WP 1.16

USB251xB Compatibility with the USB-IF Battery Charging Specification Revision 1.1

1 Introduction

The Universal Serial Bus (USB) is the interface of choice for nearly all modern portable electronic computing devices. In addition to providing a simple connection point for data transfers, the USB connector also provides power. The original USB specifications describe the use of this power for the internal device circuitry. The marketplace responded by building millions of devices that use this power for many purposes including the charging of batteries contained in portable devices such as cell phones, MP3 players, and iPods.

In order to further expand the usefulness of USB for power delivery, the USB-IF released Battery Charging Specification, revision 1.1 (BC1.1), which permits a device to consume as much as 1.8A of power via USB cable. This substantial increase beyond the 500 mA that is permitted by the USB specifications (1.1 and 2.0) allows portable devices to charge at a much higher rate than was previously permitted. **The SMSC USB251xB family of hub controllers are BC1.1 capable.**

2 The USB251xB's Battery Charging Capability

The SMSC USB251xB hub family has been designed to be compatible with BC1.1 by incorporating the circuitry for a Downstream Charging Port. The designation of a Downstream Charging Port is important because the BC1.1 specification defines 3 classes of devices:

- Dedicated Charging Ports
- Downstream Charging Ports
- Portable Devices

The primary difference between a Dedicated Charging Port and a Downstream Charging Port is USB data communication. A Dedicated Charging Port has no ability to send or receive USB data packets, whereas a Downstream Charging Port has this capability.

The USB251xB includes the circuitry to enable a portable device to detect that it is attached to a Downstream Charging Port along with all the normal circuitry associated with a USB Hub Controller. The USB251xB is a controller that isn't able to directly source the power used by downstream USB devices. Consequently, it relies on external port power control circuitry to actually provide the power and over-current protection. An OEM will need to carefully select the port power control device to ensure that the requirements of the BC1.1 specification are achieved.

2.1 Usage Model of a Downstream Charging Port

The functionality of a Downstream Charging Port is as follows:

> A Downstream Charging Port is a downstream port on a device that complies with the USB 2.0 definition of a host or a hub, except that it is required to support the Downstream Charging Port features specified herein.
>
> When not in a USB session, a Downstream Charging Port output a voltage of VDM_SRC (0.5V - 0.7V) on its D- line when it senses a voltage greater than VDAT_REF (0.25V - 0.4V) but less than VLGC (0.8V - 2.0V), on its D+ line.
>
> A Downstream Charging Port is capable of outputting a current of ICDP (0.5A min.) from VBUS at any time.[1]

In this white paper, please note that the term “battery charging handshake” is used to refer to the output of V_{DM_SRC} on D- when V_{DAT_REF} is detected on the D+ line. The USB251xB will perform this handshake whenever a device is attached to one of the downstream ports regardless of the presence of a host controller on the upstream port. The subsequent behavior will vary based on the presence or absence of a host controller.

Also, the terms “attach” and “connect” are used as they are defined in the Battery Charging Specification. Attach is a physical connection between device and host. Connect is when the downstream device asserts the D+ pullup in response to the detection of VBUS per the USB 2.0 specification.

2.1.1 USB251xB Operation when Connected to a USB Host Controller

In this mode, the downstream port power is controlled by the Host controller. Once the host instructs the hub to assert downstream port power, the portable device will detect VBUS and the device will then be required to initiate a battery charging handshake. Once complete, the BC1.1 compliant portable device will know that it can charge. The device may elect to attempt to “connect” and the USB251xB will respond like a normal USB hub in every aspect. As an example, if the device is high-speed (HS) capable, a HS chirp handshake will occur. In every signalling case, the portable device must not consume more current than is permitted by the Battery Charging specification.

2.1.2 USB251xB Operation when not Connected to a USB Host Controller

In general, USB specifications define behavior and functionality when connected to a host controller. This is also true for BC1.1 with respect to a Downstream Charging Port. The USB251xB enables battery charging capability when not attached to a host and does this in a manner that is nearly identical to the behavior when connected to the USB Host, but this behavior is not defined by BC1.1.

The USB251xB will enable the downstream port power on each battery charging enabled port at all times. The battery charging handshake is enabled and once complete, the BC1.1 compliant portable device will know that it can charge. The device may elect to attempt to “connect”, but since a host is not present on the upstream port, there will be no response. The device would be expected to enter a suspend state and is permitted to continue to charge per BC1.1.

2.1.3 USB251xB Charging Behavior when Switching from Host Disconnected to Connected Mode

SMSC sampled several portable devices and determined that the preferred behavior is for the portable device to detect the mode change when the host is re-connected (from a disconnected state) on the USB251xB’s upstream port. This preference exists because a portable device may negate the D+ pullup after an implementation dependent time period if the host never started a USB enumeration process. SMSC installed a mechanism to ensure that the portable device will re-detect the charger

1. Adapted from Section 1.4.4 of BC1.1.

when a host is present. This was done for critical satisfactory end user experience when the host detects the available USB device to ensure reliable data transfers.

When a connected host on the upstream port of the USB251xB begins the hub's USB enumeration process, the enable signal (PRT_PWR) to the port power controller will be negated, which will cause VBUS 5V to the downstream portable device to drop to ~0V.

Near the end of the hub enumeration process, the host will instruct the hub to enable downstream port power. When this occurs, the portable device will detect the assertion of VBUS and this will trigger a new charger detection sequence by the portable device. The time interval that VBUS to the portable device is dropped will be host dependent.

2.1.4 USB251xB Charging Behavior when Switching from Host Connected to Disconnected Mode

In this case, there appears to be no benefit to forcing the portable device re-detect the charger. The USB251xB will not negate PRT_PWR and therefore VBUS to the downstream device will not be interrupted when the host is disconnected. The portable device will see a USB suspend from the hub.If the portable device is enabled to charge when the host was connected, it will continue to charge uninterrupted even though the host is no longer connected to the USB251xB.

3 Using the USB251xB in a Dedicating Charging Port Mode

As stated previously, the USB251xB doesn't implement the Dedicated Charging Port circuitry as defined in the BC1.1 specification, so it will not directly support operation as a Dedicated Charging Port.

It is possible to create a product that supports operation both as a Dedicated Charging Port and a Downstream Charging Port through the use of components external to the USB251xB. To support this dual use capacity, an OEM must first resolve the following two issues:

First, the USB DP and DM lines must be shorted, through a 200Ω max resistor, so that a portable device can detect the charger as a Dedicated Charging Port.

Second, the port power controller is required to limit the current. The operation of this current limit is different than a normal USB port power controller that typically shuts off the voltage when an over-current condition is experienced. The current limit described in BC1.1 for a Dedicated Charging Port is supposed to reduce the voltage as the current is increased. The purpose is to reduce the voltage drop across the portable device's PMIC as it attempts to charge a battery at higher current levels for a faster charge time. Low cost PMIC devices are linear devices which will have to dissipate the voltage drop as heat, and this extra heat is problematic for these devices.

The extra circuitry required to support a Dedicated Charging Port mode can be enabled when the upstream VBUS to the USB251xB is absent, thus enabling both of the above conditions to be met. Conversely, if VBUS to the USB251xB is present, the above mentioned circuitry would be disabled and the USB251xB would function in Downstream Charging Port mode.

The extra circuitry would typically include a USB Switch for the DP and DM signals. In addition, the circuitry would include either a specialized USB port power control device or a secondary power limiting device that would be switched into the circuit. Please contact the SMSC Applications Engineering team for assistance.

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