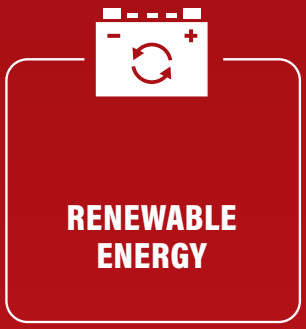
ROLLS R-SERIES & S-SERIES DROP-IN LFP BATTERY OPERATING MANUAL

Rolls

BATTERY ENGINEERING

Recommended safety, installation, operation and troubleshooting procedures for Rolls R-Series and S-Series 12V, 24V, 36V, and 48V LFP (Lithium Iron Phosphate) batteries.


RENEWABLE
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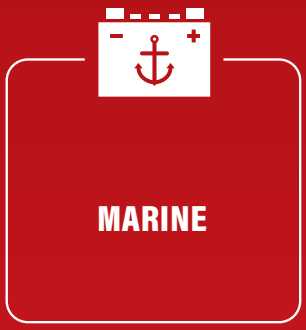
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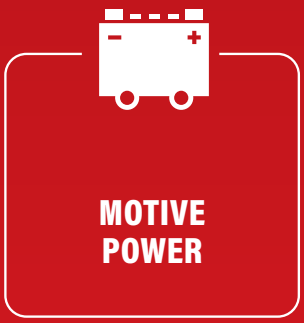
MOTIVE
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ROLLS R-SERIES AND S-SERIES LFP BATTERIES

Rolls R-Series and S-Series drop-in 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 and performance found in other Rolls Battery products.

This manual provides detailed instructions for safe and proper installation, operation, and care of Rolls R-Series and S-Series drop-in 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 and conditions for full details.

NOTE: This manual offers installation, charging, and troubleshooting guidance specific to Rolls **R-Series and S-Series Drop-in 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.

See Rolls 24V & 48V LFP ESS Battery Operating Manual for usage instructions specific to 19" rack, floor and wall mount ESS models.

This document is NOT APPLICABLE to the following models	
48V ESS LFP Models (S48-100LFP ESS)	**24V & 48V ESS LFP Models** (S24-2800LFP ESS and S48-6650LFP ESS)
	

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

LFP Battery	Lead-Acid Battery
Cell Voltage = 3.2V	Cell Voltage = 2.0V
Battery Nominal Voltage 12.8V (4 cells)	Battery Nominal Voltage 12.0V (6 cells)
Battery Nominal Voltage 25.6V (8 cells)	Battery Nominal Voltage 24.0V (12 cells)
Battery Nominal Voltage 38.4V (12 cells)	Battery Nominal Voltage 36.0V (18 cells)
Battery Nominal Voltage 51.2V (16 cells)	Battery Nominal Voltage 48.0V (24 cells)

VERSION HISTORY/CHANGELOG

Rev.	Changelog	Author/Editor	Date
1.0	Release Version - R-Series Revision	Jordan Torrealba	2021/12/14
2.0	Release Version – R-Series and S-Series Revision	Jordan Torrealba	2023/07/25

WARNING: Explosion, Electrocution, Or Fire Hazard

- A battery can present a risk of electric shock, burns, fire, or explosion.
- Ensure cables are properly sized for the system current and cable runs are as short as possible.
- Ensure cables between batteries are of equal length, reducing line inductance and voltage spikes, which can damage the BMS.
- Ensure adequate airflow around batteries and that they are clear of debris, 2cm/1" spacing is recommended.
- Never smoke or allow a spark or flame near the batteries.
- Always use insulated tools.
- Avoid dropping tools onto batteries or other exposed electrical parts.
- Prolonged exposure to cold temperatures can cause significant damage to batteries, proportional to charge and discharge current:
    - Never charge an R-Series drop-in LFP battery or bypass the heating controls on an S-Series drop-in LFP battery below 0°C (32°F).
    - Never discharge an R-Series or S-Series drop-in LFP battery below -20°C (-4°F).
- Never charge a battery with a deformed or bulging case.
- Do not expose a Rolls drop-in LFP battery to heat more than 60°C (140°F) during operation, and do not store for extended periods of time above 45°C (113°F). Do not incinerate or expose to open flame.
- If a battery must be decommissioned, always remove the grounded terminal from the battery first. Make sure all connected devices are shut down.
- When installing, leave adequate clearance between batteries 2cm/1" is recommended.
- When replacing batteries, use the same make, model, and quantity of batteries.
- Do not mix old and new batteries, or batteries with different nominal voltages.
- Avoid dropping batteries during the installation process.
- Do not dismantle or remove the battery components.
- Battery maintenance should be carried out by qualified personnel under the guidance of Rolls Battery.

STORAGE

Rolls R-Series & S-Series drop-in LFP batteries should be stored in an environment with temperatures between -5°C (23°F) and 45°C (113°F). 20°C (68°F) is recommended.

If seasonally stored in a space which will fall below -5°C (23°F), it is recommended to **discharge** the battery to between 60-80%, **disconnect** the battery from any external system and **store** the battery in an alternative location above -5°C (23°F).

Rolls drop-in LFP batteries self-discharge and should be charged, at minimum, once per year, even when in distributor stock or storage. For temperatures above 40°C (104°F) the battery should be charged every 3 months. Do not store Rolls R-Series & S-Series drop-in LFP batteries at temperatures above 45°C (113°F).

INSTALLATION

Rolls R-Series & S-Series drop-in LFP batteries may be installed in any orientation* (except upside down) as required by the application. Rolls drop-in LFP batteries must be installed in an indoor space and out of direct sunlight.

*Front Terminal (FT) models are installed on one side only. Refer to the label for which.

All installations should consider the ambient temperature. If installed in a region with freezing temperatures or extreme heat, special care should be given. **Rolls R-Series drop-in LFP batteries cannot be charged below 0°C (32°F), nor discharged below -20°C (-4°F)** and doing so will severely degrade the internal cells. Similarly, operation above 55°C (131°F) will negatively impact longevity, performance, and safety. Rolls S-Series drop-in LFP batteries feature internal heating to compensate for reduced temperatures but are still limited in the external temperatures they can tolerate. Refer to the datasheet or label of your specific model for accurate information.

Waking up the Battery

If you have just received your battery, it may have entered a low power sleep mode during transit. In this state, the Bluetooth receiver will be off, and the voltage will be between 2V-10V, waiting to sense an external device. For R-Series drop-in LFP models, connect a charger or load to “wake up” that unit and enable charging, discharging, and a Bluetooth connection. To wake up an S-Series drop-in LFP battery, do this, or press and hold the reset button located below the onboard screen.

TERMINAL TORQUE

Terminal connections must be properly torqued. Rolls R-Series & S-Series drop-in 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.

CABLE CONNECTIONS

All cable connections should be adequately sized, insulated, and undamaged. Connectors should be clean and properly mated with the battery terminals to ensure a secure and low resistance connection. Terminal connections should be torqued to the recommended specification in TERMINAL TORQUE. Although Rolls R-Series and S-Series drop-in LFP batteries do not require maintenance such as cell inspection & watering, routine inspection of cabling and terminal connections should be performed semi-annually. Double check torque specification and that lugs cannot be rotated after installation. If the batteries are installed in a high vibration environment, this should be done more frequently.

Amperage	25	30	40	55	75	95	130	150	170	195	260
Wire Gage	14	12	10	8	6	4	2	1	1/0	2/0	4/0

NOTE: Undersized or improperly insulated cables may lead to cable and/or battery damage, charging issues, terminal heating, or fire. The gauge table above is provided for reference only. Always refer to the connector and wire manufacturers' specifications prior to purchase and installation.

Like lead acid batteries, connecting devices (like batteries, inverters, chargers, MPPTs, etc.) at different voltages can result in large current spikes and arcing. Sparks may fly if you are connecting a power supply or charger with high output capacitance, or a discharged inverter with high input capacitance, as the battery rapidly charges the components in the device. Connecting terminals quickly and decisively is recommended for the least component wear and tear, or using in-line overcurrent protection devices such as an open breaker, to eliminate arcing.

BMS PROTECTION SUMMARY

Rolls R-Series drop-in 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 for the internal cells. The switch architecture of the BMS allows charge and discharge to be stopped independently. Under these undesirable operating conditions, the internal BMS can independently interrupt charge or discharge, or disconnect it fully, as required.

BATTERY LIMIT	PROTECTION	RESET METHOD	COMMENTS
Cell/Pack Overvoltage	Charge Interruption	Automatic reset after time delay or discharge	If occurring more than 3 times in 2 minutes, discharge is required
Cell/Pack Undervoltage	Discharge Interruption	Automatic reset after time delay or charge	If occurring more than 3 times in 2 minutes, charge is required
Extended Pack Undervoltage (Stored While Empty)	Battery Cannot be Recovered	Always charge R-Series Batteries within 72 hours of full discharge	-
Pack Overcurrent or Short Circuit	Charge and Discharge Interruption	Automatically reset after time delay	If occurring more than 3 times in 2 minutes, charge is required
High temperature at BMS or Cell*	Charge and Discharge Interruption	Automatically reset after cooling	BMS will display alarm when approaching disconnect
Low temperature at BMS or Cell*	Charge Interruption	Automatically reset after warming	BMS will display alarm when approaching disconnect
Extreme low temperature at BMS or Cell	Charge and Discharge Interruption	Automatically reset after warming	BMS will display alarm when approaching disconnect
(S-Series only) Secondary Overcurrent Protection	Charge and Discharge Interrupted, external fuse is blown.	Replace fuse	Secondary protection is also recommended for all R-Series batteries.

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

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 a substantial state-of-charge (SOC) difference, see BATTERY VOLTAGE - CONNECTING IN SERIES/PARALLEL.

CONNECTION LIMITS

R-SERIES MODEL	MAX UNITS SERIES CONNECTION	MAX UNITS PARALLEL CONNECTION
12 VOLT LFP	4 (48V System)	4 (6 if not series connected)
24 VOLT LFP	2 (48V System)	4 (6 if not series connected)
36 VOLT LFP	1 (36V System)	6 (no series connection)
48 VOLT LFP	1 (48V System)	6 (no series connection)

NOTE: Rolls R-Series & S-Series drop-in models **cannot** be mixed. Batteries should only be combined in the same capacity, and voltage, from the same product line.

CONNECTING IN SERIES

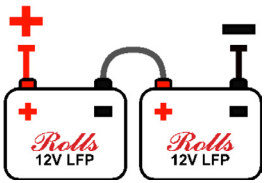
Rolls R-Series and S-Series 12V and 24V LFP batteries may be combined in series strings to achieve higher operating voltages by connecting the positive terminal of one battery to the negative terminal of the next battery. Don't connect different voltages in series. For example, do not connect a 12V and 24V battery to reach 36V, use 3 12V batteries instead, or a single 36V battery.

EXAMPLE SERIES CONFIGURATIONS

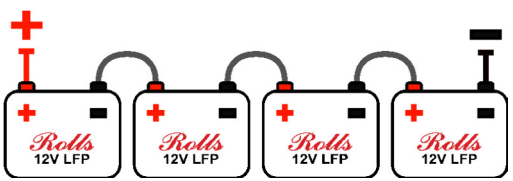
For **24V** Applications	12V batteries in series - Two (2)	2 x 12.8V = 25.6V
	24V battery in series - One (1)	1 x 25.6V = 25.6V
For **36V** Applications	12V batteries in series - Three (3)	3 x 12.8V = 38.4V
	36V battery in series - One (1)	1 x 38.4V = 38.4V
For **48V** Applications	12V batteries in series - Four (4)	4 x 12.8V = 51.2V
	24V battery in series - Two (2)	2 x 25.6V = 51.2V
	48V battery in series - One (1)	1 x 51.2V = 51.2V

NOTE: Do not connect batteries in strings above 48V nominal.

Example 24V Configuration: Two 12V batteries in series



Example 48V Configuration: Four 12V batteries in series



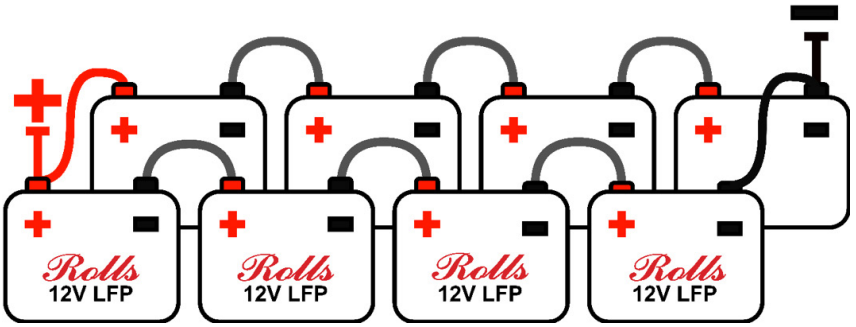
CONNECTING IN PARALLEL

You may combine Rolls R-Series or S-Series drop-in LFP batteries of the same model together in up to four (4) parallel strings to increase system capacity. If no series connections are made, up to six (6) batteries of the same model may be connected in parallel.

Refer to the example below showing eight (8) 12V R-Series drop-in LFP batteries connected in a 48V configuration; four (4) connected in series and two (2) parallel strings (4S2P). Up to four (4) 48V parallel strings of 12V or 24V R-Series drop-in LFP models may be connected. Parallel string configurations greater than 48V in series, four in parallel (4S4P or 2S4P) are not supported currently.

NOTE: When connecting parallel strings of Rolls R-Series or S-Series drop-in LFP batteries of the same model, the recommended current limit increases proportional to the number of parallel strings.

48V Configuration: Connecting Eight (8) x 12V R-Series batteries
Four (4) in series with two (2) parallel series strings



NOTE: Strings are independent. External connections should be staggered, i.e., the positive lead is connected to string one, whereas the negative lead is connected to string two.

NOTE: Keep cabling the same resistance (gauge and length) between batteries and strings to ensure proper current sharing. Attempt to minimize length to reduce the magnitude of inductive voltage spikes at the battery.

CAUTION

- Failure to follow the following safety instructions may result in personal injury or damage to the equipment.
- R-Series batteries should be fully charged in parallel before connecting for series cycling, see page 9.
- Do not connect more than four (4) strings of batteries in parallel.

BATTERY VOLTAGE - CONNECTING IN SERIES/ PARALLEL

For initial balancing prior to connecting batteries in series, each battery should be connected in parallel (you may connect above the maximum of four (4) batteries in parallel, but not for regular cycling) and fully 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	36V NOMINAL	48V NOMINAL
RECOMMENDED INITIAL BALANCING VOLTAGE	14.0V	**Balance initially at 12V NOMINAL**		

If you are unable to charge the batteries individually, the voltage of each battery should be within 30mV (0.03V) 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 if 1 or 2 parallel strings is used, or every 6 months in systems with 3 or 4 parallel strings. If the batteries are cycled frequently at high charge/discharge currents this may be done more often.

Absorption time can also help with balancing. For a single string, absorption times of 20-30 minutes is recommended, or up to 60 minutes for 4 strings. See 3-STAGE CHARGING - LEGACY LEAD-ACID SYSTEMS, INVERTER/CHARGER HARDWARE for more information on using legacy chargers with R and S-Series LFP.

BLUETOOTH/APP CONNECTIVITY

GET IT ON Google Play

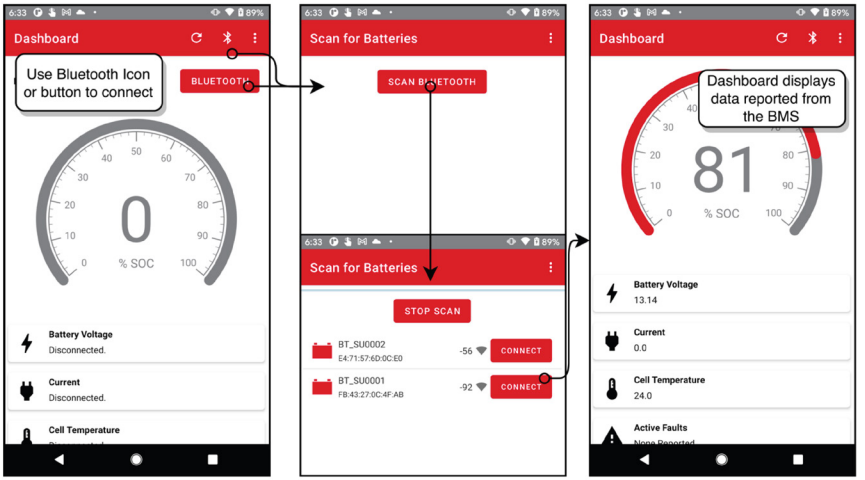
Download on the App Store

Waking up the Battery

This is also discussed above in Waking up the Battery.

If you have just received your battery, it may have entered a low power sleep mode during transit. In this state, the Bluetooth will not broadcast a signal your device can connect to. For R-Series drop-in LFP models, connect a charger or load to "wake up" that unit and enable a Bluetooth connection. To wake an S-Series drop-in LFP battery, press the reset button located below the onboard screen.

Establishing a Connection

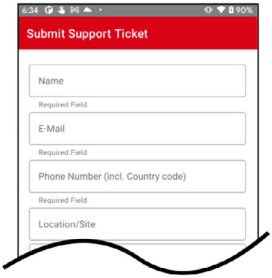


First, select the Bluetooth icon ( ) from the top bar. Your device will search for batteries within signal range. If your battery cannot be found, try waking up the battery (above), and ensure no devices which may block or interfere with a wireless signal are nearby. All batteries within range will be listed by the app. If you have multiple batteries to connect to, consult the lasered serial number on the side of the unit to keep track of each battery. Consider installing them in ascending order, or an order you can easily remember. Bluetooth names may not be sequential but will be unique.

Dashboard & Support Screens

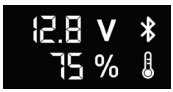
The main Dashboard screen has a display of estimated state-of-charge (SOC), the connected battery, battery voltage, current, internal cell temperature, and any active fault codes.

Using the app, you can submit a support ticket directly to our service team, you will receive email confirmation and be contacted by us regarding your issue. Please fill this out with as much relevant information as you can to better aide our support personnel.



ADDITIONAL S-SERIES FEATURES

DISPLAY

	Regular State: Voltage, SOC, Heat/Bluetooth Status
	Error State: Error Code is displayed.

BMS ERROR CODE REFERENCE (Repeated in Appendix A)

CODE	DESCRIPTION	ACTION
ER0	Other/Unknown	Refer to App, contact support@rollsbattery.com
ER1	Over Voltage	Discharge Battery
ER2	Under Voltage	Charge Battery
ER3	Over Temperature	Battery is too hot, consider the ambient temperature, insulation and spacing between batteries.
ER4	Under Temperature	Battery is too cold, consider insulation to environment, and environment generally. Check heating status – battery may need time to heat.
ER5	Charge Over Current	Adjust charger setpoints to match max current for your unit.
ER6	Short Circuit/Discharge	Adjust charger setpoints to match max current for your unit and **use caution on install** to avoid accidentally short circuiting your battery.
ER7	Imbalance	If consistently occurring, reduce charge setpoints and leave at CV voltage to rebalance cells.
ER8	Switch Over Temperature	Possibly Address Cooling/Insulation, Current, and External Temperature. If this continues at currents below specification, please contact support.

STATUS BUTTON

New S-Series drop-in LFP models feature a button located below the integrated screen on the top of the case. This button enables the user to quickly see their battery voltage and estimated state-of-charge (SOC), without connecting to the app, or grabbing a multimeter. It can also be used to quickly put the battery into or out of sleep mode, enabling better peace of mind when receiving and storing your S-Series LFP battery.

DESCRIPTION	ACTION
Short Press	Turn on display (SOC and voltage) and Bluetooth search.
Long Press (3 Seconds)	Put battery into or out of sleep/storage mode.

FUSE ACCESS

S-SERIES FUSE REFERENCE				
Rolls S-Series	Ratings		Part Number	
	Current	Voltage	Littelfuse	Generic
S24-50 LFP	100A	58V	142.5631.6102 (M5)	ANS - 100 (M5)
S12-100 LFP	200A	58V	142.5631.6202 (M5)	ANS - 200 (M5)
S24-100 LFP	200A	70V	0998200.UX-2M8 (M8)	ANM - 200 (M8)
S12-135 LFP, S12-150 LFP, S24-150 LFP	300A	70V	0998300.UX-2M8 (M8)	ANM - 300 (M8)
S12-200 LFP, S12-300 LFP	400A	70V	0998400.UX-2M8 (M8)	ANM - 400 (M8)

FUSE REPLACEMENT PROCEDURE

If the fuse on your S-Series drop-in LFP model is blown, it is likely that there is a secondary effect which has caused this to occur. This may be caused by an imbalance causing charge equalization between batteries (at very high currents), a component drawing too much current, or a BMS issue causing the secondary protection to be necessary. If you have checked all connected devices, the balance of connected series strings or batteries, and the BMS through the app, and still need to replace the fuse on your S-Series drop-in model, best practices are as follows:

1. Remove fuse access cover.
2. Visually inspect the fuse, or employ a continuity tester, to ensure the fuse is blown.
3. Using a battery isolator switch or disconnecting the positive terminal, remove the battery from the system.
4. Remove the fuse bolts from the fuse, and remove the fuse.
5. Replace the fuse and reconnect the fuse bolts, using proper torque:
    a. M8 (ANM) 10-12nm.
    b. M5 (ANS) 6-8nm.

   Note: The fuse is not directional, but it is recommended to place the window facing up. for quicker identification.
6. Reconnect the battery isolator, or positive terminal connection following existing system setup procedures.

UPGRADED CONSTRUCTION

S-Series drop-in LFP models improve on construction techniques, repairability, and technology, upgrading wiring into busbars and upgrading soldered BMS connections to screw terminals. Accessible cases improve repairability, and externally accessible fusing improves safety. The external screen makes quickly finding errors in a large pack trivial, and the on/off button makes waking from sleep mode even easier.

CASE ACCESS

The case cover on Rolls S-Series drop-in LFP models is externally accessible via the available fasteners which allows for certified service by Rolls and authorized repair technicians. Accessing case internals without authorization will void the manufacturer's warranty and is not recommended as it will expose conductors that bypass the BMS and safety features of the battery.

BATTERY CHARGING

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

Rolls R-Series and S-Series drop-in LFP batteries may cycle or be stored in a partial state of charge (PSOC). Rolls R-Series and S-Series drop-in 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 cycle life. To prevent over-discharge, the BMS will disconnect the battery when the low voltage cut-off is reached, protecting the battery from overdischarge.

NOTE: Chargers that require the detection of voltage at the battery terminals to charge may fail to wake the R-Series and S-Series drop-in LFP battery from a state of under-voltage protection or sleep.

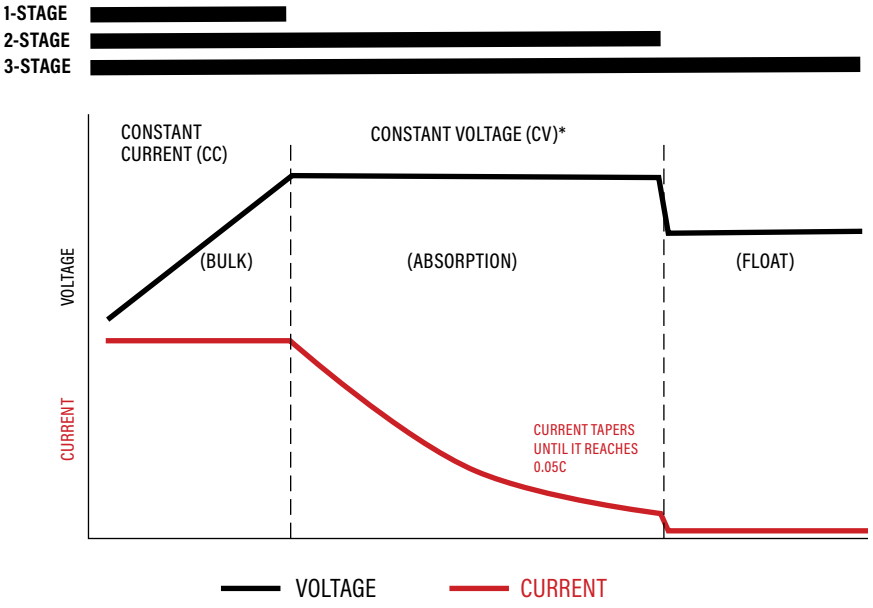
NOTE: LFP cells do not need maintenance charges like equalization, pulse charge, overcharge, or any others typically recommended or required for lead-acid batteries.

NOTE: The recommended and maximum continuous charge & discharge rates are specific to each R-Series and S-Series drop-in LFP model and are determined by capacity, cell, and BMS technology. This is provided on the product label.

CHARGING GUIDELINES

Rolls R-Series and S-Series drop-in LFP batteries may 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 of the BMS.

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 R-Series S-Series drop-in 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 the recommended drop-in 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 for optimal balancing.

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			
Recommended Charging Current for Optimal Life			
Temperature Range		**Optimal Current**	
-20-0°C (-4-32°F)		≤ 0.1C (S-Series only)	
0-10°C (32-50°F)		≤ 0.2C	
10-35°C (50-95°F)		≤ 0.5C	
35-55°C (95-131°F)		≤ 0.2C	
Maximum Continuous Charging Current			
R-Series	0.5C	S-Series	1C*

*Up to a maximum of 200A.

SYSTEM	12V NOMINAL	24V NOMINAL	36V NOMINAL	48V NOMINAL
TERMINATION VOLTAGE	14.4V	28.8V	43.2V	57.6V

NOTE: 1-Stage CC Charging may be required if charging from a source which is not efficient to run at lower power, like a generator. However, it may only charge the battery to 90-95% SOC and provide 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			
Recommended Charging Current for Optimal Life			
Temperature Range		**Optimal Current**	
-20-0°C (-4-32°F)		≤ 0.1C (S-Series only)	
0-10°C (32-50°F)		≤ 0.2C	
10-35°C (50-95°F)		≤ 0.5C	
35-55°C (95-131°F)		≤ 0.2C	
Maximum Continuous Charging Current			
R-Series	0.5C	**S-Series**	1C*

*Up to a maximum of 200A.

SYSTEM	12V NOMINAL	24V NOMINAL	36V NOMINAL	48V NOMINAL
RECOMMENDED ABSORPTION VOLTAGE	14.4V	28.8V	43.2V	57.6V
ABSORPTION RANGE (ACCEPTABLE)	14.0V – 14.6V	28.0V - 29.2V	42.0V – 43.8V	56.0V - 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 R-Series and S-Series LFP batteries:

3-STAGE CHARGE PROFILE			
Recommended Charging Current for Optimal Life			
Temperature Range		**Optimal Current**	
-20-0°C (-4-32°F)		≤ 0.1C (S-Series only)	
0-10°C (32-50°F)		≤ 0.2C	
10-35°C (50-95°F)		≤ 0.5C	
35-55°C (95-131°F)		≤ 0.2C	
Maximum Continuous Charging Current			
R-Series	0.5C	**S-Series**	1C*

*Up to a maximum of 200A.

SYSTEM	12V NOMINAL	24V NOMINAL	36V NOMINAL	48V NOMINAL
BULK to ABS VOLTAGE	14.4V	28.8V	43.2V	57.6V
ABSORPTION VOLTAGE	14.4V	28.8V	43.2V	57.6V
ABS to FLOAT	≤0.05C	≤0.05C	43.2V	≤0.05C
FLOAT VOLTAGE	13.6V	27.2V	40.8V	54.4V

Temperature Compensation: If the inverter/charger or charge controller uses temperature compensation this should be turned off when charging Rolls R-Series and S-Series 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 and will simply lead to the BMS disconnecting the charging path. 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 TEMPERATURE

Due to the chemistry of LFP cells, these batteries cannot accept high charge current at low operating temperatures without cell damage and permanent capacity loss.

Rolls R-Series drop-in LFP batteries may be safely charged between 0°C to 55°C (32°F to 131°F). However, because cycle wear is accelerated below 10°C (50 °F) the charge should be limited to 0.2C (20% of battery capacity) for optimal longevity. Similarly, at high temperatures, charge current should be limited to ≤0.2C when operating at temperatures from 35°C to 55°C (95°F to 131°F) as noted below.

Rolls S-Series drop-in LFP batteries may be charged at lower temperatures due to their internal heating which allows them to compensate for external temperatures down to as low as -20°C. If the batteries are typically charged at low temperatures [-20-0°C (-4-32°F)], proper insulation is required to keep the batteries at their warmed temperature.

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

TEMPERATURE	RECOMMENDED CHARGE CURRENT
0-10°C (32-50°F)	≤ 0.2C
10~35°C (50-95°F)	≤ 0.5C
35~55°C (95-122°F)	≤ 0.2C

NOTE: Due to the internal chemistry, LFP batteries can be discharged at lower temperatures than they may be charged. So, at low temperatures between -20°C and 0°C, R-Series drop-in LFP batteries will still be effective in discharging, but no energy may be put into the batteries.

The recommended and maximum continuous charge current is specified for each Rolls R-Series and S-Series drop-in LFP model as a function of capacity, cell and internal BMS.

RECYCLING

Rolls R-Series and S-Series drop-in 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 R-Series and S-Series LFP batteries protects them from unsafe voltage, current, and temperature conditions. It keeps cells balanced to ensure pack capacity is maintained. A BMS is required for any lithium-ion battery system with series-connected cells due to the safety requirements and performance characteristics of the cells.

C-RATE
Battery charge and discharge rates are often described as a "C-Rate", defined as:

$$C - Rate = \frac{(Rated\ Capacity)}{(Charge/Discharge\ Current)}$$

For example, if a 100Ah battery was charged at 50A, but discharged at 100A, it would be charged at a rate of C/2 and discharged at a rate of C. This rate is independent of system voltage.

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 R-Series 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, long calendar life and safety, in overcharge conditions, 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, these are multiples of 3.2V, sometimes simplified to 12V, 24V and 48V to match with compatible lead-acid systems.

APPENDIX A: S-SERIES BMS QUICK ERROR CODE REFERENCE

CODE	LEAD-ACID BATTERY	ACTION
ER0	Other/Unknown	Refer to App, contact support@rollsbattery.com
ER1	Over Voltage	Discharge Battery
ER2	Under Voltage	Charge Battery
ER3	Over Temperature	Battery is too hot, consider the ambient temperature, insulation and spacing between batteries.
ER4	Under Voltage	Battery is too cold, consider insulation to environment, and environment generally. Check heating status – battery may need time to heat.
ER5	Charge Over Current	Adjust charger setpoints to match max current for your unit.
ER6	Short Circuit/Discharge Overcurrent	Adjust charger setpoints to match max current for your unit and use caution on install to avoid accidentally short circuiting your battery.
ER7	Imbalance	If consistently occurring, reduce charge setpoints and leave at CV voltage to rebalance cells.
ER8	Switch Over Temperature	Possibly Address Cooling/Insulation, Current, and External Temperature. If this continues at currents below specification, please contact support.

APPENDIX B: BMS PROTECTION SUMMARY REFERENCE

CODE	PROTECTION	RESET METHOD	COMMENTS
Cell/Pack Overvoltage	Charge Interruption	Automatic reset after time delay or discharge.	If occurring more than 3 times in 2 minutes, discharge is required.
Cell/Pack Undervoltage	Discharge Interruption	Automatic reset after time delay or charge.	If occurring more than 3 times in 2 minutes, charge is required.
Extended Pack Undervoltage (Stored While Empty)	Battery Cannot be Recovered	Always charge R-Series Batteries within 72 hours of full discharge.	–
Pack Overcurrent or Short Circuit	Charge and Discharge Interruption	Automatically reset after time delay.	If occurring more than 3 times in 2 minutes, charge is required.
High temperature at BMS or Cell*	Charge and Discharge Interruption	Automatically reset after cooling.	BMS will display alarm when approaching disconnect.
Low temperature at BMS or Cell*	Charge Interruption	Automatically reset after warming.	BMS will display alarm when approaching disconnect.
Extreme low temperature at BMS or Cell	Charge and Discharge Interruption	Automatically reset after warming.	BMS will display alarm when approaching disconnect.
(S-Series only) Secondary Overcurrent Protection	Charge and Discharge Interrupted, external fuse is blown	Replace fuse	Secondary protection is also recommended for all R-Series batteries.

CONTACTS

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