Advancing the E-Bike Industry with MPS Power Supplies

Introduction

E-bikes are integrating lithium batteries to meet the demands for higher power density, longer life cycles, and improved safety. With emerging infrastructures such as Internet of Things (IoT), e-bikes are facing rapid development, from hardware assembly to service systems. This article provides an overview of MPS's power products that provide simple ways to improve and redefine e-bikes.

New Energy Metering Solution for Multi-String Lithium Batteries

In a battery management system (BMS), accurately estimating the internal state of the battery pack poses one of the biggest challenges. Implementing a solution that can accurately monitor the battery's state is critical to improving the device performance as well as user experience.

The MP279x family of battery monitors are designed as a complete analog front-end (AFE) monitoring and protection solution on lithium-ion battery strings up to 16 series cells. The MP279x family provides the following features:

- ±5mV cell measurement accuracy (25°C)
- Synchronized current and cell voltage measurements
- High-side N-channel MOSFET drivers for charge and discharge control
- Extensive, configurable hardware protections
- Coulomb counting
- Passive balancing

The MPF4279x family of battery monitors provide highly accurate estimates of key battery information on lithium-ion battery strings up to 16 series cells. The MPF4279x family provides the following features:

- Pack and individual cell state-of-charge (SOC)
- Pack and individual cell state-of-health (SOH)
- Remaining run time and charge time
- Instantaneous available power

Figure 1 shows a functional block diagram based on the MP297x family and MPF4279x family.

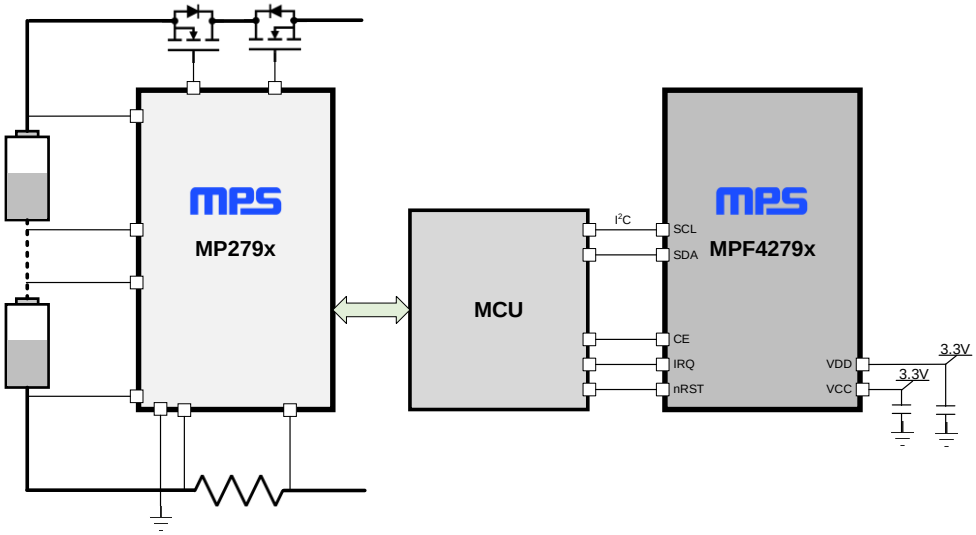

Figure 1: BMS Functional Block Diagram Based on the MP297x Family and MPF4279x Family

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A 600W, High Power Density Battery Charging Solution

With the rapid development of lithium-ion battery packs, the mainstream demand for high-power charging adapters has emerged. Traditional flyback architecture has proven to be insufficient to meet the frequency, efficiency, and power density requirements of high-power adapters. To meet these requirements, MPS offers the HR1211 as a high-performance, digital, PFC and LLC combo controller.

Figure 2 shows the reference design board for the EVHR1211-Y-00B, which includes the HR1211, HF500-15, MP6925A, and MP2009.

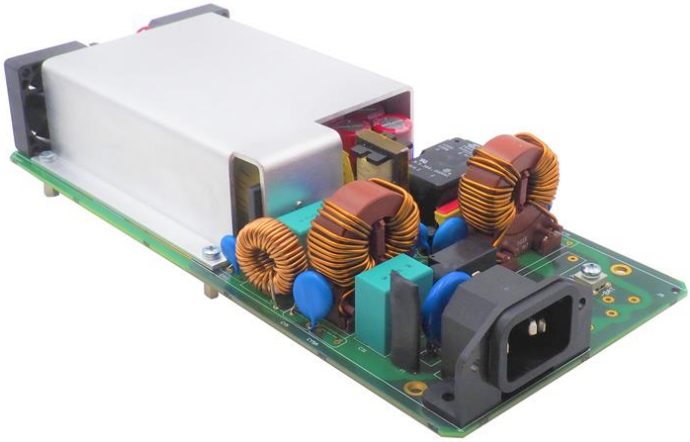

Figure 2: EVHR1211-Y-00B Reference Design Board

Figure 3 shows the functional block diagram for this design.

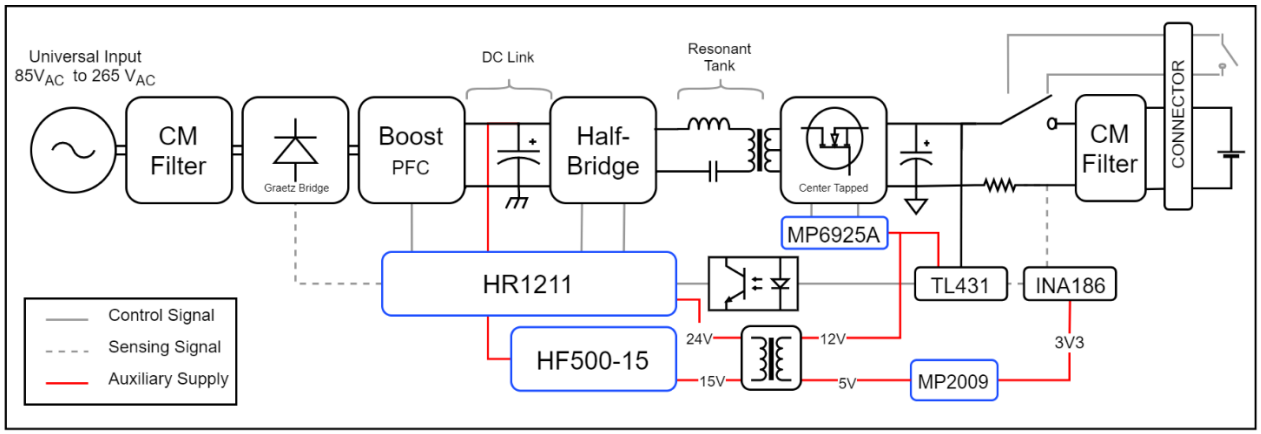

Figure 3: Functional Block Diagram

The HR1211's integrated PFC controller eliminates the requirement for low-frequency filters while maintaining an excellent power factor level.

The MP6925A is a related solution that features a synchronous rectification scheme, which replaces the secondary diode. This significantly improves efficiency and ensures that the battery is properly charged through constant-current (CC) and constant-voltage (CV) control. As a result, the solution achieves a higher power density to reduce the overall solution cost (see Figure 4).

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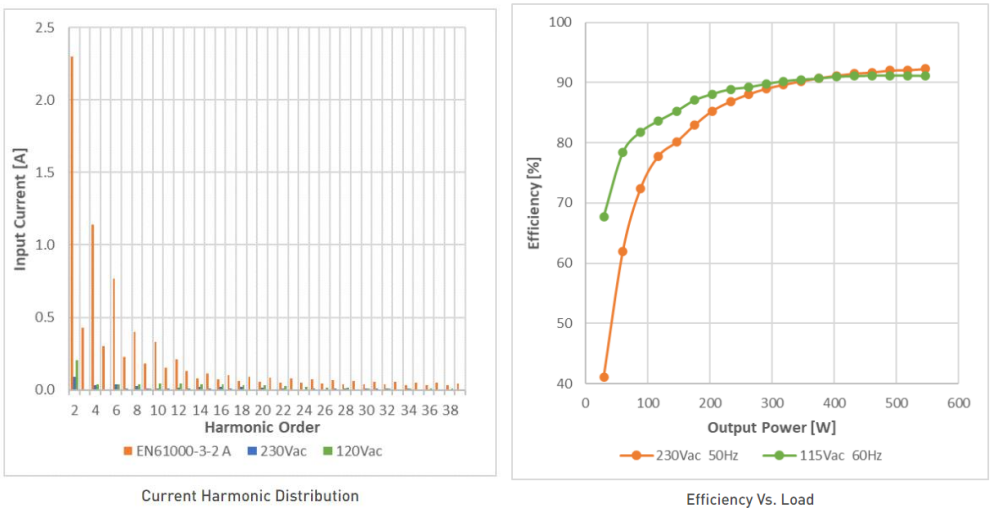

Current Harmonic Distribution

Efficiency Vs. Load

Figure 4: 600W Charging Solution Performance of the EVHR1211-Y-00B Reference Design

100V, High-Efficiency Step-Down Converter

The rated voltage for battery packs currently ranges from 48V for e-bikes, to at least 60V for light electric motorcycles. When considering the motor's back electromotive force (EMF) in a BMS scheme, a power chip that can withstand up to 100V is typically required to power the main control and communication on the board.

Figure 5 shows the MP4581, a synchronous step-down converter that can withstand 100V with a 0.8A load current capability.

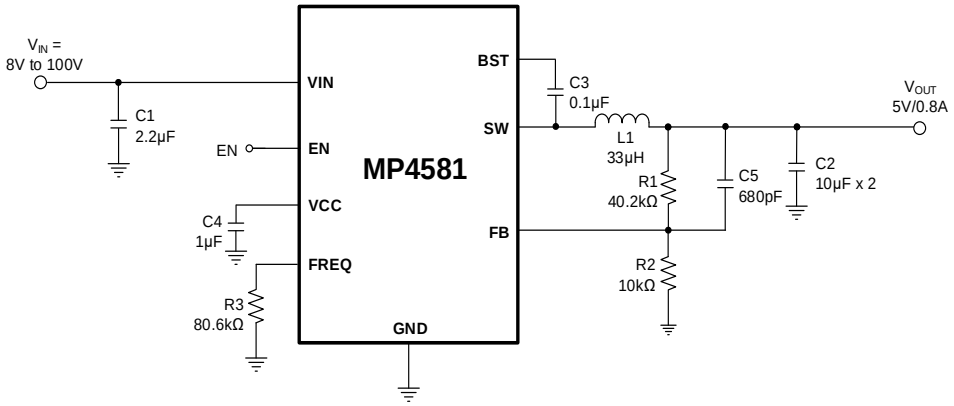

Figure 5: MP4581 Application Circuit

The MP4581 can reach an input voltage (V_{IN}) of up to 100V. It can also automatically enter pulse-skip mode (PSM) under light-load conditions to improve operation efficiency. The MP4581 achieves low standby power consumption with its extremely low 15µA quiescent current (I_Q). Figure 6 shows a comparison of the MP4581's I_Q relative to similar parts.

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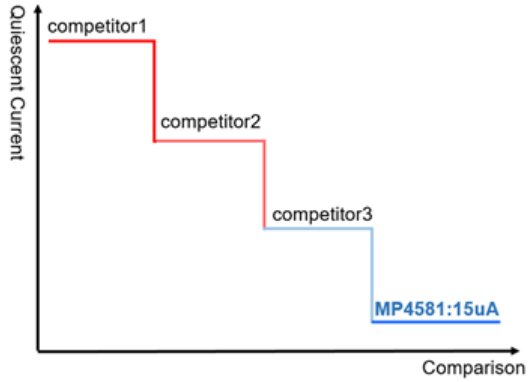

Figure 6: The MP4581's Low I_Q

Figure 7 shows the MP4581's efficiency curve.

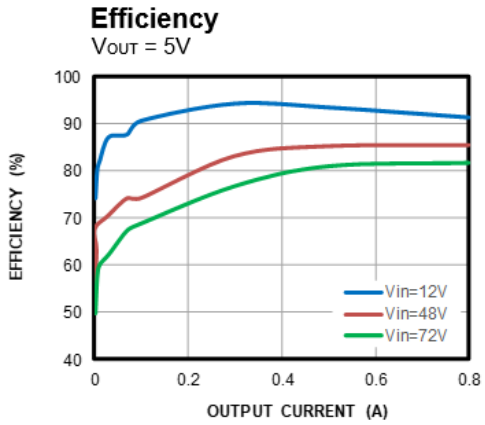

Figure 7: MP4581 Efficiency Curve

Implementation of a Maximum Power Point Tracking (MPPT) Algorithm for Small Solar Panels

Lithium Battery Charging Scheme

More people are becoming accustomed to bike-sharing services as a means of transportation, where riders can quickly use an app to rent bicycles for a certain time or distance. Shared bicycles are typically equipped with batteries, in addition to small photovoltaic panels (a type of solar panel) that power the central control unit.

In a photovoltaic charging system, two key design issues include ensuring that the photovoltaic panels provide maximum power to the shared bicycle central control system, and controlling the backup battery to seamlessly switch between power supplies when there is insufficient light.

The MP2731 is a single-cell lithium-ion battery charge management solution that is perfectly adapted to photovoltaic input applications. Figure 8 shows the functional block diagram of the MP2731.

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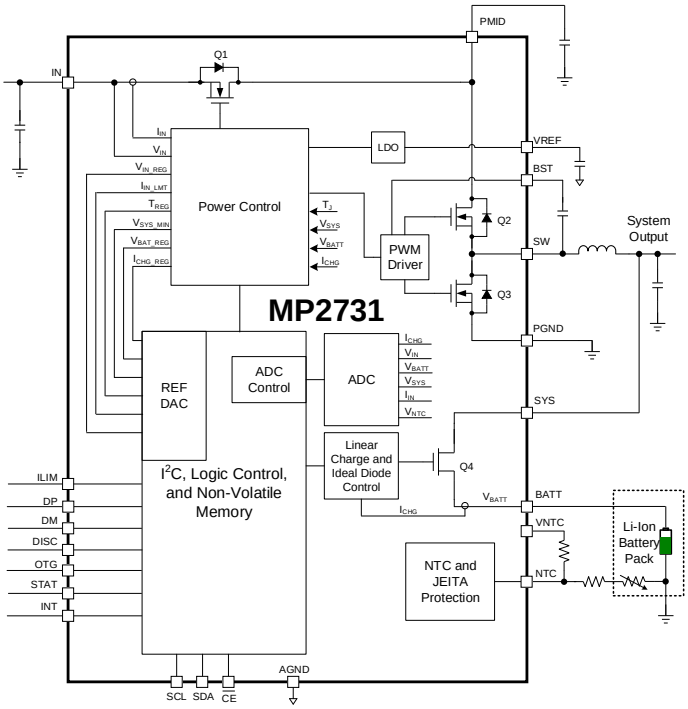

Figure 8: Functional Architecture of the MP2731

Among its cutting-edge features, the MP2731 has three important benefits: an integrated, configurable V_{IN} loop, a built-in analog-to-digital converter (ADC), and narrow-voltage DC (NVDC) power path management. These features are described below.

- Configurable V_{IN} loop: By controlling the V_{IN} loop, the photovoltaic panel's output voltage (V_{OUT}) can be adjusted easily.
- Built-in ADC: V_{IN} and the input current are collected and converted into digital information, which is then stored in the register. This allows the host computer to calculate the photovoltaic panel's output power (P_{OUT}).
- NVDC architecture: NVDC power management allows the system to seamlessly switch between using the photovoltaic panel or the backup battery as a power source.

A photovoltaic charging scheme with the MP2731 can efficiently track the maximum P_{OUT} of the photovoltaic panels, with a tracking accuracy up to 96.8% (see Figure 9).

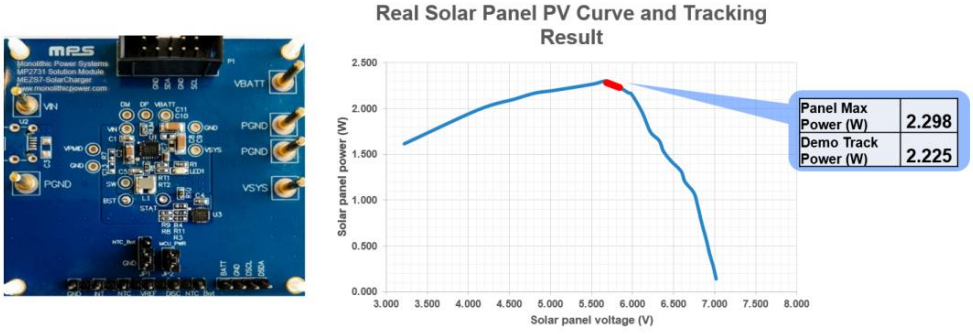

Figure 9: MP2731 Evaluation Board and Measured MPPT Tracking Accuracy

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Conclusion

As e-bikes and bike-sharing services become more widespread, MPS is leading the wave of e-bikes with products such as the MPF4279x family, HR1211, MP6925A, MP4581, and MP2731. From controllers to battery chargers to converters, MPS can improve e-bike solutions at multiple stages of the design process.

For more information on fuel gauge solutions, see the full battery management fuel gauge solution with the MPF42790.

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