USB3813

USB 2.0 Hi-Speed 3-Port Hub Controller Optimized for Portable Applications

PRODUCT FEATURES

Datasheet

Highlights

- Hub Controller IC with 3 downstream ports
- High-Speed Inter-Chip (HSIC) support
  - 1 downstream HSIC port
- USB-IF Battery Charger revision 1.2 support on up & downstream ports (DCP, CDP, SDP)
- Battery charging support for Apple® devices
- **FlexConnect**: Downstream port 1 able to swap with upstream port, allowing master capable devices to control other devices on the hub
- USB to I²C™/SPI bridge endpoint support
- USB Link Power Management (LPM) support
- SUSPEND pin for remote wakeup indication to host
- Vendor Specific Messaging (VSM) support
- Enhanced OEM configuration options available through OTP or SMBus Slave Port
- Flexible power rail support
  - VBUS or VBAT only operation
  - 3.3V only operation
  - VBAT + 1.8V operation
  - 3.3V + 1.8V operation
- 30-ball (2.9x2.5mm) WLCSP, RoHS compliant package

Target Applications

- Mobile phones
- Tablets
- Ultrabooks
- Digital still cameras
- Digital video camcorders
- Gaming consoles
- PDAs
- Portable media players
- GPS personal navigation devices
- Media players/viewers

Additional Features

- **MultiTRAK**™
  - Dedicated Transaction Translator per port
- **PortMap**
  - Configurable port mapping and disable sequencing
- **PortSwap**
  - Configurable differential intra-pair signal swapping
- **PHYBoost**™
  - Programmable USB transceiver drive strength for recovering signal integrity
- **VariSense**™
  - Programmable USB receiver sensitivity
- Low power operation
- Full Power Management with individual or ganged power control of each downstream port
- Built-in Self-Powered or Bus-Powered internal default settings provide flexibility in the quantity of USB expansion ports utilized without redesign
- Supports “Quad Page” configuration OTP flash
  - Four consecutive 200 byte configuration pages
- Fully integrated USB termination and Pull-up/Pull-down resistors
- On-chip Power On Reset (POR)
- Internal 3.3V and 1.2V voltage regulators
- On Board 24MHz Crystal Driver, Resonator, or External 24MHz clock input
- Environmental
  - Commercial temperature range support (0ºC to 70ºC)
  - Industrial temperature range support (-40ºC to 85ºC)

Order Number(s):

ORDER NUMBER	TEMPERATURE RANGE	PACKAGE TYPE
USB3813-1080XY	0°C to +70°C	30-ball WLCSP
USB3813-1080XY-TR	0°C to +70°C	30-ball WLCSP (Tape & Reel)
USB3813i-1080XY	-40°C to +85°C	30-ball WLCSP
USB3813i-1080XY-TR	-40°C to +85°C	30-ball WLCSP (Tape & Reel)

This product meets the halogen maximum concentration values per IEC61249-2-21

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Chapter 1 General Description

The USB3813 is a low-power, OEM configurable, MTT (Multi-Transaction Translator) USB 2.0 hub controller with 3 downstream ports and advanced features for embedded USB applications. The USB3813 is fully compliant with the USB 2.0 Specification, USB 2.0 Link Power Management Addendum, High-Speed Inter-Chip (HSIC) USB Electrical Specification Revision 1.0, and will attach to an upstream port as a Full-Speed hub or as a Full-/Hi-Speed hub. The 3-port hub supports Low-Speed, Full-Speed, and Hi-Speed (if operating as a Hi-Speed hub) downstream devices on all of the enabled downstream (non-HSIC) ports. HSIC ports support only Hi-Speed operation.

The USB3813 has been specifically optimized for mobile embedded applications. The pin-count has been reduced by optimizing the USB3813 for mobile battery-powered embedded systems where power consumption, small package size, and minimal BOM are critical design requirements. Standby mode power has been minimized and reference clock inputs can be aligned to the customer's specific mobile application. Flexible power rail options ease integration into energy efficient designs by allowing the USB3813 to be powered in a single-source (VBUS, VBAT, 3.3V) or a dual-source (VBAT + 1.8, 3.3V + 1.8) configuration. Additionally, all required resistors on the USB ports are integrated into the hub, including all series termination and pull-up/pull-down resistors on the D+ and D– pins.

The USB3813 supports both upstream battery charger detection and downstream battery charging. The USB3813 integrated battery charger detection circuitry supports the USB-IF Battery Charging (BC1.2) detection method and most Apple devices. These circuits are used to detect the attachment and type of a USB charger and provide an interrupt output to indicate charger information is available to be read from the device's status registers via the serial interface. The USB3813 provides the battery charging handshake and supports the following USB-IF BC1.2 charging profiles:

- DCP: Dedicated Charging Port (Power brick with no data)
- CDP: Charging Downstream Port (1.5A with data)
- SDP: Standard Downstream Port (0.5A with data)
- Custom profiles loaded via SMBus or OTP

The USB3813 provides an additional USB endpoint dedicated for use as a USB to I^2C/SPI interface, allowing external circuits or devices to be monitored, controlled, or configured via the USB interface. Additionally, the USB3813 includes many powerful and unique features such as:

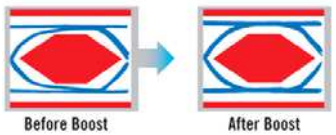
FlexConnect, which provides flexible connectivity options. The USB3813's downstream port 1 can be swapped with the upstream port, allowing master capable devices to control other devices on the hub.

MultiTRAK™ Technology, which utilizes a dedicated Transaction Translator (TT) per port to maintain consistent full-speed data throughput regardless of the number of active downstream connections. MultiTRAK™ outperforms conventional USB 2.0 hubs with a single TT in USB full-speed data transfers.

PortMap, which provides flexible port mapping and disable sequences. The downstream ports of a USB3813 hub can be reordered or disabled in any sequence to support multiple platform designs with minimum effort. For any port that is disabled, the USB3813 hub controllers automatically reorder the remaining ports to match the USB host controller's port numbering scheme.

PortSwap, which adds per-port programmability to USB differential-pair pin locations. PortSwap allows direct alignment of USB signals (D+/D-) to connectors to avoid uneven trace length or crossing of the USB differential signals on the PCB.

PHYBoost, which provides programmable levels of Hi-Speed USB signal drive strength in the downstream port transceivers. PHYBoost attempts to restore USB signal integrity in a compromised system environment. The graphic on the right shows an example of Hi-Speed USB eye diagrams before and after PHYBoost signal integrity restoration.



VariSense, which controls the USB receiver sensitivity enabling programmable levels of USB signal receive sensitivity. This capability allows operation in a sub-optimal system environment, such as when a captive USB cable is used.

The USB3813 is available in commercial (0°C to +70°C) and industrial (-40°C to +85°C) temperature range versions.

1.1 Block Diagram

Figure 1.1 details the internal block diagram of the USB3813.

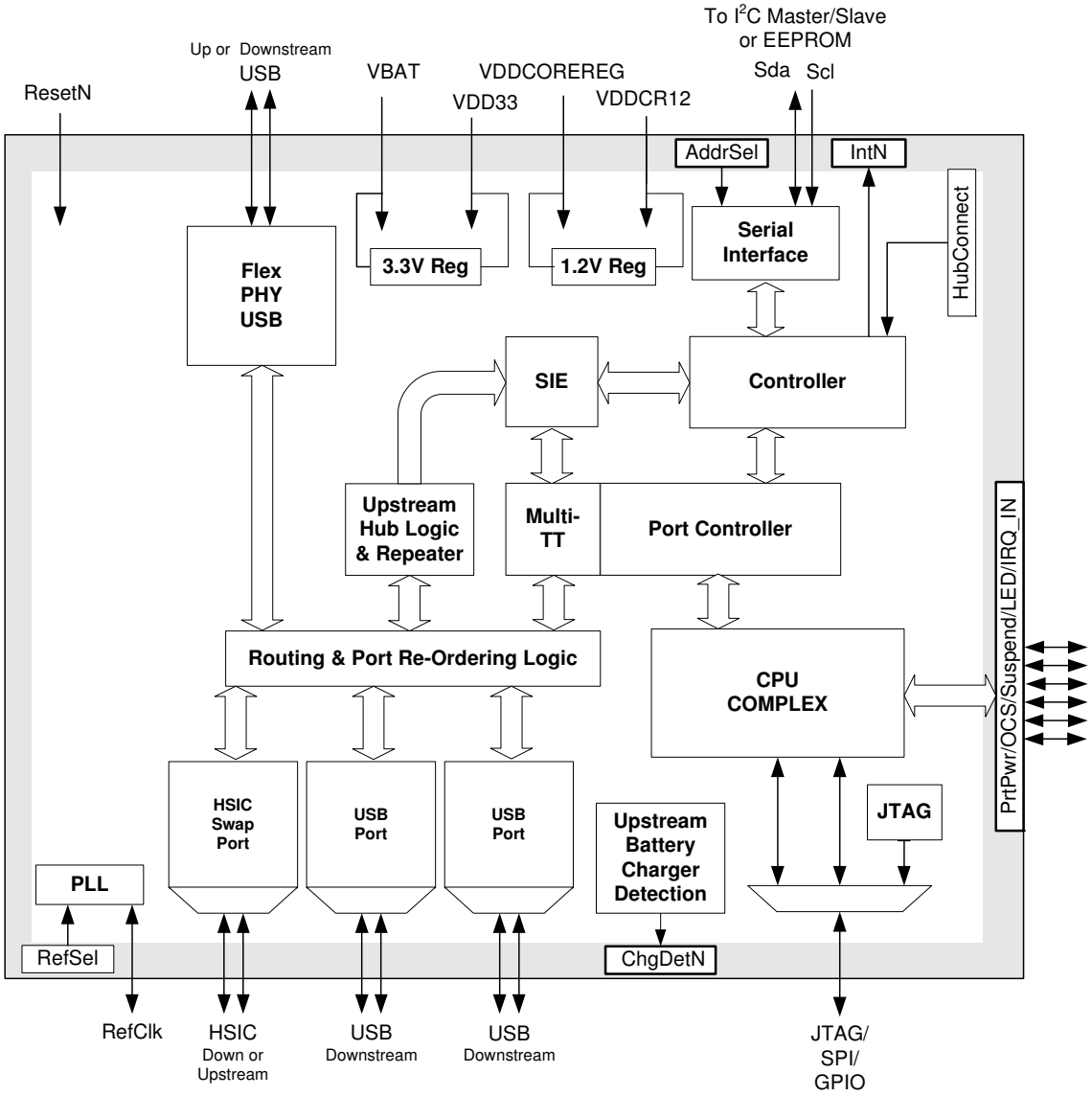


Figure 1.1 System Block Diagram

Chapter 2 Acronyms and Definitions

2.1 Acronyms

EOP: End of Packet

EP: Endpoint

FS: Full-Speed

GPIO: General Purpose I/O (that is input/output to/from the device)

HS: Hi-Speed

HSOS: High Speed Over Sampling

HSIC: High-Speed Inter-Chip

I²C®: Inter-Integrated Circuit

LS: Low-Speed

OTP: One Time Programmable

PCB: Printed Circuit Board

PCS: Physical Coding Sublayer

PHY: Physical Layer

SMBus: System Management Bus

UUID: Universally Unique IDentification

2.2 Reference Documents

1. *UNICODE UTF-16LE For String Descriptors* USB Engineering Change Notice, December 29th, 2004, http://www.usb.org
2. *Universal Serial Bus Specification*, Revision 2.0, April 27th, 2000, http://www.usb.org
3. *Battery Charging Specification*, Revision 1.2, Dec. 07, 2010, http://www.usb.org
4. *High-Speed Inter-Chip USB Electrical Specification*, Version 1.0, Sept. 23, 2007, http://www.usb.org
5. *I²C-Bus Specification*, Version 1.1, http://www.nxp.com
6. *System Management Bus Specification*, Version 1.0, http://smbus.org/specs

Chapter 3 Ball Descriptions

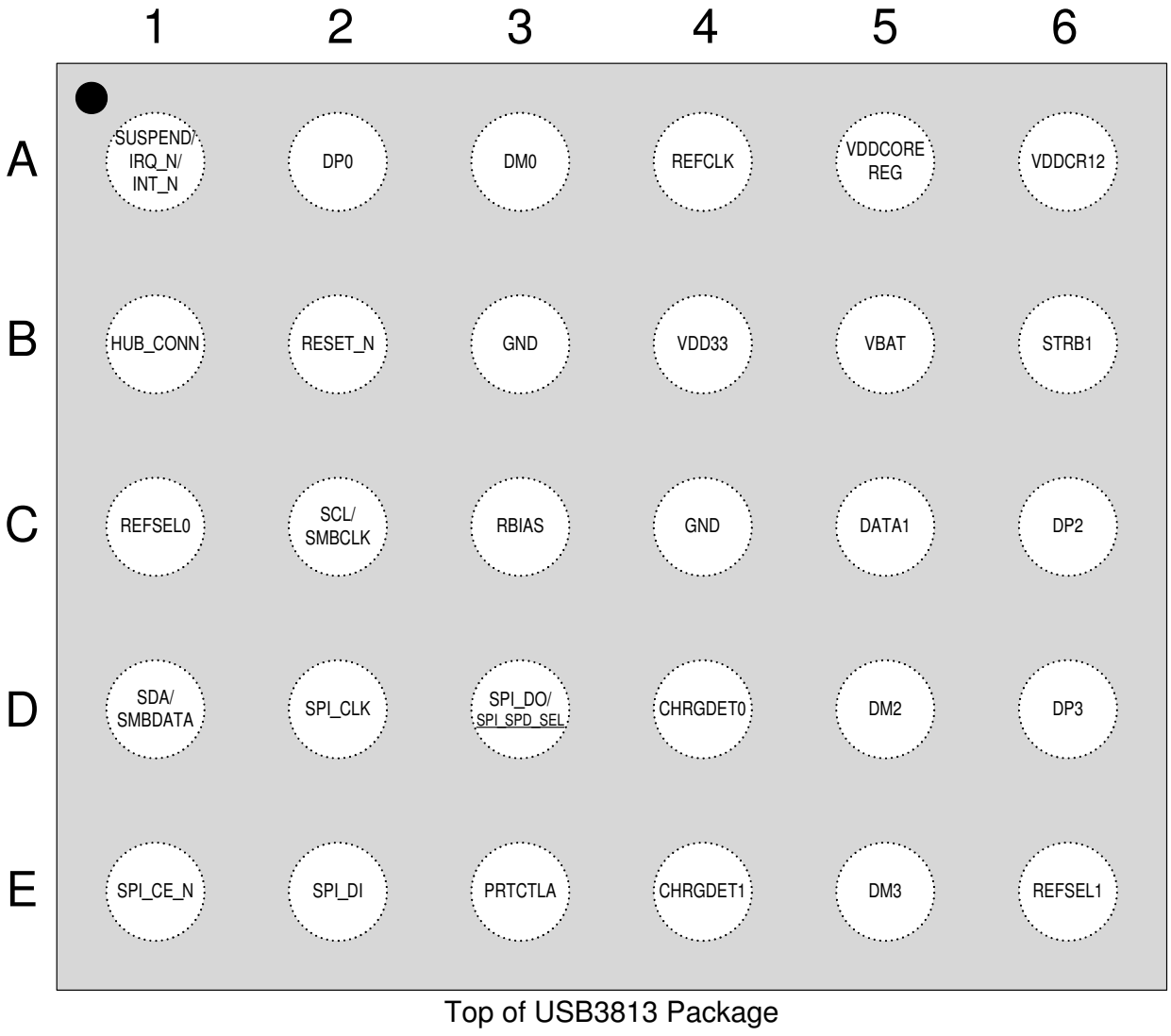


Figure 3.1 30-WLCSP Pin Assignments

3.1 Ball Descriptions

This section provides a detailed description of each ball. The signals are arranged in functional groups according to their associated interface.

The "_N" symbol in the signal name indicates that the active, or asserted, state occurs when the signal is at a low voltage level. For example, RESET_N indicates that the reset signal is active low. When "_N" is not present after the signal name, the signal is asserted when at the high voltage level.

The terms assertion and negation are used exclusively. This is done to avoid confusion when working with a mixture of "active low" and "active high" signals. The term assert, or assertion, indicates that a signal is active, independent of whether that level is represented by a high or low voltage. The term negate, or negation, indicates that a signal is inactive.

Note: The buffer type for each signal is indicated in the BUFFER TYPE column of Table 3.1. A description of the buffer types is provided in Section 3.3.

Table 3.1 Ball Descriptions

NUM BALLS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
USB/HSIC INTERFACES				
1	Upstream USB D+ (Flex Port 0)	DP0	AIO	Upstream USB Port 0 D+ data signal. **Note:** The upstream Port 0 signals can be optionally swapped with the downstream Port 1 signals.
1	Upstream USB D- (Flex Port 0)	DM0	AIO	Upstream USB Port 0 D- data signal. **Note:** The upstream Port 0 signals can be optionally swapped with the downstream Port 1 signals.
1	Downstream HSIC Data (Swap Port 1)	DATA1	HSIC	Downstream HSIC Port 1 DATA signal. **Note:** The downstream Port 1 signals can be optionally swapped with the upstream Port 0 signals.
1	Downstream HSIC Strobe (Swap Port 1)	STRB1	HSIC	Downstream HSIC Port 1 STROBE signal. **Note:** The downstream Port 1 signals can be optionally swapped with the upstream Port 0 signals.
1	Downstream USB D+ (Port 2)	DP2	AIO	Downstream USB Port 2 D+ data signal.
1	Downstream USB D- (Port 2)	DM2	AIO	Downstream USB Port 2 D- data signal.
1	Downstream USB D+ (Port 3)	DP3	AIO	Downstream USB Port 3 D+ data signal.
1	Downstream USB D- (Port 3)	DM3	AIO	Downstream USB Port 3 D- data signal.

Table 3.1 Ball Descriptions (continued)

NUM BALLS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
I²C/SMBUS INTERFACE				
1	I²C Serial Clock Input	SCL	I_SMB	I²C serial clock input.
	SMBus Clock	SMBCLK	I_SMB	SMBus serial clock input.
1	I²C Serial Data	SDA	IS/OD8	I²C bidirectional serial data.
	SMBus Serial Data	SMBDATA	IS/OD8	SMBus bidirectional serial data.
SPI MASTER INTERFACE				
1	SPI Chip Enable Output	SPI_CE_N	O12	Active-low SPI chip enable output. **Note:** If the SPI is enabled, this pin will be driven high in powerdown states.
1	SPI Clock Output	SPI_CLK	O12	SPI clock output
1	SPI Data Output	SPI_DO	O12	SPI data output
	SPI Speed Select Configuration Strap	SPI_SPD_SEL	IS (PD)	This strap is used to select the speed of the SPI. 0 = 30MHz (default) 1 = 60MHz **Note:** If the latched value on reset is 1, this pin is tri-stated when the chip is in the suspend state. If the latched value on reset is 0, this pin is driven low during a suspend state. See Note 3.2 for more information on configuration straps.
1	SPI Data Input	SPI_DI	IS (PD)	SPI data input
MISC.				
1	Reference Clock Input	REFCLK	ICLK	This signal is the reference clock input. The clock input frequency is configured via REFSEL[1:0]. Refer to Section 8.4, "Reference Clock," on page 41 for additional information.
1	Reference Clock Select 0 Input	REFSEL0	IS	This signal, combined with REFSEL1, selects the reference clock input frequency. The reference select input must be set to correspond to the frequency applied to the REFCLK input. Refer to Section 8.4, "Reference Clock," on page 41 for additional information.

Table 3.1 Ball Descriptions (continued)

NUM BALLS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	Reference Clock Select 1 Input	REFSEL1	IS	This signal, combined with REFSEL0, selects the reference clock input frequency. The reference select input must be set to correspond to the frequency applied to the REFCLK input. Refer to Section 8.4, "Reference Clock," on page 41 for additional information.
1	System Reset Input	RESET_N	I_RST	This active-low signal allows external hardware to reset the device. **Note:** The active-low pulse must be at least 5us wide. Refer to Section 8.3.2, "External Chip Reset (RESET_N)," on page 40 for additional information.
1	External USB Transceiver Bias Resistor	RBIAS	AI	A 12.0kΩ (+/- 1%) resistor is attached from ground to this pin to set the transceiver's internal bias settings.
1	Hub Connect Input	HUB_CONN	IS	This signal is used to control the hub communication stage. The device will transition to the hub communications stage when this pin is asserted high. Two methods of use may be used: **Tie to +3.3V:** The hub will automatically transition to the communications stage when configuration is complete. **Transition from low to high:** The hub will transition to the communications stage after configuration is complete and this signal transitions from low to high. Refer to Section 8.5, "Hub Connect (HUB_CONN)," on page 42 for additional information.
1	Charge Detect 0 Output	CHRGDET0	O8	This signal, in conjunction with CHRGDET1, can be configured to communicate information that can affect the level of current that the system may draw from the upstream USB VBUS wire. Refer to Section 8.1.1.1, "Charger Detection (CHRGDET[1:0])," on page 37 for additional information.
1	Charge Detect 1 Output	CHRGDET1	O8	This signal, in conjunction with CHRGDET0, can be configured to communicate information that can affect the level of current that the system may draw from the upstream USB VBUS wire. Refer to Section 8.1.1.1, "Charger Detection (CHRGDET[1:0])," on page 37 for additional information.

Table 3.1 Ball Descriptions (continued)

NUM BALLS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	Suspend Output	SUSPEND	PU	This signal is used to indicate that the entire hub has entered the USB suspend state and that VBUS current consumption should be reduced in accordance with the USB specification. Refer to Section 8.7, "Suspend (SUSPEND)," on page 42 for additional information. **Note:** SUSPEND must be enabled via the Protouch configuration tool.
	Interrupt Request Input	IRQ_N	IS	This active-low signal allows external hardware to interrupt the device. Refer to Section 8.8, "Interrupt Requests (IRQ_N)," on page 43 for additional information.
	Interrupt Output	INT_N	OD8	This active-low signal allows the device to output an interrupt to external hardware. Refer to Section 8.9, "Interrupt Output (INT_N)," on page 43 for additional information.
1	USB Port Control	PRTCTLA	OD8/IS (PU)	This pin functions as both the downstream USB port power enable output (PRTPWRA) and the downstream USB port over-current sense input (OCSA_N).
POWER				
1	Battery Power Supply Input	VBAT	P	Battery power supply input. When VBAT is connected directly to a +3.3V supply from the system, the internal +3.3V regulator runs in dropout and regulator power consumption is eliminated. A 4.7 µF (<1 Ω ESR) capacitor to ground is required for regulator stability. The capacitor should be placed as close as possible to the device. Refer to Chapter 4, "Power Connections," on page 17 for power connection information.
1	+3.3V Power Supply	VDD33	P	+3.3V power supply. A 1.0 µF (<1 Ω ESR) capacitor to ground is required for regulator stability. The capacitor should be placed as close as possible to the device. Refer to Chapter 4, "Power Connections," on page 17 for power connection information.
1	+1.8-3.3V Core Power Supply Input	VDDCOREREG	P	+1.8-3.3V core power supply input to internal +1.2V regulator. This pin may be connected to VDD33 for single supply applications when VBAT equals +3.3V. Running in a dual supply configuration with VDDCOREREG at a lower voltage, such as +1.8V, may reduce overall system power consumption. Refer to Chapter 4, "Power Connections," on page 17 for power connection information.
1	+1.2V Core Power Supply	VDDCR12	P	+1.2V core power supply. A 1.0 µF (<1 Ω ESR) capacitor to ground is required for regulator stability. The capacitor should be placed as close as possible to the device. Refer to Chapter 4, "Power Connections," on page 17 for power connection information.

Table 3.1 Ball Descriptions (continued)

NUM BALLS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
2	Ground	GND	P	Ground

Note 3.2 Configuration strap values are latched on Power-On Reset (POR) and the rising edge of RESET_N (external chip reset). Configuration straps are identified by an underlined symbol name. Signals that function as configuration straps must be augmented with an external resistor when connected to a load. Refer to Section 6.3, "Device Configuration Straps," on page 26 for additional information.

3.2 Pin Assignments

Table 3.2 30-WLCSP Package Ball Assignments

BALL	1	2	3	4	5	6
A	SUSPEND/ IRQ_N/INT_N	DP0	DM0	REFCLK	VDDCOREREG	VDDCR12
B	HUB_CONN	RESET_N	GND	VDD33	VBAT	STRB1
C	REFSEL0	SCL/ SMBCLK	RBIAS	GND	DATA1	DP2
D	SDA/ SMBDATA	SPI_CLK	SPI_DO/ SPI_SPD_SEL	CHRGDET0	DM2	DP3
E	SPI_CE_N	SPI_DI	PRTCTLA	CHRGDET1	DM3	REFSEL1

3.3 Buffer Type Descriptions

Table 3.3 Buffer Types

BUFFER TYPE	DESCRIPTION
IS	Schmitt-triggered input
I_RST	Reset Input
I_SMB	I^2C/SMBus Clock Input
O8	Output with 8 mA sink and 8 mA source
OD8	Open-drain output with 8 mA sink
O12	Output with 12 mA sink and 12 mA source
HSIC	*High-Speed Inter-Chip (HSIC) USB Specification, Version 1.0* compliant input/output
PU	50 µA (typical) internal pull-up. Unless otherwise noted in the pin description, internal pull-ups are always enabled. **Note:** Internal pull-up resistors prevent unconnected inputs from floating. Do not rely on internal resistors to drive signals external to the device. When connected to a load that must be pulled high, an external resistor must be added.
PD	50 µA (typical) internal pull-down. Unless otherwise noted in the pin description, internal pull-downs are always enabled. **Note:** Internal pull-down resistors prevent unconnected inputs from floating. Do not rely on internal resistors to drive signals external to the device. When connected to a load that must be pulled low, an external resistor must be added.
AIO	Analog bi-directional
ICLK	Crystal oscillator input pin
P	Power pin

Chapter 4 Power Connections

4.1 Integrated Power Regulators

The integrated 3.3V and 1.2V power regulators provide flexibility to the system in providing power the device. Several different configurations are allowed in order to align the power structure to supplies available in the system.

The regulators are controlled by RESET_N. When RESET_N is brought high, the 3.3V regulator will turn on. When RESET_N is brought low the 3.3V regulator will turn off.

4.1.1 3.3V Regulator

The device has an integrated regulator to convert from VBAT to 3.3V.

4.1.2 1.2V Regulator

The device has an integrated regulator to convert from a variable voltage input on VDDCOREREG to 1.2V. The 1.2V regulator is tolerant to the presence of low voltage (~0V) on the VDDCOREREG pin in order to support system power solutions where a supply is not always present in low power states.

The 1.2V regulator supports an input voltage range consistent with a 1.8V input in order to reduce power consumption in systems which provide multiple power supply levels. In addition, the 1.2V regulator supports an input voltage up to 3.3V for systems which provide only a single power supply. The device will support operation where the 3.3V regulator output can drive the 1.2V regulator input such that VBAT is the only required supply.

4.2 Power Configurations

The device supports operation with no back current when power is connected in each of the following configurations. Power connection diagrams for these configurations are included in Section 4.3, "Power Connection Diagrams," on page 18.

4.2.1 Single Supply Configurations

4.2.1.1 VBAT Only

VBAT must be tied to the VBAT system supply. VDD33 and VDDCOREREG must be tied together on the board. In this configuration the 3.3V and 1.2V regulators will be active.

4.2.1.2 3.3V Only

VBAT must be tied to the 3.3V system supply. VDD33 and VDDCOREREG must be tied together on the board. In this configuration the 3.3V regulator will operate in dropout mode and the 1.2V regulator will be active.

4.2.2 Dual Supply Configurations

4.2.2.1 VBAT + 1.8V

VBAT must be tied to the VBAT system supply. VDDCOREREG must be tied to the 1.8V system supply. In this configuration, the 3.3V regulator and the 1.2V regulator will be active.

4.2.2.2 3.3V + 1.8V

VBAT must be tied to the 3.3V system supply. VDDCOREREG must be tied to the 1.8V system supply. In this configuration the 3.3V regulator will operate in dropout mode and the 1.2V regulator will be active.

4.3 Power Connection Diagrams

Figure 4.1 illustrates the power connections for the USB3813 with various power supply configurations.

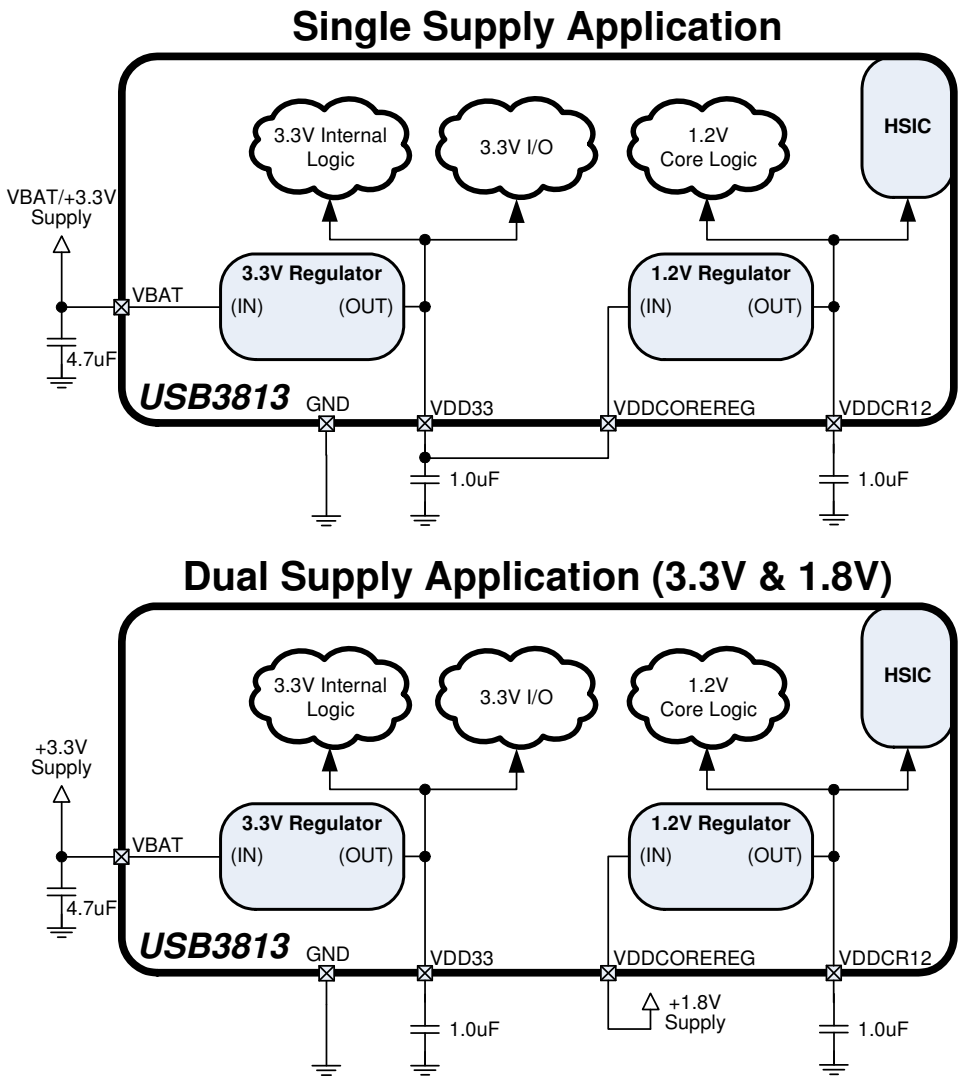


Figure 4.1 Power Connections

Chapter 5 Modes of Operation

The device provides two main modes of operation: Standby Mode and Hub Mode. The operating mode of the device is selected by setting values on primary inputs according to the table below.

Table 5.1 Controlling Modes of Operation

RESET_N INPUT	RESULTING MODE	SUMMARY
0	**Standby**	**Lowest Power Mode**: No functions are active other than monitoring the RESET_N input. All port interfaces are high impedance. All regulators are powered off.
1	**Hub**	**Full Feature Mode**: Device operates as a configurable USB hub with battery charger detection. Power consumption is based on the number of active ports, their speed, and amount of data transferred.

Note: Refer to Section 8.3.2, "External Chip Reset (RESET_N)," on page 40 for additional information on RESET_N.

The flowchart in Figure 5.1 shows the modes of operation. It also shows how the device traverses through the Hub mode stages (shown in bold.) The flow of control is dictated by control register bits shown in italics as well as other events such as availability of a reference clock. The remaining sections in this chapter provide more detail on each stage and mode of operation.

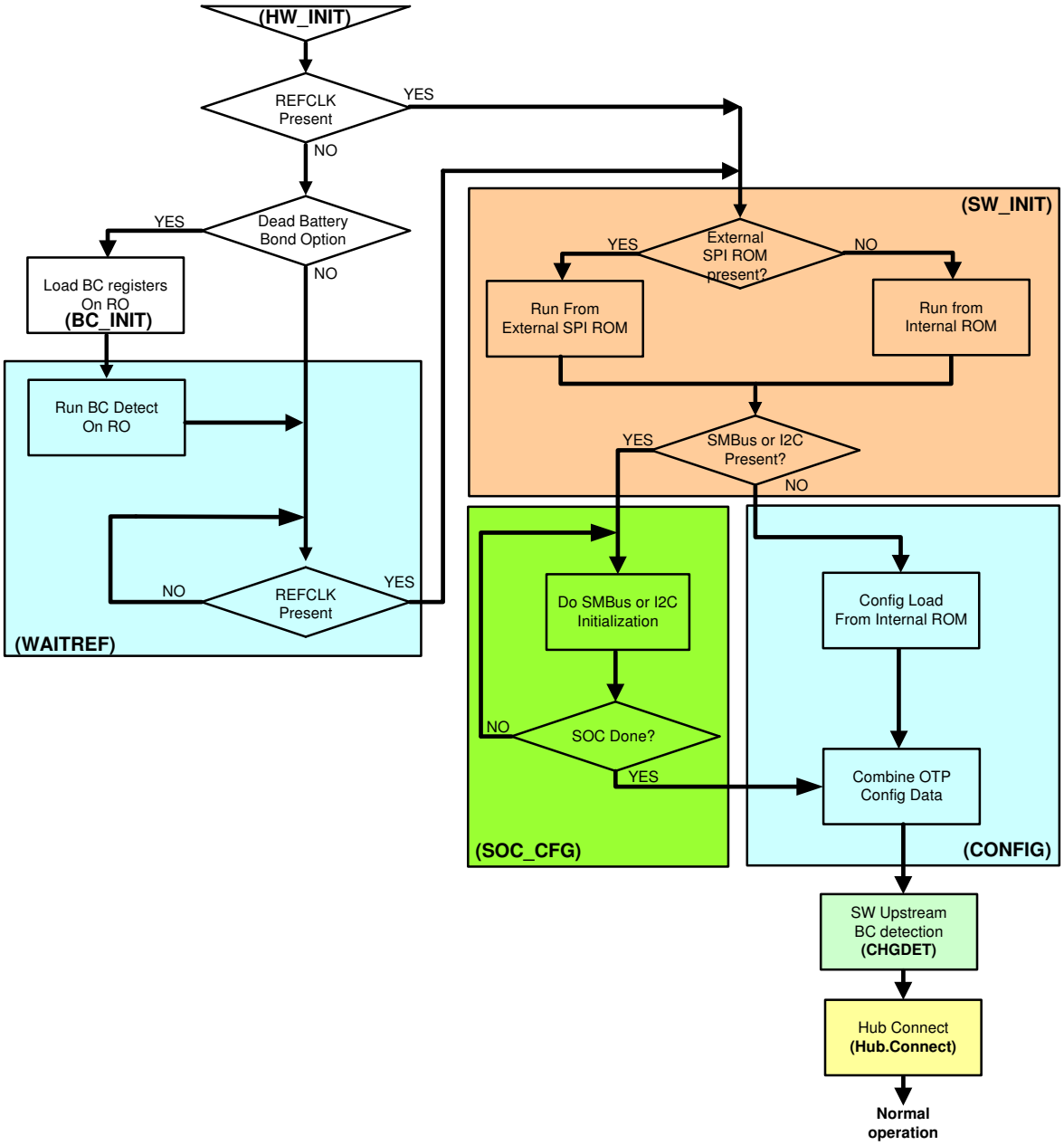


Figure 5.1 Hub Operational Mode Flowchart

5.1 Boot Sequence

5.1.1 Standby Mode

If the external hardware reset is asserted, the hub will be in Standby Mode. This mode provides a very low power state for maximum power efficiency when no signaling is required. This is the lowest power state. In Standby Mode all internal regulators are powered off, the PLL is not running, and core logic is powered down in order to minimize power consumption. Because core logic is powered off, no configuration settings are retained in this mode and must be re-initialized after RESET_N is negated high.

5.1.2 Hardware Initialization Stage (HW_INIT)

The first stage is the initialization stage and occurs on the negation of RESET_N. In this stage the 1.2V regulator is enabled and stabilizes, internal logic is reset, and the PLL locks if a valid REFCLK is supplied. Configuration registers are initialized to their default state and strap input values are latched. The device will complete initialization and automatically enter the next stage. Because the digital logic within the device is not yet stable, no communication with the device using the SMBus is possible. Configuration registers are initialized to their default state.

If there is no REFCLK present, the next state is BC_INIT. If there is a REFCLK present, the next state is SW_INIT.

5.1.3 Battery Charging Initialization Stage (BC_INIT)

This state is entered to deal with the dead battery condition. The processor Ring Oscillator (RO) is enabled. The processor is woken up for a short period. In that period, the processor reads the OTP to determine what type(s) of upstream battery charging detection will be done. Based on the settings, the firmware will program the upstream battery charging registers appropriately.

The processor loads the battery charging registers with the values out of OTP memory. Once the processor has initialized the BC registers, it turns off the ring oscillator. If the hardware detects the presence of REFCLK, it switches over to regular operation of the PLL.

5.1.4 Wait REFCLK Stage (WAITREF)

In this stage, the reference clock is checked for activity. If the reference clock is active, the device will continue to the Hub configuration stage. If the reference clock is not active but battery charger detection is enabled, the detection sequence will begin while operating on an internal ring oscillator.

If the PLL locks while battery charger detection is still in progress, the sequence will be aborted until the battery charger detection stage. If aborted, no results are captured. If battery charger detection completes, the results of the battery charger detection may be communicated through the INT_N pin function, CHRGDET pin function or neither based on the default ROM settings.

If the reference clock is provided before entering hub mode, the device will transition to the Software Initialization stage (SW_INIT) without pausing in the WAITREF stage. Otherwise, the device will transition to the SW_INIT stage once a valid reference clock is supplied and the PLL has locked. If the hardware detects the presence of REFCLK, it switches over to regular operation of the PLL.

Note: During this stage the SMbus is not functional.

5.1.5 Software Initialization Stage (SW_INIT)

Once the hardware is initialized, the firmware can begin to execute. The internal firmware checks for an external SPI ROM. The firmware looks for an external SPI flash device that contains a valid

signature of “2DFU” (device firmware upgrade) beginning at address 0xFFFA. If a valid signature is found, then the external ROM is enabled and the code execution begins at address 0x0000 in the external SPI device. If a valid signature is not found, then execution continues from internal ROM. SPI ROMs used with the device must be 1 Mbit and support either 30 MHz or 60 MHz. The frequency used is set using the SPI_SPD_SEL configuration strap. Both 1- and 2-bit SPI operation is supported. For optimum throughput, a 2-bit SPI ROM is recommended. Both mode 0 and mode 3 SPI ROMS are also supported. Refer to Section 6.3.1, "SPI Speed Select (SPI_SPD_SEL)," on page 27 for additional information on selection of the SPI speed.For all other configurations, the firmware checks for the presence of an external I^2C/SMBus. It does this by asserting two pull down resistors on the data and clock lines of the bus. The pull downs are typically 50Kohm. If there are 10Kohm pull-ups present, the device becomes aware of the presence of an external SMBus/I^2C bus. If a bus is detected, the firmware transitions to the SOC_CFG state.

5.1.6 SOC Configuration Stage (SOC_CFG)

In this stage, the SOC may modify any of the default configuration settings specified in the integrated ROM such as USB device descriptors, or port electrical settings, and control features such as upstream battery charging detection.

There is no time limit. In this stage the firmware will wait indefinitely for the SMBus/I^2C configuration. When the SOC has completed configuring the device, it must write to register 0xFF to end the configuration.

5.1.7 Configuration Stage (CONFIG)

Once the SOC has indicated that it is done with configuration, then all the configuration data is combined. The default data, the SOC configuration data, the OTP data are all combined in the firmware and device is programmed.

After the device is fully configured, it will go idle and then into suspend if there is no VBUS or Hub.Connect present. Once VBUS is present, and upstream battery charging is enabled, the device will transition to the Battery Charger Detection Stage (CHGDET). If VBUS is present, and upstream battery charging is not enabled, the device will transitions to the Connect (Hub.Connect) stage.

5.1.8 Battery Charger Detection Stage (CHGDET)

After configuration, if enabled, the device enters the Battery Charger Detection Stage. If the battery charger detection feature was disabled during the CONFIG stage, or the HUB_CONN pin is asserted, the device will immediately transition to the Hub Connect (Hub.Connect) stage. If the battery charger detection feature remains enabled, the battery charger detection sequence is started automatically.

If a charger is detected during this stage, the device asserts the CHRGDET[1:0] output pin function if the charger type identified is not masked. If the charger detection remains enabled, the device will transition to the Hub.Connect stage if using the hardware detection mechanism.

5.1.9 Hub Connect Stage (Hub.Connect)

Once the CHGDET stage is completed, the device enters the Hub.Connect stage. USB connect can be initiated by asserting the HUB_CONN pin high. The device will remain in the Hub.Connect stage indefinitely until the HUB_CONN pin is deasserted.

5.1.10 Normal Mode

Lastly the SOC enters the Normal Mode of operation. In this stage, full USB operation is supported under control of the USB Host on the upstream port. The device will remain in the normal mode until the operating mode is changed by the system.

If RESET_N is asserted low, then Standby Mode is entered. The device may then be placed into any of the designated Hub stages. Asserting the soft disconnect on the upstream port will cause the Hub to return to the Hub.Connect stage until the soft disconnect is negated. If the HUB_CONN pin transitions from asserted to negated, the device will return to the Hub.Connect stage.

To save power, communication over the SMBus is not supported while in USB Suspend. The system can, however, command the device to wake up by the asserting the IRQ_N pin. The system can prevent the device from going to sleep by asserting the ClkSusp control bit of the Configure Portable Hub Register anytime before entering USB Suspend. While the device is kept awake during USB Suspend, it will provide the SMBus functionality at the expense of not meeting USB requirements for average suspend current consumption.

Chapter 6 Device Configuration

The device supports a large number of features (some mutually exclusive), and must be configured in order to correctly function when attached to a USB host controller. The hub can be configured either internally or externally depending on the implemented interface.

Microchip provides a comprehensive software programming tool, Pro-Touch, for configuring the USB3813 functions, registers and OTP memory. All configuration is to be performed via the Pro-Touch programming tool. For additional information on the Pro-Touch programming tool, contact your local Microchip sales representative.

6.1 Configuration Method Selection

The hub will interface to external memory depending on the configuration of the device pins associated with each interface type. The device will first check whether an external SPI ROM is present. If present, the device will operate entirely from the external ROM. When an external SPI ROM is not present, the device will check whether the SMBus is configured. When the SMBus is enabled, it can be used to configure the internal device registers via the XDATA address space, or to program the internal OTP memory. If no external options are detected, the device will operate using the internal default and configuration strap settings. The order in which device configuration is attempted is summarized below:

1. SPI (Reading the configuration from an SPI ROM)
2. SMBus (either writing the configuration registers in the XDATA address space, or to OTP)
3. Internal default settings (with or without configuration strap over-rides)

Note: Refer to Chapter 7, "Device Interfaces," on page 28 for detailed information on each device configuration interface.

6.2 Customer Accessible Functions

The following USB or SMBus accessible functions are available to the customer via the Pro-Touch Programming Tool.

Note: For additional programming details, refer to the Pro-Touch Programming Tool User Manual.

6.2.1 USB Accessible Functions

6.2.1.1 VSM commands over USB

By default, Vendor Specific Messaging (VSM) commands to the hub are enabled. The supported commands are:

- Enable Embedded Controller
- Disable Embedded Controller
- Enable Special Resume
- Disable Special Resume
- Reset Hub

6.2.1.2 I²C Master Access over USB

Access to I²C devices is performed as a pass-through operation from the USB Host. The device firmware has no knowledge of the operation of the attached I²C device. The supported commands are:

- Enable I²C pass through mode
- Disable I²C pass through mode
- I²C write
- I²C read
- Send I²C start
- Send I²C stop

6.2.1.3 SPI Access over USB

Access to an attached SPI device is performed as a pass-through operation from the USB Host. The device firmware has no knowledge of the operation of the attached SPI device. The supported commands are:

- Enable SPI pass through mode
- Disable SPI pass through mode
- SPI write
- SPI read

Note: Refer to Section 7.1, "SPI Interface," on page 28 for additional information on the SPI interface.

6.2.1.4 OTP Access over USB

The OTP ROM in the device is accessible via the USB bus. All OTP parameters can modified via the USB Host. The OTP operates in Single Ended mode. The supported commands are:

- Enable OTP reset
- Set OTP operating mode
- Set OTP read mode
- Program OTP
- Get OTP status
- Program OTP control parameters

6.2.1.5 Battery Charging Access over USB

The Battery charging behavior of the device can be dynamically changed by the USB Host when something other than the preprogrammed or OTP programmed behavior is desired. The supported commands are:

- Enable/Disable battery charging
- Upstream battery charging mode control
- Downstream battery charging mode control
- Battery charging timing parameters
- Download custom battery charging algorithm

6.2.1.6 Other Embedded Controller functions over USB

The following miscellaneous functions may be configured via USB:

- Enable/Disable Embedded controller enumeration
- Program Configuration parameters.
- Program descriptor fields:
  —Language ID
  —Manufacturer string
  —Product string
  —idVendor
  —idProduct
  —bcdDevice

6.2.2 SMBus Accessible Functions

6.2.2.1 OTP Access over SMBus

The device's OTP ROM is accessible over SMBus. All OTP parameters can modified via the SMbus Host. The OTP can be programmed to operate in Single-Ended, Differential, Redundant, or Differential Redundant mode, depending on the level of reliability required. The supported commands are:

- Enable OTP reset
- Set OTP operating mode
- Set OTP read mode
- Program OTP
- Get OTP Status
- Program OTP control parameters

6.2.2.2 Configuration Access over SMBus

The following functions are available over SMBus prior to the hub attaching to the USB host:

- Program Configuration parameters.
- Program descriptor fields:
  —Language ID
  —Manufacturer string
  —Product string
  —idVendor
  —idProduct
  —bcdDevice
- Program Control Register

6.3 Device Configuration Straps

Configuration straps are multi-function pins that are driven as outputs during normal operation. During a Power-On Reset (POR) or an External Chip Reset (RESET_N), these outputs are tri-stated. The high or low state of the signal is latched following de-assertion of the reset and is used to determine the default configuration of a particular feature. Configuration straps are latched as a result of a Power-On Reset (POR) or a External Chip Reset (RESET_N). Configuration strap signals are noted in Chapter 3,

"Ball Descriptions," on page 10 and are identified by an underlined symbol name. The following sub-sections detail the various configuration straps.

Configuration straps include internal resistors in order to prevent the signal from floating when unconnected. If a particular configuration strap is connected to a load, an external pull-up or pull-down should be used to augment the internal resistor to ensure that it reaches the required voltage level prior to latching. The internal resistor can also be overridden by the addition of an external resistor.

Note: The system designer must guarantee that configuration straps meet the timing requirements specified in Section 9.5.2, "Reset and Configuration Strap Timing," on page 50 and Section 9.5.1, "Power-On Configuration Strap Valid Timing," on page 49. If configuration straps are not at the correct voltage level prior to being latched, the device may capture incorrect strap values.

Note: Configuration straps must never be driven as inputs. If required, configuration straps can be augmented, or overridden with external resistors.

6.3.1 SPI Speed Select (SPI_SPD_SEL)

This strap is used to select the speed of the SPI as follows:

Table 6.1 SPI_SPD_SEL Configuration Definitions

SPI_SPD_SEL	DEFINITION
'0'	30 MHz SPI Operation (Default)
'1'	60 MHz SPI Operation

Note: If the latched value on reset is 1, this pin is tri-stated when the chip is in the suspend state. If the latched value on reset is 0, this pin is driven low during a suspend state.

Chapter 7 Device Interfaces

The USB3813 provides multiple interfaces for configuration and external memory access. This chapter details the various device interfaces and their usage.

Note: For information on device configuration, refer to Chapter 6, "Device Configuration," on page 24.

7.1 SPI Interface

The device is capable of code execution from an external SPI ROM. On power up, the firmware looks for an external SPI flash device that contains a valid signature of `2DFU` (device firmware upgrade) beginning at address 0xFFFA. If a valid signature is found, then the external ROM is enabled and the code execution begins at address 0x0000 in the external SPI device. If a valid signature is not found, then execution continues from internal ROM. The following sections describe the interface options to the external SPI ROM.

The SPI interface is always enabled after reset. It can be disabled by setting the SPI_DISABLE bit in the UTIL_CONFIG1 register.

Note: For SPI timing information, refer to Section 9.5.7, "SPI Timing," on page 51.

7.1.1 Operation of the Hi-Speed Read Sequence

The SPI controller will automatically handle code reads going out to the SPI ROM address. When the controller detects a read, the controller drives SPI_CE_N low, and outputs 0x0B, followed by the 24-bit address. The SPI controller outputs a DUMMY byte. The next eight clocks will clock-in the first byte. When the first byte is clocked-in, a ready signal is sent back to the processor, and the processor gets one byte.

After the processor gets the first byte, its address will change. If the address is one more than the last address, the SPI controller will clock out one more byte. If the address is anything other than one more than the last address, the SPI controller will terminate the transaction by driving SPI_CE_N high. As long as the addresses are sequential, the SPI Controller will continue clocking data in.

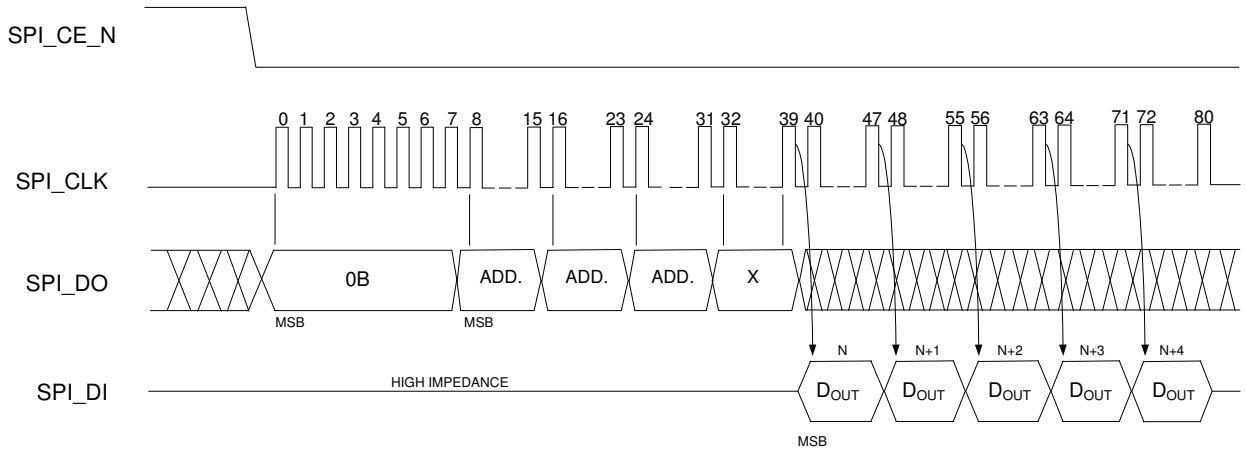


Figure 7.1 SPI Hi-Speed Read Sequence

7.1.2 Operation of the Dual High Speed Read Sequence

The SPI controller also supports dual data mode. When configured in dual mode, the SPI controller will automatically handle XDATA reads going out to the SPI ROM. When the controller detects a read, the controller drives SPI_CE_N low and outputs 0x3B (the value must be programmed into the SPI_FR_OPCODE Register) followed by the 24 bit address. Bits 23 through Bit 17 are forced to zero, and address bits 16 through 0 are directly from the XDATA address bus. Because it is in fast read mode, the SPI controller then outputs a DUMMY byte. The next four clocks will clock-in the first byte. The data appears two bits at a time on SPI_DO and SPI_DI. When the first byte is clocked in, a ready signal is sent back to the processor, and the processor gets one byte.

After the processor gets the first byte, its address will change. If the address is one more than the last address, the SPI controller will clock out one more byte. If the address in anything other than one more than the last address, the SPI controller will terminate the transaction by driving SPI_CE_N high. As long as the addresses are sequential, the SPI Controller will continue clocking data in.

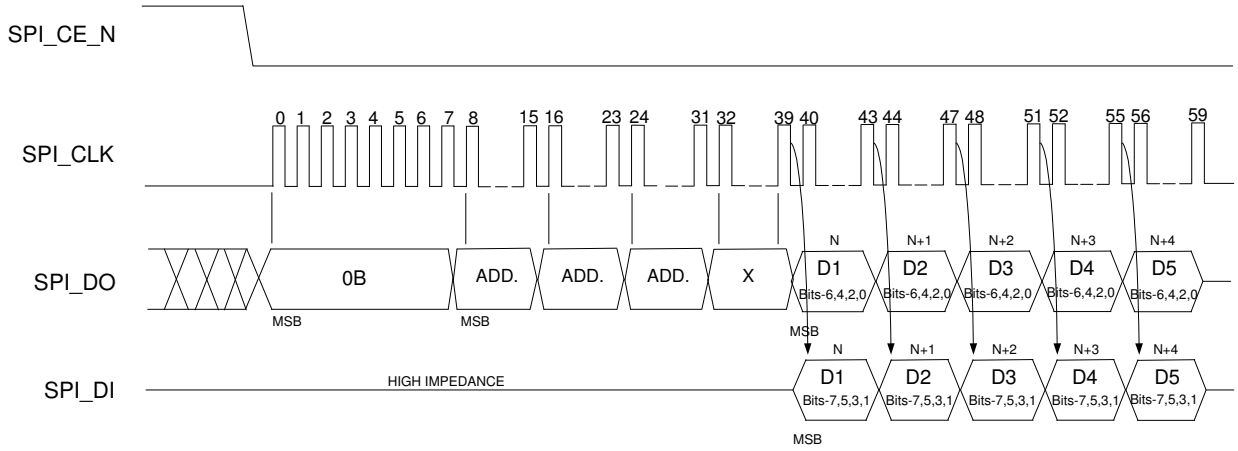


Figure 7.2 SPI Dual Hi-Speed Read Sequence

7.1.3 32 Byte Cache

There is a 32-byte pipeline cache with an associated base address pointer and length pointer. Once the SPI controller detects a jump, the base address pointer is initialized to that address. As each new sequential data byte is fetched, the data is written into the cache and the length is incremented. If the sequential run exceeds 32 bytes, the base address pointer is incremented to indicate the last 32 bytes fetched. If the firmware performs a jump, and the jump is in the cache address range, the fetch is done in 1 clock from the internal cache instead of an external access.

7.1.4 Interface Operation to the SPI Port When Not Performing Fast Reads

There is a 8-byte command buffer (SPI_CMD_BUF[7:0]), an 8-byte response buffer (SPI_RESP_BUF[7:0]), and a length register that counts out the number of bytes (SPI_CMD_LEN). Additionally, there is a self-clearing GO bit in the SPI_CTL register. Once the GO bit is set, device drives SPI_CE_N low and starts clocking. It will then output SPI_CMD_LEN x 8 number of clocks. After the first COMMAND byte has been sent out, the SPI_DI input is stored in the SPI_RESP buffer. If the SPI_CMD_LEN is longer than the SPI_CMD_BUF, don't cares are sent out on the SPI_DO output.

This mode is used for program execution out of internal RAM or ROM.

Automatic reads and writes happen when there is an external XDATA read or write, using the serial stream that has been previously discussed.

7.1.5 Erase Example

To perform a SCTR_ERASE, 32BLK_ERASE, or 64BLK_ERASE, the device writes 0x20, 0x52, or 0xD8, respectively to the first byte of the command buffer, followed by a 3-byte address. The length of the transfer is set to 4 bytes. To perform this, the device drives SPI_CE_N low, then counts out 8 clocks. It then outputs on SPI_DO the 8 bits of command, followed by 24 bits of address of the location to be erased. When the transfer is complete, SPI_CE_N goes high, while the SPI_DI line is ignored in this example.

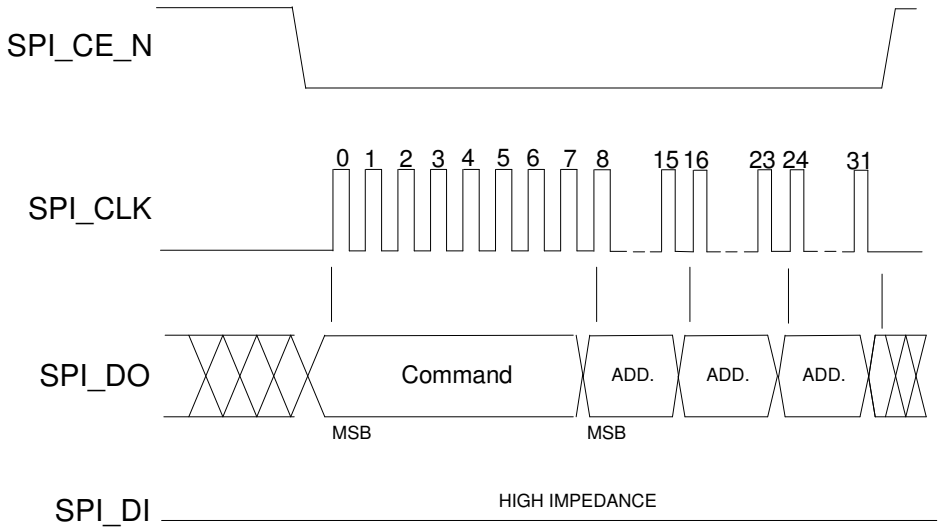


Figure 7.3 SPI Erase Sequence

7.1.6 Byte Program Example

To perform a Byte Program, the device writes 0x02 to the first byte of the command buffer, followed by a 3-byte address of the location that will be written to, and one data byte. The length of the transfer is set to 5 bytes. The device first drives SPI_CE_N low, then SPI_DO outputs 8 bits of command, followed by 24 bits of address, and one byte of data. SPI_DI is not used in this example.

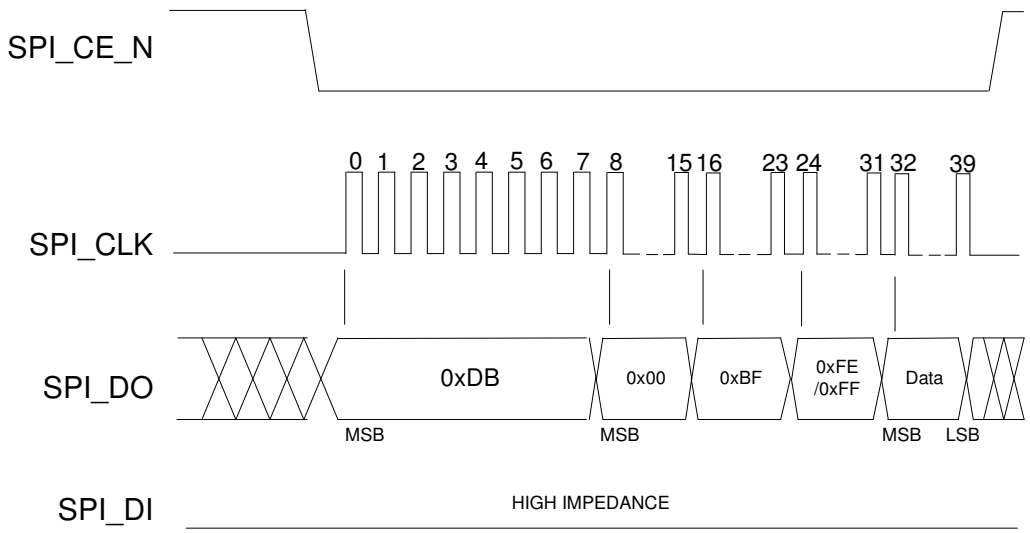


Figure 7.4 SPI Byte Program Sequence

7.1.7 Command Only Program Example

To perform a single byte command such as the following:

- WRDI
- WREN
- EWSR
- CHIP_ERASE
- EBSY
- DBSY

The device writes the opcode into the first byte of the SPI_CMD_BUF and the SPI_CMD_LEN is set to one. The device first drives SPI_CE_N low, then 8 bits of the command are clocked out on SPI_DO. SPI_DI is not used in this example.

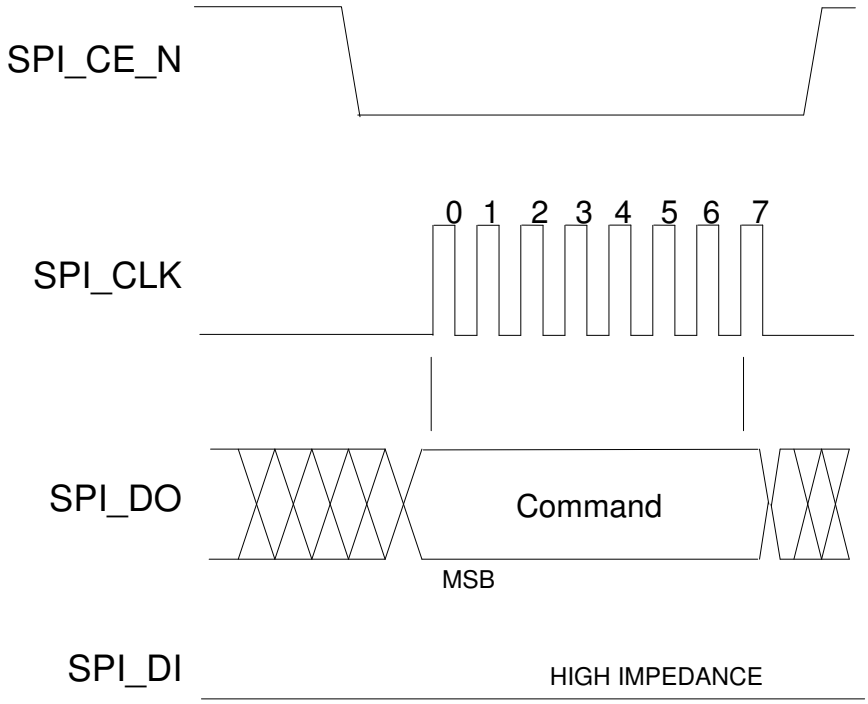


Figure 7.5 SPI Command Only Sequence

7.1.8 JEDEC-ID Read Example

To perform a JEDEC-ID command, the device writes 0x9F into the first byte of the SPI_CMD_BUF. The length of the transfer is 4 bytes. The device first drives SPI_CE_N low, then SPI_DO is output with 8 bits of the command, followed by the 24 bits of dummy bytes (due to the length being set to 4). When the transfer is complete, SPI_CE_N goes high. After the first byte, the data on SPI_DI is clocked into the SPI_RSP_BUF. At the end of the command, there are three valid bytes in the SPI_RSP_BUF. In this example, 0xBF, 0x25, 0x8E.

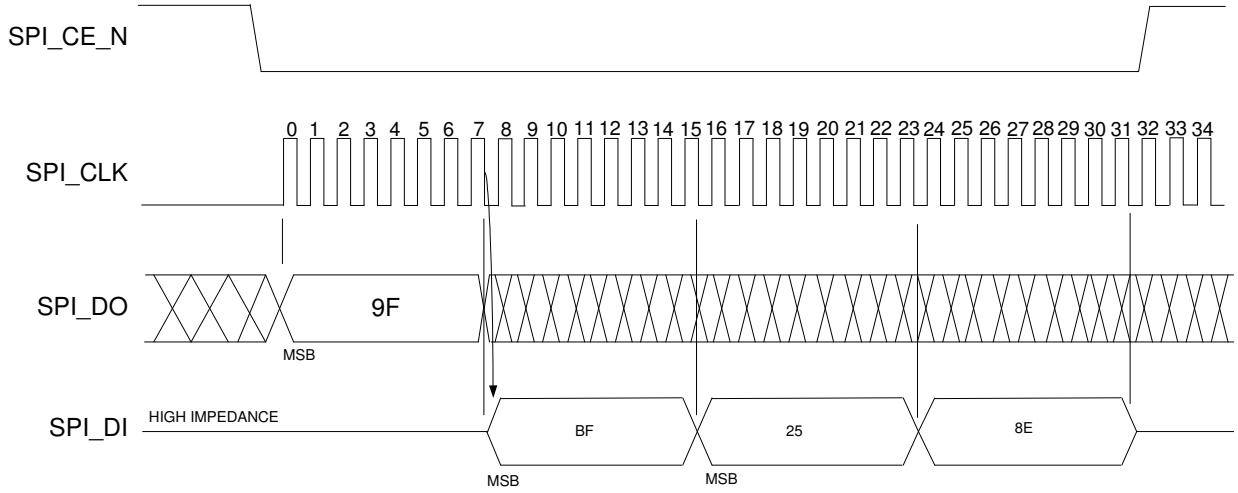


Figure 7.6 SPI JEDEC-ID Read Sequence

7.2 I²C Master Interface

The I²C master interface implements a subset of the I²C Master Specification (Please refer to the *Philips Semiconductor Standard I²C-Bus Specification* for details on I²C bus protocols). The device's I²C master interface conforms to the Standard-Mode I²C Specification (100 kbit/s transfer rate and 7-bit addressing) for protocol and electrical compatibility. The device acts as the master and generates the serial clock SCL, controls the bus access (determines which device acts as the transmitter and which device acts as the receiver), and generates the START and STOP conditions.

Note: Extensions to the I²C Specification are not supported.

Note: All device configuration must be performed via the Pro-Touch Programming Tool. For additional information on the Pro-Touch programming tool, contact your local sales representative.

7.2.1 I²C Message Format

7.2.1.1 Sequential Access Writes

The I²C interface supports sequential writing of the device's register address space. This mode is useful for configuring contiguous blocks of registers. Figure 7.7 shows the format of the sequential

write operation. Where color is visible in the figure, blue indicates signaling from the I2C master, and gray indicates signaling from the slave.

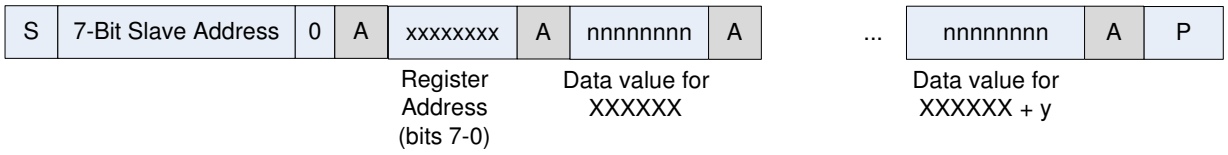


Figure 7.7 I2C Sequential Access Write Format

In this operation, following the 7-bit slave address, the 8-bit register address is written indicating the start address for sequential write operation. Every subsequent access is a data write to a data register, where the register address increments after each access and an ACK from the slave occurs. Sequential write access is terminated by a Stop condition.

7.2.1.2 Sequential Access Reads

The I2C interface supports direct reading of the device registers. In order to read one or more register addresses, the starting address must be set by using a write sequence followed by a read. The read register interface supports auto-increment mode. The master must send a NACK instead of an ACK when the last byte has been transferred.

In this operation, following the 7-bit slave address, the 8-bit register address is written indicating the start address for the subsequent sequential read operation. In the read sequence, every data access is a data read from a data register where the register address increments after each access. The write sequence can end with optional Stop (P). If so, the read sequence must begin with a Start (S). Otherwise, the read sequence must start with a Repeated Start (Sr).

Figure 7.8 shows the format of the read operation. Where color is visible in the figure, blue and gold indicate signaling from the I2C master, and gray indicates signaling from the slave.

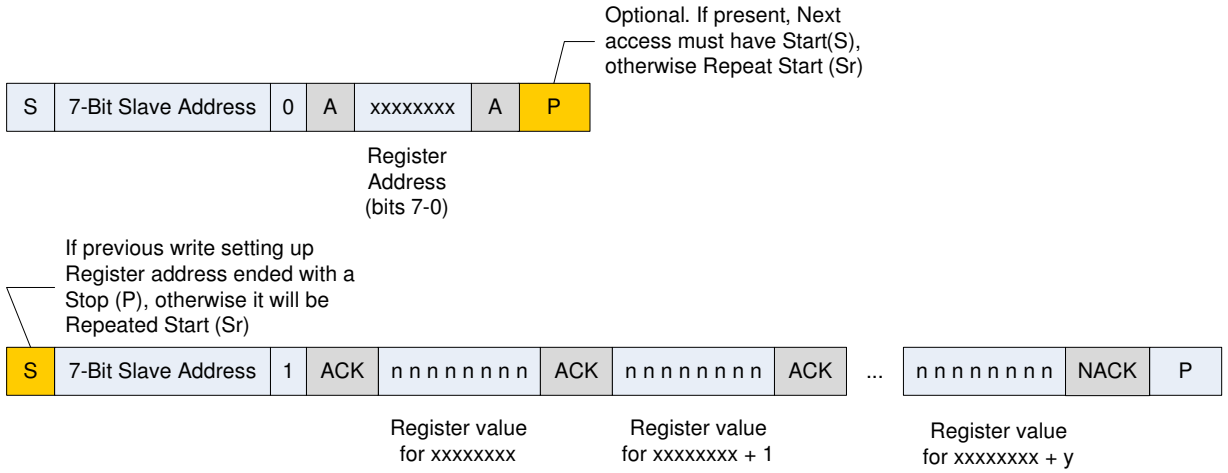


Figure 7.8 I2C Sequential Access Read Format

7.2.2 Pull-Up Resistors for I^2C

The circuit board designer is required to place external pull-up resistors (10 kΩ recommended) on the SDA & SCL signals (per SMBus 1.0 Specification) to Vcc in order to assure proper operation.

7.3 SMBus Slave Interface

The USB3813 includes an integrated SMBus slave interface, which can be used to access internal device run time registers or program the internal OTP memory. SMBus detection is accomplished by detection of pull-up resistors (10 KΩ recommended) on both the SMBDATA and SMBCLK signals. To disable the SMBus, a pull-down resistor of 10 KΩ must be applied to SMBDATA. The SMBus interface can be used to configure the device as detailed in Section 6.1, "Configuration Method Selection," on page 24.

Note: All device configuration must be performed via the Pro-Touch Programming Tool. For additional information on the Pro-Touch programming tool, contact your local Microchip sales representative.

Chapter 8 Functional Descriptions

This chapter provides additional functional descriptions of key device features.

8.1 Battery Charger Detection & Charging

The USB3813 supports both upstream battery charger detection and downstream battery charging. The integrated battery charger detection circuitry supports the USB-IF Battery Charging (BC1.2) detection method and most Apple devices. These circuits are used to detect the attachment and type of a USB charger and provide an interrupt output to indicate charger information is available to be read from the device's status registers via the serial interface. The USB3813 provides the battery charging handshake and supports the following USB-IF BC1.2 charging profiles:

- DCP: Dedicated Charging Port (Power brick with no data)
- CDP: Charging Downstream Port (1.5A with data)
- SDP: Standard Downstream Port (0.5A with data)
- Custom profiles loaded via SMBus or OTP

The following sub-sections detail the upstream battery charger detection and downstream battery charging features.

8.1.1 Upstream Battery Charger Detection

Battery charger detection is available on the upstream facing port. The detection sequence is intended to identify chargers which conform to the Chinese battery charger specification, chargers which conform to the USB-IF Battery Charger Specification 1.2, and most Apple devices.

In order to detect the charger, the device applies and monitors voltages on the upstream DP and DM balls. If a voltage within the specified range is detected, the CHRGDET[1:0] signals will be asserted and the device will be updated to reflect the proper status.

The device includes the circuitry required to implement battery charging detection using the Battery Charging Specification. When enabled, the device will automatically perform charger detection upon entering the Hub.ChgDet stage in Hub Mode. The device includes a state machine to provide the detection of the USB chargers listed in the table below.

Table 8.1 Chargers Compatible with Upstream Detection

USB ATTACH TYPE	DP/DM PROFILE	CHARGERTYPE
DCP (Dedicated Charging Port)	Shorted < 200ohm	001
CDP (Charging Downstream Port)	VDP reflected to VDM	010 (EnhancedChrgDet = 1)
SDP (Standard Downstream Port) USB Host or downstream hub port	15Kohm pull-down on DP and DM	011
Apple Low Current Charger	Apple	100
Apple High Current Charger	Apple	101
Apple Super High Current Charger	DP=2.7V DM=2.0V	110

Table 8.1 Chargers Compatible with Upstream Detection (continued)

USB ATTACH TYPE	DP/DM PROFILE	CHARGERTYPE
Apple Charger Low Current Charger (500mA)	DP=2.0V DM=2.0V	100
Apple Charger High Current Charger (1000mA)	DP=2.0V DM=2.7V	101

If a custom charger detection algorithm is desired, the SMBus registers can also be used to control the charger detection block to implement a custom charger detection algorithm. In order to avoid negative interactions with automatic battery charger detection or normal hub operation, the user should only attempt Custom battery charger detection during the Hub.Config stage or Hub.Connect stage. No logic is implemented to disable custom detection at other times - it is up to the user software to observe this restriction.

The SMBus registers and associated general purpose interrupts are primarily intended for communication with the SOC. To facilitate operation when the SOC is not in a mode which can service the SMBus, additional output signals dedicated specifically to charger detection (CHRGDET[1:0]) are provided. This output can be used to communicate with a second device such as a PMIC. The type of charger which affects the CHRGDET[1:0] state can be selected in the Charge Detect Mask Register.

There is a possibility that the system is not running the reference clock when battery charger detection is required (for example if the battery is dead or missing). During the Hub.WaitRefClk stage the battery charger detection sequence can be configured to be followed regardless of the activity of REFCLK by relying on the operation of the internal oscillator.

Note: Battery charger detection is not available when utilizing HSIC on the upstream port.

8.1.1.1 Charger Detection (CHRGDET[1:0])

The CHRGDET[1:0] output function can be programmed to communicate information that can affect the level of current that the system may draw from the upstream USB VBUS wire. CHRGDET[1:0] can be set to identify that a specific type of charger was discovered or that an event on the device occurred such as USB Device Suspend or the USB Device has been configured. Either bit of the function can be enabled on a single pin if the resolution of two pins is not required. The output function tracks the CHG_DET[1:0] bits of the .

The charger detect output can be used to communicate directly to a PMIC GPIO that a charger has been identified. In this way, there is no communication required over the SMBus by the SOC. This facilitates a dead battery case where there is insufficient battery power to activate the SOC or its SMBus to query the cause of an interrupt. The encoding of CHRGDET[1:0] can be seen in Table 8.2.

Table 8.2 CHRGDET[1:0] Configuration Definitions

CHRGDET[1:0]	DEFINITION
‘00’	No selected chargers or status identified. Draw no current from VBUS.
‘01’	VBUS detect without enumeration. Draw unconfigured current from VBUS (100mA max).
‘10’	Device enumerated, Set Config seen. Draw configured current from VBUS (500mA max).

Table 8.2 CHRGDET[1:0] Configuration Definitions (continued)

CHRGDET[1:0]	DEFINITION
'11'	Charger detected. Draw battery charger current from VBUS (1.0A+). **Note:** The actual current amount for the charger will be system dependant.

8.1.2 Downstream Battery Charging

The device can be configured by an OEM to have the downstream ports to support battery charging. The Hub's role in battery charging is to provide an acknowledge to a device's query as to if the hub system supports USB battery charging. The hub silicon does not provide any current or power FETs or any additional circuitry to actually charge the device. Those components must be provided as externally by the OEM.

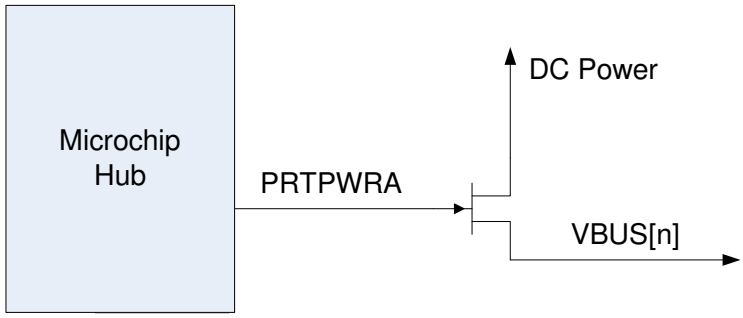


Figure 8.1 Battery Charging External Power Supply

If the OEM provides an external supply capable of supplying current per the battery charging specification, the hub can be configured to indicate the presence of such a supply to the device.This indication, per the PRTCTLA output, is for all downstream ports.

Note: Battery charging is not available on downstream HSIC ports.

8.1.2.1 Downstream Battery Charging Modes

In the terminology of the USB Battery Charging Specification, if a port is configured to support battery charging, the downstream port is a considered a CDP (Charging Downstream Port) if connected to a USB host, or a DCP (Dedicated Charging Port) if not connected to a USB host. If the port is not configured to support battery charging, the port is considered an SDP (Standard Downstream Port). All charging ports have electrical characteristics different from standard non-charging ports.

A downstream port will behave as a CDP, DCP, or SDP depending on the port's configuration and mode of operation. The port will not switch between a CDP/DCP or SDP at any time after initial power-up and configuration. A downstream port can be in one of three modes shown in the table below.

Table 8.3 Downstream Port Types

USB ATTACH TYPE	DP/DM PROFILE
DCP (Dedicated Charging Port)	Apple charging mode or China Mode (Shorted < 200ohm) or MCHP custom mode
CDP (Charging Downstream Port)	VDP reflected to VDM
SDP (Standard Downstream Port) USB Host or downstream hub port	15Kohm pull-down on DP and DM

8.1.2.2 Downstream Battery Charging Configuration

Configuration of ports to support battery charging is performed via USB configuration, SMBus configuration, or OTP. The Battery Charging Enable Register provides per port battery charging configuration. Starting from bit 1, this register enables battery charging for each down stream port when asserted. Bit 1 represents port 1 and so on. Each port with battery charging enabled asserts the corresponding PRTPWR register bit.

8.1.2.3 Downstream Over-Current Management

It is the devices responsibility to manage over-current conditions. Over-Current Sense (OCS) is handled according to the USB specification. For battery charging ports, PRTPWRA is driven high (asserted) after hardware initialization. If an OCS event occurs, the PRTPWRA is negated.

If there is an over-current event in DCP mode, the port is turned off for one second and is 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. This retry persists for indefinitely. The indefinite retry prevents a defective device from permanently disabling the port.

In CDP or SDP mode, the port power and over-current events are controlled by the USB 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 enable its port power. If the over current still exists, it will be notified at that point.

8.2 Flex Connect

This feature allows the upstream port to be swapped with downstream physical port 1. Only downstream port 1 can be swapped physically. Using port remapping, any logical port (number assignment) can be swapped with the upstream port (non-physical).

Flex Connect is enabled/disabled via two control bits in the Connect Configuration Register. The FLEXCONNECT configuration bit switches the port, and EN_FLEX_MODE enables the mode.

8.2.1 Port Control

Once EN_FLEX_MODE bit is set, the functions of certain pins change, as outlined below.

If EN_FLEX_MODE is set and FLEXCONNECT is not set:

1. SUSPEND outputs '0' to keep any upstream power controller off

If EN_FLEX_MODE is set and FLEXCONNECT is set:

1. The normal upstream VBUS pin becomes a don't care
2. SUSPEND becomes PRTPWR1/OCS1_N for the port power controller for the connector port

8.3 Resets

The device has the following chip level reset sources:

- Power-On Reset (POR)
- External Chip Reset (RESET_N)
- USB Bus Reset

8.3.1 Power-On Reset (POR)

A power-on reset occurs whenever power is initially supplied to the device, or if power is removed and reapplied to the device. A timer within the device will assert the internal reset per the specifications listed in Section 9.5.1, "Power-On Configuration Strap Valid Timing," on page 49.

8.3.2 External Chip Reset (RESET_N)

A valid hardware reset is defined as assertion of RESET_N, after all power supplies are within operating range, per the specifications in Section 9.5.2, "Reset and Configuration Strap Timing," on page 50. While reset is asserted, the device (and its associated external circuitry) enters Standby Mode and consumes minimal current.

Assertion of RESET_N causes the following:

1. The PHY is disabled and the differential pairs will be in a high-impedance state.
2. All transactions immediately terminate; no states are saved.
3. All internal registers return to the default state.
4. The external crystal oscillator is halted.
5. The PLL is halted.
6. The HSIC Strobe and Data pins are driven low.

Note: All power supplies must have reached the operating levels mandated in Section 9.2, "Operating Conditions**," on page 45, prior to (or coincident with) the assertion of RESET_N.

8.3.3 USB Bus Reset

In response to the upstream port signaling a reset to the device, the device performs the following:

Note: The device does not propagate the upstream USB reset to downstream devices.

1. Sets default address to 0.
2. Sets configuration to: Unconfigured.
3. Moves device from suspended to active (if suspended).
4. Complies with Section 11.10 of the USB 2.0 Specification for behavior after completion of the reset sequence.

The host then configures the device in accordance with the USB Specification.

8.4 Reference Clock

The device's reference clock (REFCLK) input can be driven with a square wave from 0V to VDD33 and is compatible with several different reference frequencies as shown in Table 8.4. The REFSEL[1:0] inputs must be configured to select the default input reference clock frequency that matches the clock frequency applied to REFCLK. The REFSEL[1:0] inputs are latched upon entering the HUB.config stage and are ignored afterward. REFSEL[1:0] settings are provided in Table 8.4.

Note: The frequencies shown for each REFSEL[1:0] combination in Table 8.4 are the default values. The frequencies associated with each specific REFSEL[1:0] value can be customized to support other frequencies. Refer to the Pro-Touch Configuration Tool documentation for additional information.

Table 8.4 Default Reference Clock Frequencies

REFSEL[1:0]	FREQUENCY (MHz)
'00'	38.4
'01'	26.0
'10'	19.2
'11'	12.0

8.5 Hub Connect (HUB_CONN)

HUB_CONN is the equivalent of VBUS. The device will connect to the upstream host when either of the following conditions are met:

- If there is no I^2C master present, the device will attach when HUB_CONN is high.
- If there is an I^2C master present, the device will wait until the master has configured the device and signalled completion by setting USB_ATTACH in the STCD register. Once the USB_ATTACH bit it set, the device will connect once HUB_CONN is high.

Refer to Section 5.1.9, "Hub Connect Stage (Hub.Connect)," on page 22 for additional information.

8.6 Link Power Management (LPM)

The device supports the L0 (On), L1 (Sleep), and L2 (Suspend) link power management states per the USB 2.0 Link Power Management Addendum. These supported LPM states offer low transitional latencies in the tens of microseconds versus the much longer latencies of the traditional USB suspend/resume in the tens of milliseconds. The supported LPM states are detailed in Table 8.5. For additional information, refer to the USB 2.0 Link Power Management Addendum.

Table 8.5 LPM State Definitions

STATE	DESCRIPTION	ENTRY/EXIT TIME TO L0
L2	Suspend	Entry: ~3 ms Exit: ~2 ms
L1	Sleep	Entry: ~65 us Exit: ~100 us
L0	Fully Enabled (On)	-

Note: State change timing is approximate and is measured by change in power consumption.

Note: System clocks are stopped only in suspend mode or when power is removed from the device.

8.7 Suspend (SUSPEND)

When enabled, the SUSPEND signal can be used to indicate that the entire hub has entered the USB suspend state and that VBUS current consumption should be reduced in accordance with the USB specification. Selective suspend set by the host on downstream hub ports have no effect on this signal because there is no requirement to reduce current consumption from the upstream VBUS. Suspend can be used by the system to monitor and dynamically adjust how much current the PMIC draws from VBUS to charge the battery in the system during a USB session. Because it is a level indication, it will assert or negate to reflect the current status of suspend without any interaction through the SMBus.

A negation of this signal indicates no level suspend interrupt and device has been configured by the USB Host. The full configured current can be drawn from the USB VBUS pin on the USB connector for charging - up to 500mA - depending on descriptor settings. When asserted, this signal indicates a suspend interrupt or that the device has not yet been configured by USB Host. The current draw can be limited by the system according to the USB specification. The USB specification limits current to 100mA before configuration, and up to 12.5mA in USB suspend mode.

8.8 Interrupt Requests (IRQ_N)

The IRQ_N I^2C request input pin may be used by the SOC when it desires to communicate with the device during the HUB.Communication stage, assuring the device's SMBus is active and ready to respond - even during USB suspend. In order to meet USB suspend current limits, most blocks in the device, including the SMBus controller, are in a low power state and are not capable of operation.

When the device observes the assertion of IRQ_N, if the device is in suspend mode, it will enable to PLL and allow serial communication to be achieved. When the IRQ_N pin is negated the device will return to its normal suspend current consumption. The IRQ_N alternate function can be implemented at the same time as the INT_N interrupt output, on the same physical pin.

Note: Asserting the IRQ_N input while the device is in suspend mode will increase the instantaneous current consumption above the average suspend current requirement. Therefore, this feature should be used briefly and sparingly.

8.9 Interrupt Output (INT_N)

INT_N is a general interrupt pin intended to communicate select condition changes within the device. The conditions which may cause an interrupt are detailed in the . The conditions which cause the interrupt to assert can be controlled through use of the Serial Port Interrupt Mask Register.

The general interrupt and all interrupt conditions are functionally latched and event driven. Once the interrupt or any of the conditions have asserted, the status bit will remain asserted until the SOC negates the bit using the SMBus. The bits will then remain negated until a new event condition occurs. The latching nature of the register causes the status to remain even if the condition that caused the interrupt ceases to be active. The event driven nature of the register causes the interrupt to only occur when a new event occurs - when a condition is removed and then is applied again. For example, if the battery charger detection routine has completed and the SOC negates the interrupt status, it will not cause an interrupt just because the charger detection is still completed. A new charger detection routine must run before the associated interrupt will assert again.

Chapter 9 Operational Characteristics

9.1 Absolute Maximum Ratings*

VBAT Supply Voltage (Note 9.1) . . . . . 0 V to +5.5 V

VDDCOREREG Supply Voltage (Note 9.1) . . . . . 0 V to +3.6 V

Positive voltage on input signal pins, with respect to ground (Note 9.2) . . . . . 3.6 V

Negative voltage on input signal pins, with respect to ground (Note 9.3) . . . . . -0.5 V

Positive voltage on REFCLK, with respect to ground VDDCR12

Positive voltage on HSIC signals, with respect to ground . . . . . 1.32 V

Positive voltage on USB DP/DM signals, with respect to ground (Note 9.4) . . . . . 5.5 V

Storage Temperature . . . . . -55°C to +150°C

Lead Temperature Range . . . . . Refer to JEDEC Spec. J-STD-020

HBM ESD Performance . . . . . JEDEC Class 3A

Note 9.1 When powering this device from laboratory or system power supplies, it is important that the absolute maximum ratings not be exceeded or device failure can result. Some power supplies exhibit voltage spikes on their outputs when AC power is switched on or off. In addition, voltage transients on the AC power line may appear on the DC output. If this possibility exists, it is suggested to use a clamp circuit.

Note 9.2 This rating does not apply to the following signals: All USB DM/DP pins, REFCLK, and all HSIC signals.

Note 9.3 This rating does not apply to the HSIC signals.

Note 9.4 This rating applies only when VDD33 is powered.

*Stresses exceeding those listed in this section could cause permanent damage to the device. This is a stress rating only. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Functional operation of the device at any condition exceeding those indicated in Section 9.2, "Operating Conditions**", Section 9.4, "DC Specifications", or any other applicable section of this specification is not implied. Note, device signals are NOT 5 volt tolerant unless specified otherwise.

9.2 Operating Conditions**

VBAT Supply Voltage . . . . . +2.9 V to +5.5 V

VDDCOREREG Supply Voltage . . . . . Note 9.5

Power Supply Rise Time . . . . . Note 9.6

Ambient Operating Temperature in Still Air (T_A) . . . . . Note 9.7

Note 9.5 +1.6 V to +2.0 V when VDDCOREREG is connected to an external +1.8V power supply, +3.0 V to +3.6 V when VDDCOREREG is connected to VDD33.

Note 9.6 The power supply rise time requirements vary dependent on the usage of the external reset (RESET_N). If RESET_N is asserted at power-on, the power supply rise time must be 10mS or less ($t_{RT(max)}$ = 10mS). If RESET_N is not used at power-on (tied high), the power supply rise time must be 1mS or less ($t_{RT(max)}$ = 1mS). Higher voltage supplies must always be at an equal or higher voltage than lower voltage supplies. Figure 9.1 illustrates the supply rise time requirements.

Note 9.7 0°C to +70°C for commercial version, -40°C to +85°C for industrial version.

**Proper operation of the device is guaranteed only within the ranges specified in this section.

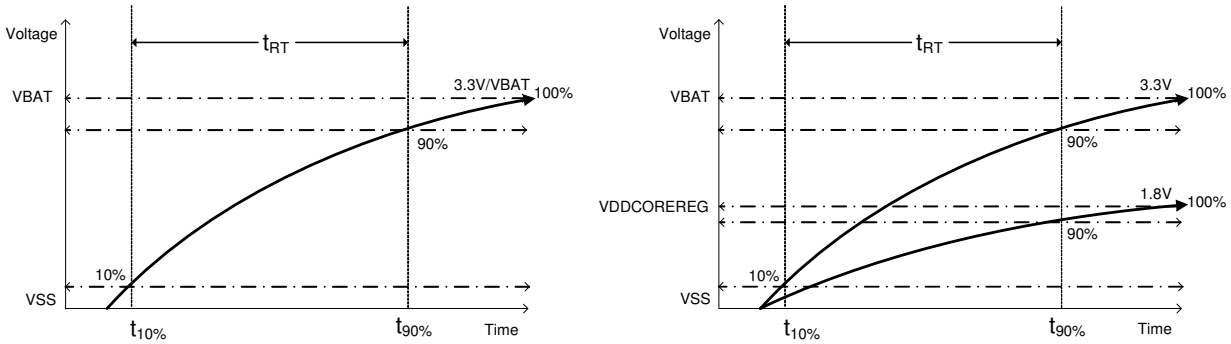


Figure 9.1 Single/Dual Supply Rise Time Models

9.3 Power Consumption

This section details the power consumption of the device as measured during various modes of operation. Power dissipation is determined by temperature, supply voltage, and external source/sink requirements.

9.3.1 Operational / Unconfigured

Table 9.1 Operational/Unconfigured Power Consumption

	TYPICAL (mA)		MAXIMUM (mA)	
	VBAT	VDDCOREREG	VBAT	VDDCOREREG
HS Host / 1 HSIC Device	15	30	15	35
HS Host / 1 HS Devices	25	30	30	35
HS Host / 2 HS Devices	40	40	45	45
HS Host / 1 HSIC, 2 HS Devices	20	35	25	40
HS Host / 1 FS Device	15	25	20	30
HS Host / 2 FS Devices	20	30	20	35
HS Host / 1HSIC, 2 FS Devices	20	35	25	40
Unconfigured	10	20	-	-

9.3.2 Suspend / Standby

9.3.2.1 Single Supply

The following table details the device power consumption when configured with a single VBAT supply For additional information on power connections, refer to Chapter 4, "Power Connections," on page 17.

Table 9.2 Single Supply Suspend/Standby Power Consumption

MODE	SYMBOL	TYPICAL @ 25°C	COMMERCIAL MAX	INDUSTRIAL MAX	UNIT
Suspend	I_{VBAT}	300	1200	1650	uA
Standby	I_{VBAT}	0.4	2.0	2.4	uA

Note: Typical values measured with VBAT = 4.2V. Maximum values measured with VBAT = 5.5V.

9.3.2.2 Dual Supply

The following table details the device power consumption when configured with a dual supply (VBAT and 1.8V VDDCOREREG) For additional information on power connections, refer to Chapter 4, "Power Connections," on page 17.

Table 9.3 Dual Supply Suspend/Standby Power Consumption

MODE	SYMBOL	TYPICAL @ 25°C	COMMERCIAL MAX	INDUSTRIAL MAX	UNIT
Suspend	$I_{VDDCOREREG}$	90	1000	1700	uA
	I_{VBAT}	200	250	250	uA
Standby	$I_{VDDCOREREG}$	0.1	1.2	2.0	uA
	I_{VBAT}	0.4	2.1	2.5	uA

Note: Typical values measured with VBAT = 4.2V, VDDCOREREG = 1.8V. Maximum values measured with VBAT = 5.5V, VDDCOREREG = 2.0V.

9.4 DC Specifications

Table 9.4 DC Electrical Characteristics

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
IS Type Input Buffer						
Low Input Level	V_{IL}	-0.3		0.8	V	
High Input Level	V_{IH}	2.0		3.6	V	
I_RST Type Input Buffer						
Low Input Level	V_{IL}	-0.3		0.4	V	
High Input Level	V_{IH}	1.25		3.6	V	
I_SMB Type Input Buffer						
Low Input Level	V_{IL}	-0.3		0.35	V	
High Input Level	V_{IH}	1.25		3.6	V	
O8 Type Buffers						
Low Output Level	V_{OL}			0.4	V	I_{OL} = 8 mA
High Output Level	V_{OH}	VDD33 - 0.4			V	I_{OH} = -8 mA
OD8 Type Buffer						
Low Output Level	V_{OL}			0.4	V	I_{OL} = 8 mA
O12 Type Buffers						
Low Output Level	V_{OL}			0.4	V	I_{OL} = 12 mA
High Output Level	V_{OH}	VDD33 - 0.4			V	I_{OH} = -12 mA
HSIC Type Buffers						
Low Input Level	V_{IL}	-0.3		0.35*VDDCR12	V	
High Input Level	V_{IH}	0.65*VDDCR12		VDDCR12+0.3	V	
Low Output Level	V_{OL}			0.25*VDDCR12	V	
High Output Level	V_{OH}	0.75*VDDCR12			V	
ICLK Type Buffer (REFCLK Input)						
Low Input Level	V_{IL}	-0.3		0.35	V	
High Input Level	V_{IH}	0.8		3.6	V	

9.5 AC Specifications

This section details the various AC timing specifications of the device.

9.5.1 Power-On Configuration Strap Valid Timing

Figure 9.2 illustrates the configuration strap timing requirements, in relation to power-on, for applications where RESET_N is not used at power-on. The operational levels (V_{opp}) for the external power supplies are detailed in Section 9.2, "Operating Conditions**," on page 45.

Note: For RESET_N configuration strap timing requirements, refer to Section 9.5.2, "Reset and Configuration Strap Timing," on page 50.

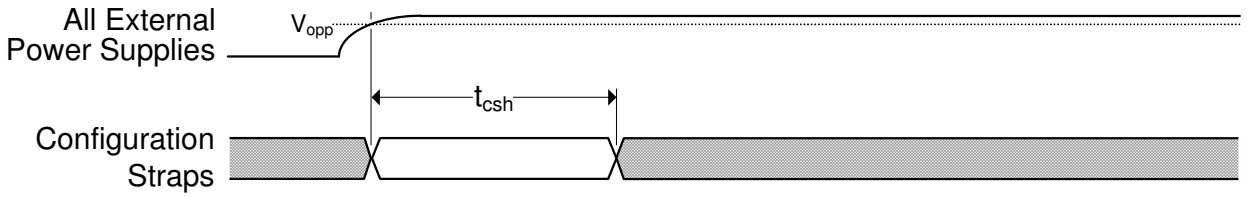


Figure 9.2 Power-On Configuration Strap Valid Timing

Table 9.5 Power-On Configuration Strap Valid Timing

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{csh}	Configuration strap hold after external power supplies at operational levels	1			ms

9.5.2 Reset and Configuration Strap Timing

Figure 9.3 illustrates the RESET_N timing requirements and its relation to the configuration strap signals. Assertion of RESET_N is not a requirement. However, if used, it must be asserted for the minimum period specified.

Refer to Section 8.3, "Resets," on page 40 for additional information on resets. Refer to Section 6.3, "Device Configuration Straps," on page 26 for additional information on configuration straps.

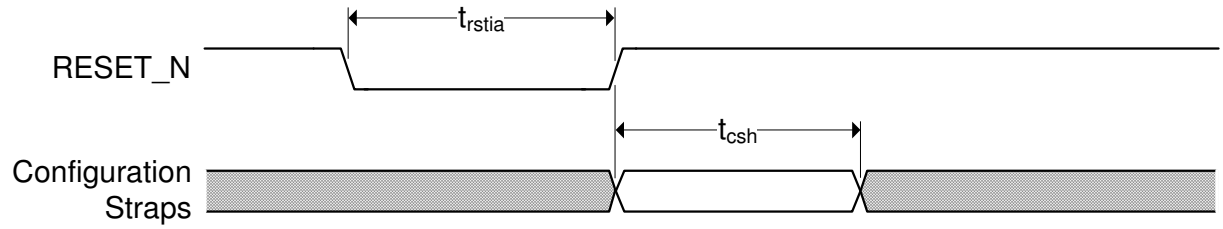


Figure 9.3 RESET_N Configuration Strap Timing

Table 9.6 RESET_N Configuration Strap Timing

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{rstia}	RESET_N input assertion time	5			us
t_{csh}	Configuration strap hold after RESET_N deassertion	1			ms

9.5.3 USB Timing

All device USB signals conform to the voltage, power, and timing characteristics/specifications as set forth in the *Universal Serial Bus Specification*. Please refer to the *Universal Serial Bus Specification*, Revision 2.0, available at http://www.usb.org.

9.5.4 HSIC Timing

All device HSIC signals conform to the voltage, power, and timing characteristics/specifications as set forth in the *High-Speed Inter-Chip USB Electrical Specification*. Please refer to the *High-Speed Inter-Chip USB Electrical Specification*, Version 1.0, available at http://www.usb.org.

9.5.5 SMBus Timing

All device SMBus signals conform to the voltage, power, and timing characteristics/specifications as set forth in the *System Management Bus Specification*. Please refer to the *System Management Bus Specification*, Version 1.0, available at http://smbus.org/specs.

9.5.6 I^2C Timing

All device I^2C signals conform to the 100KHz Standard Mode (Sm) voltage, power, and timing characteristics/specifications as set forth in the *I^2C-Bus Specification*. Please refer to the *I^2C-Bus Specification*, available at http://www.nxp.com.

9.5.7 SPI Timing

The following specifies the SPI timing requirements for the device.

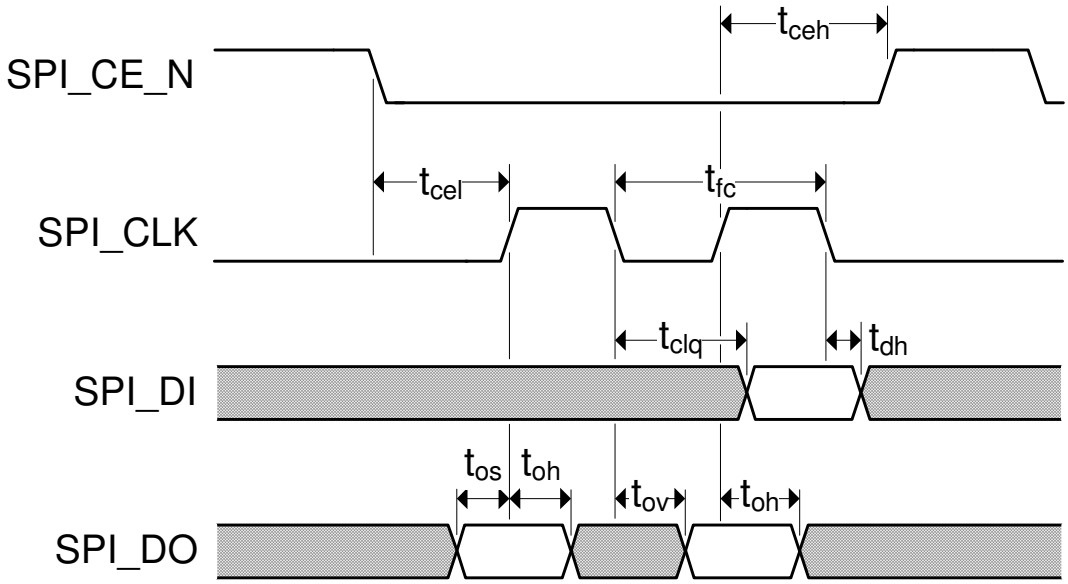


Figure 9.4 SPI Timing

Note: The SPI can be configured for 30 MHz or 60 MHz operation via the SPI_SPD_SEL configuration strap. 30 MHz operation timing values are shown in Table 9.7. 60 MHz operation timing values are shown in Table 9.8.

Table 9.7 SPI Timing Values (30 MHz Operation)

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{fc}	Clock frequency			30	MHz
t_{ceh}	Chip enable (SPI_CE_EN) high time	100			ns
t_{clq}	Clock to input data			13	ns
t_{dh}	Input data hold time	0			ns
t_{os}	Output setup time	5			ns
t_{oh}	Output hold time	5			ns
t_{ov}	Clock to output valid	4			ns
t_{cel}	Chip enable (SPI_CE_EN) low to first clock	12			ns
t_{ceh}	Last clock to chip enable (SPI_CE_EN) high	12			ns

Table 9.8 SPI Timing Values (60 MHz Operation)

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{fc}	Clock frequency			60	MHz
t_{ceh}	Chip enable (SPI_CE_EN) high time	50			ns
t_{clq}	Clock to input data			9	ns
t_{dh}	Input data hold time	0			ns
t_{os}	Output setup time	5			ns
t_{oh}	Output hold time	5			ns
t_{ov}	Clock to output valid	4			ns
t_{cel}	Chip enable (SPI_CE_EN) low to first clock	12			ns
t_{ceh}	Last clock to chip enable (SPI_CE_EN) high	12			ns

9.6 Clock Specifications

The device can accept a 24 MHz single-ended clock oscillator input. REFCLK should be driven with a clock that adheres to the specifications outlined in Section 9.6.1, "External Reference Clock (REFCLK)".

9.6.1 External Reference Clock (REFCLK)

The following input clock specifications are suggested:

- ± 350 PPM

The input frequency of REFCLK is user configurable. Refer to Section 8.4, "Reference Clock" for additional information on configuring a reference clock input.

Note: The external clock is recommended to conform to the signalling levels designated in the JEDEC specification on 1.2V CMOS Logic.

Chapter 10 Package Outline

Note: For the most current package drawings, see the Microchip Packaging Specification at http://www.microchip.com/packaging.

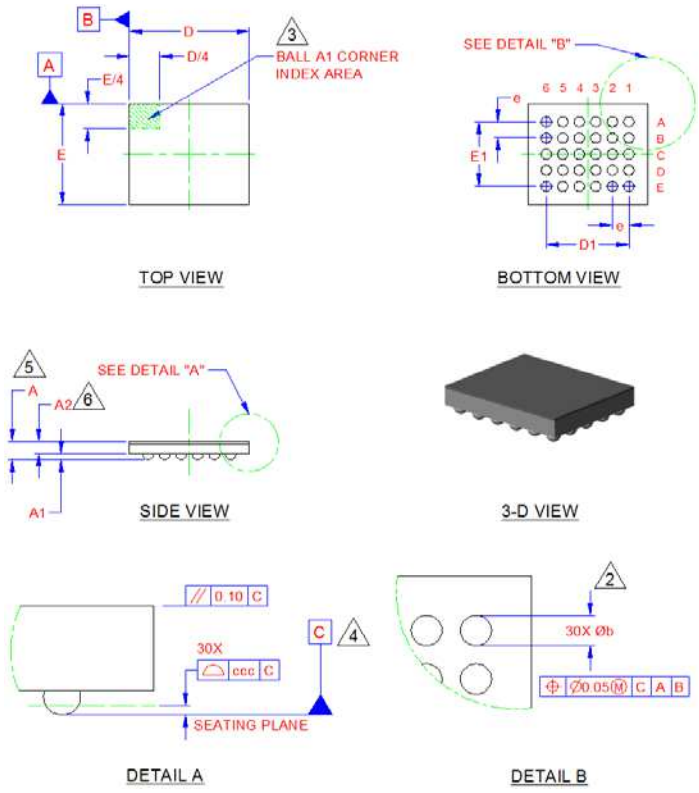


Figure 10.1 30-WLCSP Package

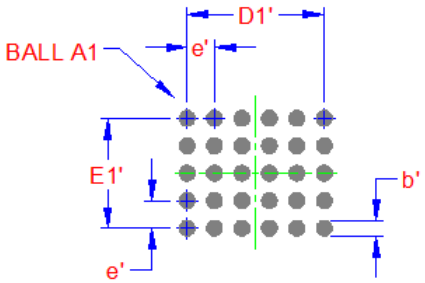
Table 10.1 30-WLCSP Dimensions

	MIN	NOMINAL	MAX	REMARKS
A	-	0.56	0.62	Overall Package Height
A1	0.16	0.20	0.24	Standoff
A2	-	-	0.38	Package Thickness
D	2.87	2.90	2.93	X Die Size
E	2.47	2.50	2.53	Y Die Size
D1		2.00 BSC		X End Balls Distance
E1		1.60 BSC		Y End Balls Distance
b	0.20	0.25	0.30	Ball Diameter
e		0.40 BSC		Ball Pitch
ccc	0	-	0.05	Coplanarity

Notes:

Notes:

1. All dimensions are in millimeters unless otherwise noted.
2. Dimension “b” is measured at the maximum ball diameter parallel to primary datum “C”.
3. The ball A1 identifier may vary, but is always located within the zone indicated.
4. Primary datum “C” and the seating plane are defined by the spherical crowns of the contact solder balls.
5. Dimension “A” does not include attached external features, such as a heat sink or chip capacitors. Dimension “A(max)” is given for the extremely thin variation of the package profile height.
6. Dimension “A2” includes a die coating thickness.



LAND PATTERN DIMENSIONS			
SYMBOL	MIN	NOM	MAX
D1'	-	2.00	-
E1'	-	1.60	-
b'	0.23	0.23	-
e'	-	0.40	-

THE USER MAY MODIFY THE PCB LAND PATTERN DIMENSIONS, BASED ON THEIR EXPERIENCE AND/OR PROCESS CAPABILITY

Figure 10.2 30-WLCSP Recommended Land Pattern

Chapter 11 Datasheet Revision History

Table 11.1 Revision History

REVISION LEVEL & DATE	SECTION/FIGURE/ENTRY	CORRECTION
USB3813 Revision A replaces the previous SMSC version revision 1.1		
Rev. 1.1 (12-06-13)	SMBus Runtime Registers	Register definitions removed. These definitions are provided in application note *AN 26.18 "SMBus Slave Interface for the USB253x/USB3x13/USB46x4"*.
Rev. 1.1 (09-24-13)	Table 9.4, "DC Electrical Characteristics," on page 48	Updated ICLK V_{IH} max from "VDDCR12" to "3.6"
	Section 9.6.1, "External Reference Clock (REFCLK)," on page 52	Removed 50% duty cycle requirement.
Rev. 1.0 (06-17-13)	Initial Release	

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
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