
Battery Nominal Voltage 12.8V – 4 cells	Battery Nominal Voltage 12.0V – 6 cells

WARNING: Explosion, Electrocution, Or Fire Hazard

- A battery can present a risk of electric shock, burns from high short circuit current, fire, or explosion.
- Observe proper precautions.
- Ensure all cables are properly sized.
- Ensure adequate spacing and clearance requirements are strictly enforced around each battery.
- Ensure adequate airflow around batteries and that they are clear of debris.
- Never smoke or allow a spark or flame near the batteries.
- Always use insulated tools.
- Avoid dropping tools onto batteries or other electrical parts.
- Never charge a battery below 0°C.
- Never discharge a battery below -20°C.
- Never charge a battery with a deformed or bulging case.
- Do not expose a Rolls LFP battery to heat in excess of 58°C (136°F) during operation, 60°C (140°F) in storage; do not incinerate or expose to open flames.
- If a battery must be removed, always remove the grounded terminal from the battery first. Make sure all devices are disconnected.

IMPORTANT

- When installing, leave adequate clearance between batteries.
- When replacing batteries, use the same make, model & quantity of batteries.
- Do not mix old and new batteries.
- Avoid any fall or collision during the installation process.
- Do not dismantle or remove the battery components.
- Battery maintenance should be carried out by qualified personnel.
- Do not expose a Rolls LFP battery to heat in excess of 58°C (136°F) during operation, 60°C (140°F) in storage; do not incinerate or expose to open flames.

STORAGE

Rolls 12V & 24V LFP batteries may be stored in an environment with temperatures between -20°C (-4°F) and +60°C (140°F) and between 10% and 90% relative humidity.

If seasonally stored in a space which will fall below -20°C, it is recommended to **discharge** the battery to between 60-80%, **disconnect** the battery from any external system and **store** the battery above -20°C.

Rolls LFP batteries do self-discharge and should be charged once per year, at minimum when stored for extended periods. For temperatures above 40°C (104°F) the battery should be charged every 3 months. Do not store Rolls 12V & 24V LFP batteries at temperatures above 60°C (140°F).

INSTALLATION

Rolls 12V & 24V LFP batteries must be installed upright. Rolls LFP models must be installed in an indoor space and out of direct sunlight.

All installations should consider the ambient temperature. If installed in a region with freezing temperatures or extreme heat, special care should be given. **LFP batteries cannot be charged below 0°C, nor discharged below -20°C** and doing so will severely degrade the internal cells. Similarly, operation above 58°C will negatively impact longevity and performance.

CABLE CONNECTIONS

All cable connections should be adequately sized, insulated and free of damage. The cable connectors should be clean and properly mated with the battery terminals to ensure a snug connection. Terminal connections should be torqued to the recommended specification. Although Rolls LFP batteries do not require maintenance, routine inspection of all cabling and terminal connections is recommended.

AMPERAGE	25	30	40	55	75	95	130	150	170	195	260
WIRE GAUGE	14	12	10	8	6	4	2	1	1/0	2/0	4/0

Note: Undersized cables may lead to cable and/or battery damage, charging issues, terminal heating, or fire.

TERMINAL TORQUE

Terminal connections must be properly torqued. 12V and 24V Rolls LFP batteries using M8 fasteners should be torqued to **10-12Nm**.

DO NOT OVERTORQUE: In the event of a damaged terminal, do not attempt to repair the terminal, do not use the battery if the recommended torque cannot be met.

CONNECTIONS

MODEL	MAX UNITS SERIES CONNECTION	MAX UNITS PARALLEL CONNECTION
12 VOLT LFP	4	2
24 VOLT LFP	1	2

Note: 12V & 24V batteries **cannot** be mixed. 24V batteries cannot be series-connected.

CONNECTING IN SERIES

Rolls 12V LFP batteries can be combined in series strings (maximum four (4) batteries for 48-volts) to achieve higher operating voltages by connecting the positive terminal of one battery to the negative terminal of the next battery.

12V LFP MODELS

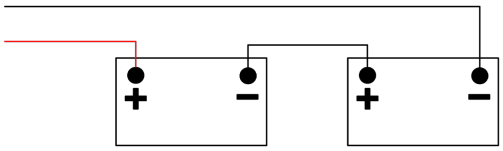
Two (2) 12V batteries in series: 2 x 12.8V = 25.6V (nominal) for **24V** applications

Three (3) 12V batteries in series: 3 x 12.8V = 38.4V (nominal) for **36V** applications

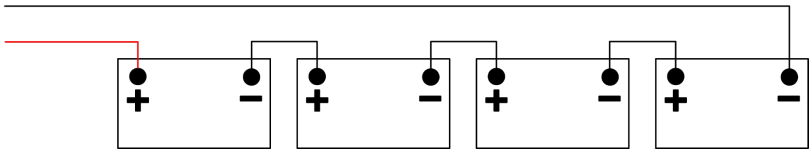
Four (4) 12V batteries in series: 4 x 12.8V = 51.2V (nominal) for **48V** applications

Note: Do not connect more than **four (4)** 12V batteries in series. Connecting more than **four (4)** 12V batteries in series exceeds the voltage limit of the BMS.

24V Configuration: connecting two (2) 12V LFP batteries in series



48V Configuration: connecting four (4) 12V LFP batteries in series



CAUTION

- Failure to follow the following safety instructions may result in personal injury or damage to the equipment!
- The difference in voltage between each unit must be less than 15mV before connecting in series.
- Do not connect more than four (4) 12V batteries or one (1) 24V battery in series.
- Do not connect different batches, different types, old and new batteries in series.
- Series connection is **not** supported with Rolls 24V LFP batteries.

CONNECTING IN PARALLEL

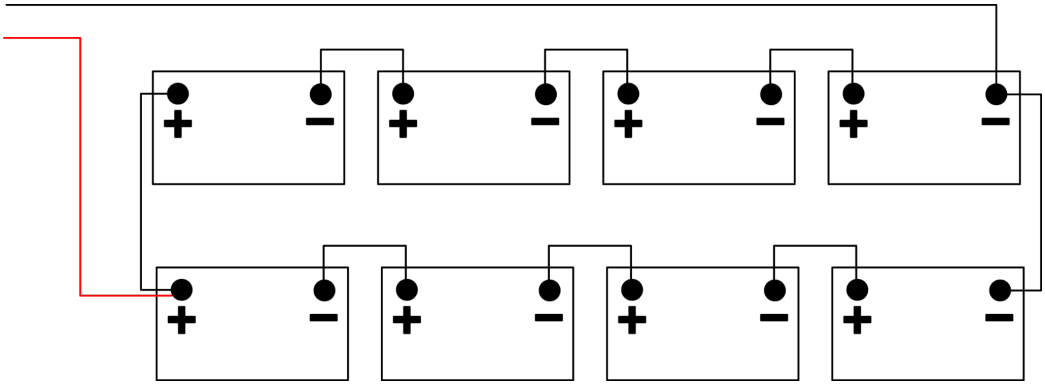
You may combine Rolls 12V LFP batteries together in up to two (2) parallel strings to increase battery bank capacity.

Refer to the example below showing eight (8) 12V LFP batteries connected in a 48V configuration; four (4) connected in series and two (2) parallel strings (4S2P). Up to two (2) 48V parallel strings of 12V LFP models may be connected. Parallel string configurations greater than four in series, 2 in parallel (4S2P) are not supported at this time.

Note: unlike lead-acid batteries, when connecting Rolls LFP batteries in parallel to increase total storage capacity the recommended charge current is limited to the specifications for the individual battery model, not the total capacity of the battery bank.

48V Configuration: Connecting Eight (8) x 12V LFP batteries

Four (4) in series with two (2) parallel series strings



Note: Strings are independent, external positive lead is connected to string one, whereas the negative lead is connected to string two.

CAUTION

- Failure to follow the following safety instructions may result in personal injury or damage to the equipment!
- The voltage difference between units should be less than 15mV before connecting in parallel.
- Do not connect more than two (2) parallel strings of 12V or 24V LFP batteries.
- Using batteries in parallel does not increase the current limit for charge and discharge, only the capacity of the pack.
- Do not connect different batches, types, old and new batteries in parallel.
- If replacing a lead acid system with lithium iron phosphate batteries, charger settings must be updated for the new batteries.

BATTERY MANAGEMENT SYSTEM (BMS) PROTECTION SUMMARY

Rolls LFP batteries include a built-in battery management system (BMS) which offers protection in conditions where the battery voltage, current or operating/cell temperature may be unsafe or damaging. The switch architecture of the BMS allows charge and discharge to be stopped independently. Under these undesirable operating conditions, the internal BMS will interrupt the current into or out of the battery, or disconnect it fully, as required.

BATTERY LIMIT	PROTECTION	NOTES
Cell/Pack Overvoltage	Charge Interruption	Discharge to reset
Cell/Pack Undervoltage	Discharge Interruption	Charge to reset
Extended Cell/Pack Undervoltage (Extended period of storage)	Charge *and* Discharge Interruption	Non-resettable, do **NOT** attempt to recover battery.
Pack Overcurrent or Short Circuit	Charge *and* Discharge Interruption	Automatically reset after time delay
High temperature at BMS or Cell*	Charge *and* Discharge Interruption	Automatically reset after cooling
Low temperature at BMS or Cell*	Charge Interruption	Automatically reset after warming
Extreme low temperature at BMS or Cell	Charge *and* Discharge Interruption	Automatically reset after warming

*Temperatures outside of the ideal operating range require a reduction in charge/discharge current for optimal battery life.

The specific setpoint to enable protection and to reconnect may vary based on the specific battery. Consult the appropriate specification for your Rolls LFP model.

The BMS also has cell-balancing functionality to balance each internal cell to the same state of charge, enabling the full pack capacity. However, this is not sufficient to balance severely imbalanced cells with SOC difference above 2.5%, see below.

BATTERY VOLTAGE: CONNECTING IN SERIES AND/OR PARALLEL

For initial balancing prior to connecting batteries in series, each battery should be connected in parallel (above the two (2) batteries in parallel, but **not** for regular cycling) and charged (or charged individually) using a 2-stage CC/CV charger at a reduced CV voltage corresponding to the low end of the acceptable charge range (see below), leaving the battery at the absorption/CV voltage for at least 24 hours.

SYSTEM VOLTAGE	12V NOMINAL	24V NOMINAL	48V NOMINAL
RECOMMENDED INITIAL BALANCING VOLTAGE	14.0V	28.0V	56.0V

Before connecting for cycling (following the limitations noted in connections), verify voltages are within a 15mV (0.015V) range once each battery has been off the charger for 15 minutes. This way all series-connected batteries will be at 100% SOC.

If you are unable to charge the batteries individually, the voltage of each battery should be within 15mV (0.015V) before putting them in service. This will minimize the severity of a charge imbalance between batteries which results in reduced pack capacity. LFP batteries, even those with similar open circuit voltages may be at drastically different SOC, due to the flat relationship between open circuit voltage and SOC for LFP cells.

Although the BMS provides over-voltage protection to each cell, developing a charge imbalance between batteries is still possible. Rolls recommends disconnecting and fully charging each battery individually once per year, at minimum. If the batteries are cycled frequently at high charge/discharge currents this may be done more often.

BATTERY CHARGING

Although a lithium-specific charger is recommended, Rolls 12V LFP models are compatible with most common lead-acid battery chargers for the nominal voltage of the pack. The recommended and maximum continuous charge currents are specified on the product label.

Rolls LFP batteries may rest or be stored in a partial state-of-charge (PSOC). Rolls LFP batteries should be cycled from 0% depth of discharge (DoD) or 100% state of charge (SOC), to 80% DOD or 20% SOC for optimal life. To prevent over-discharge, the BMS will disconnect the battery when the low voltage cut-off is reached, corresponding to a DOD of 95% or SOC of 5%.

Note: Chargers that require the detection of voltage at the battery terminals to charge may fail to wake the LFP battery from a state of under-voltage protection.

Note: When connecting Rolls LFP 12V or 24V batteries in parallel, the recommended and maximum continuous charge current specified for the model must be followed and does not increase with the addition of a parallel string.

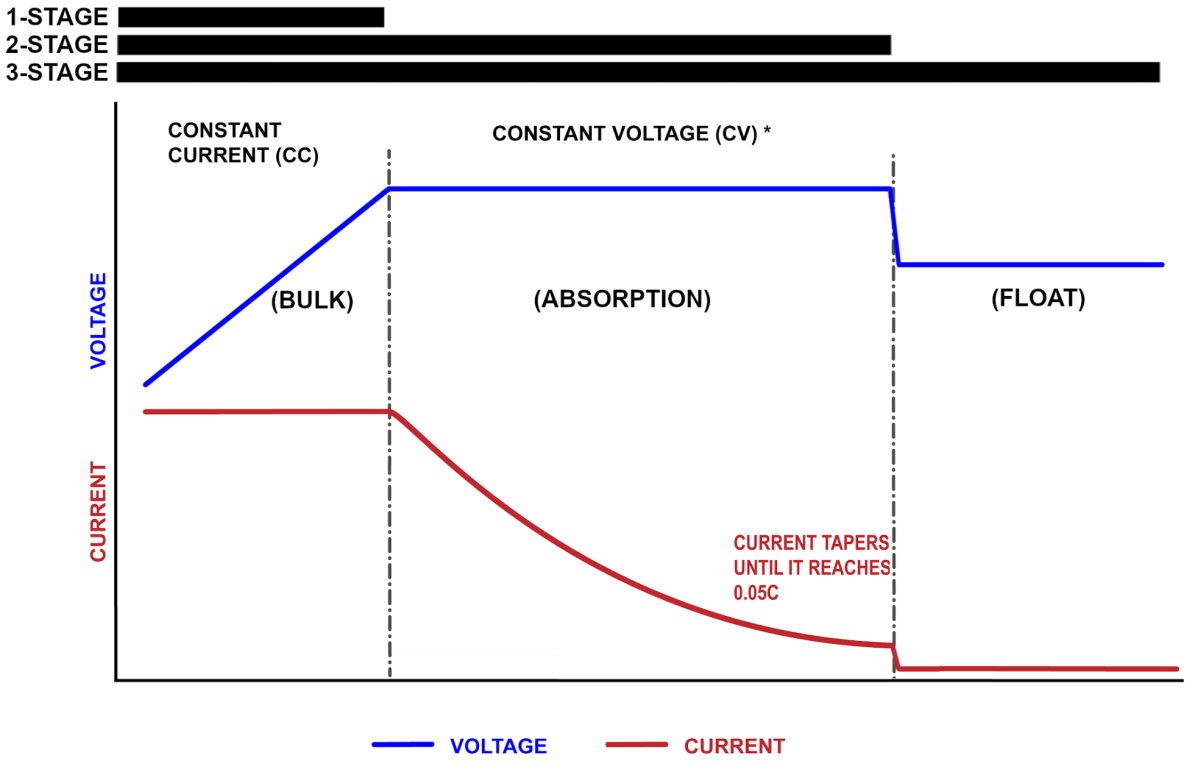
Note: the recommended and maximum continuous charge & discharge current are specific to each LFP model and vary by cell and BMS technology. This information is provided on the product label.

Note: The battery does not need maintenance charges like equalization, pulse charge, overcharge reconciliation, or any others typically recommended or required for lead acid batteries.

CHARGING GUIDELINES

Rolls LFP Batteries can be charged in a 1, 2, or 3-Stage charge profile, shown below. The specifics and recommended setpoints for these charge regimes are explained in this section, with the recommended charge profile being a 2-Stage charge.

Representation of 1, 2, and 3-Stage Charging Profiles



Representation of recommended 2-Stage Constant Current/Constant Voltage (CC/CV) charging. The dotted line represents the transition from CC to CV when the voltage limit is reached. Once the battery reaches the constant voltage limit, the battery is held by the charger at this voltage until the current decreases to 0.05C. At this point the battery is at 100% state-of-charge (SOC). Any current continuing to flow in the float stage is attributable to balancing activity at the BMS.

The recommended and maximum continuous charge current is specified for each Rolls LFP model as a function of capacity. This information is noted in the model specifications and on the battery label.

1-STAGE CHARGING: CC (CONSTANT CURRENT)

When charging with a single-stage constant current charger, charge at the recommended charge current, by operating temperature, until the battery reaches its termination voltage.

1-STAGE CHARGE PROFILE		CHARGE CURRENT & PARAMETERS	
RECOMMENDED CHARGE CURRENT *Do not exceed maximum continuous charge current		≤0.1C at 0~5°C (32-41°F) ≤0.2C at 5~10°C (41-50°F) ≤0.5C at 10~35°C (50-95°F) ≤0.2C at 35~50°C (95-122°F)	
SYSTEM VOLTAGE	12V NOMINAL	24V NOMINAL	48V NOMINAL
TERMINATION VOLTAGE	14.6V	29.2V	58.4V

Note: 1-Stage CC Charging may be required if charging from a source which is not efficient to run at lower power. However, it may only charge the battery to 90-95% SOC. 1-Stage charging also offers very little time to balance cells. For these reasons, 2-Stage CC/CV charging is recommended to ensure the battery reaches full SOC.

2-STAGE CHARGING:

CC/CV (CONSTANT CURRENT/CONSTANT VOLTAGE)

When charging with a two-stage constant current/constant voltage (CC/CV) charger, charge at the recommended charge current, by operating temperature, until the battery reaches the “absorption” voltage or constant voltage (CV) limit. The charger then holds the battery at CV until the charge current decreases to ≤0.05C (termination current).

The recommended absorption (constant voltage) voltage is shown below. If the charger has a pre-set voltage setting or cannot be programmed, an absorption voltage in the range below is also acceptable. Note: lower voltage will lead to longer charge times.

2-STAGE CHARGE PROFILE		CHARGE CURRENT & PARAMETERS	
RECOMMENDED CHARGE CURRENT *Do not exceed maximum continuous charge current		≤0.1C at 0~5°C (32-41°F) ≤0.2C at 5~10°C (41-50°F) ≤0.5C at 10~35°C (50-95°F) ≤0.2C at 35~50°C (95-122°F)	
SYSTEM VOLTAGE	**12V NOMINAL**	**24V NOMINAL**	**48V NOMINAL**
RECOMMENDED ABSORPTION VOLTAGE	14.6V	29.2V	58.4V
ABSORPTION VOLTAGE RANGE (ACCEPTABLE)	14V – 14.6V	28V - 29.2V	56V - 58.4V
TERMINATION CURRENT	≤0.05C		

Note: If charge time is not a concern within your system architecture, reducing the absorption voltage will increase charge time, but allows the BMS more time to ensure all cells remain balanced. As batteries age, small changes in manufacturing or due to uneven wear may present themselves, requiring more time to maintain balance.

3-STAGE CHARGING:
LEGACY LEAD-ACID SYSTEMS, INVERTER/CHARGER HARDWARE

When programming an inverter/charger or charge controller equipment using a 3-stage charge sequence (2-stage with an additional “float voltage” after the charge is terminated), the following charging parameters should be programmed to properly charge Rolls 12V & 24V LFP batteries:

3-STAGE CHARGE PROFILE		CHARGE CURRENT & PARAMETERS	
RECOMMENDED CHARGE CURRENT *Do not exceed maximum continuous charge current		≤0.1C at 0~5°C (32-41°F) ≤0.2C at 5~10°C (41-50°F) ≤0.5C at 10~35°C (50-95°F) ≤0.2C at 35~50°C (95-122°F)	
CHARGER SETTINGS	**12V SYSTEM**	**24V SYSTEM**	**48V SYSTEM**
BULK to ABS VOLTAGE	14.4V	28.8V	57.6V
ABSORPTION VOLTAGE	14.4V	57.6V	57.6V
ABS to FLOAT	≤0.05C	≤0.05C	≤0.05C
FLOAT VOLTAGE	13.6V	27.2V	54.4V

Temperature Compensation: If the inverter/charger or charge controller uses temperature compensation this should be turned off when charging Rolls LFP models. Turn off the temperature compensation settings and disconnect the sensor to ensure the correct voltage regulation from the charging device.

Equalization: Equalization should never be used; elevated charge voltages are unacceptable for LFP batteries. It should be turned off, or the equalization voltage setpoint should be reduced to the appropriate system float voltage, above.

Some charger models may require additional firmware, programming or parameters. Please contact your inverter/charger or charge controller manufacturer for assistance with these settings, if required.

CHARGING SOURCE: LEAD-ACID BATTERY CHARGER

Customers may choose to replace lead-acid batteries with lithium models. Most lead-acid battery chargers may be used to charge Rolls LFP models if the charger is properly configured to operate within recommended charge current and voltage limits.

The pre-programmed voltage settings for AGM or OPzV GEL models may be in line with LFP charge voltage settings and can sometimes be used if direct voltage control is not possible for your charger. However, flooded batteries often require higher charge voltage settings. If left configured for charging flooded batteries, the higher charge voltage can trigger the BMS to restrict charging to protect the battery, effectively resulting in a 1-stage charge. If this occurs repeatedly, or the charger cannot be configured at a lower charge voltage, it may be necessary to replace the charger.

CHARGING TEMPERATURE

Due to the chemistry of Lithium-ion cells, these batteries cannot accept high charge current at lower operating temperatures without risking cell damage and permanent loss of capacity.

Rolls LFP batteries may be safely charged between 0°C to 50°C (32°F to 122°F). However, wear is accelerated from 0~5°C (32-41°F), charge current should be limited to 0.1C (10% of battery capacity) to prevent degradation. As the cell temperature rises during the charging process, the battery will gradually accept a higher charge current. However, to prevent the BMS from shutting off due to over-temperature protection at very high operating temperatures, the charge current should be limited to ≤0.2C when operating at temperatures from 35°C to 50°C (95°F to 122°F) as noted below.

To maintain optimum performance and durability of Rolls LFP batteries, the following charge current limits should be followed:

TEMPERATURE	RECOMMENDED CHARGE CURRENT
0°C (32°F) OR COLDER	**DO NOT CHARGE**
0~5°C (32-41°F)	0.1C
5~10°C (41-50°F)	≤0.2C
10~35°C (50-95°F)	≤0.5C
35~50°C (95-122°F)	≤0.2C
>50°C (>122°F)	**DO NOT CHARGE**

Note: Due to the internal chemistry, batteries can be discharged at lower temperatures than they can be charged at. So, at low temperatures between -10°C and 0°C, batteries will be available for discharge but not charge.

If the battery is installed where temperatures vary, it is recommended to limit charge current to allow uninterrupted charging at extreme operating temperatures. Alternatively, the charge current limit may be adjusted seasonally to allow quicker charge times while operating in warmer/colder temperatures.

TROUBLESHOOTING

Rolls 12V & 24V LFP lithium batteries are extremely reliable and offer excellent charge/discharge currents & cycle life. However, like any battery, there are certain conditions where the battery may not operate as expected. These situations are typically the result of misuse, abuse, a non-optimal operating condition or improper storage.

Troubleshooting is a great time to check your system for and wear or degradation:

- Check batteries for bulging or deformation.
- Check and re-torque all battery terminals, as necessary.
- Check lugs for signs of heating.
- Check for frayed cables.
- Verify cable insulation is in good condition.

Below are examples of potential issues you may encounter with Rolls 12V & 24V LFP lithium models. Follow the appropriate troubleshooting procedure to restore, balance or reset the battery or ancillary hardware.

The BMS is designed to protect the cells inside the battery from unsafe conditions, based on temperature, voltage and current parameters. If the voltage of the pack or any individual cell falls outside of the acceptable range, the battery will be prevented from charging and/or discharging to protect the internal cells. Typically, a disconnected battery, or one that is unable to charge, or discharge is the result of one of these safety protections being engaged.

BATTERY DID NOT CHARGE DESPITE AVAILABLE SOLAR ENERGY

Problem: Despite previously available solar energy, batteries are fully discharged.

Possible Cause: Low temperature prevents charging, not discharging, so the battery was never disconnected from the system. The battery continued to serve the load but could not be recharged, resulting in a fully discharged battery which was unable to safely accept available charge.

Solution: Battery space (not batteries directly) may need be heated. If the problem persists, automatic space heating, or insulation should be considered.

TERMINAL VOLTAGE IS ABSENT OR LOW

Problem: Using a multimeter to check terminal voltage, the battery voltage reading is low or there is no voltage at the terminal.

Possible Causes:

- The voltage of a cell within the battery has dropped below 2V causing the microprocessor to enable under-voltage protection.
- The battery's state-of-charge (SOC) has dropped below 5% from an extended idle period or heavy use, enabling under-voltage protection.
- The battery has overheated causing the microprocessor to enable over-temperature protection.

Solution: To resolve situations where terminal voltage is absent or low:

1. Allow the battery to cool and recheck terminal voltage.
2. Connect the battery to a charger to wake the battery and recover terminal voltage. If the battery is out of balance resulting in a cell below the average pack state of charge, the back should be left at CV voltage for balancing. Depending on the battery's voltage and state of balance, it may take up to 48 hours to completely charge and balance the battery.

CHARGER DISCONNECTS ON CONNECTION OR AT BEGINNING OF CHARGE

Problem: CV charger surpasses its current limit and stops charging during charge cycle.

Possible Cause: Chargers designed for constant voltage charging lead acid batteries were designed for a specific range of battery impedances. LFP cells have a much lower impedance than lead acid batteries, which can result in an inrush of current. If this occurs late in the charge cycle, refer to the troubleshooting steps noted below for "**Battery Current Reduces to Zero While Charging**".

Solution: Reset the charger and try again.

BATTERY CURRENT REDUCES TO ZERO WHILE CHARGING

Problem: Battery current disappears while charging.

Possible causes:

- The battery has overheated or is too cold, triggering temperature protection.
- The battery pack is out-of-balance, one or more internal cells are outside of the acceptable voltage range.
- Charger voltage is too high.

Solution: To resolve situations where current disappears when charging:

1. Allow the battery to cool.
2. Disconnect and apply a 14.0 V charge voltage (for 12V LFP Batteries) for 48 hours to balance the charge on all cells, especially any cells reading a lower voltage, even if the difference is small (<0.005mV).
3. Ensure charger voltage is set to 14.6 V or less, verifying accurate voltage output with a multimeter where possible. If the problem continues to occur, reduce charger voltage and leave topped up for 48 hours of balancing. If the problem persists after allowing cells time to balance, reduce charger voltage.
4. If using a Lead-acid charger: Ensure charger is not performing maintenance such as equalization or entering a float voltage above allowable voltage range. Ensure temperature-based voltage compensation (which should not be used with LFP batteries) is turned off. If you cannot reduce the charger voltage, a new charger may be required.

5. If cells are nearing or past their end-of-life, stored improperly, or were subject to operation outside their intended conditions, capacity imbalances may be present, causing charging to be stopped consistently. If this is the case, batteries can still be discharged and cycled if charging is interrupted, however the imbalance will limit the overall capacity of the pack.

BATTERY CURRENT REDUCES TO ZERO WHILE DISCHARGING

Problem: Battery Current Disappears when Charging

Possible Causes:

- Inverter/Charger low voltage disconnect set too low, below BMS disconnect.
- The battery has overheated or is too cold, triggering temperature protection.
- One or more internal cells is out-of-balance, resulting in a cell reaching the low voltage disconnect.

Solution: First, verify inverter/charger settings for low voltage disconnect are verified to be correct for the given battery. Monitor battery temperature, ensure ambient temperature is within safe operating range and no heating is occurring at the terminals. If no other symptoms can be identified and the problem persists, allow the battery to stay at the absorption/constant voltage limit for 48 hours to rebalance cells.

SERIES-CONNECTED BATTERY BANK DOES NOT HAVE THE AVAILABLE ENERGY IT SHOULD

Problem: Series-connected battery bank appears to have substantially less available energy than it should. Charge or discharge may be cut off early.

Possible Cause: Due to storage conditions, batteries from different batches, or usage, batteries were connected at different states of charge. The result is a battery bank with one battery that is first to be fully discharged, resulting in discharge being disconnected, and one which is the first to be charged, resulting in charger disconnection. The BMS is designed to account for small variations cell-to-cell, balancing ≤2.5% imbalance, not larger imbalances between differently used batteries.

Even a small difference in the open circuit voltage of the batteries can indicate a substantially different state of charge. The best way to identify a battery that is out of balance is in the fully charged or fully discharged state.

Solution: Batteries should be disconnected and recharged individually following a 2-stage charge, tapering to ≤0.05C for each battery. Batteries may be connected in parallel up to two (2) cells to improve speed of the process. Always follow recommended specifications when charging batteries.

RECYCLING

Rolls LFP batteries should be properly disposed of at an authorized lithium recycling facility. Do not remove product labels and/or recycling information from the battery case.

The battery should be fully discharged before disposal. To prevent a possible short circuit or explosion, the terminals should be covered with a protective cap or non-conductive tape before disposal.

LFP GLOSSARY

AMP, AMPERE: Unit of electrical current. Abbreviated “A”.

AMP-HOUR: Unit of electrical energy, one amp of current flowing for one hour. Abbreviated “Ah”.

BMS (BATTERY MANAGEMENT SYSTEM): The BMS, or Battery Management System, is an electronic device which protects the cells inside a battery. The BMS used in Rolls LFP batteries protects them from unsafe voltage, current, and temperature conditions, and balances cells for optimal pack performance. A BMS is required for any lithium-ion battery system.

CELL: A single battery, independent of chemistry. Each cell is at the base voltage for the given chemistry; 2.0V for flooded lead acid, 3.2V for lithium iron phosphate. Many cell form factors exist, resulting in different capacities and performance characteristics. These may be combined in series to form a battery of higher voltage.

CC/CV (CONSTANT CURRENT/CONSTANT VOLTAGE): The typical charge profile of a LFP battery. CC/CV or Constant Current/Constant Voltage charging is a 2-stage charge, first at constant current until the battery voltage reaches a given limit, and then at constant voltage as the current accepted by the battery naturally reduces until the battery is full.

CYCLE: A “cycle” is a somewhat arbitrary term used to describe the process of discharging a fully charged battery down to a particular state of discharge. For Rolls LFP Batteries, a cycle is defined as 90% depth of discharge, or going from full charge down to 10% state-of-charge.

CYCLE LIFE: The total energy throughput of a battery, defined in terms of the amount of equivalent charge/discharge cycles it can withstand before its effective capacity is reduced to a certain amount, usually 80% of original/rated capacity.

LFP (LITHIUM IRON PHOSPHATE): LFP, or Lithium Iron Phosphate is a specific type of Lithium-ion battery chemistry. Referring to the cathode material of the battery, this chemistry is characterized by its long cycle life, calendar life and safety, compared to other battery chemistries.

SOC (STATE OF CHARGE): State of Charge (SOC) represents the fullness of the battery from 0%-100%

VOLT: The unit of electrical potential or “pressure”. For the LFP cell chemistry, batteries often come in 3, 6, 12, 24, 48-volt configurations.