Design Guide: TIDA-HVBMS-ESS-PLTFRM

High-Voltage Li-Ion and $LiFePO_4$ Battery Pack With Up to 1500V Combination Reference Design

Description

This reference design includes three designs for high-voltage Lithium-ion (Li-ion) and lithium iron phosphate ($LiFePO_4$) battery packs up to 1500V. The individual reference designs combined in this architecture are the battery management unit TIDA-101279, the high-voltage management unit TIDA-010272, and the battery control unit TIDA-010253. The design monitors each cell voltage, cell temperature, bus voltage, shunt current, insulation impedance, and protects the battery pack for safe use. These features make this reference design applicable for high-capacity battery pack applications.

Features

- ±2.4mV cell voltage accuracy at –40°C to 125°C without calibration
- ±0.5% bus voltage accuracy at 25°C
- ±10mA at 25°C, < 10A; ±0.1% error at 25°C, > 10A of shunt current
- Supports stackable architecture through daisy chain and Controller Area Network (CAN) interface up to 1500V
- Robust daisy-chain communication with data reclocking and ring architecture
- Robust and programmable battery cell and pack protection

Resources

TIDA-HVBMS-ESS-PLTFRM, TIDA-010279	Design Folder
TIDA-010253, TIDA-010272	Design Folder

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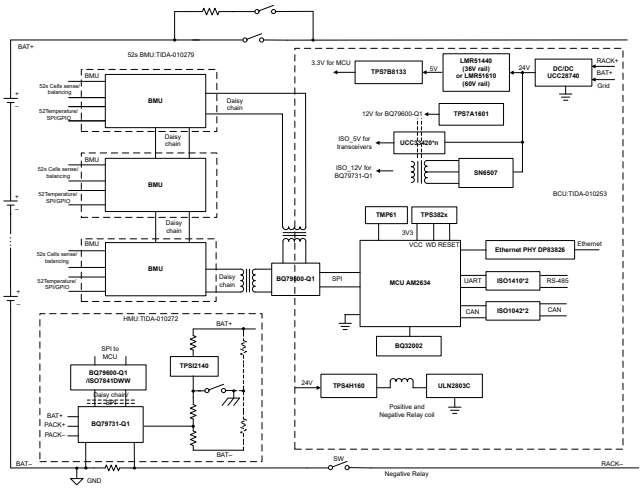
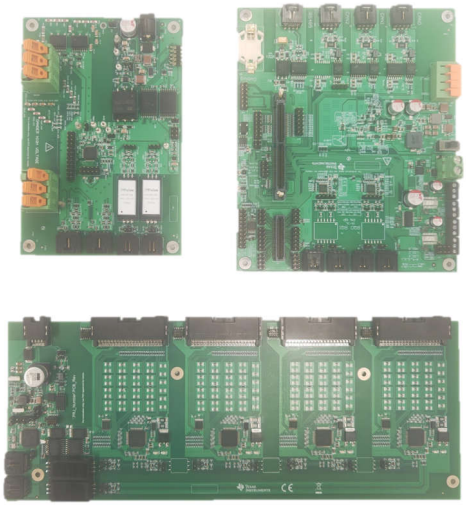
Applications

- ESS – Battery management system (BMS)





1 System Description

Currently, battery energy storage systems (BESS) play an important role in residential, commercial and industrial, and grid energy storage and management. These systems are developing towards high-precision monitoring, predictive protection, intelligent management, and are environmentally sustainable.

A BESS contains several battery packs and each pack consists of battery cells in a matter of series and parallel connection. The battery packs and cells require a proper working and storage temperature, voltage range, current range for life cycle and safety. The designer must monitor and protect the battery cell at the pack level. A battery management unit (BMU) is a controller that monitors the voltage and temperature of each battery cell in the pack and high measurement accuracy is required. The high-voltage monitor unit (HMU) part of a BMS is a critical component that focuses on managing and maintaining the safety of the high-voltage aspects of a battery rack.

The information collected by the BMU and HMU is transmitted to the rack-level controller battery control unit (BCU) for safety and charging management. A robust and fast-speed communication is also required between the BMU and the BCU. For the communication interface, a controller area network (CAN) is traditionally and widely used for robustness of communication. However, a daisy chain shows an advantage in cost especially in high-capacity battery pack applications where cost is a concern for a CAN structure which consists of many BMU nodes and CAN interface devices.

Combining the BMU, BCU, and HMU designs make this architecture a whole BESS system for high-capacity battery pack applications which can be applied in residential, commercial and industrial, and grid energy storage systems.

2 System Overview

A BMU is responsible for the cell voltage and temperature sensing and cell balancing. The HMU is responsible for monitoring the voltage and current of the battery pack, controlling the relays, and performing insulation detection. A BCU is responsible for the SOC calculation and external communication of the battery cluster, and processes all data in a unified manner.

In Figure 2-1, the three boards are connected as a whole in the following manner:

- Voltage and temperature information collected by the BMU are transmitted to the BCU board through universal asynchronous receiver-transmitter (UART) or daisy chain.
- High-voltage and insulation sampling information detected by the HMU is transmitted to the BCU through the SPI or daisy chain.
- BCU calculates and processes the signals from HMU and BMU boards, and provides outward RS-485, CAN, and Ethernet communication interfaces.

2.1 Block Diagram

Figure 2-1 shows the system block diagram.

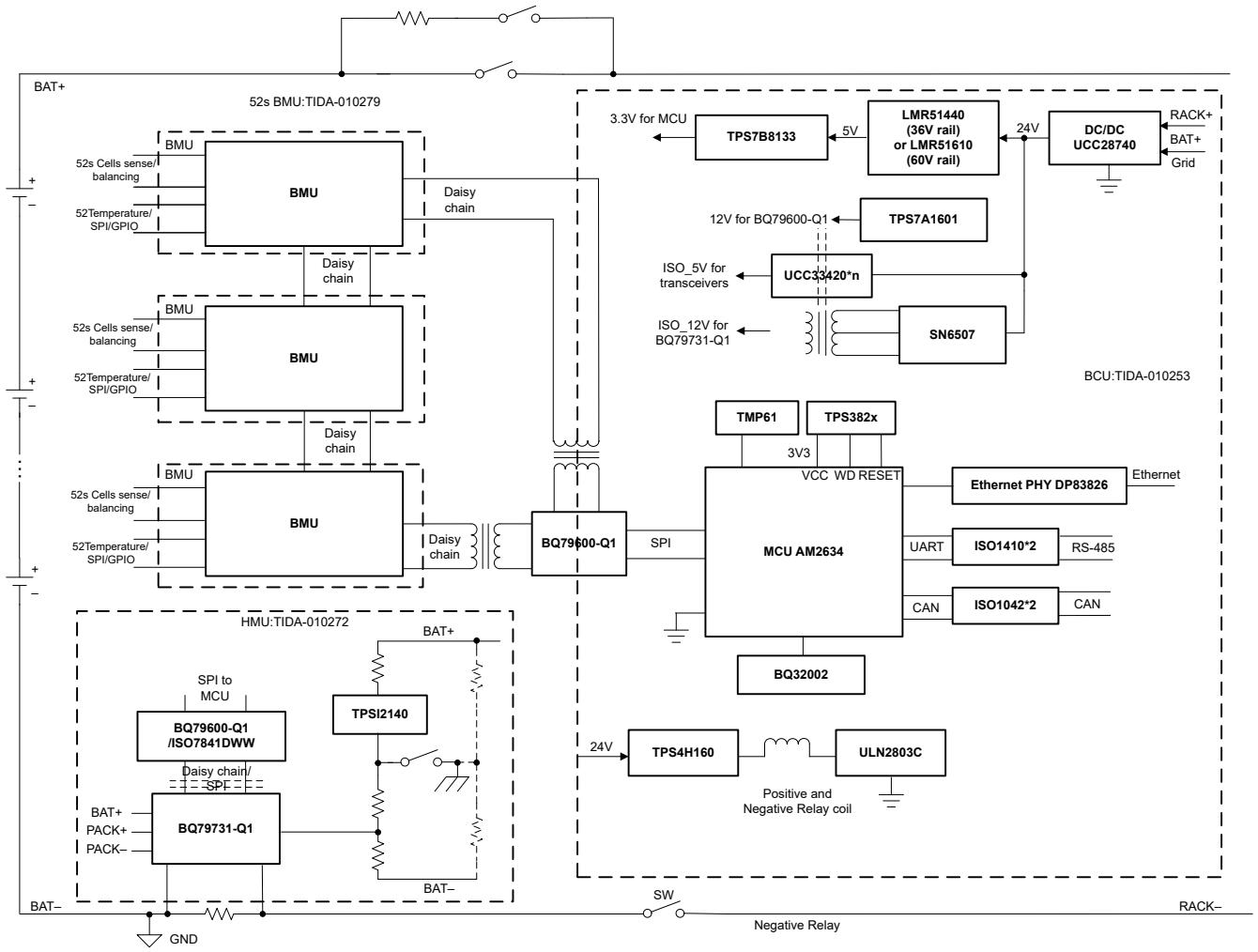


Figure 2-1. TIDA-HVBMS-ESS-PLTFRM

2.2 Highlighted Reference Designs

2.2.1 TIDA-010279

This reference design is a full cell-temperature sensing and high cell-voltage accuracy Lithium-ion (Li-ion), lithium iron phosphate ($LiFePO_4$) battery pack (52s). The design monitors each cell voltage, cell temperature, and protects the battery pack for safe use. This design supports both daisy-chain and controller area network (CAN) interfaces for a stackable communication up to 1500V battery energy storage systems. These features make this reference design applicable for high-capacity battery pack applications.

2.2.2 TIDA-010272

This reference design is a high-voltage, current and insulation impedance accuracy lithium-ion (Li-ion), $LiFePO_4$ battery rack. The design monitors four high-voltage bus inputs, one shunt current and temperature, and one insulation impedance of the battery. The design protects the battery rack to maintain safe operation. The design provides an onboard serial peripheral interface (SPI) and off-board daisy-chain communication interface, allowing for a cost-effective stackable connection and reinforced isolation. These features make this reference design applicable for high-capacity battery rack applications.

2.2.3 TIDA-010253

This reference design is a central controller for a high-voltage Lithium-ion (Li-ion), lithium iron phosphate ($LiFePO_4$) battery rack. This design provides driving circuits for high-voltage relay, communication interfaces, (including RS-485, controller area network (CAN), daisy chain, and Ethernet), an expandable interface to humidity sensor, high-voltage analog-to-digital converter (ADC), and current sensor.

This design uses a high-performance microcontroller to develop and test applications. These features make this reference design applicable for a central controller of high-capacity battery rack applications.

3 Design and Documentation Support

3.1 Design Files

3.1.1 Schematics

To download the schematics, see the design files at TIDA-HVBMS-ESS-PLTFRM.

3.1.2 BOM

To download the schematics, see the design files at TIDA-HVBMS-ESS-PLTFRM.

3.2 Documentation Support

1. Texas Instruments, *TIDA-010279: Up to 1500V Stackable Battery Management Unit Reference Design for Energy Storage Systems Design Guide*
2. Texas Instruments, *TIDA-010253: Battery Control Unit Reference Design for Energy Storage Systems Design Guide*
3. Texas Instruments, *TIDA-010272: 1500V High-Voltage Rack Monitor Unit Reference Design for Energy Storage Systems Design Guide*
4. Texas Instruments, *$LiFePO_4$ Design Considerations Application Note*
5. Texas Instruments, *BQ78706 Functional Safety-Compliant 14S Battery Monitor Data Sheet*
6. Texas Instruments, *How to Stack Battery Monitors for High-cell-count Industrial Applications* E2E™ forum
7. Texas Instruments, *Texas Instruments, Insulation Resistance Detection Designs in GESS-BMS Application Brief*
8. Texas Instruments, *Expanding Functionality of Cell Supervision Unit in Battery Management Systems Application Brief*

3.3 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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4 About the Author

JUNHUA YAN, is a TI system engineer from the SEM *Energy Infrastructure* team. Junhua focuses on battery pack and energy storage system applications and has created several designs to address industrial battery pack design challenges.

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