ENPHASE

TECHNICAL BRIEF

IQ Battery 5P battery management system

Applicable regions: North America

Contents

Overview

Enphase IQ Battery 5P is a fully engineered AC-coupled energy storage solution. The battery system is certified to UL 9540 and tested to UL 9540A. The Enphase IQ Battery system is AC-coupled to the premises wiring using safe wiring techniques. The battery cell uses a Lithium Iron Phosphate (LiFePO4) (LFP) cathode material, which offers good electrical performance with low resistance for a high current rating, long cycle life, enhanced safety, and tolerance to abuse. The Enphase IQ Battery systems use advanced IQ8D-BAT Microinverters intended to address grid-tied and off-grid applications. The IQ8D-BAT Microinverters are fully certified to UL 1741-SB and IEEE 1547.1-2020. An example of a whole home backup system where the IQ Battery is used is described in the following diagram.

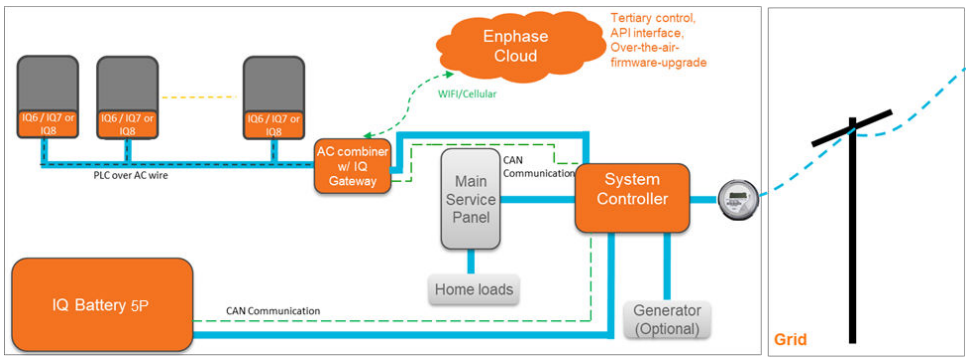

Figure 1: IQ Battery whole home backup system diagram

IQ Battery components

The following figure shows the IQ Battery 5P block diagram with major components.

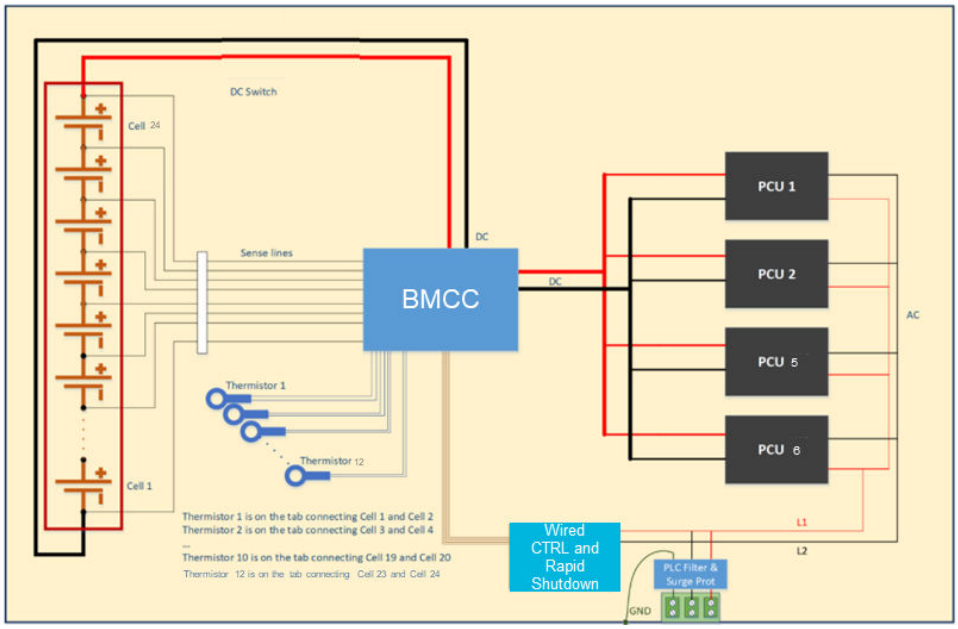

Figure 2: IQ Battery internal diagram

Power control unit (PCU): Each IQ8D-BAT Microinverter, or power conversion unit (PCU), can provide bi-directional power. The PCU can convert AC to DC power when charging the battery or convert DC to AC power when discharging the battery to supply power to loads. There are six PCUs in the IQ Battery 5P, with each PCU capable of 640 VA of bi-directional continuous power and 1280 VA peak power. These PCUs are connected in parallel and share equal power while charging or discharging the battery module (cell pack). In a rare scenario, if one PCU fails, the remaining PCUs will still operate, and the IQ Battery can still charge or discharge at reduced power.

Battery management system (BMS): The BMS monitors the voltage, current, state of charge (SoC), and temperature of each cell within the battery module to ensure safe operation and mitigate thermal runaway (TR). Unique to Enphase is the ability to monitor the health (temperature, voltage, current, and SoC) of each cell. Other systems do not monitor every cell and can only monitor groups of cells or just the entire cell packs, which may hide a latent problem. The BMS performs voltage balancing of each cell to ensure all cells share power equally. The BMS also checks and protects each cell from over/under voltage, over current, and over/under temperature conditions. In case of abnormal behavior due to voltage, current, or temperature, the BMS will cease power transfer and shut the battery system down.

The BMS also acts as the local controller for the IQ Battery 5P. It interacts with the PCUs within IQ Battery and communicates externally with the IQ Gateway, which is responsible for communicating with the Enphase Cloud (refer to the system diagram in Figure 2). Any alarms, errors, or warning messages, along with system status messages, are sent to installers and system owners to inform them about the system's state.

Cell pack: The IQ Battery 5P has one cell pack, which is configured with 24 cells connected in series. Each cell is composed of a Lithium Iron Phosphate chemistry (LiFePO4). The key benefits of LiFePO4 are its high current rating and long cycle life, as well as good thermal stability, enhanced safety,

and tolerance if abused. LiFePO4 is recognized in the industry as one of the safest chemistries for common use in residential installations.

Battery management system (BMS) functionality

The BMS of IQ Battery 5P has the following functions:

- **Monitoring and communication:** The BMS monitors each cell's voltage, temperature, and current in the battery module and performs cell voltage balancing. The BMS communicates to the IQ Gateway through the CTRL cable.
- **Manage charging and discharging:** The BMS calculates the state of charge (SoC) for each cell and the allowed charging and discharging currents to ensure cell currents conform to the allowed limits. The BMS calculates the maximum permitted charging and discharging currents to maximize each cell's performance while keeping the cell safe. For example, the charging current may be reduced at extreme temperatures or when SoC reaches maximum.
- **Protection:**The BMS protects each cell and battery module in the following manner:
  - The BMS calculates the maximum permitted charging and discharging currents based on the cell pack's status in a way that keeps the cells safe. It ensures that the commanded currents are within the permitted limits.
  - The BMS integrates a safety fuse at the positive terminal of the cell pack, which protects the cell pack from catastrophic failure.
  - If the battery is close to the operating range limits (voltage, current, temperature, SoC, SoH (State of Health)), the BMS reports warnings to the IQ Gateway through the wired communication link. In such scenarios, the BMS will also ensure that the allowed charging or discharging currents are set to zero or safe values, as appropriate.
  - When operating maximum limits are reached, the BMS can turn off the charging or discharging paths by controlling:
    - A charge Field Effect Transistor (cFET), which, when open, prohibits charging the battery. When the cFET is open, the battery can only charge through a diode to ensure the cell pack parameters do not go out of the allowed operating range. This diode path is limited to milliamperes of current.
    - A discharge Field Effect Transistor (dFET), which, when open, prohibits discharging the battery. When the dFET is open, the battery can only discharge through a diode to ensure the cell pack parameters do not go out of the allowed operating range. This diode path is limited to milliamperes of current.
  - The BMS contains an independent circuit that monitors the cell voltages. When the voltage rises out of operating range on any of the cells, this circuit turns off both the charge and discharge FETs. When any cell reaches 3.7 V, the BMS resets the on-board integrated circuits that communicate between the BMS and the PCUs. This is to ensure that PCUs follow the commanded charge currents and ensure that no communication faults prevent the commands from BMS from reaching the PCUs. After a timeout, if communication is not restored, the BMS shuts down power production, and charging or discharging currents go to zero.
  - When events are generated, they are logged in the Enphase Cloud platform, and the installer and system owner are notified of any issues.
  - The BMS contains an independent circuit that monitors the cell temperatures. This circuit opens the charge and discharge FETs and shuts down production when it detects elevated temperatures on any of the cells.

Revision history

Revision	Date	Description
TEB-00168-1.0	July 2024	Initial release.