**APPLICATION NOTE**

**Automatic Detection of USB Port vs Wall Adapter Power**

**Introduction**

Skyworks AAT3685 is a versatile Lithium-ion/polymer (Li-ion/poly) battery charge control IC capable of charging single-cell Li-ion/poly batteries at constant current rates up to 1 A. The AAT3685 also uses an automatic charge reduction technique that allows the device to safely operate from Universal Serial Bus (USB) port power sources for charging batteries. This unique charger can be programmed for two discrete constant current charge levels. Collectively, these features make the AAT3685 an ideal solution for portable product applications that use both an AC wall adapter and a USB port for a charge source supply through a single input power connector.

Highly integrated portable products that use the USB port for both data communication and as a power source typically rely on their internal USB interface controller to detect the presence of a USB port connection. In this manner, a device can be set up so the battery charge controller defaults to a fast charge constant current based on the capacity of a wall adapter when power is applied and no USB port host is detected.

When a device is connected to an actual USB port, the system detects a USB host ID and can then set the battery charge controller to a level at or below 500 mA to match the current capacity available from most USB ports.

Using a USB controller to detect and set the charger I/C for USB charging works well for devices that possess such capabilities. However, for low-cost products that do not contain a USB interface controller or do not have a requirement for data transfer, detecting the presence of a USB port versus a higher power wall adapter can be problematic.

The AAT3685 can solve this dilemma with the addition of a simple external circuit using just two resistors and a general purpose NPN bi-polar transistor.

For additional information about the AAT3685, refer to the device Data Sheet, document #201888.

**USB Port vs Adapter Power Selection Using USB Port ID**

The AAT3685 circuit shown in Figure 1 has the battery charge current programmed by two set resistors, RSETH and RSETL. The constant charge current is selected by the system microcontroller using the AAT3685 PWRSET function. The USB control is programmed so that when no host USB ID is detected, the system defaults to the high battery charge current level set by RSETH, which may be as high as 1 A.

When a USB ID is detected from a USB host, the system selects the lower charge current set by RSETL. Typically, RSETL is programmed for a 500 mA charge rate. If the detected USB port is incapable of supplying 500 mA because of other system load demands or due to a fault with the port, the AAT3685 charge reduction function automatically reduces the battery charge current level to prevent the USB port from shutting down. The AAT3685 Data Sheet provides a more detailed description of the automatic charge reduction function.

**Solution for Low-Cost Systems With No USB Controller**

The solution shown in Figure 1 is the obvious choice when a device has the full capabilities provided by an integrated USB controller and system microprocessor. However, many low-cost devices that do not use a USB controller do not have the benefit of integrated hardware and firmware battery charger control.

A simple circuit can be implemented to control the AAT3685 PWRSEL function to toggle the appropriate charge current level depending upon the type of power source connected to the device. To solve the USB port versus wall adapter power dilemma, the USB port, itself, provides a simple solution.

The USB Specification (Rev 2.0) mandates the D+ and D– data lines to be terminated with a 15 kΩ ± 5% impedance. This data bus termination impedance is valid for both low-speed and full-speed devices.

Refer to the USB Specification, Rev 2.0, Chapter 7, Section 7.1.5.1, for additional information regarding USB port source and termination impedance. See Figures 2 and 3 for USB port data bus terminations as defined in the USB Rev. 2.0 specification.

If a wall adapter that uses a USB connector to provide power to a portable product leaves the D+/D– data pins open or not connected, there is an easy way to differentiate between a wall adapter and a real USB port that share the same input connection to the device. The USB port will possess a 15 kΩ impedance to ground on both the D+ and D– pins, where the wall adapter will exhibit an infinite impedance to ground. Refer to Figures 4 and 5 to see the simplified equivalents between a wall adapter and an actual USB port.
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Figure 1. AAT3685 with USB ID Controlled Charge Current

Figure 2. Full-Speed Device Cable and Resistor Connections

Figure 3. Low-Speed Device Cable and Resistor Connections
Application Circuit for Automatic Power Source Detection

For simple low-cost products that do not have the luxury of USB port control functions, a simple discrete circuit can be used in place of a microcontroller to affect power source detection and selection of the appropriate battery charge current level. Figure 6 shows the complete AAT3685 application circuit with the automatic power source detection. All that is required for the typical AAT3685 application circuit is the addition of two resistors and a low-cost NPN bi-polar transistor. A common 2N2222A or equivalent device is sufficient.

Figures 7 and 8 show the equivalent circuits for both wall adapter and USB port power operation. When a wall adapter is applied to the device input connector, the SETH resistor is selected and the AAT3685 charges the applied battery at this preset high level, which may be programmed up to 1 A.

Figure 8 depicts a USB port power source connected to the device input. The internal 15 kΩ impedance on the D+ data line pulls the base of the NPN transistor low and, in effect, pulls the PWRSEL pin on the AAT3685 low.

The AAT3685 then sets the battery charge current to a lower charge current as programmed by SETL. This lower charge current for USB charging is typically set to 500 mA. Since the AAT3685 provides an automatic charge reduction feature, the system designer does not need to worry about the capabilities of any given USB port. If the port in question cannot source a full 500 mA for any reason, the automatic charge reduction function reduces the battery charge current to the level necessary to maintain a USB port voltage for valid operation.

Conclusion

By adding three low-cost discrete components to the AAT3685 application circuit, a simple automatic power detection system can be implemented for cost-sensitive portable products that do not use complex USB data controllers.

Besides automatic power source detection, the AAT3685 provides fault-free operation with a wide variety of host USB ports and always charges a Li-ion/poly battery with the greatest constant charge current for a given situation. Collectively, with USB port power functions and the ability to accept power from a high current wall adapter, battery charging times are reduced to the minimum possible for any given power source.
Figure 6. Complete AAT3685 USB/ADP Source Supply Auto-Detect Circuit

Figure 7. AAT3685 Power Detection Circuit; Wall Adapter Power Detection, Charge Current Set to RSETH High Level

Figure 8. AAT3685 Power Detection Circuit; USB Port Detection, Charge Current Set to RSETL Low Level