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UCS1003-1/2/3

USB Port Power Controller with Charger Emulation

Features

- Port Power Switch with Two Current Limit Behaviors:
  - 2.9V to 5.5V source voltage range
  - Up to 3.0A current (2.85A typical) with 55 mΩ on resistance
  - Overcurrent trip or Constant-Current Limiting
  - Soft turn-on circuitry
  - Selectable current limit
  - UCS1003-1 has programmable current limit via the SMBus 2.0/I^2C protocol
  - Dynamic thermal management
  - Undervoltage Lockout (UVLO) and Overvoltage Lockout (OVLO)
  - Backdrive, back-voltage protection
  - Latch or auto-recovery (low test current) Fault handling
  - Selectable active-high or active-low power switch enable
  - BC1.2 V_{BUS} discharge port renegotiation function
- Selectable/Automatic Cycling of Universal Serial Bus (USB) Data Line Charger Emulation Profiles:
  - USB-IF BC1.2 Charging Downstream Port (CDP) and Dedicated Charging Port (DCP) modes, Chinese Telecommunications Industry Standard YD/T 1591-2009 and most Apple® Inc., Samsung and RIM® protocols standard
  - UCS1003-1 supports other charger emulation profiles as defined via the SMBus 2.0/I^2C protocol
  - Supports 12W charging emulation
  - USB 2.0 compliant high-speed data switch (in Data Pass-Through, SDP and CDP modes)
  - Nine preloaded charger emulation profiles for maximum compatibility coverage of the peripheral devices
  - UCS1003-1 has one custom programmable charger emulation profile for portable device support for fully host-controlled charger emulation
- Supports Active Cables
- UCS1003-1 Supports Self-Contained Current Monitoring and Rationing for Power Allocation Applications
- UCS1003-1 and UCS1003-3 have Low-Power Attach Detection and Open-Drain (A_DET#) Pin
- UCS1003-2 has Charging Active (CHRG#) Open-Drain Pin
- Ultra Low-Power Sleep State
- Optional Split Supply Support for V_S and V_{DD} for Low Power in System Standby States
- Wake on Attach USB (UCS1003-1 and UCS1003-3)
- UCS1003-1 Supports SMBus 2.0/I^2C Communications:
  - Supports block write and read
  - Multiple SMBus addresses
- Wide Operating Temperature Range: -40°C to +85°C
- IEC61000-4-2 8/15 kV Electrostatic Discharge (ESD) Immunity
- UL Recognized and EN/IEC 60950-1 (CB) Certified

Description

The UCS1003-1/2/3 family of devices provides a USB port power switch for precise control of up to 3.0A continuous current (2.85A typical) with Overcurrent Limit (OCL), dynamic thermal management, latch or auto-recovery (low test current) Fault handling, selectable active-high or active-low enable, Undervoltage and Overvoltage Lockout, backdrive protection and back-voltage protection.

Split supply support for V_S and V_{DD} is an option for low power in system standby states. This gives battery-operated applications (such as on-board computers) the ability to detect attachments from a Sleep or OFF state. After the Attach Detection is flagged, the system can decide to wake-up and/or provide charging.

In addition to Power Switching and Current-Limiting modes, the UCS1003-1/2/3 will automatically charge a wide variety of portable devices, including USB-IF BC1.2, YD/T-1591 (2009), most Apple Inc., Samsung, RIM and many others. Nine preloaded charger emulation profiles maximize the compatibility coverage of the peripheral devices. Additionally, a customizable charger emulation profile is available in UCS1003-1 to accommodate unique existing and future portable device handshaking/signature requirements.

The UCS1003-1 also provides current monitoring to allow intelligent management of system power and charge rationing for controlled delivery of current, regardless of the host power state. This is especially important for battery-operated applications that want to provide power and do not want to drain the battery excessively.

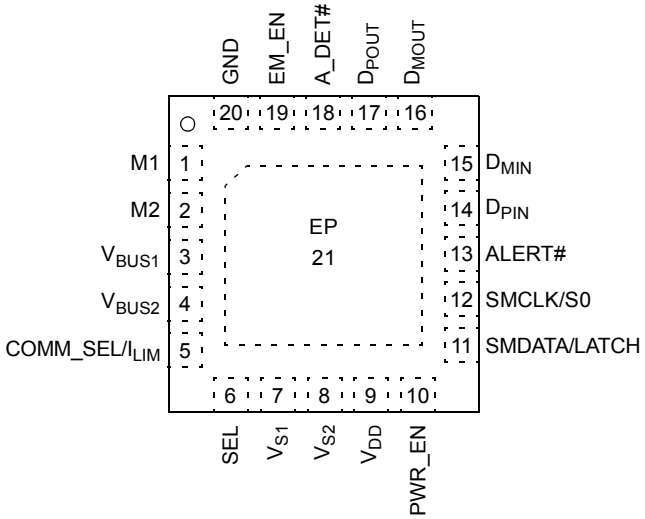
The UCS1003-1/2/3 family is available in a 4 mm x 4 mm 20-pin QFN package.

Applications

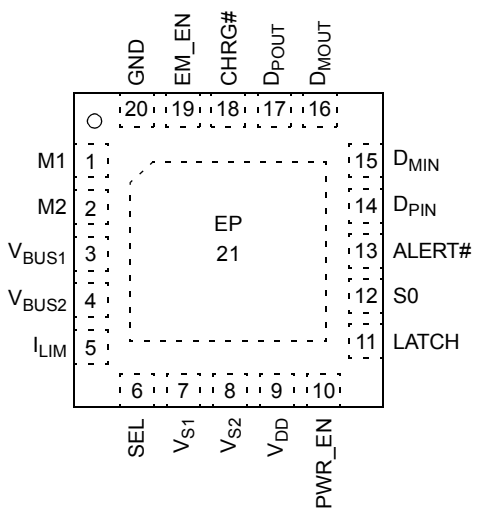
- Notebook and Netbook Computers
- Tablets and E-Book Readers
- Desktops and Monitors
- Docking Stations and Printers
- AC-DC Wall Adapters

Package Type

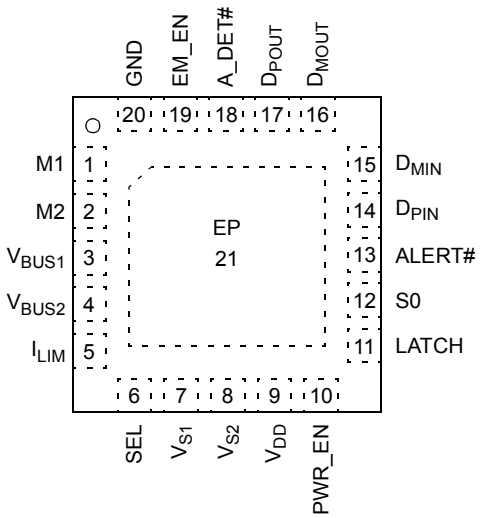
UCS1003-1
4x4 QFN*



UCS1003-2
4x4 QFN*

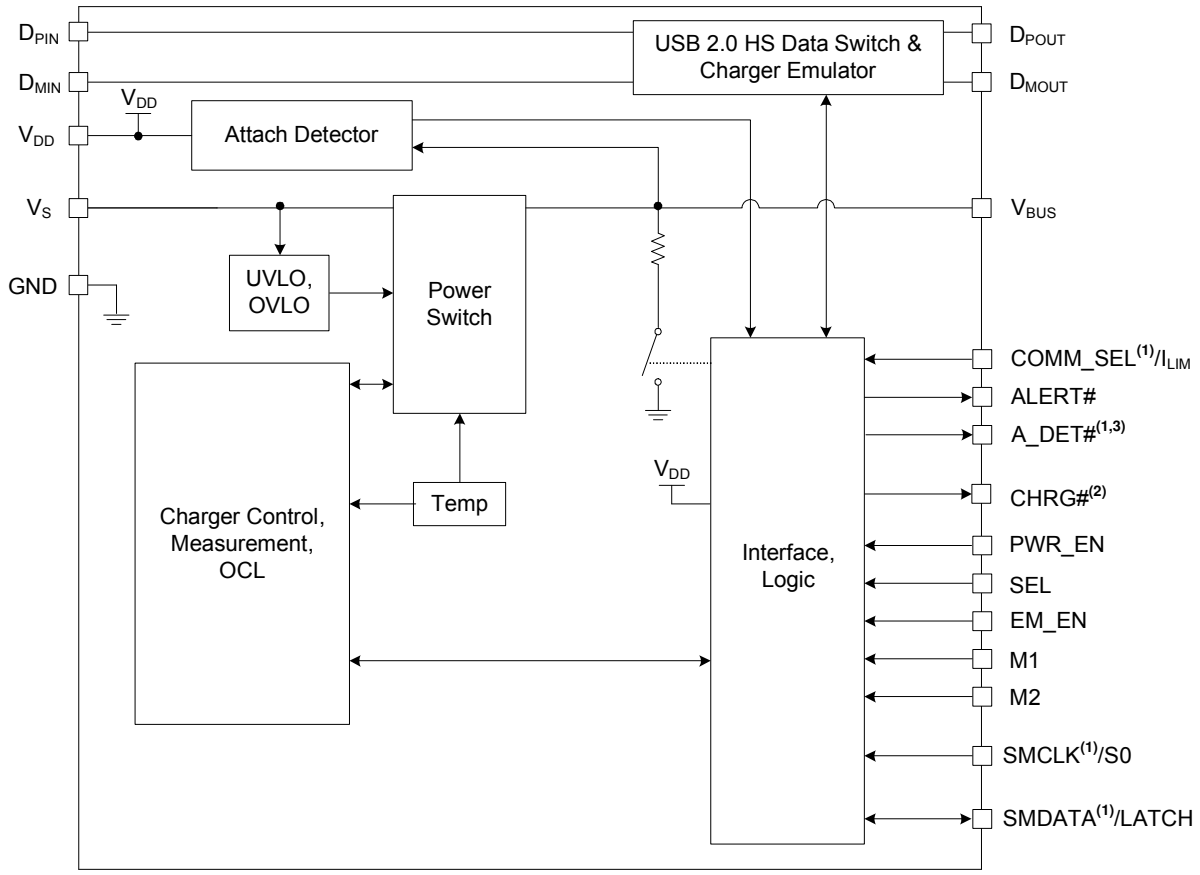


UCS1003-3
4x4 QFN*



* Includes Exposed Thermal Pad (EP); see Table 3-1.

Block Diagram



Note 1: Available for UCS1003-1 only.
2: Available for UCS1003-2 only.
3: Available for UCS1003-3 only.

NOTES:

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings†

Voltage on V_{DD}, V_S and V_{BUS} Pins ..... -0.3 to 6V

Pull-up Voltage (V_{PULLUP}) ..... -0.3 to V_{DD} + 0.3V

Data Switch Current (I_{HSW_ON}), Switch On ..... ±50 mA

Port Power Switch Current ..... Internally Limited

Data Switch Pin Voltage To Ground (D_{POUT}, D_{PIN}, D_{MOUT}, D_{MIN}); (V_{DD} powered or unpowered) ..... -0.3 to V_{DD} + 0.3V

Differential Voltage Across Open Data Switch ($D_{POUT} – D_{PIN}$, $D_{MOUT} – D_{MIN}$, $D_{PIN} – D_{POUT}$, $D_{MIN} – D_{MOUT}$) ..... V_{DD}

Voltage on any Other Pin to Ground ..... -0.3 to V_{DD} + 0.3V

Current on any Other Pin ..... ±10 mA

Package Power Dissipation ..... Table 1-1

Operating Ambient Temperature Range ..... -40 to +125°C

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

† Notice: Stresses above those listed under “Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

TABLE 1-1: POWER DISSIPATION SUMMARY

Board	Package	θ_{JC}	θ_{JA}	Derating Factor Above +25°C	T_A < +25°C Power Rating	T_A < +70°C Power Rating	T_A < +85°C Power Rating
High K (see **Note 1**)	20-pin QFN 4 x 4 mm	6°C/W	41°C/W	24.4 mW°/C	2193 mW	1095 mW	729 mW
Low K (see **Note 1**)	20-pin QFN 4 x 4 mm	6°C/W	60°C/W	16.67 mW°/C	1498 mW	748 mW	498 mW

Note 1: Junction to ambient (θ_{JA}) is dependent on the design of the thermal vias. A High K board uses a thermal via design with a thermal landing soldered to the PCB ground plane, with 0.3 mm (12 mil) diameter vias in a 3x3 matrix (9 total) at 0.5 mm (20 mil) pitch. The board is multilayer with 1-ounce internal power and ground planes and 2-ounce copper traces on top and bottom. A Low K board is a two-layer board without thermal via design, with 2-ounce copper traces on the top and bottom.

TABLE 1-2: ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise specified, V_{DD} = 4.5V to 5.5V, V_S = 2.9V to 5.5V, V_{PULLUP} = 3V to 5.5V, T_A = -40°C to +85°C; all Typical values at V_{DD} = V_S = 5V, T_A = +27°C.

Characteristic	Sym.	Min.	Typ.	Max.	Unit	Conditions
Power Supply						
Supply Voltage	V_{DD}	4.5	5	5.5	V	**(Note 1)**
Source Voltage	V_S	2.9	5	5.5	V	**(Note 1)**
Supply Current in Active (I_{DD_ACTIVE} + I_{VS_ACT})	I_{ACTIVE}	—	650	750	µA	Average current, I_{BUS} = 0 mA
Supply Current in Sleep (I_{DD_SLEEP} + I_{VS_SLEEP})	I_{SLEEP}	—	5	15	µA	Average current, $V_{PULLUP} \le V_{DD}$
Supply Current in Detect (I_{DD_DETECT} + I_{VS_DETECT})	I_{DETECT}	—	185	—	µA	Average current, no portable device attached
Power-on Reset						
V_S Low Threshold	V_{S_UVLO}	—	2.5	—	V	V_S voltage increasing
V_S Low Hysteresis	$V_{S\_UVLO\_HYST}$	—	100	—	mV	V_S voltage decreasing
V_{DD} Low Threshold	V_{DD_TH}	—	4	—	V	V_{DD} voltage increasing
V_{DD} Low Hysteresis	$V_{DD\_TH\_HYST}$	—	500	—	mV	V_{DD} voltage decreasing
I/O Pins – SMCLK (UCS1003-1), SMDATA (UCS1003-1), EM_EN, M1, M2, PWR_EN, S0, LATCH, ALERT#, A_DET# (UCS1003-1 and UCS1003-3), CHRG# (UCS1003-2) – DC Parameters						
Output Low Voltage	V_{OL}	—	—	0.4	V	I_{SINK_IO} = 8 mA, SMDATA, ALERT#, A_DET#, CHRG#
Input High Voltage	V_{IH}	2.0	—	—	V	PWR_EN, EM_EN, M1, M2, LATCH, S0, SMDATA, SMCLK
Input Low Voltage	V_{IL}	—	—	0.8	V	PWR_EN, EM_EN, M1, M2, LATCH, S0, SMDATA, SMCLK
Leakage Current	I_{LEAK}	—	—	±5	µA	Powered or unpowered, $V_{PULLUP} \le V_{DD}$
Interrupt Pins – AC Parameters						
ALERT#, A_DET# Pins Blanking Time	t_{BLANK}	—	25	—	ms	
ALERT# Pin Interrupt Masking Time	t_{MASK}	—	5	—	ms	
SMBus/I^2C Timing (UCS1003-1 only)						
Input Capacitance	C_{IN}	—	5	—	pF	
Clock Frequency	f_{SMB}	10	—	400	kHz	
Spike Suppression	t_{SP}		—	50	ns	**(Note 2)**
Bus Free Time Stop to Start	t_{BUF}	1.3	—	—	µs	

Note 1: For split supply systems using the Attach Detection feature, V_S must not exceed V_{DD} + 150 mV.

2: This parameter is ensured by design and not 100% tested.

3: This parameter is characterized, but not 100% production tested.

4: The current measurement full-scale range maximum value is 3.0A. However, the UCS1003-1 cannot report values above I_{LIM} (if $I_{BUS\_R2MIN} \le I_{LIM}$) or above I_{BUS_R2MIN} (if $I_{BUS\_R2MIN} > I_{LIM}$ and $I_{LIM} \le$ 1.68A).

5: The Min and Max values represent the boundaries of a programmable range for UCS1003-1 only. Each value in the range is typical.

TABLE 1-2: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise specified, V_{DD} = 4.5V to 5.5V, V_S = 2.9V to 5.5V, V_{PULLUP} = 3V to 5.5V, T_A = -40°C to +85°C; all Typical values at V_{DD} = V_S = 5V, T_A = +27°C.

Characteristic	Sym.	Min.	Typ.	Max.	Unit	Conditions
Start Setup Time	$t_{SU:STA}$	0.6	—	—	µs	
Start Hold Time	$t_{HD:STA}$	0.6	—	—	µs	
Stop Setup Time	$t_{SU:STO}$	0.6	—	—	µs	
Data Hold Time	$t_{HD:DAT}$	0	—	—	µs	When transmitting to the master
Data Hold Time	$t_{HD:DAT}$	0.3	—	—	µs	When receiving from the master
Data Setup Time	$t_{SU:DAT}$	0.6	—	—	µs	
Clock Low Period	t_{LOW}	1.3	—	—	µs	
Clock High Period	t_{HIGH}	0.6	—	—	µs	
Clock/Data Fall Time	t_{FALL}	—	—	300	ns	Min = 20 + 0.1 C_{LOAD} ns **(Note 3)**
Clock/Data Rise Time	t_{RISE}	—	—	300	ns	Min = 20 + 0.1 C_{LOAD} ns **(Note 3)**
Capacitive Load	C_{LOAD}	—	—	400	pF	Per bus line **(Note 2)**
Time-out	$t_{TIMEOUT}$	25	—	35	ms	Disabled by default **(Note 2)**
Idle Reset	t_{IDLE_RESET}	350	—	—	µs	Disabled by default **(Note 2)**
High-Speed Data Switch						
High-Speed Data Switch – DC Parameters						
Switch Leakage Current	I_{HSW_OFF}	—	±0.5	—	µA	Switch open – D_{PIN} to D_{POUT}, D_{MIN} to D_{MOUT} or all four pins to ground; $V_{DD} \le V_S$
Charger Resistance	R_{CHG}	—	2	—	MΩ	D_{POUT} or D_{MOUT} to V_{BUS}, or ground (see Figure 1-2), BC1.2 DCP charger emulation is active
On Resistance	R_{ON_HSW}	—	2	—	Ω	Switch closed, V_{DD} = 5V Test Current = 8 mA, Test Voltage = 0.4V (see Figure 1-2)
On Resistance	$R_{ON\_HSW\_1}$	—	5	—	Ω	Switch closed, V_{DD} = 5V, Test Current = 8 mA, Test Voltage = 3.0V (see Figure 1-2)
Delta-On Resistance	ΔR_{ON_HSW}	—	±0.3	—	Ω	Switch closed, V_{DD} = 5V, I_{TST} = 8 mA, V_{TST} = 0 to 1.5V (see Figure 1-2)
High-Speed Data Switch – AC Parameters						
D_P, D_M Capacitance to Ground	C_{HSW_ON}	—	4	—	pF	Switch closed, V_{DD} = 5V
D_P, D_M Capacitance to Ground	C_{HSW_OFF}	—	2	—	pF	Switch open, V_{DD} = 5V

Note 1: For split supply systems using the Attach Detection feature, V_S must not exceed V_{DD} + 150 mV.

2: This parameter is ensured by design and not 100% tested.

3: This parameter is characterized, but not 100% production tested.

4: The current measurement full-scale range maximum value is 3.0A. However, the UCS1003-1 cannot report values above I_{LIM} (if $I_{BUS\_R2MIN} \le I_{LIM}$) or above I_{BUS_R2MIN} (if $I_{BUS\_R2MIN} > I_{LIM}$ and $I_{LIM} \le 1.68A$).

5: The Min and Max values represent the boundaries of a programmable range for UCS1003-1 only. Each value in the range is typical.

TABLE 1-2: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise specified, V_{DD} = 4.5V to 5.5V, V_S = 2.9V to 5.5V, V_{PULLUP} = 3V to 5.5V, T_A = -40°C to +85°C; all Typical values at V_{DD} = V_S = 5V, T_A = +27°C.

Characteristic	Sym.	Min.	Typ.	Max.	Unit	Conditions
Turn-Off Time	t_{HSW_OFF}	—	400	—	µs	Time from state control (EM_EN, M1, M2) switch on to switch off, R_{TERM} = 50Ω, C_{LOAD} = 5 pF
Turn-On Time	t_{HSW_ON}	—	400	—	µs	Time from state control (EM_EN, M1, M2) switch off to switch on, R_{TERM} = 50Ω, C_{LOAD} = 5 pF
Propagation Delay	t_{PD}	—	0.25	—	ns	R_{TERM} = 50Ω, C_{LOAD} = 5 pF
Propagation Delay Skew	Δt_{PD}	—	25	—	ps	R_{TERM} = 50Ω, C_{LOAD} = 5 pF
Rise/Fall Time	$t_{F/R}$	—	10	—	ns	R_{TERM} = 50Ω, C_{LOAD} = 5 pF
D_P – D_M Crosstalk	X_{TALK}	—	-40	—	dB	R_{TERM} = 50Ω, C_{LOAD} = 5 pF
Off Isolation	O_{IRR}	—	-30	—	dB	R_{TERM} = 50Ω, C_{LOAD} = 5 pF, f = 240 MHz
-3 dB Bandwidth	BW	—	1100	—	MHz	R_{TERM} = 50Ω, C_{LOAD} = 5 pF, V_{DPOUT} = V_{DMOUT} = 350 mV DC
Total Jitter	t_J	—	200	—	ps	R_{TERM} = 50Ω, C_{LOAD} = 5 pF, Rise Time = Fall Time = 500 ps at 480 Mbps (PRBS = 2^{15} – 1)
Skew of Opposite Transitions of the Same Output	$t_{SK(P)}$	—	20	—	ps	R_{TERM} = 50Ω, C_{LOAD} = 5 pF
Port Power Switch						
Port Power Switch – DC Parameter						
Overvoltage Lockout	V_{S_OV}	—	6	—	V	
On Resistance	R_{ON_PSW}	—	55	—	mΩ	4.75V < V_S < 5.25V
V_S Leakage Current	I_{LEAK_VS}	—	2.2	—	µA	Sleep state into V_S pin
Back-Voltage Protection Threshold	V_{BV_TH}	—	150	—	mV	V_{BUS} > V_S, V_S > V_{S_UVLO}
Backdrive Current	I_{BD_1}	—	0	3	µA	V_{DD} < V_{DD_TH}, Any powered power pin to any unpowered power pin; current out of unpowered pin **(Note 3)**
	I_{BD_2}	—	0	2	µA	V_{DD} < V_{DD_TH}, Any powered power pin to any unpowered power pin, except for V_{DD} to V_{BUS} in Detect power state and V_S to V_{BUS} in Active power state; current out of unpowered pin **(Note 3)**

Note 1: For split supply systems using the Attach Detection feature, V_S must not exceed V_{DD} + 150 mV.

2: This parameter is ensured by design and not 100% tested.

3: This parameter is characterized, but not 100% production tested.

4: The current measurement full-scale range maximum value is 3.0A. However, the UCS1003-1 cannot report values above I_{LIM} (if $I_{BUS\_R2MIN} \leq I_{LIM}$) or above I_{BUS_R2MIN} (if $I_{BUS\_R2MIN} > I_{LIM}$ and $I_{LIM} \leq$ 1.68A).

5: The Min and Max values represent the boundaries of a programmable range for UCS1003-1 only. Each value in the range is typical.

TABLE 1-2: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise specified, V_{DD} = 4.5V to 5.5V, V_S = 2.9V to 5.5V, V_{PULLUP} = 3V to 5.5V, T_A = -40°C to +85°C; all Typical values at V_{DD} = V_S = 5V, T_A = +27°C.

Characteristic	Sym.	Min.	Typ.	Max.	Unit	Conditions
Selectable Current Limits	I_{LIM1}	—	570	—	mA	I_{LIM} Resistor = 0 or 47 kΩ **(UCS1003-1 only)**
						I_{LIM} Resistor = 47 kΩ **(UCS1003-2/3)** (minimum mA setting)
	I_{LIM2}	—	1000	—		I_{LIM} Resistor = 10 kΩ or 56 kΩ **(UCS1003-1 only)**
						I_{LIM} Resistor = 56 kΩ **(UCS1003-2/3)**
	I_{LIM3}	—	1130	—		I_{LIM} Resistor = 12 kΩ or 68 kΩ **(UCS1003-1 only)**
						I_{LIM} Resistor = 68 kΩ **(UCS1003-2/3)**
	I_{LIM4}	—	1350	—		I_{LIM} Resistor = 15 kΩ or 82 kΩ **(UCS1003-1 only)**
						I_{LIM} Resistor = 82 kΩ **(UCS1003-2/3)**
	I_{LIM5}	—	1680	—		I_{LIM} Resistor = 18 kΩ or 100 kΩ **(UCS1003-1 only)**
						I_{LIM} Resistor = 100 kΩ **(UCS1003-2/3)**
	I_{LIM6}	—	2050	—		I_{LIM} Resistor = 22 kΩ or 120 kΩ **(UCS1003-1 only)**
						I_{LIM} Resistor = 120 kΩ **(UCS1003-2/3)**
	I_{LIM7}	—	2280	—		I_{LIM} Resistor = 27 kΩ or 150 kΩ **(UCS1003-1 only)**
						I_{LIM} Resistor = 150 kΩ **(UCS1003-2/3)**
	I_{LIM8}	2700	2850	3000		I_{LIM} Resistor = 33 kΩ or V_{DD} **(UCS1003-1 only)**
						I_{LIM} Resistor = V_{DD} **(UCS1003-2/3)**
Pin Wake Time	t_{PIN_WAKE}	—	3	—	ms	
SMBus Wake Time	t_{SMB_WAKE}	—	4	—	ms	**(UCS1003-1 only)**
Idle Sleep Time	t_{IDLE_SLEEP}	—	200	—	ms	**(UCS1003-1 only)**

Note 1: For split supply systems using the Attach Detection feature, V_S must not exceed V_{DD} + 150 mV.

2: This parameter is ensured by design and not 100% tested.

3: This parameter is characterized, but not 100% production tested.

4: The current measurement full-scale range maximum value is 3.0A. However, the UCS1003-1 cannot report values above I_{LIM} (if $I_{BUS\_R2MIN} \leq I_{LIM}$) or above I_{BUS_R2MIN} (if $I_{BUS\_R2MIN} > I_{LIM}$ and $I_{LIM} \leq 1.68A$).

5: The Min and Max values represent the boundaries of a programmable range for UCS1003-1 only. Each value in the range is typical.

TABLE 1-2: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise specified, V_{DD} = 4.5V to 5.5V, V_S = 2.9V to 5.5V, V_{PULLUP} = 3V to 5.5V, T_A = -40°C to +85°C; all Typical values at V_{DD} = V_S = 5V, T_A = +27°C.

Characteristic	Sym.	Min.	Typ.	Max.	Unit	Conditions
Thermal Regulation Limit	T_{REG}	—	110	—	°C	Die temperature at which current limit will be reduced
Thermal Regulation Hysteresis	T_{REG_HYST}	—	10	—	°C	Hysteresis for t_{REG} functionality; temperature must drop by this value before I_{LIM} value is restored to normal operation
Thermal Shutdown Threshold	T_{TSD}	—	135	—	°C	Die temperature at which port power switch will turn off
Thermal Shutdown Hysteresis	T_{TSD_HYST}	—	35	—	°C	After shutdown, due to T_{TSD} being reached, die temperature drop required before port power switch can be turned on again
Auto-Recovery Test Current	I_{TEST}	—	190	—	mA	Portable device attached, V_{BUS} = 0V, Die Temp < T_{TSD}
Auto-Recovery Test Voltage	V_{TEST}	—	750	—	mV	Portable device attached, V_{BUS} = 0V before application, Die Temp < T_{TSD} programmable **(UCS1003-1 only)**, 250-1000 mV, default listed
Discharge Impedance	$R_{DISCHARGE}$	—	100	—	Ω	
Port Power Switch – AC Parameters						
Turn-On Delay	t_{ON_PSW}	—	0.75	—	ms	PWR_EN active toggle to switch on time, V_{BUS} discharge is not active
Turn-Off Time	$t_{OFF\_PSW\_INA}$	—	0.75	—	ms	PWR_EN inactive toggle to switch off time, C_{BUS} = 120 µF
Turn-Off Time	$t_{OFF\_PSW\_ERR}$	—	1	—	ms	Overcurrent error, V_{BUS} min error or discharge error to switch off, C_{BUS} = 120 µF
Turn-Off Time	$t_{OFF\_PSW\_ERR}$	—	100	—	ns	TSD or backdrive error to switch off, C_{BUS} = 120 µF
V_{BUS} Output Rise Time	t_{R_BUS}	—	1.1	—	ms	Measured from 10% to 90% of V_{BUS}, C_{LOAD} = 220 µF, I_{LIM} = 1.0A
Soft Turn-on Rate	$\Delta I_{BUS}/\Delta_t$	—	100	—	mA/µs	
Temperature Update Time	t_{DC_TEMP}	—	200	—	ms	Programmable **(UCS1003-1 only)** 200-1600 ms, default listed

Note 1: For split supply systems using the Attach Detection feature, V_S must not exceed V_{DD} + 150 mV.

2: This parameter is ensured by design and not 100% tested.

3: This parameter is characterized, but not 100% production tested.

4: The current measurement full-scale range maximum value is 3.0A. However, the UCS1003-1 cannot report values above I_{LIM} (if $I_{BUS\_R2MIN} \leq I_{LIM}$) or above I_{BUS_R2MIN} (if $I_{BUS\_R2MIN} > I_{LIM}$ and $I_{LIM} \leq 1.68A$).

5: The Min and Max values represent the boundaries of a programmable range for UCS1003-1 only. Each value in the range is typical.

TABLE 1-2: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise specified, V_{DD} = 4.5V to 5.5V, V_S = 2.9V to 5.5V, V_{PULLUP} = 3V to 5.5V, T_A = -40°C to +85°C; all Typical values at V_{DD} = V_S = 5V, T_A = +27°C.

Characteristic	Sym.	Min.	Typ.	Max.	Unit	Conditions
Short-Circuit Response Time	t_{SHORT_LIM}	—	1.5	—	µs	Time from detection of short to current limit applied; no C_{BUS} applied
Short-Circuit Detection Time	t_{SHORT}	—	6	—	ms	Time from detection of short to port power switch disconnect and ALERT# pin assertion
Latched Mode Cycle Time	t_{UL}	—	7	—	ms	From PWR_EN edge transition from inactive to active to begin error recovery
Auto-Recovery Mode Cycle Time	t_{CYCLE}	—	25	—	ms	Time delay before error condition check, programmable **(UCS1003-1 only)** 10-25 ms, default listed
Auto-Recovery Delay	t_{RST}	—	20	—	ms	Portable device attached, V_{BUS} must be ≥ V_{TEST} after this time, programmable **(UCS1003-1 only)** 10-25 ms, default listed
Discharge Time	$t_{DISCHARGE}$	—	200	—	ms	Amount of time discharge resistor applied, programmable **(UCS1003-1 only)** 100-400 ms, default listed
Port Power Switch Operation with Trip Mode Current Limiting						
Region 2 Current Keep-out	I_{BUS_R2MIN}	—	0.12	—	A	
Minimum V_{BUS} Allowed at Output	V_{BUS_MIN}	1.5	2.0	2.25	V	
Port Power Switch Operation with Constant-Current Limiting (Variable Slope)						
Region 2 Current Keep-out	I_{BUS_R2MIN}	—	1.68	—	A	
Minimum V_{BUS} Allowed at Output	V_{BUS_MIN}	1.5	2.0	2.25	V	
Current Measurement (UCS1003-1 only) – DC						
Current Measurement Range	I_{BUS_M}	0	—	2988.6	mA	Range 0-255 LSB **(Note 4)**
Reported Current Measurement Resolution	D_{IBUS_M}	—	11.72	—	mA	1 LSB
Current Measurement Accuracy		—	±2	—	%	180 mA < I_{BUS} < I_{LIM}
		—	±2	—	LSB	I_{BUS} < 180 mA
Current Measurement (UCS1003-1 only) – AC						
Sampling Rate		—	500	—	µs	

Note 1: For split supply systems using the Attach Detection feature, V_S must not exceed V_{DD} + 150 mV.

2: This parameter is ensured by design and not 100% tested.

3: This parameter is characterized, but not 100% production tested.

4: The current measurement full-scale range maximum value is 3.0A. However, the UCS1003-1 cannot report values above I_{LIM} (if $I_{BUS\_R2MIN} \leq I_{LIM}$) or above I_{BUS_R2MIN} (if $I_{BUS\_R2MIN} > I_{LIM}$ and $I_{LIM} \leq$ 1.68A).

5: The Min and Max values represent the boundaries of a programmable range for UCS1003-1 only. Each value in the range is typical.

TABLE 1-2: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise specified, V_{DD} = 4.5V to 5.5V, V_S = 2.9V to 5.5V, V_{PULLUP} = 3V to 5.5V, T_A = -40°C to +85°C; all Typical values at V_{DD} = V_S = 5V, T_A = +27°C.

Characteristic	Sym.	Min.	Typ.	Max.	Unit	Conditions
Charge Rationing (UCS1003-1 only) - DC						
Accumulated Current Measurement Accuracy		—	±4.5	—	%	
Charge Rationing (UCS1003-1 only) – AC						
Current Measurement Update Time	t_{PCYCLE}	—	1	—	s	
Attach/Removal Detection						
V_{BUS} Bypass – DC						
On Resistance	R_{ON_BYP}	—	50	—	Ω	
Leakage Current	I_{LEAK_BYP}	—	—	3	µA	Switch off (**Note 2**)
Current Limit	I_{DET_CHG} / I_{BUS_BYP}	—	2	—	mA	V_{DD} = 5V and V_{BUS} > 4.75V
Attach/Removal Detection – DC						
Attach Detection Threshold	I_{DET_QUAL}	—	800	—	µA	Programmable **(UCS1003-1 only)** 200-1000 µA, default listed
Primary Removal Detection Threshold	$I_{REM\_QUAL\_ACT}$	—	700	—	µA	Programmable **(UCS1003-1 only)** 100-900 µA, default listed, Active power state
	$I_{REM\_QUAL\_DET}$	—	800	—	µA	Programmable **(UCS1003-1 only)** 200-1000 µA, default listed, Detect power state (see **Section 8.4 "Removal Detection"**)
Attach/Removal Detection – AC						
Attach Detection Time	t_{DET_QUAL}	—	100	—	ms	Time from attach to A_DET# assert **(UCS1003-1 and UCS1003-3 only)**
Removal Detection Time	t_{REM_QUAL}	—	1000	—	ms	
Allowed Charge Time	t_{DET_CHARGE}	—	800	—	ms	C_{BUS} = 500 µF maximum, programmable 200-2000 ms, default listed
Charger Emulation Profile						
General Emulation – DC						
Charging Current Threshold	I_{BUS_CHG}	—	46.9	—	mA	Default value for **UCS1003-1**
		—	175.8	—	mA	**UCS1003-2** and **UCS1003-3**

Note 1: For split supply systems using the Attach Detection feature, V_S must not exceed V_{DD} + 150 mV.

2: This parameter is ensured by design and not 100% tested.

3: This parameter is characterized, but not 100% production tested.

4: The current measurement full-scale range maximum value is 3.0A. However, the UCS1003-1 cannot report values above I_{LIM} (if $I_{BUS\_R2MIN} \leq I_{LIM}$) or above I_{BUS_R2MIN} (if $I_{BUS\_R2MIN} > I_{LIM}$ and $I_{LIM} \leq 1.68A$).

5: The Min and Max values represent the boundaries of a programmable range for UCS1003-1 only. Each value in the range is typical.

TABLE 1-2: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise specified, V_{DD} = 4.5V to 5.5V, V_S = 2.9V to 5.5V, V_{PULLUP} = 3V to 5.5V, T_A = -40°C to +85°C; all Typical values at V_{DD} = V_S = 5V, T_A = +27°C.

Characteristic	Sym.	Min.	Typ.	Max.	Unit	Conditions
Charging Current Threshold Range	$I_{BUS\_CHG\_RNG}$	11.72	—	175.8	mA	**(Note 5)**
DP-DM Shunt Resistor Value	R_{DCP_RES}	—	—	200	Ω	Connected between D_{POUT} and D_{MOUT}, $0V < D_{POUT} = D_{MOUT} < 3V$
Response Magnitude (voltage divider option resistance range)	SX_RXMAG_ DVDR	93	—	200	kΩ	**(Note 5)**
Resistor Ratio Range (voltage divider option)	SX_RATIO	0.25	—	0.66	V/V	**(Note 5)**
Resistor Ratio Accuracy (voltage divider option)	SX_RATIO_ ACC	—	±0.5	—	%	Average over range
Response Magnitude (resistor option range)	SX_RXMAG_ RES	1.8	—	150	kΩ	**(Note 5)**
Internal Resistor Tolerance (resistor option)	SX_RXMAG_ RES_ACC	—	±10	—	%	Average over range
Response Magnitude (voltage option range)	SX_RXMAG_ VOLT	0.4	—	2.2	V	**(Note 5)**
Voltage Option Accuracy	SX_RXMAG_ VOLT_ACC	—	±1	—	%	No load, average over range
Voltage Option Accuracy	SX_RXMAG_ VOLT_ACC_ 150	—	-6	—	%	150 µA load, average over range
Voltage Option Accuracy	SX_RXMAG_ VOLT_ACC_ 250	—	-10	—	%	250 µA load, average over range
Voltage Option Output	SX_RXMAG_ VOLT_BC	0.5	—	—	V	D_{MOUT} = 0.6V, 250 µA load **(Note 3)**
Response Magnitude (zero volt option range)	SX_PUPD	10	—	150	µA	SX_RXMAG_VOLT = 0 **(Note 5)**
Pull-Down Current Accuracy	SX_PUPD _ ACC_3p6	—	±5	—	%	D_{POUT} or D_{MOUT} = 3.6V, compliance voltage
Pull-Down Current	SX_PUPD _ ACC_BC	50	—	—	µA	Setting = 100 µA, D_{POUT} or D_{MOUT} = 0.15V compliance voltage **(Note 3)**
Stimulus Voltage Threshold Range	SX_TH	0.3	—	2.2	V	**(Note 5)**
Stimulus Voltage Accuracy	SX_TH_ ACC	—	±2	—	%	Average over range
Stimulus Voltage Accuracy	SX_TH_ACC_ BC	0.25	—	—	V	At SX_TH = 0.3V **(Note 3)**

Note 1: For split supply systems using the Attach Detection feature, V_S must not exceed V_{DD} + 150 mV.

2: This parameter is ensured by design and not 100% tested.

3: This parameter is characterized, but not 100% production tested.

4: The current measurement full-scale range maximum value is 3.0A. However, the UCS1003-1 cannot report values above I_{LIM} (if $I_{BUS\_R2MIN} \leq I_{LIM}$) or above I_{BUS_R2MIN} (if $I_{BUS\_R2MIN} > I_{LIM}$ and $I_{LIM} \leq 1.68A$).

5: The Min and Max values represent the boundaries of a programmable range for UCS1003-1 only. Each value in the range is typical.

TABLE 1-2: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise specified, V_{DD} = 4.5V to 5.5V, V_S = 2.9V to 5.5V, V_{PULLUP} = 3V to 5.5V, T_A = -40°C to +85°C; all Typical values at V_{DD} = V_S = 5V, T_A = +27°C.						
Characteristic	**Sym.**	**Min.**	**Typ.**	**Max.**	**Unit**	**Conditions**
General Emulation – AC						
Emulation Reset Time	t_{EM_RESET}	—	50	—	ms	Default
Emulation Reset Time Range	$t_{EM\_RESET\_RNG}$	50	—	175	ms	**(Note 5)**
Emulation Time-out Range	$t_{EM\_TIMEOUT}$	0.8	—	12.8	s	**(Note 5)**
Stimulus Delay, SX_TD Range	t_{STIM_DEL}	0	—	100	ms	**(Note 5)**
Emulation Delay	t_{RES_EM}	—	—	0.5	s	Time from set impedance to impedance appearing on D_P/D_M **(Note 3)**

Note 1: For split supply systems using the Attach Detection feature, V_S must not exceed V_{DD} + 150 mV.

2: This parameter is ensured by design and not 100% tested.

3: This parameter is characterized, but not 100% production tested.

4: The current measurement full-scale range maximum value is 3.0A. However, the UCS1003-1 cannot report values above I_{LIM} (if $I_{BUS\_R2MIN} \leq I_{LIM}$) or above I_{BUS_R2MIN} (if $I_{BUS\_R2MIN} > I_{LIM}$ and $I_{LIM} \leq 1.68A$).

5: The Min and Max values represent the boundaries of a programmable range for UCS1003-1 only. Each value in the range is typical.

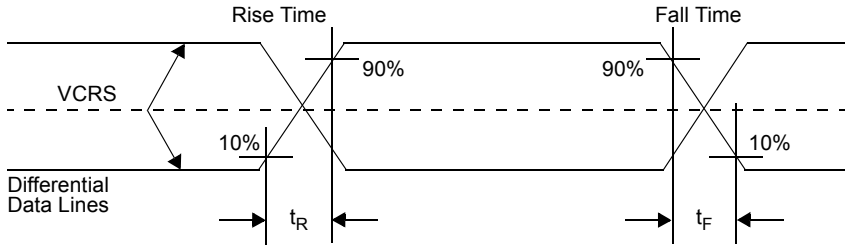


FIGURE 1-1: *USB Rise Time/Fall Time Measurement.*

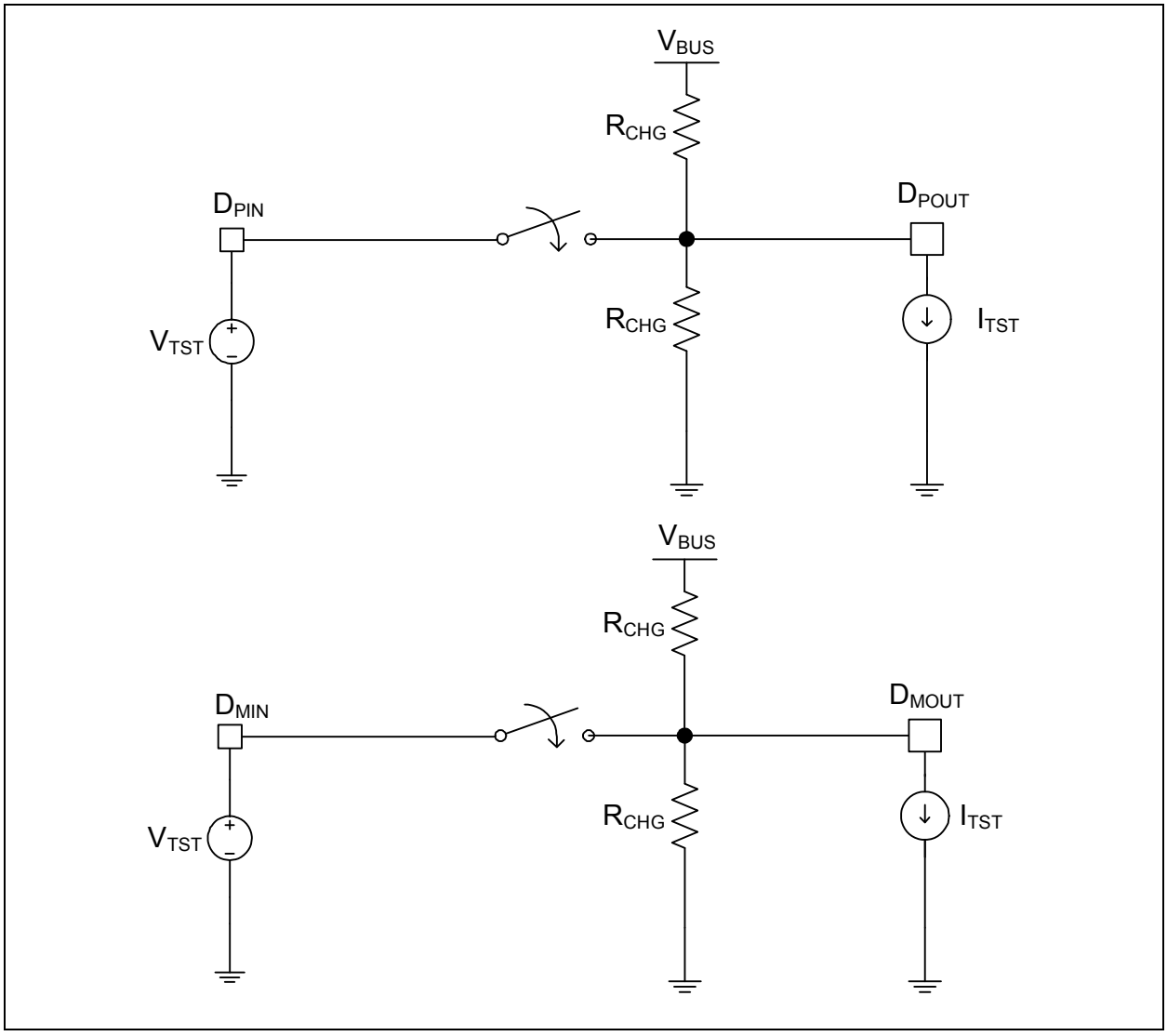


FIGURE 1-2: *Description of DC Terms.*

TABLE 1-3: TEMPERATURE SPECIFICATIONS

Parameters	Sym	Min	Typ	Max	Units	Conditions
Temperature Ranges						
Operating Temperature Range	T_A	-40	—	+85	°C	
Storage Temperature Range	T_A	-55	—	+150	°C	
Thermal Package Resistances (see Table 1-1)						

NOTES:

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

Note: Unless otherwise indicated, $V_{DD} = V_S = 5V$, $T_A = +27°C$.

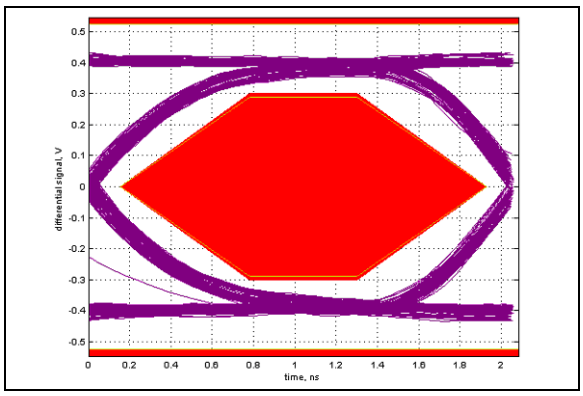


FIGURE 2-1: *USB-IF High-Speed Eye Diagram (Without Data Switch).*

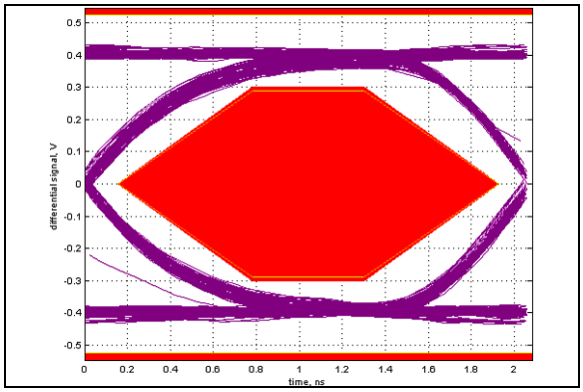


FIGURE 2-2: *USB-IF High-Speed Eye Diagram (With Data Switch).*

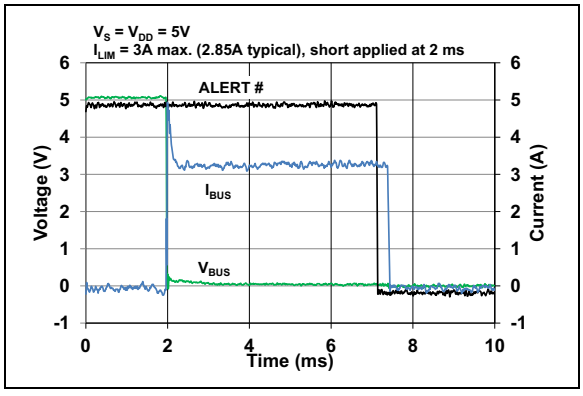


FIGURE 2-3: *Short Applied After Power-up.*

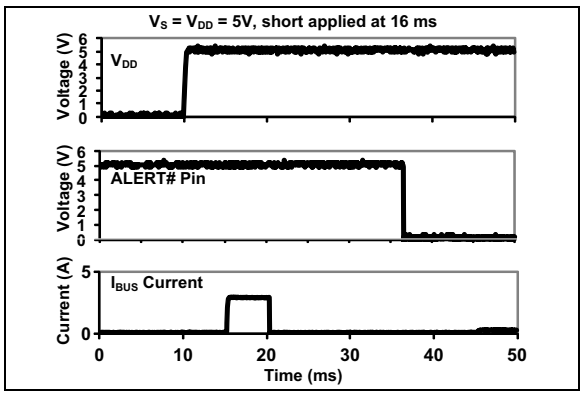


FIGURE 2-4: *Power-up Into a Short.*

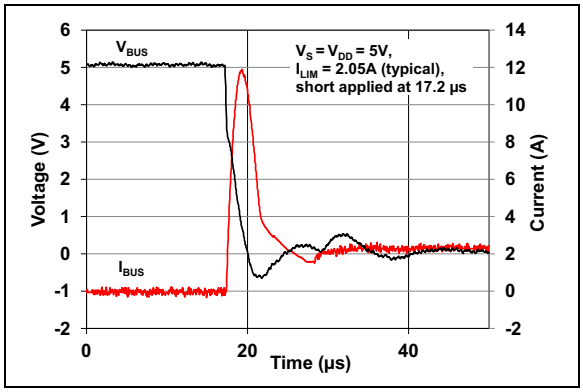


FIGURE 2-5: *Internal Power Switch Short Response.*

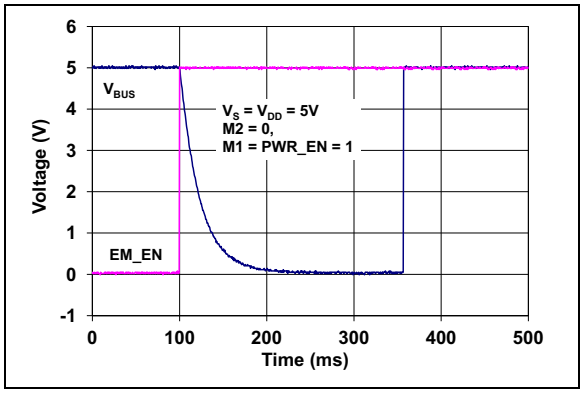


FIGURE 2-6: *V_{BUS} Discharge Behavior.*

Note: Unless otherwise indicated, $V_{DD} = V_S = 5V$, $T_A = +27°C$.

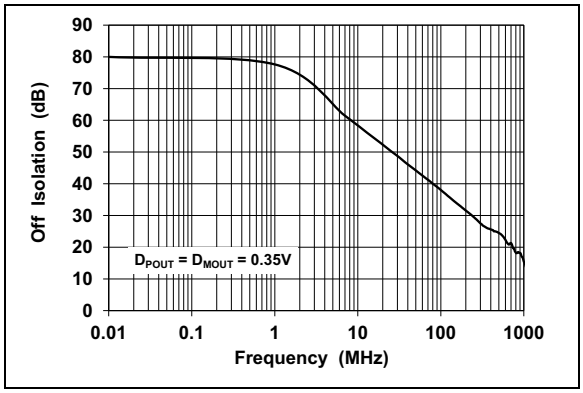


FIGURE 2-7: *Data Switch Off Isolation vs. Frequency.*

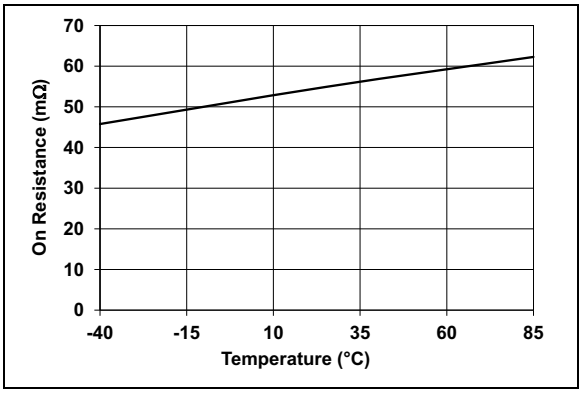


FIGURE 2-10: *Power Switch On Resistance vs. Temperature.*

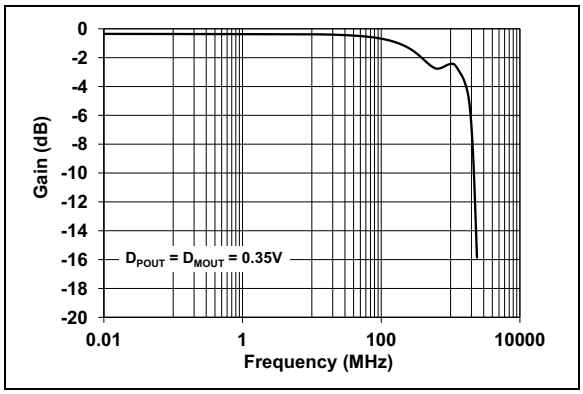


FIGURE 2-8: *Data Switch Bandwidth vs. Frequency.*

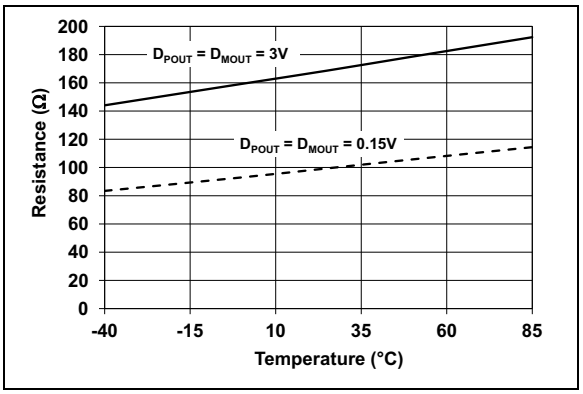


FIGURE 2-11: *R_{DCP_RES} Resistance vs. Temperature.*

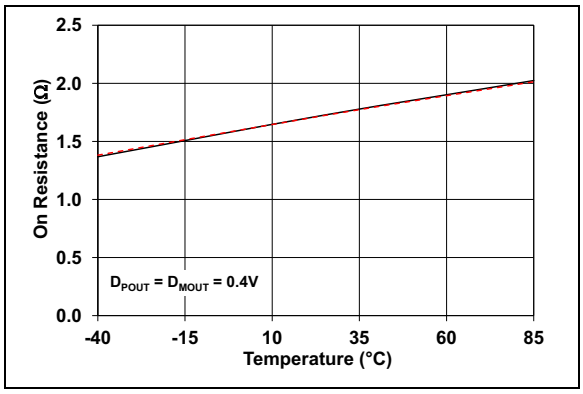


FIGURE 2-9: *Data Switch On Resistance vs. Temperature.*

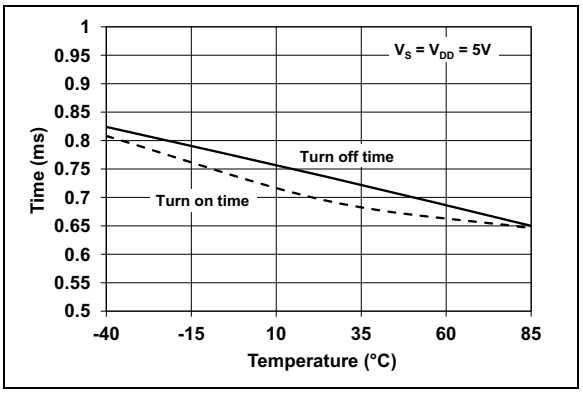


FIGURE 2-12: *Power Switch On/Off Time vs. Temperature.*

Note: Unless otherwise indicated, $V_{DD} = V_S = 5V$, $T_A = +27°C$.

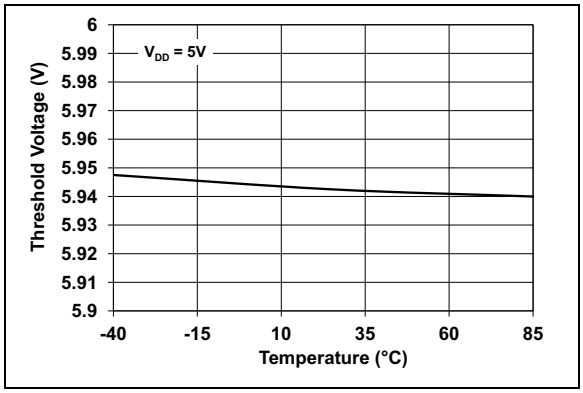


FIGURE 2-13: *V_S Overvoltage Threshold vs. Temperature.*

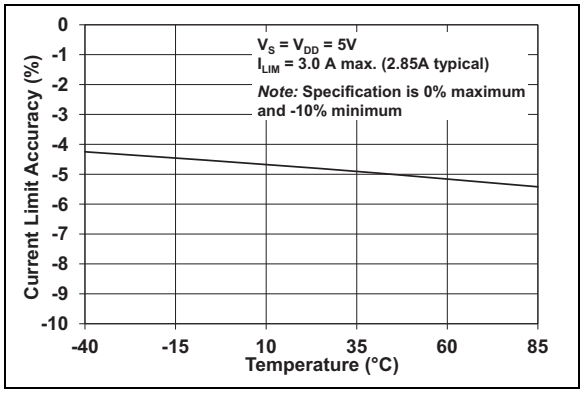


FIGURE 2-16: *Trip Current Limit Operation vs. Temperature.*

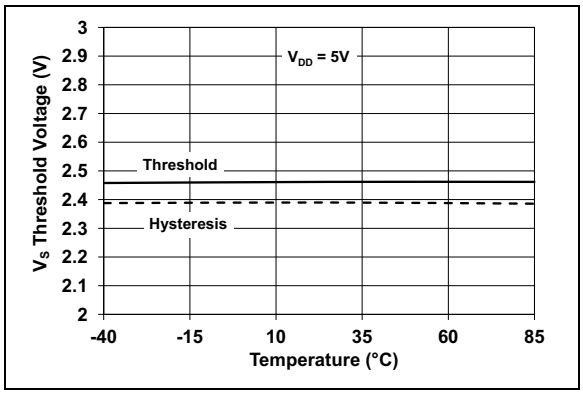


FIGURE 2-14: *V_S Undervoltage Threshold vs. Temperature.*

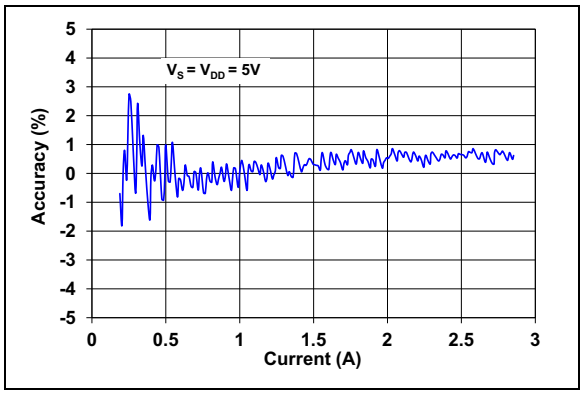


FIGURE 2-17: *I_{BUS} Measurement Accuracy.*

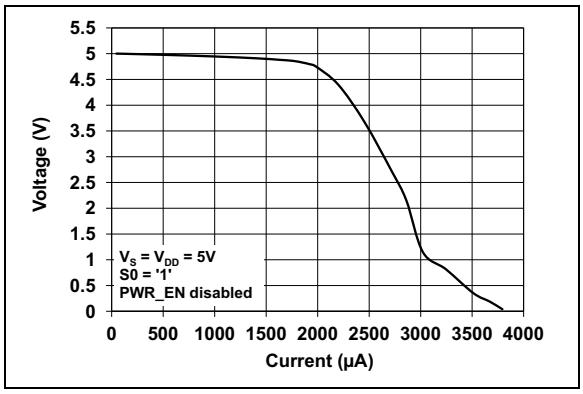


FIGURE 2-15: *Detect State V_{BUS} vs. I_{BUS}.*

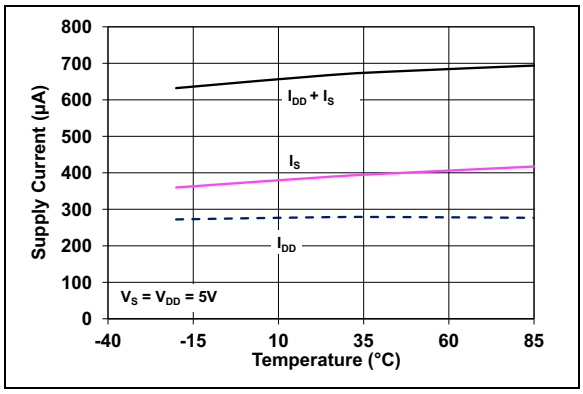


FIGURE 2-18: *Active State Current vs. Temperature.*

Note: Unless otherwise indicated, $V_{DD} = V_S = 5V$, $T_A = +27°C$.

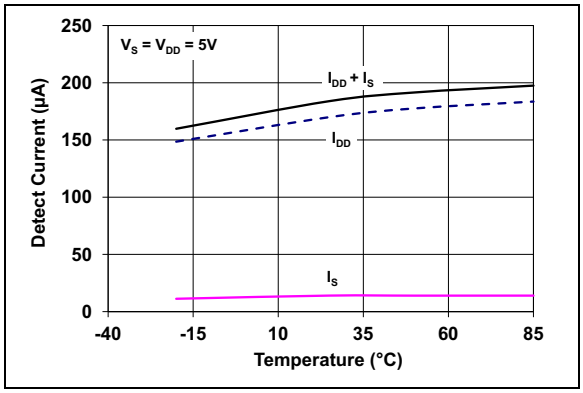


FIGURE 2-19: *Detect State Current vs. Temperature.*

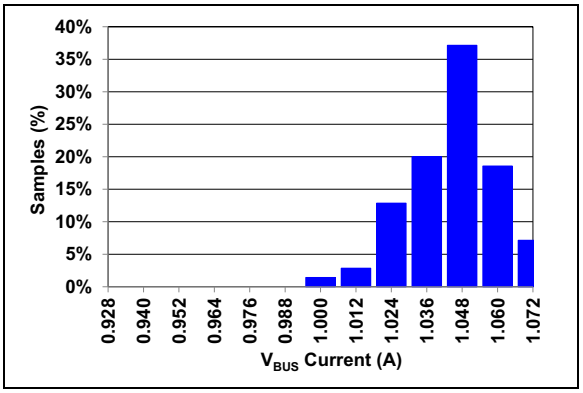


FIGURE 2-22: *I_{LIM2} Trip Current Distribution.*

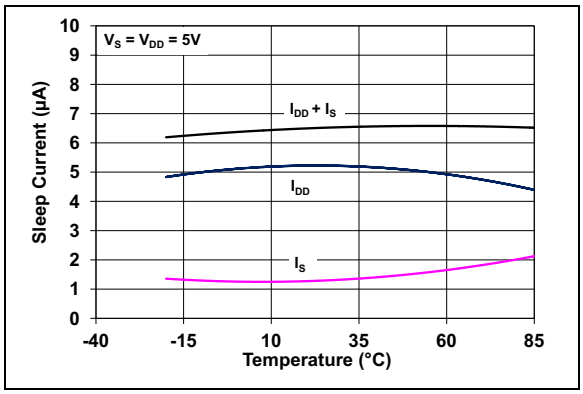


FIGURE 2-20: *Sleep State Current vs. Temperature.*

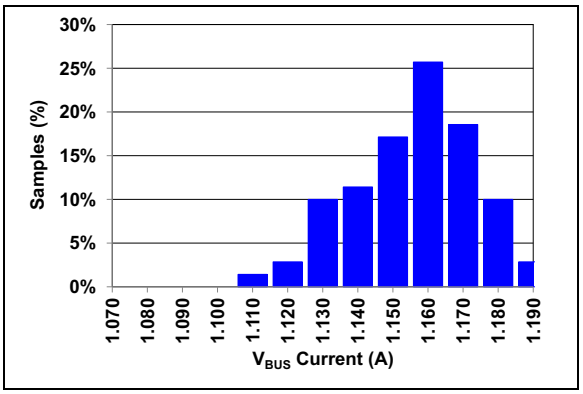


FIGURE 2-23: *I_{LIM3} Trip Current Distribution.*

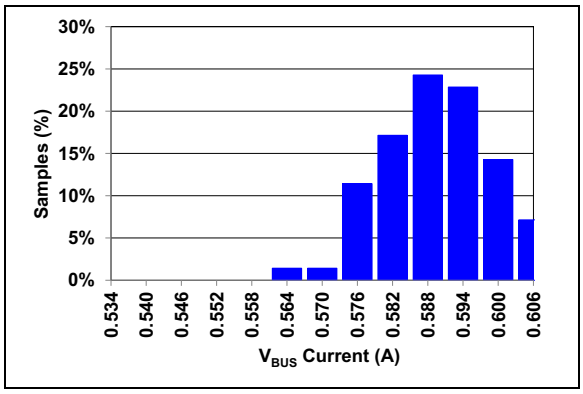


FIGURE 2-21: *I_{LIM1} Trip Current Distribution.*

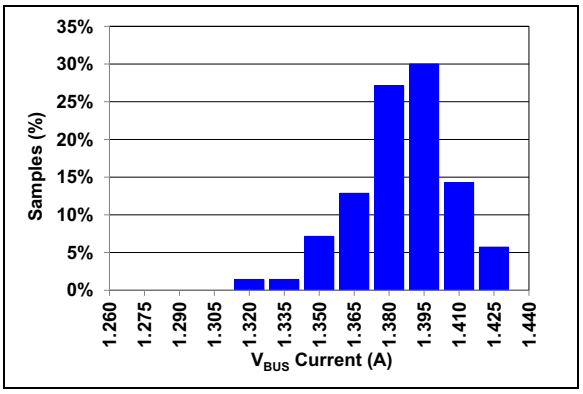


FIGURE 2-24: *I_{LIM4} Trip Current Distribution.*

Note: Unless otherwise indicated, $V_{DD} = V_S = 5V$, $T_A = +27°C$.

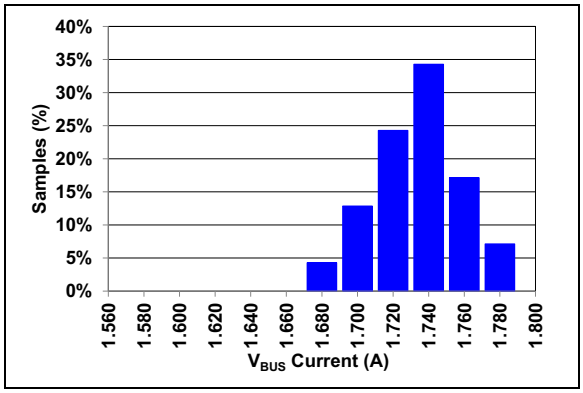


FIGURE 2-25: *I_{LIM5} Trip Current Distribution.*

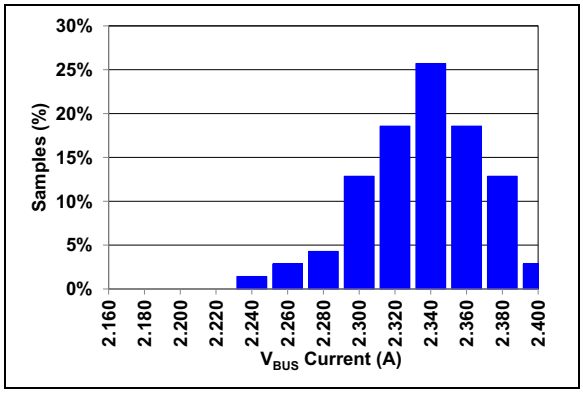


FIGURE 2-27: *I_{LIM7} Trip Current Distribution.*

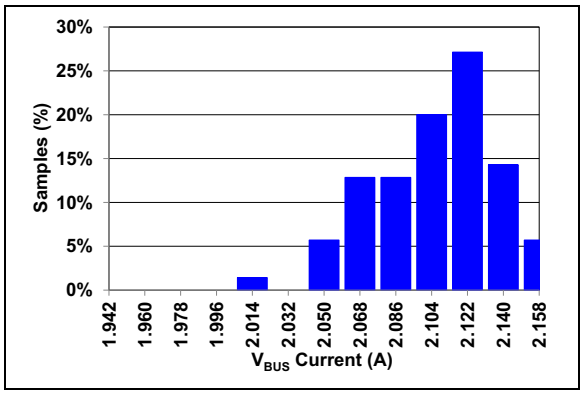


FIGURE 2-26: *I_{LIM6} Trip Current Distribution.*

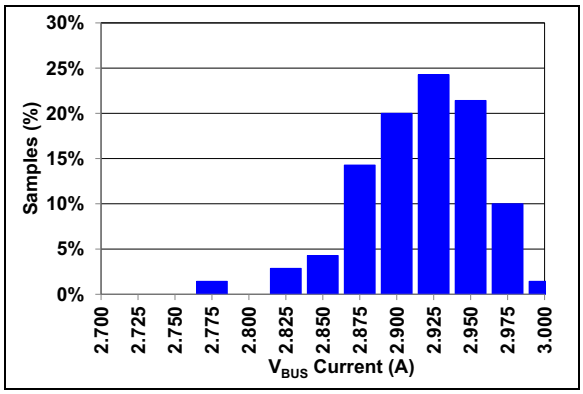


FIGURE 2-28: *I_{LIM8} Trip Current Distribution.*

NOTES:

3.0 PIN DESCRIPTION

Descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

UCS1003-1/2/3 4x4 QFN	Symbol	Function	Pin Type	Connection Type if Pin Not Used
1	M1	Active Mode Selector Input #1.	DI	Connect to ground or V_{DD} **(Note 3)**
2	M2	Active Mode Selector Input #2.	DI	Connect to ground or V_{DD} **(Note 3)**
3	V_{BUS1}	Voltage output from power switch. These pins are internally connected and must be tied together.	Hi-Power **(Note 1)**	Leave open
4	V_{BUS2}			
5	COMM_SEL/I_{LIM}	COMM_SEL (**UCS1003-1 only**) – Selects SMBus or Stand-Alone mode of operation (see Table 11-1).	AIO	n/a
		I_{LIM} – Selects the hardware current limit at power-up.		
6	SEL	Selects polarity of PWR_EN control, and in the UCS1003-1, the SMBus address (see Table 11-2).	AIO	n/a
7	V_{S1}	Voltage input to power switch. These pins are internally connected and must be tied together.	Hi-Power	Connect to ground
8	V_{S2}			
9	V_{DD}	Main power supply input for chip functionality.	Power	n/a
10	PWR_EN	Port power switch enable input. Polarity determined by SEL pin.	DI	Connect to ground or V_{DD} **(Note 3)**
11	SMDATA/LATCH	**SMDATA** (**UCS1003-1 only**) – SMBus data input/output (requires pull-up resistor).	DIOD	n/a
		LATCH – In Stand-Alone mode, latch/auto-recovery Fault handling mechanism selection input (see **Section 7.5 "Fault Handling Mechanism"**).	DI	
12	SMCLK/S0	**SMCLK** (**UCS1003-1 only**) – SMBus clock input (requires pull-up resistor).	DI	n/a
		S0 – In Stand-Alone mode, enables Attach/Removal Detection feature (see **Section 5.3.6 "S0 Input"**).		

Note 1: Total leakage current from Pins 3 and 4 (V_{BUS}) to ground must be less than 100 µA for proper Attach/Removal Detection operation.

2: It is recommended to use 2 MΩ pull-down resistors on the D_{POUT} and/or D_{MOUT} pin if a portable device stimulus is expected when using the customer charger emulation profile with the high-speed data switch open. The 2 MΩ value is based on BC1.1 impedance characteristics for Dedicated Charging Ports.

3: To ensure operation, the PWR_EN pin must be enabled, as determined by the SEL pin decode, when it is not driven by an external device. Furthermore, one of the M1, M2 or EM_EN pins must be connected to V_{DD} if all three are not driven from an external device. If the PWR_EN pin is disabled, or all of the M1, M2 and EM_EN pins are connected to ground, the UCS1003-1 will remain in the Sleep or Detect state unless activated via the SMBus (UCS1003-2 and UCS1003-3 will remain in Sleep or Detect state indefinitely).

TABLE 3-1: PIN FUNCTION TABLE (CONTINUED)

UCS1003-1/2/3 4x4 QFN	Symbol	Function	Pin Type	Connection Type if Pin Not Used
13	ALERT#	Active-low error event output flag (requires pull-up resistor).	OD	Connect to ground
14	D_{PIN}	USB data input (plus).	AIO	Connect to ground or ground through a resistor
15	D_{MIN}	USB data input (minus).	AIO	Connect to ground or ground through a resistor
16	D_{MOUT}	USB data output (minus).	AIO **(Note 2)**	Connect to ground
17	D_{POUT}	USB data output (plus).	AIO **(Note 2)**	Connect to ground
18	A_DET# (**UCS1003-1** and **UCS1003-3**)	Active-low device Attach Detection output flag (requires pull-up resistor).	OD	Connect to ground
	CHRG# (**UCS1003-2**)	Active-low “Charging Active” output flag (requires pull-up resistor).	OD	Connect to ground
19	EM_EN	Active mode selector input.	DI	Connect to ground or V_{DD} **(Note 3)**
20	GND	Ground.	Power	n/a
21	EP	Exposed thermal pad. Must be connected to electrical ground.	EP	n/a

Note 1: Total leakage current from Pins 3 and 4 (V_{BUS}) to ground must be less than 100 µA for proper Attach/Removal Detection operation.

2: It is recommended to use 2 MΩ pull-down resistors on the D_{POUT} and/or D_{MOUT} pin if a portable device stimulus is expected when using the customer charger emulation profile with the high-speed data switch open. The 2 MΩ value is based on BC1.1 impedance characteristics for Dedicated Charging Ports.

3: To ensure operation, the PWR_EN pin must be enabled, as determined by the SEL pin decode, when it is not driven by an external device. Furthermore, one of the M1, M2 or EM_EN pins must be connected to V_{DD} if all three are not driven from an external device. If the PWR_EN pin is disabled, or all of the M1, M2 and EM_EN pins are connected to ground, the UCS1003-1 will remain in the Sleep or Detect state unless activated via the SMBus (UCS1003-2 and UCS1003-3 will remain in Sleep or Detect state indefinitely).

TABLE 3-2: PIN TYPES DESCRIPTION

Pin Type	Description
Power	This pin is used to supply power or ground to the device.
Hi-Power	This pin is a high-current pin.
AIO	Analog Input/Output – This pin is used as an I/O for analog signals.
DI	Digital Input – This pin is used as a digital input. This pin will be glitch-free.
DIOD	Open-Drain Digital Input/Output – This pin is bidirectional. It is open-drain and requires a pull-up resistor. This pin will be glitch-free.
OD	Open-Drain Digital Output – Used as a digital output. It is open-drain and requires a pull-up resistor. This pin will be glitch-free.
EP	Exposed Thermal Pad.