Integrated Battery-Charging Solution with Power Path Management

A new single-cell power management IC with flexible configuration, rich functions, and high efficiency integrates as many analog circuits as possible, and operates with a simple, economical single-chip microcontroller to provide a compact solution for mobile power products. Compared to a traditional solution, it can save one switching charger, one inductor, and one USB interface IC. **Min Xu, Staff Application Engineer, Monolithic Power Systems, USA**

To achieve compact design for battery-powered devices, the battery is usually not removable and the capacity is limited by the space reserved for the battery. As a result, the operation time of the device is a major concern as devices are built with more and more power-consuming functions. To improve the portability of battery-powered devices, another auxiliary charging device with greater battery capacity is often used, such as power banks.

Power banks have been popular as an auxiliary charging device for many years because of the conflict between the increased demand for portable device performance and the limits on battery size and capacity. However, for a power bank to be considered to have good performance, compact design (for lower weight) and higher efficiency (for longer operation time) have become more necessary. There is a similar pattern with charging cases for other devices.

The conventional solution is to use a separate charging device – either a linear charger IC or switching charger IC – and a boost converter with a blocking FET to serve as power input and output, respectively (see Figure 1). However, this is not an ideal solution for meeting consumer or manufacturer demands.

New innovation

The MP2696A is a single-cell power management IC with flexible configuration, rich functions, and high efficiency. The IC integrates as many analog circuits as possible, and operates with a simple, economical single-chip MCU to provide an incredibly compact solution for mobile power products (see Figure 2).

Compared to a traditional solution, it can save one switching charger, one inductor, and one USB interface IC. The MP2696A offers a number of features that improve efficiency and performance:

- Bidirectional operation mode to support charge and discharge using single inductor
- Integrated pass-through path with protection and independent control
- Programmable JEITA battery temperature protection thresholds
- Integrated FETs with low conduction resistance
- Integrated programmable input current limit and input voltage limit
- Automatically enters sleep mode when no load is connected
- Automatically INT output when a smartphone is connected
- Integrated enumeration interface to output maximum power for smartphone

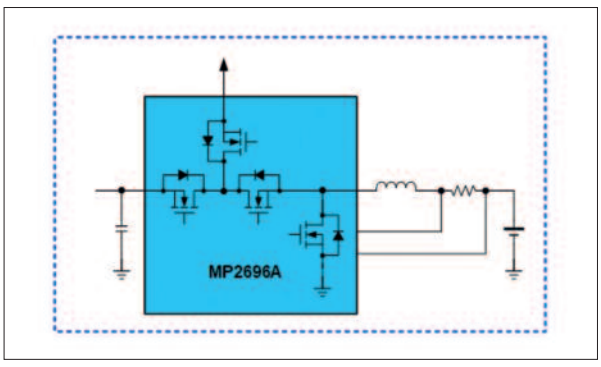


Figure 2: High integration with bidirectional operation mode

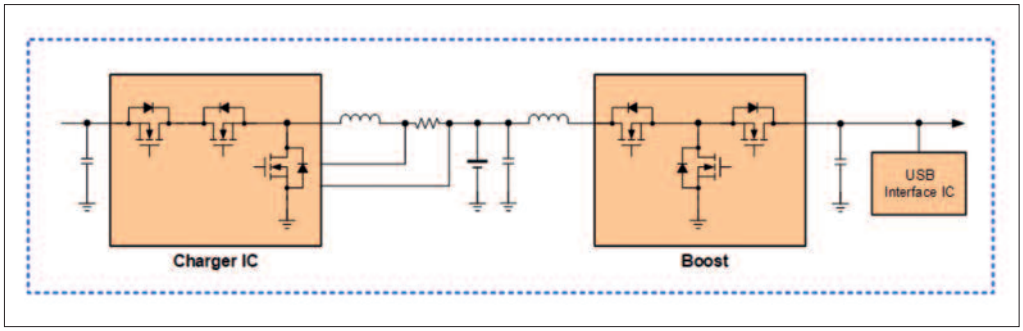


Figure 1: Conventional IC charger and boost converter

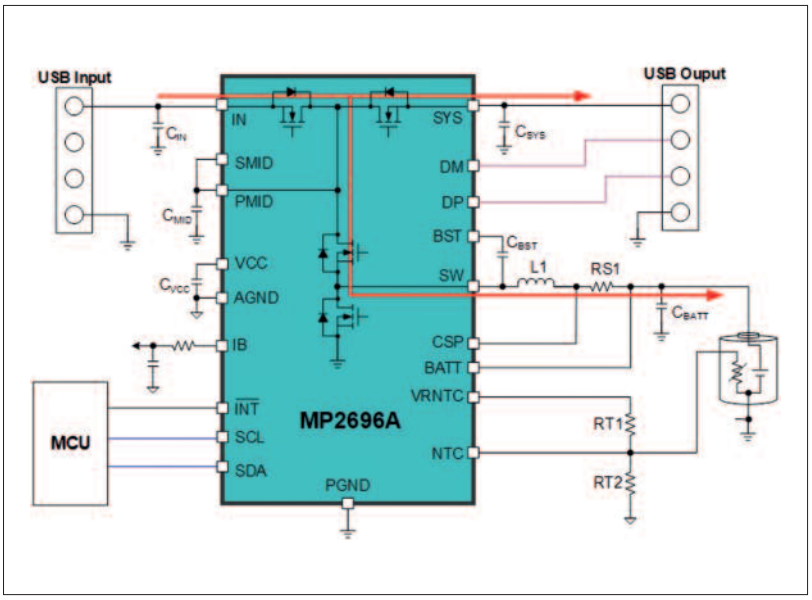


Figure 3: **Power flow in charging mode**

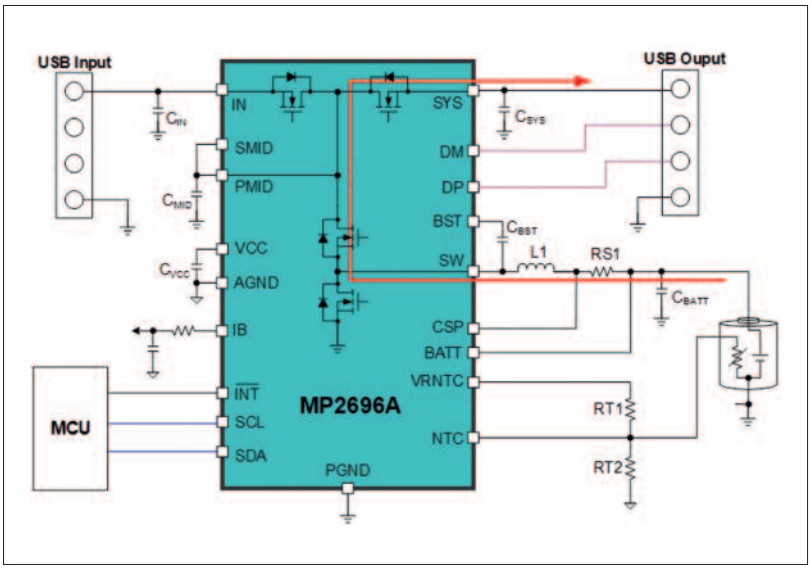


Figure 4: **Power Flow in discharge mode**

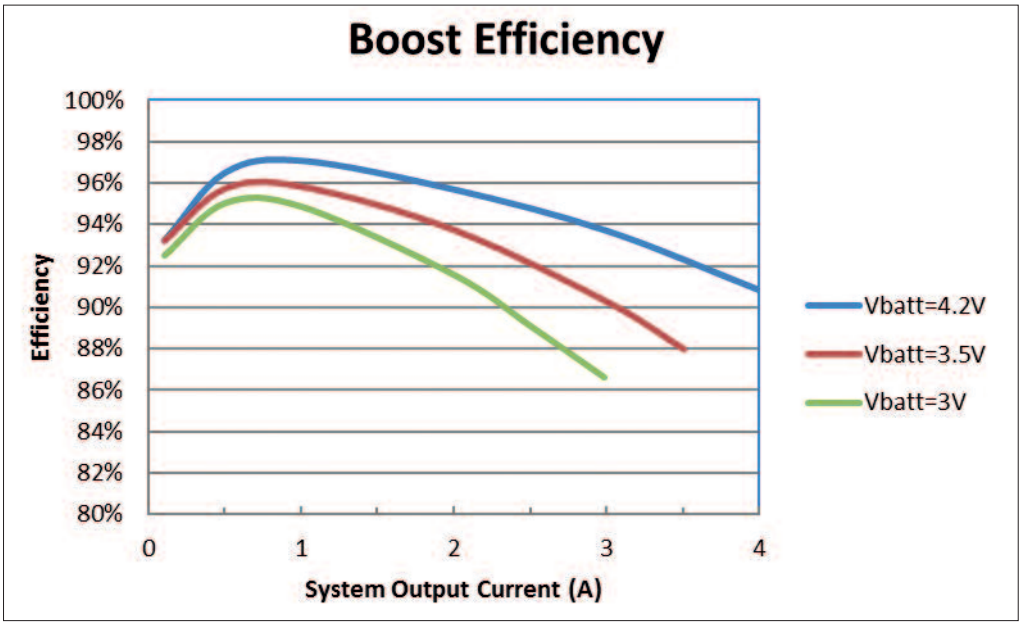
The MP2696A communicates with the MCU through the I²C interface. It is capable of bidirectional operation in charge mode or boost discharge mode, which makes it very suitable for power bank and charging case applications. The operation mode and parameters can be flexibly set by the MCU. The operation status and any fault event are also indicated through status and fault registers.

Charging mode

The MP2696A is designed for a USB input, and can withstand up to 16 V input voltage. As the typical input voltage of the USB port is 5 V, the voltage rating of the device guarantees the robustness of the power bank even if a high surge voltage is generated at the cable plug.

The device has a programmable input current limit and input voltage limit. Up to 3 A input current limit allows to be compliant with 15 W Type-C port electrical characteristic requirements (see Figure 3). Together with the MCU, it limits the input current based on the input power supply, which ensures that it meets BC1.2 and USB Type-C specifications. Thanks to an additional input voltage limit, the MP2696A charges the battery with an optimized charge current, reducing the charge time regardless of what type of adaptor is applied.

The MP2696A can operate reversely in boost mode to provide 5 V output with up to 3.6 A at the SYS terminal (see Figure 4). It also has an output cable voltage drop compensation function, and an output current loop to regulate the output current when the load current exceeds the output current limit setting. When the load current increases, the IC slightly increases the output voltage to ensure that the output voltage after the cable is constant, and the



LEFT Figure 5: **Efficiency in discharge mode**

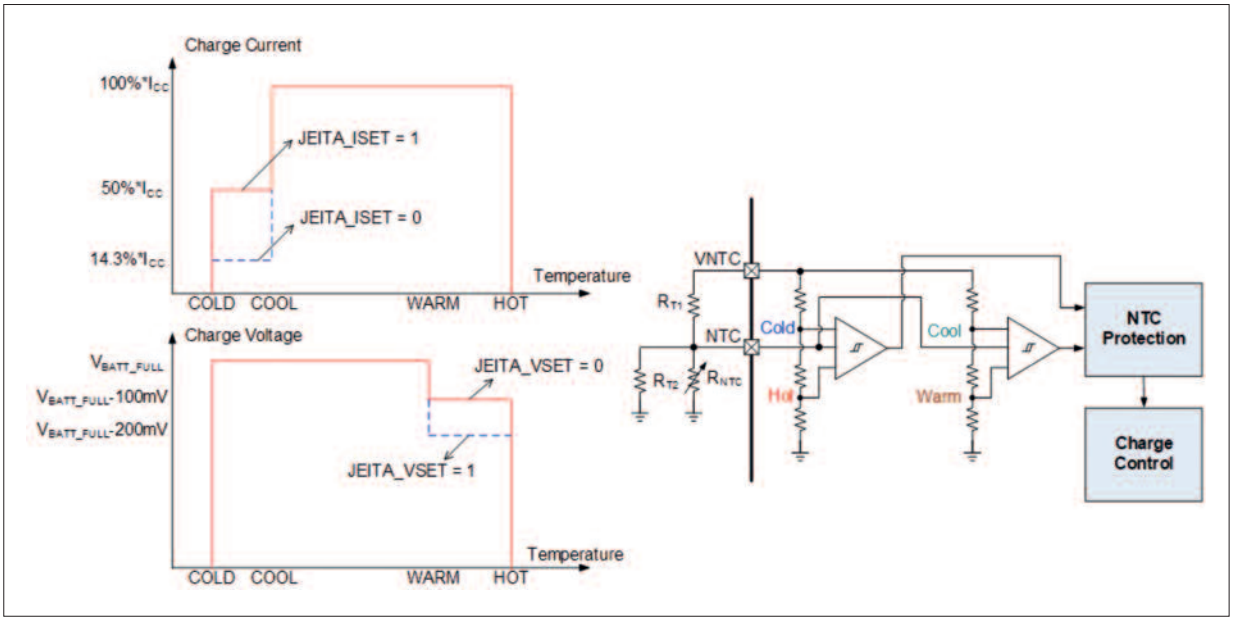


Figure 6: **Temperature protections**

compensation value can be programmed.

The extreme low on resistance of integrated FETs mean the MP2696A performs with outstanding efficiency, and makes it suitable for application in highly compact designs (Figure 5).

Protections and smart detection

The MP2696A offers robust protections in all modes. In charge mode, it has input over-voltage protection, battery over-voltage protection, a charge safety timer, and a watchdog timer. In discharge mode, it has battery under-voltage lockout and output short-circuit protection. These hardware protections guarantee safe charging in the event that the MCU software fails.

Battery temperature monitoring and protection are becoming increasingly critical in battery-powered portable devices. The Japan Electronics and Information Technology Industrial Association (JEITA) standard to optimize charging in different battery temperature conditions is becoming a mandatory feature in battery charging applications. The MP2696A not only supports this JEITA standard, but also provides programmable protection temperature points and actions within warm and cool temperature ranges (see Figure 6).

The MP2696A monitors the voltage ratio between the NTC and VNTC pins for battery temperature information, since the thermistor values change with temperature. Then the IC compares the measured ratio to its internal ratio difference to determine what the temperature range is, and how to adjust charge voltage and current. Therefore, the customer can change the I²C register to adjust the temperature thresholds without having to change the resistor divider on the board. Configuring the I?C register this way allows software engineers to save a great deal of effort on MCU coding.

When the load current falls below the programmable threshold, the IC notifies the MCU that the load is removed so that the MCU can disable boost discharge and enter standby mode. The device also detects the load connections and reports to the MCU, at which point the MCU responds and wakes up the boost discharge. This eliminates the need for many external discrete components to detect the load connection. The IC also provides an analog output at the IB pin to provide real battery current information during charging or discharging, which helps the MCU estimate the battery's capacity more accurately.

Conclusion

Together with simple MCU, the MP2696A provides a compact design solution for power bank or charging case applications. It integrates power FETs with low on resistance to support bidirectional operation, as well as a load connection detection circuit and a USB downstream enumeration interface. This allows for a very compact design and lower BOM cost. The device has a programmable JEITA temperature protection threshold to easily meet battery characteristic requirements from different vendors, outstanding efficiency performance, and lots of hardware protections. Best of all, the MP2696A is easy to use and saves design effort according to the provided reference design.