TI Designs: TIDA-01556
Maximum Power Point Tracking Algorithm for Low-Power Solar Battery Charging Reference Design

Description

This reference design is a software implementation of a basic maximum power point tracking algorithm for a single-cell battery charging system using a solar panel input. This design removes the requirement for extra circuitry and complex firmware by using integrated features of the charger to achieve maximized charging current all through a simple I²C-based control scheme.

Resources

TIDA-01556	Design Folder
bq25895	Product Folder
MSP430FR4133	Product Folder

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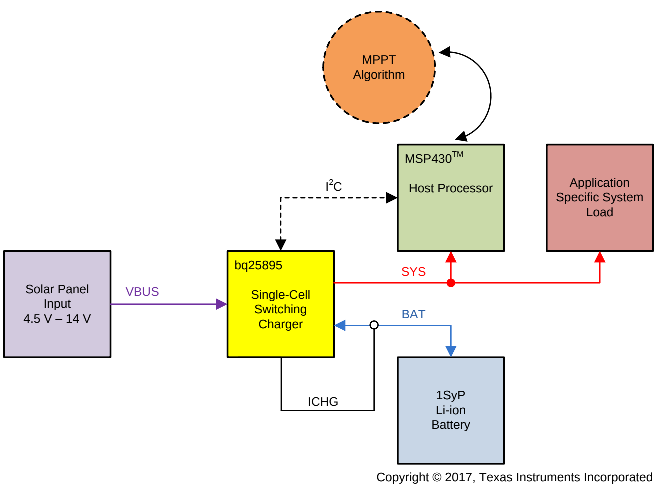
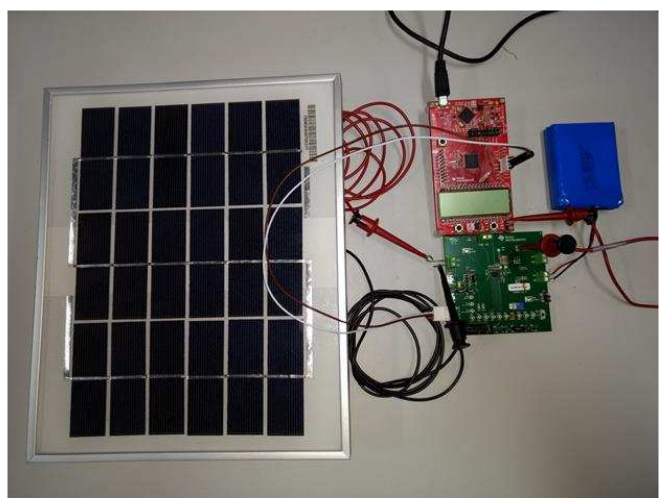
Features

- Integrated 7-bit ADC to Monitor Input Voltage, Battery Voltage, and Charge Current
- Adjustable Input Voltage Limit With 100-mV Resolution
- High Charge Efficiency with 93% at 2 A and 91% at 3 A
- Wide Input Voltage Operating Range From 3.9 V to 14 V
- Integrated Reverse Blocking FET for Solar Input Protection
- Input High-Impedance Mode for Open Circuit Voltage

Applications

- E-Bike
- IP Network Camera
- Power Bank Solutions





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1 System Description

This reference design is a software implementation of a simple MPPT algorithm for a single-cell Li-ion battery charging system with a solar panel input. To maximize the output power of the solar panel, a tracking algorithm must have the ability to monitor input power and adjust load impedance, which typically requires extra circuitry and complex firmware.

In this simple algorithm, the bq25895 single-cell switching charger is used along with the MSP430FR4133 microcontroller (MCU) to support the software control. Using the charger's integrated analog-to-digital converter (ADC) and an input power management control loop, input and output power are measured, and the load as seen by the solar panel is dynamically adjusted. Using only I²C communication with the charger, the MCU can monitor and select the peak power point that maximizes the battery charging current.

1.1 Key System Specifications

The bq25895 has an operating input range between 3.9 V and 14 V, which allows for solar panels with typical open circuit voltage ratings of up to 12 V. The charger also has an integrated 7-bit ADC that can measure the input voltage with 100 mV and charging current with 50 mA of precision. The adjustable input voltage dynamic power management loop (V_{IN}DPM) can be configured in 100-mV steps, which enables the software to regulate the input operating voltage. High impedance (HIZ) mode will disable internal biasing and the buck converter—essentially unloading a solar input source. This software uses these elements along with high-charging efficiency to manipulate the load impedance seen at the input and maximize the battery charging current.

2 System Overview

2.1 Block Diagram

Figure 1 shows the block diagram of the TIDA-01556 reference design.

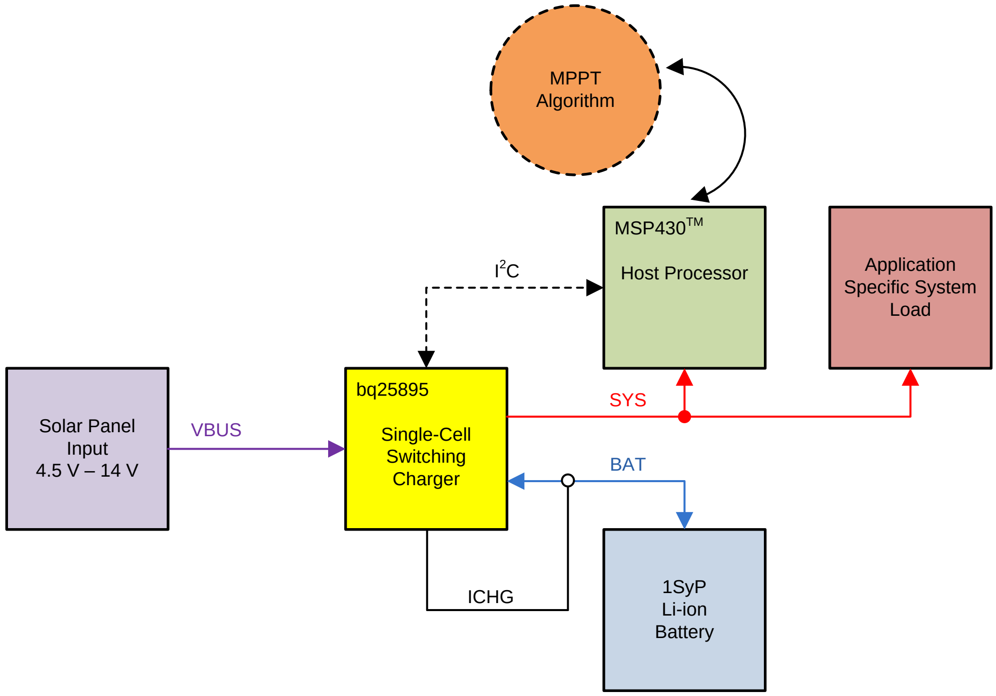

Figure 1. TIDA-01556 Block Diagram

2.2 Design Considerations

Due to the control scheme of this algorithm (described in Section 2.4.4), several considerations must be made to ensure proper algorithm functionality. First, the battery voltage level must be large enough for the charger to be above the pre-charge threshold and low enough to avoid the constant voltage (CV) mode of charging. Both pre-charge and CV modes of operation prevent the charge current from moving linearly with input power. Secondly, the system load must be low (less than 100 mA) and constant (±50-mA variation) during the sampling period in order to avoid inaccuracies in tracking. To maximize power, the charger must never be in supplement mode operation where the battery discharges current into the system. Other internal clamps must be neglected through either the charge current setting or the input current limit (I_{IN}DPM) setting, which avoids limiting charge current or input power respectively.

2.3 Highlighted Products

2.3.1 bq25895

The bq25895 device has the following key features:

- Integrated 7-bit ADC for system monitoring (voltage, temperature, charge current)
  - Measure input voltage with 100-mV resolution and charging current with 50-mA resolution
  - Burst and one-second continuous sampling modes with 10-ms typical conversion rate
- Adjustable V_{IN}DPM thresholds to regulate input voltage for unknown input current capability
  - Supports range from 3.9 V to 14 V in 100-mV steps
- High-efficiency 5-A, 1.5-MHz switched-mode buck charge
  - 93% charge efficiency at 2-A and 91% charge efficiency at 3-A charge current