AN 26.19

USB Battery Charging with the Microchip/SMSC USB2534 Hub Controller

1 Introduction

The Universal Serial Bus (USB) is the most used computer interface in the world. It started as an expansion bus for personal computers, but has proliferated quickly due to its flexibility, performance, and hot plug capability. It is used by most portable electronic devices that require PC connectivity for file transfers. These devices include MP3 players, digital cameras, cellphones, and tablets. Since a standard USB bus downstream port can provide at least 500 mA of current, it was convenient to use it for charging these devices. This document describes how this current limit can be increased and how the SMSC USB2534 Hub Controller with RapidCharge™ can be used to implement a system solution to efficiently charge portable devices.

Unless stated otherwise, references to the USB2534 also apply to the following parts: USB2533, USB2532, USB4604, USB4624, USB3613, and USB3813.

1.1 References

a. SMSC, USB2534 Datasheet. Revision 1.0.
e. SMSC, SMBus Slave Interface for the USB253x/USB3x13/USB46x4 Application Note. Rev. 1.0.

1.2 Definitions

Attach - A downstream device is attached to a USB upstream port when there is a physical cable between the two.

Connect - A downstream device is connected to a USB upstream port when there is a physical cable between the two and the device has pulled either D+ or D- high with a 1.5 kΩ resistor.

Dedicated Charging Port (DCP) - A USB downstream port that outputs power for battery charging but it is not capable to enumerate a downstream device. A DCP shall source \( I_{DCP} \) (0.5 A to 5 A) at an average voltage of \( V_{CHG} \) (4.75 V to 5.25 V). A DCP is required to connect the D+ and D- lines with a resistance \( R_{DCP, DAT} < 200 \Omega \).

Charging Downstream Port (CDP) - A USB downstream port that outputs power for battery charging and complies with the USB 2.0 specification for a USB host or hub downstream port. A CDP shall source \( I_{CDP} \) (1.5 A to 5 A) at an average voltage of \( V_{CHG} \) (4.75 V to 5.25 V). If a PD is attached but not connected, a CDP shall output a voltage of \( V_{DM, SRC} \) (0.5 V to 0.7 V) on its D- line if the voltage at D+ is greater than \( V_{DAT, REF} \) (0.25 V) and less than \( V_{LGC} \) (0.8 V).

Standard Downstream Port (SDP) - A USB downstream port that complies with the USB 2.0 specification for a USB host or hub downstream port. An SDP pulls the D+ and D- signals to ground.
with 15 kΩ resistors and can source up to 500 mA to a configured device. The limit increases to 900 mA if it is a USB 3.0 downstream port.

Accessory Charging Adapter (ACA) - Is an adapter which allows a single USB device to be connected to a charger and another device at the same time.

Dead Battery - A dead battery is defined as a battery with charge low enough as to prevent a device from successfully powering up.

Portable Device (PD) - A portable device is a device which is compliant to the USB 2.0 specification and the BC1.2 specification and can draw charging current from USB.

USB Charger - A USB charger is a device with a DCP, such as wall chargers and car chargers.

Charging Port - A DCP, CDP, ACA, or ACA dock.

## 2 USB Battery Charging

### 2.1 Overview

Any standard USB port can charge a device if the current required is < 500 mA (USB 2.0) or < 900 mA (USB 3.0). If the current required exceeds these limits then both the charging device and the charging port must follow a protocol to enable battery charging. A downstream battery charging port is responsible for providing the proper handshake signaling to the charging device to indicate that it is attached to a charging port and can draw currents above the standard USB limits. The proper signaling varies depending on the portable device. Some portable devices follow USB-IF BC1.2 protocols, but there is an installed base of devices that use proprietary handshake protocols referred here as legacy modes for battery charging.

### 2.2 Legacy Battery Charging

Legacy devices support some form of battery charging detection intended for use with a dedicated charger. Some of these chargers short D+ to D- directly or connect them through a series resistor.

For charger detection, some legacy devices assert a voltage on D+ by connecting a pull-up and then sensing a voltage on D-. If a positive voltage is detected, the device can assume it is plugged into a dedicated charger and not a standard USB port. Other devices pull down one data line while pulling up the other. Once the device detects a charger by the presence of a voltage on D-, it can start charging from the VBUS connection at current levels that exceeds the USB specification.

Other legacy devices rely on the charger to drive fixed voltages (> 1 V) on the D+ and D- data lines, these are referred to as SE1 chargers. If these voltages are sensed by the charging device, the device assumes it is plugged into a dedicated charger and starts charging. A standard USB downstream port would not present these fixed voltages on the D+, D- lines.

### 2.3 USB-IF BC1.2 Specification

The USB-IF Battery Charging Specification ([Section 1.1, "References"](#)) defines current limits and protocols to allow portable devices to draw current from USB host ports, hub downstream ports, and dedicated chargers with USB ports in excess of 500 mA (USB 2.0 port) or 900 mA (USB 3.0 port).
2.3.1 Charger Detection

The portable device (PD) is responsible for charger detection, Figure 2.1 shows the charger detection hardware required.

There are five functional blocks as follows:

1. **VBUS Detect** - A portable device (PD) includes a session valid comparator, VBUS has to be above the $V_{OTG\_SESS\_VLD}$ threshold before the charger detection is initiated.

2. **Data Contact Detect (DCD)** - This is an optional block used to confirm that the data lines made contact during attachment. A current source $I_{DP\_SRC}$ on D+ and a pulldown resistor $R_{DM\_DWN}$ on D- are turned on. If the D+ line goes low this indicates that data lines are attached to a charging port or a standard port and the logic proceeds to start Primary Detection. A timeout circuit is...
required to insure that Primary Detection starts $T_{DCD\_TIMEOUT}$ after attach in case contact is not detected or the DCD block is not present.

a. Figure 2.2 shows the DCD circuit when attached to a DCP port. Note that D+ will go low because it will be connected to pull-down resistor $R_{DM\_DWN}$ through $R_{DCP\_DAT}$.
b. Figure 2.3 shows the DCD circuit when attached to an SDP port or a CDP port. In this case, D+ will go low because it will be connected to pull-down resistor R_{DP\_DWN}.

![Figure 2.3 Data Contact Detect, SDP](image-url)
3. **Primary Detection** - A PD is required to implement primary detection, which is used to distinguish between an SDP and a charging port. When a PD is attached and powered, the PD enables \( V_{DP\_SRC} \) and \( I_{DM\_SINK} \).

   a. If the PD is attached to a DCP (Figure 2.4), \( V_{DP\_SRC} \) is reflected on D- through resistor \( R_{DCP\_DAT} < 200 \Omega \). If D- > \( V_{DAT\_REF} \), the PD can assume it is attached to a DCP or a CDP. Some non BC1.2 PDs pull D+/D- high, which may cause this detection to fail.

![Figure 2.4 Primary Detection, DCP](image-url)
b. If the PD is attached to a CDP (Figure 2.5), the CDP detects $D^+ > V_{DAT\_REF}$ and turns on $V_{DM\_SRC}$ which drives up the $D^-$ line. If $D^- > V_{DAT\_REF}$, the PD is attached to a CDP or DCP.

Figure 2.5 Primary Detection, CDP
c. If the PD is attached to an SDP (Figure 2.6), D- < V_{DAT\_REF} due to pulldown R_{DM\_DWN} and the PD assumes it is attached to an SDP.

Figure 2.6 Primary Detection, SDP
4. **Secondary Detection** - If a PD is ready for enumeration within $T_{SLVD,CON,PWD}$ after VBUS detection it can bypass secondary detection, otherwise it is required to implement secondary detection. Secondary detection is used to distinguish between a DCP and a CDP port. The PD enables voltage source $V_{DM\_SRC}$ and current sink $I_{DP\_SINK}$.

a. If the PD is attached to a DCP (Figure 2.7), $V_{DM\_SRC}$ is reflected on D+ through resistor $R_{DCP\_DAT} < 200 \Omega$. If $D+ > V_{DAT\_REF}$, the PD can assume it is attached to a DCP. Some non BC1.2 PDs pull $D+/D-$ high, which may cause this detection to fail.

![Figure 2.7 Secondary Detection, DCP](image-url)
b. If the PD is attached to a CDP (Figure 2.8), D+ < \( V_{\text{DAT_REF}} \) due to pulldown \( R_{\text{DP_DWN}} \) and the PD can assume it is attached to a CDP.

5. **ACA Detection** - ACA detection support for a PD is optional, and only PD devices with a USB Micro-AB connector can support ACA detection, as detection is done by measuring the resistance of the ID pin. For more details on ACA and ACA dock detection, refer to the BC1.2 (Section 1.1, "References") specification.
3 USB2534 Downstream Battery Charging

3.1 Overview

The SMSC USB2534 hub controller includes RapidCharge™ technology for providing the proper handshake signalling to portable devices on downstream ports to enable battery charging. A battery charging device that is connected to a USB port must verify that it is connected to a charging port before drawing current that would exceed the limits established in the USB specification (500 mA for a USB 2.0 port, 900 mA for a USB 3.0 port).

The proper signaling varies depending on the portable device. Some portable devices will adhere to the USB-IF BC1.2 specification, but there are devices that use proprietary handshake protocols referred here as legacy modes for battery charging. To be able to charge most portable devices it is necessary to provide the proper handshake signals for legacy, Chinese Telecommunications Industry battery charger specification YD/T 1591-2009, and BC1.2 devices. The USB2534 with RapidCharge™ includes all these protocols to implement a complete battery charging solution supporting devices from Apple®, Samsung, and others.

3.2 Battery Charging Modes

In the terminology of the USB battery charging specification (see Section 1.2, "Definitions"), if a USB downstream port is configured to support battery charging, the port is a Charging Downstream Port (CDP) if it can enumerate the device, or Dedicated Charging Port (DCP) if it cannot enumerate a device. If the port is not configured to support battery charging, the port is a Standard Downstream Port (SDP).

The downstream port can be in one of three modes shown in the table below.

<table>
<thead>
<tr>
<th>USB ATTACH TYPE</th>
<th>DP/DM PROFILE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCP (Dedicated Charging Port)</td>
<td>SE1 Mode or China Mode (Shorted &lt; 200 Ω) or SMSC custom mode</td>
</tr>
<tr>
<td>CDP (Charging Downstream Port)</td>
<td>VDP reflected to VDM</td>
</tr>
<tr>
<td>SDP (Standard Downstream Port) USB Host or downstream hub port</td>
<td>15 kΩ pull-down on DP and DM</td>
</tr>
</tbody>
</table>

3.3 Battery Charging Configuration

The USB2534 downstream ports can be enabled for battery charging by adding a pullup resistor (10 kΩ) on the battery charging configuration strap (BC_ENx) for corresponding port x. These straps are sampled at reset and if they are sampled high the corresponding port is enabled for battery charging, for specific pinout refer to device datasheet (Section 1.1).

Battery charging can also be enabled by use of the battery charging configuration registers that reside in the USB2534. These configuration registers are used by the internal ROM firmware to configure the battery charging functionality for each port. These registers can be modified by a configuration programmed in the One Time Programmable (OTP) memory using the Protouch tool (see Section 3.9, "ProTouch Programming Tool," on page 18). The battery charging configuration registers defaults to
0x00 at reset if the configuration strap pullups are not present and to 0xD3 for the corresponding port if the BC_EN strap is present. There is a configuration register for each port. The configuration register fields are shown in Table 3.2:

**Table 3.2 Battery Charging Configuration Fields**

<table>
<thead>
<tr>
<th>NAME</th>
<th>R/W</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCP/China Current limit</td>
<td>R/W</td>
<td>SMSC UCS 1002 power controller current limit for China / DCP mode. This field is set by the OEM using 8051 configuration load options. 00 = 500 mA, 01 = 1000 mA, 10 = 1500 mA, 11 = 2000 mA</td>
</tr>
<tr>
<td>BC1.2 DCP</td>
<td>R/W</td>
<td>Battery charging BC1.2 DCP protocol</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 = BC1.2 protocol disabled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = BC1.2 protocol enabled</td>
</tr>
<tr>
<td>China</td>
<td>R/W</td>
<td>China mode enable bit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 = China mode disabled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = China mode enabled</td>
</tr>
<tr>
<td>Samsung</td>
<td>R/W</td>
<td>Samsung mode enable bit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 = Samsung mode disabled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = Samsung mode enabled</td>
</tr>
<tr>
<td>SE1 2A</td>
<td>R/W</td>
<td>SE1 2A mode enable bit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 = SE1 2A mode disabled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = SE1 2A mode enabled</td>
</tr>
<tr>
<td>SE1</td>
<td>R/W</td>
<td>SE1 mode enable bit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 = SE1 mode disabled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = SE1 mode enabled</td>
</tr>
<tr>
<td>BC_EN</td>
<td>R/W</td>
<td>Battery charging enable bit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 = Battery charging is disabled for corresponding port</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = Battery charging is enabled for corresponding port as configured by bits 7:1.</td>
</tr>
</tbody>
</table>

### 3.4 Battery Charging in DCP Mode

When there is no upstream VBUS, and consequently no USB host connected on the upstream port, the downstream battery charging enabled ports will operate as DCP ports. The battery charging enabled ports will exit this mode if the upstream port has a host connection. DCP mode will also be entered if the USB2534 is suspended and remote wakeup is disabled.

In DCP mode battery charging the port will attempt to handshake with and identify the BC capable device. In DCP mode the device always starts in SE1 mode. It cannot detect that an SE1 device is attached, but can detect that a non-SE1 device is attached when the device toggles DM or DP.
Upon entering RapidCharge™ mode the USB2534 goes into SE1 Charging Mode and the port presents the SE1 voltage levels. If an SE1 device is attached, it will passively detect the SE1 levels and begin to charge. The DCP will not be able to detect the presence of the SE1 device. The Port remains in SE1 Charging Mode while the SE1 PD is charging.

If a BC 1.2 device is attached, its $I_{DM_{SINK}}$ is strong enough to pull the D- line low. Likewise, Legacy Charging devices have been observed to pull the D- line low upon attach. To accommodate this, the Downstream Port transitions to Legacy Charging Mode (Figure 3.2) if the Classic D- Linestate is detected as low. The D- Linestate is debounced to avoid false detects from device plug-ins.
Upon entering Legacy Charging Port mode, the Downstream Port cycles Port Power for more than $T_{\text{VBUS_REAPP}} = 100 \text{ ms}$ (as described in section 4.1.3 of Battery Charging Specification, Revision 1.2), enters DCP mode by shorting D+ to D- (through 200 Ω resistor) and a weak 125 kΩ pull-up is applied to D+.

**Figure 3.2 Legacy Charging Mode**

Upon entering Legacy Charging Port mode, the Downstream Port cycles Port Power for more than $T_{\text{VBUS_REAPP}} = 100 \text{ ms}$ (as described in section 4.1.3 of Battery Charging Specification, Revision 1.2), enters DCP mode by shorting D+ to D- (through 200 Ω resistor) and a weak 125 kΩ pull-up is applied to D+.
At that point, the Legacy Charging Port waits 25 s for the Charging Device to detect the Legacy Charging Port. Because the Downstream Port must return to SE1 Charging Mode if a device is removed, the Legacy Charging Port continuously monitors the D+ Linestate after the 25 s; if Charging Device is removed, D+ will be pulled high by the weak 125 kΩ pull-up on D+.

Some Charging Devices either tri-state their D+/D- outputs or pull D+ high when done with the Charging Port detection. With these devices, the Downstream Port will see D+ as high even though the device has not been removed. In general, it is not a problem to go to SE1 Charging Mode with these devices still inserted because the device has already completed its handshake by that time. However, because such a device may also pull D- low, the Downstream Port cannot simply enter SE1 Charging Mode immediately upon detection of D+ going high; otherwise, the Downstream Port would erroneously detect a new Charging Device (and therefore cycle port power) when in SE1 Charging Mode. Therefore, before going back to SE1 Charging Mode, the Downstream Port first exits DCP mode by breaking the connection between D+ and D-, enables a weak pull-up on both D+ and D- and checks that both D+ and D- are high. If they are both high, it is safe to return to SE1 Charging Mode.

Legacy battery charging applies to an existing installed base of products that support some form of battery charging detection through a dedicated charger. Legacy devices assert a voltage on D+ by attaching a pull-up and then sense a voltage on D-. If a positive voltage is detected, the device can assume it is plugged into a dedicated charger and not a real USB port. A USB host would not assert anything on D-. If a charger is detected, the device may decide to pull a current from VBUS that exceeds the USB specification.

### 3.5 Battery Charging Operation in CDP Mode

The battery charging enabled ports will exit DCP mode and enter CDP mode if the upstream port gets a host connection. On detection of the USB host SET_ADDRESS command, any BC enabled port will be turned off for at least 250mS before it can be turned on to allow the port power to decay. If the host sends a command to turn on port power, the command will be delayed appropriately. If the command is received after the timer has expired, it will be executed immediately.

When there is an upstream VBUS and an upstream connection, the downstream battery charging enabled ports will operate as CDP ports. If VBUS is present from deassertion of reset, the BC enabled port will go directly into CDP mode.

If VBUS comes after deassertion of reset, then the BC enabled ports will be in DCP mode first. The port will stay in DCP mode as VBUS is detected. The enabled ports will transition to CDP on detection of USB host SET_ADDRESS command. The BC enabled port will first be turned off. They must remain off for at least 250 mS before they can be turned on to allow the port power to decay. If the host sends a command to turn on port power, the command will be delayed appropriately. If the command is received after the timer has expired, it will be executed immediately.

The battery charging enabled ports will exit this mode and go into DCP mode if the upstream port loses the host connection, or VBUS goes away. During the transition, any BC enable port will be turned off. They must remain off for at least 250 mS before they can be turned on to allow the port power to decay. If the host sends a command to turn on port power, the command will be delayed appropriately. If the command is received after the timer has expired, it will be executed immediately.

In this mode the port power will be controlled by the USB host. Overcurrent events in CDP mode will be reported to the host.
3.6 Downstream USB CDP Mode Battery Charging Procedure

When a downstream port is configured as a charging port, the ROM firmware enables the battery charging detection circuitry shown in Figure 3.3 and turns on USB_IDAT_SINK_EN, this enables the 100 uA current sink and enables the $V_{DAT\_DET}$ comparator. The detector is now armed.

When a battery charging aware portable device is attached, the hub port detects that the voltage on USB D+ is greater than $V_{DAT\_REF}(0.25\sim0.40 \text{ V})$, but less than $V_{LOC}(0.8\sim2.0 \text{ V})$, then the hardware asserts the USB2_VDAT_DET signal. The firmware detects this signal and enables the USB2_VDAT_SRC_EN bit to drive $V_{DM\_SRC}(0.5\sim0.7 \text{ V})$ on USB DM. The PD detects this handshake response on DM and assumes it is connected to a Charging Port.

The attached device can use the secondary detection mechanism shown in Figure 2.7 Secondary Detection, DCP on page 9 and Figure 2.8 Secondary Detection, CDP on page 10 to distinguish between a DCP and a CDP.

![Figure 3.3 Phy Configured as USB Charging Downstream Port](image-url)
3.7 System Level Considerations

3.7.1 Attached versus Connected

When enabled, Battery Charging is supported in all states when attached and powered but not connected, this means that battery charging is supported at all times there is power.

3.7.2 Host Control of Battery Charging

There is no specified handshake between the Hub and Host to support battery charging on the downstream ports. Battery charging on the downstream port is a completely local event, with no reporting done to the host.

3.7.3 Charging while Suspended or Unconfigured

Battery charging is supported while the system is suspended or unconfigured. There is no USB-IF requirement to consume low power for a self powered hub in suspend state. The only requirement is for Bus powered devices which does not apply to a charging Hub.

3.8 Managing Overcurrent

The USB2534 is responsible for managing overcurrent shutdown (OCS) events. For battery charging ports PRTPWR is driven high (asserted) after hardware initialization.

If an OCS event occurs the PRTPWR is negated. The PRT_PWR will be negated for all ports in ganged configuration vs. respective PRT_PWR will be negated in the individual configuration.

An OCS event is acknowledged and filtered and stat_port_overcurrent (hub_stat_port) is generated from the OCS state machine. When the hub is in configured state and the OCS condition exists, the host will be notified.

After an OCS event the USB2534 will always deassert PRT_PWR.

3.8.1 DCP Mode Overcurrent

If there is an overcurrent event in DCP mode, the port is turned off for one second, then re-enabled. If the OCS event persists, the cycle is repeated for a total or three times. If after three attempts the OCS still persists, the cycle is still repeated, but with a retry interval of ten seconds. Continuous retries prevent defective devices from disabling the port.

3.8.2 CDP, SDP Mode Overcurrent

In CDP or SDP mode there is a USB host present, port power is controlled by the USB host, and OCS events are handled by the host.

The OCS event does not have to be registered. When and if the hub is connected to a host, the host will initialize the hub and turn on its port power. If the overcurrent condition still exist, the host will be notified.
3.9 ProTouch Programming Tool

The ProTouch tool is an SMSC developed tool used for configuration and programming of the USB2534 Hub controller. It can be used for development and prototyping where a single part is programmed or for multiple parts in a manufacturing environment.

The tool presents three tabs:

- **UCH Configuration Page** - This section shows the USB tree topology. The device to configure is selected in this page. The device and memory type are selected, along with the configuration file to program. In most cases the memory type should be set to OTP.

- **Configuration Editor Page** - This section shows the configurable fields for the part, including all the battery charging related fields. Once the configuration options are selected pressing the “Generate” button creates the OTP configuration bin file.

- **Execution Page** - The execution page is used to program the device with the OTP configuration file created. Pressing the START button programs the device.

For more information refer to the Protouch MPT User Manual (Section 1.1, "References," on page 1).

4 USB2534 Upstream Battery Charger Detection

4.1 Overview

The USB2534 hub controller includes the capability for USB upstream battery charger detection, which is used for implementing portable devices with USB charging. To have the best possibility of detecting the presence of a charger it is important to detect not only USB-IF BC1.2 compliant chargers but also legacy chargers, SE1 chargers, and chargers compliant with the Chinese Telecommunications Industry battery charger specification YD/T 1591-2009. The USB2534 implements a universal charger detection sequence that includes all these protocols for charger detection.

4.2 Charger Detection Types

The detection sequence is intended to identify chargers which conform to the Chinese Telecommunications Industry charger specification, chargers which conform to the USB-IF Battery Charger Specification 1.2, and single ended 1 chargers (SE1). The types of chargers detected is shown in Table 4.1.

<table>
<thead>
<tr>
<th>USB ATTACH TYPE</th>
<th>DP/DM PROFILE</th>
<th>CHARGERTYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCP (Dedicated Charging Port)</td>
<td>Shorted &lt; 200 Ω</td>
<td>001</td>
</tr>
<tr>
<td>CDP (Charging Downstream Port)</td>
<td>VDP reflected to VDM</td>
<td>010</td>
</tr>
<tr>
<td>(EnhancedChrgDet = 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDP (Standard Downstream Port)</td>
<td>15 kΩ pull-down on DP and DM</td>
<td>011</td>
</tr>
<tr>
<td>USB Host or downstream hub port</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE1 Charger Low Current Charger</td>
<td>DP=2.0 V DM=2.0 V</td>
<td>100</td>
</tr>
<tr>
<td>(500 mA)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Once the charger detection sequence is initiated the device provides feedback to the system through the SMBus run time registers, the INT_N, and the CHRGDET outputs. An external microcontroller can access these registers via the I2C/SMBus pins SCL and SDA. Refer to the SMSC SMBus Slave Interface for the USB253x/USB3x13/USB46x4 application note (Section 1.1, "References," on page 1) for SMBus register details.

The type of charger detected is returned in the ChargerType field in the UPstream Battery Charger Detection (UP_BC_DET) Register. The CHG_DET field encodes the current value that can be drawn from the USB upstream port.

The CHG_DET bits are reflected in the CHRGDET pins, these are useful for situations where the external MCU cannot access these registers, such as with a dead battery condition. These pins can be connected to external hardware, for example a power management IC (PMIC).

There are some registers like the Upstream Custom Battery Charger Control (UP_CUST_BC_CTL) and the Upstream Custom Battery Charger Status (UP_CUST_BC_STAT) available for implementing custom charger detection algorithms.

The following sections detail the sequence followed for battery charger detection depending on whether the automatic default sequence is utilized, or external MCU control is utilized.
4.3 Charger Detection Circuitry

The charger detection circuitry shown in Figure 4.1 is used to detect the type of charger attached to the upstream USB connector.
4.4 Automatic Charger Detection

In order to detect the charger, the device applies and monitors voltages on the USBUP_DP and USBUP_DM pins. The flowchart in Figure 4.2 details the charger detection sequence.
The timing diagram in Figure 4.3 illustrates automatic Battery Charger detection when SE1 charger
detection is enabled and enhanced battery charger detection is enabled. In this sequence no SE1
charger is found and the sequence continues to check for a charger compliant with the USB-IF BC1.2
specification. A BC1.2 compliant charger is detected and the detection sequence continues in order to
differentiate between a Dedicated Charging Port (DCP) and a Charging Downstream Port (CDP).

Figure 4.3 Charger Detection Timing – SE1 followed by Enhanced BC1.2

4.5 Battery Charger Detection Sequence - External MCU Control

An external MCU can override the automatic charger detection sequence by modifying the SMBus
runtime battery charging registers. Because the start of battery charging detection is set to occur by
default, the MCU must write to the battery charging control register or the configuration interlock
register to disable the automatic sequence before the sequence begins. If the automatic sequence is
disabled, the MCU can still initiate it manually by writing a 1 to the START_CHG_DET bit of the
Upstream Battery Charging Detect (UP_BC_DET) register.
4.6 System Considerations

All USB2534 devices support upstream battery charge detection, but the USB3816 also has the DEAD_BC feature, which forces the device to go into the BCINIT state if the REFCLK is not present within 4msec after reset is negated. The BCINIT state is designed to manage the dead battery condition. In this state the internal ring oscillator is enabled, the internal MCU reads the OTP memory and programs the upstream battery charging registers accordingly. Once this is done the MCU turns off the ring oscillator.

5 Summary

USB Battery Charging provides a convenient mechanism for recharging batteries on portable devices such as cellphones and tablets. The USB-IF published the BC1.2 Battery Charging Specification to help standardize the protocols used between chargers and charging devices to safely enable battery charging. The Microchip/SMSC USB2534 Hub Controller with RapidCharge™ provides battery charging protocols that include legacy, SE1, Chinese Telecommunications Industry YD/T 1591-2009, and USB-IF BC1.2 to implement a battery charging solution supporting devices from Apple®, Samsung, and most other devices.

The Microchip/SMSC USB2534 Hub Controller also supports battery charger detection for use in portable devices that require USB charger detection capability.
6 Application Note Revision History

Table 6.1 Revision History

<table>
<thead>
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APPLICATION NOTE