Lithionics Battery®

Pre-Charge Feature FAQ

1. What is a Pre-Charge Feature?

All modern power inverters and motor controllers have a large capacitor bank at their DC input terminals to reduce the ripple current and its associated EMI interference. Input capacitors help to provide smooth power conversion from DC to an AC sine wave and back to DC when charging the battery. When initially connecting a battery to a capacitive input, there is an inrush of current as the input capacitance is charged up to the battery voltage. With large batteries (with a low source resistance) and powerful loads (with large capacitors across the input), the inrush current can easily peak 1000A or more. A pre-charge circuit limits that inrush current, without limiting the operating current.

Below is the snapshot from the operation manual of the popular SMA Sunny Island inverters, stating the large values of their input capacitors.

- Due to the input capacity of the Sunny Island, high inrush current from the battery to Sunny Island might occur when the battery is connected to the input terminals of Sunny Island:
  - SI3.0M: approximately 30,000µF
  - SI4.4M: approximately 30,000µF
  - SI8.0H: approximately 49,000µF
  - SI6.0H: approximately 49,000µF

2. Why do I need a Pre-Charge Feature?

When connecting a Lead Acid battery to a DC input of the inverter, there is a nasty spark, which can tack weld the battery lug to the input terminal. This spark is caused by the inrush current to charge the input capacitors. Lithionics Battery has an intelligent BMS, which includes a contactor allowing the BMS to turn the battery power on/off when needed. Without the pre-charge feature that initial contact spark would happen inside the contactor and could tack weld it, preventing its normal operations and damaging the BMS and battery modules. The pre-charge feature eliminates this initial inrush of current and eliminates the nasty spark.

3. How does the Pre-Charge Feature work?

The pre-charge feature adds a resistor and another smaller contactor across the main power contactor inside the BMS. When the BMS switches on the battery power, it first closes the pre-charge contactor, which limits the inrush current via the resistor circuit to approximately 1A, safely charging the capacitors in less than 5 seconds, while the BMS is monitoring the voltage rise at the inverter input. Once the input voltage has risen to approximately 50% of the battery voltage, the main contactor is closed, and the system is ready to operate at full power.

4. **What are the limitations of Lithionics Pre-Charge feature?**
    a. **Pre-Charge current.** If customer's load equipment has very high input capacitance, such as multiple inverters connected in parallel, or a very large single inverter, then 1A of pre-charge current will not be sufficient to raise the voltage in a limited time allocated to pre-charge. A rule of thumb can be used that Lithionics Pre-Charge feature should work on total inverter power up to 5kW. If customer's inverter power is significantly higher, then custom pre-charge solution is required to increase pre-charge current.

    b. **Parasitic DC loads.** If customer's system has any DC loads in parallel with inverters and those DC loads cannot be turned off while turning on the battery power, then such DC loads will take current away from already limited pre-charge current, preventing sufficient voltage rise at the inverter DC input, causing pre-charge failure. A custom pre-charge solution with higher current could resolve this issue, or you can see if parasitic DC loads can be switched off during battery power up.

    NOTE: Lithionics Battery can offer custom BMS wiring interface for external pre-charge, so customers can install their own pre-charge resistor and contactor near the BMS unit, selecting resistor value and power to handle higher pre-charge current.

5. **Are there any configuration parameters associated with Pre-Charge Feature?**

    During pre-charge, while capacitors inside the inverter are charging up, the inverter's internal circuits also start to initialize, which consumes some of the pre-charge current, preventing full voltage rise. A compromise must be made for pre-charge time and voltage, to allow quick and sufficient voltage rise, before inverter's own consumption overcomes the pre-charge current and voltage stops rising, or even falls back down.

    There are 2 parameters in the BMS configuration which control the Pre-charge Feature behavior. Most applications will work fine with factory default values, but in some special cases customers may need to adjust them if default values produce pre-charge errors. See the BMS Configuration guide for details on entering configuration commands via Serial or Bluetooth terminal.

    - **PRCHVLT=75** Percentile target for voltage rise during pre-charge. Default value is 75%.
      If BMS produces pre-charge errors, this value must be reduced, to match with slower than expected voltage rise, which can be measured with DVM at the inverter's DC terminals during pre-charge sequence. We don't recommend going below 50% as it reduces effectiveness of pre-charge function and increases risk of contactor welding.

    - **PRCHTIME=40** Time limit for pre-charge sequence, set in 125ms increments. Default value of 40 represents 5 seconds. We do not recommend changing this value as it could produce worse results and could potentially damage pre-charge resistor inside the BMS.

6. How much does Lithionics Battery Pre-Charge feature cost?

To prevent possible BMS damage due to capacitive inrush and in order to ensure your warranty is in effect, the customer is recommended to purchase a low-cost pre-charge system integrated into our BMS at a cost of $149.00 (MSRP). The pre-charge circuit is comprised of a custom printed circuit board with integrated logic, resistor network and a pre-charge contactor system. A view of the pre-charge assembly is shown below.