USB 2.0 Port Protection with Charger Detection

Features

- USB-device charger detector
- Can tolerate USB3.0-PD with VBUS = 20V
- USB Charging-type detection
- Battery Charging 1.2 (BC1.2) – DCP
- Battery Charging 1.2 (BC1.2) – CDP
- Battery Charging 1.2 (BC1.2) – SDP
- Apple 1A, 2A & 2.4A dedicated chargers
- Samsung-Fast chargers
- YD/T-1951 dedicated chargers
- CEA-936 Carkit#1 and #2 chargers
- Integrated Power FET
- VBUS Tolerance up to 28V
- 1.7A Over-Current Protection (OCP)
- VBUS Over-Voltage Protection (OVP)
- Non-charging Accessory Detection
- USB On-The-Go (OTG) detection
- Mobile HDMI Link (MHL) device detection
- Wide Supply Voltage Range 3V to 5.5V
- I^2C Programmability
- Small Package:
  - CSP 1.5x2.0-15L
  - UQFN 3x4x0.5mm 20L

Applications

- Personal Media Players
- Mobile Phones
- Tablet

Description

PI3USB9281C provides external detection for any USB-device. The part can detect various chargers available in the market, MHL accessories, OTG accessories, and car-chargers per the CEA936 spec. It also integrates a power switch with over-voltage and over-current protections. The VBUSIN input pin can tolerate voltages up to 28V, which is important for USB3.0-PowerDelivery enabled ports. The new USB-3.0-PowerDelivery specification supports voltages up to 20V.

The PI3USB9281C can operate over a temperature range of -40 to +85 ℃.

Typical applications involve portable & consumer applications, such as tablet, smart phones, digital cameras, and notebooks with integrated Li-ion batteries that charge via USB connectors.

Block Diagram

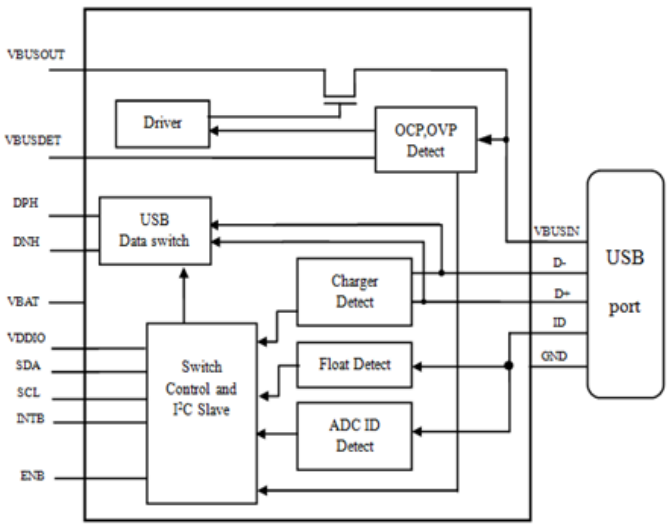


Figure 1. PI3USB9281C Block diagram

Pin Configuration

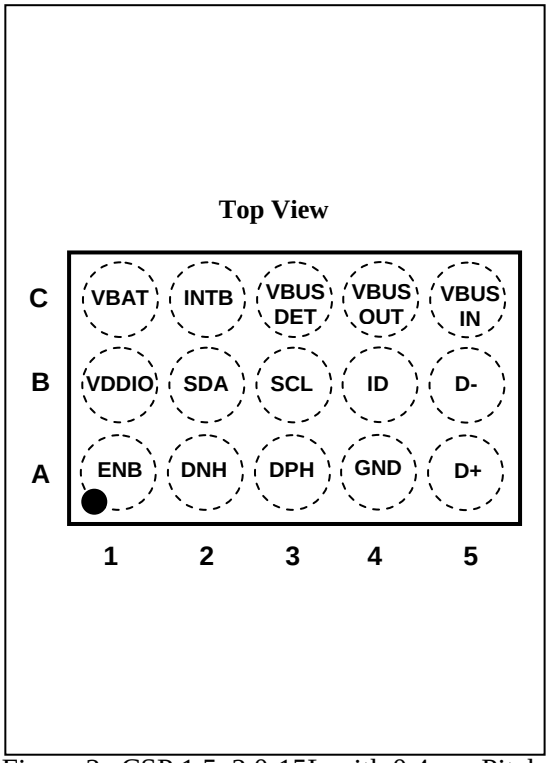


Figure 2a CSP 1.5x2.0-15L with 0.4mm Pitch

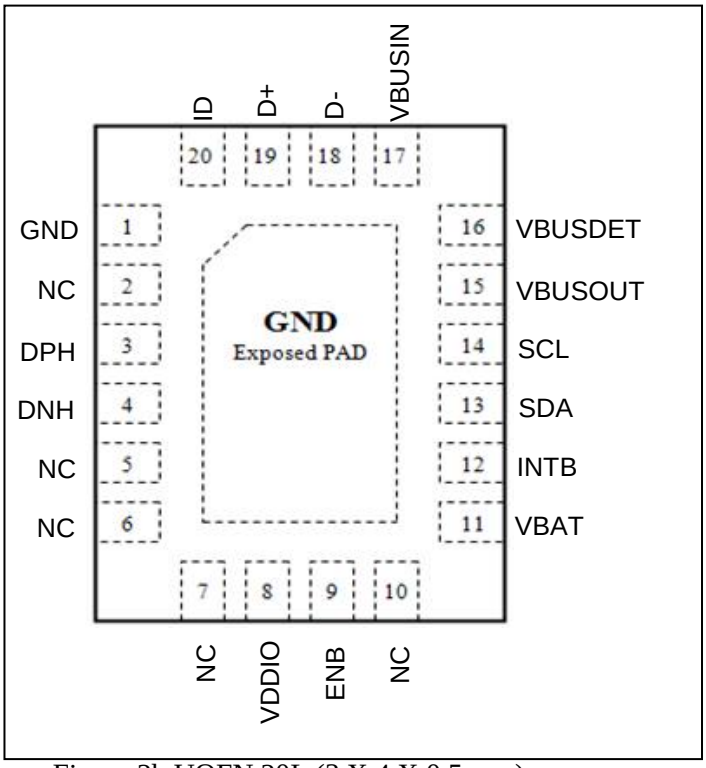


Figure 2b UQFN 20L (3 X 4 X 0.5 mm)

Pin Descriptions

Name	Type	Default State	Description
USB Interface			
DPH	Signal Path	Open	D+ signal switch path, dedicated USB port to be connected to the resident USB transceiver on the device
DNH	Signal Path	Open	D- signal switch path, dedicated USB port to be connected to the resident USB transceiver on the device
Connector Interface			
ID	Signal Path	Open	Connected to the USB connector ID pin and used for detecting accessories
D+	Signal Path	Open	Connected to the USB connector D+ pin; depending on the signaling mode
D-	Signal Path	Open	Connected to the USB connector D- pin; depending on the signaling mode
V_{BUSIN}	Power Path	NA	Input voltage supply pin to be connected to the VBUS pin of the USB connector
Power Interface			
V_{BAT}	Power	NA	Input voltage supply pin to be connected to the device battery output or to an internal regulator
V_{DDIO}	Power	NA	Baseband processor interface I/O supply pin
ENB	Input	Hi-Z	System enable for the circuit (Active Low)
GND	Power	NA	Ground
Charger Interface			
V_{BUSOUT}	Power Path	NA	Output voltage supply pin to be connected to the source voltage pin on the charger IC
V_{BUSDET}	Open-Drain Output	Hi-Z	Open-drain active LOW output when VBUSIN is valid
I^2C Interface			
SCL	Input	Hi-Z	I^2C serial clock signal to be connected to the phone-based I^2C master
SDA	Open-Drain I/O	Hi-Z	I^2C serial data signal to be connected to the phone-based I^2C master
INTB	CMOS Output	LOW	Interrupt active LOW output used to prompt the phone baseband processor to read the I^2C register bits, indicates a change in ID pin status or accessory attach status
NC		Hi-Z	No Connection

Maximum Ratings

Storage Temperature ..... -65°C to +150°C
Supply Voltage from Battery/Baseband (VBAT/VDDIO) ..... -0.5V to +6.5V
Supply Voltage from Micro-USB Connector (VBUSIN) ..... -0.5V to +28.0V
Switch I/O Voltage USB ..... -1.0V to +5.5V
Input Clamp Diode current 50mA
Charger Detect Pin Sink current (VBUSDET) 30mA
Switch I/O Current (Continuous) USB 50mA
Switch I/O Switch Peak Current (Pulsed at 1ms Duration, <10% Duty Cycle)
USB, and All Other Channels 150mA
Charger FET 2A
ESD: HBM 3500V
HBM (USB connector pins: VBUSIN, D+, D-, ID to GND) 6500V

Note:
Stresses greater than 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 these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Recommended operation conditions

Symbol	Parameter		Min.	Max.	Units
V_{BAT}	Battery Supply Voltage		3.0	5.5	V
V_{BAT_TH}	Battery Supply Voltage Threshold		-	3.0	V
V_{BUSIN}	V_{BUSIN} Pin Supply Voltage		4.0	5.5	V
V_{DDIO}	Processor Supply Voltage		1.8	5.5	V
V_{SW}	Switch I/O Voltage	USB Path Active	0	3.6	V
C_{ID}	Capacitive Load on ID Pin for Reliable Accessory Detection		0	1.0	nF
T_A	Operating Temperature		-40	85	℃

Switch Path DC Electrical Characteristics

Min and Max apply for T_A between -40 ℃ to 85 ℃ and T_J up to +125 ℃ (unless otherwise noted). Typical values are referenced to T_A=+25 ℃

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Units
USB Data Switches (D+, D-)						
R_{ONUSB}	USB Switch On-Resistance	I_{LOAD} = 8mA, $V_{D+/D-}$= 0V, 0.4V	-	2.5	3.3	Ω
USB Analog Signal Voltage Range		V_{BAT}=3.0 to 4.4V	0	-	3.6	V
Charging FET Switch						
V_{BUS_th}	VBUSIN Detection Threshold Voltage, VBAT=3.6V, ENB=0V		3.1	3.5	3.7	V
V_{BUS_hys}	VBUSIN Detection Hysteresis Voltage, VBAT=3.6V, ENB=0V			100		mV
V_{OVP}	Over-Voltage Protection (OVP) Threshold Voltage		6.2	6.8	7.2	V
R_{ONCHG}	Charging FET On-Resistance	V_{BUSIN}=4.2V-5.0V, I_{LOAD}=1A, CSP 15L	-	100	150	mΩ
		V_{BUSIN}=4.2V-5.0V, I_{LOAD}=1A, QFN 20L	-	150	200	mΩ
I_{OCP}	Over-Current Protection (OCP) Threshold Current(2)	V_{BUSIN}=5V	1.4	1.7	2.0	A
Host Interface Pins (INTB, VBUSDET)						
V_{OH}	Output High Voltage	I_{OH}=2mA, V_{BAT}=3.0 to 4.4V	0.7× V_{DDIO}	-	-	V
V_{OL}	Output Low Voltage	I_{OL}=10mA, V_{BAT}=3.0 to 4.4V	-	-	0.4	V
Current Consumption						
I_{CC}	Battery Supply Current	No Accessory Static Current, V_{BAT}=3.6V,V_{BUSIN}=0V	-	20	30	µA
		With Accessory Static Current, V_{BAT}=3.6V,V_{BUSIN}=0V	-	50	80	µA
		With Accessory Static Current, V_{BAT}=3.6V,V_{BUSIN}=5V	-	-	1	µA
$I_{STANDBY}$	Battery Supply Standby Current	V_{BAT}=3.6V,V_{BUSIN}=0V,ENB=3.6V	-	-	1	µA
I_{OFF}	Power-Off Leakage Current	V_{BAT}=0V, V_{SW}=0 to 4.4V	-	-	10	µA
$I_{ON(OFF)}$	Off Leakage Current	V_{BAT}=3.0 to 4.4V, I/O pins=0.3V, 4.1V	-0.1	0.001	0.1	µA
$I_{IDSHORT}$	Short-Circuit Current(2)	V_{BAT}=3.0 to 4.4V, ID=0V	-	5	-	mA

Note:

1. On-resistance is the voltage drop between the two terminals at the indicated current through the switch.
2. Limits based on electrical characterization data.

Capacitance (T_A = -40 ℃ to 85 ℃)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Units
C_{ONUSB}	D+, D- On Capacitance (USB Mode)	V_{BAT}=3.8V , f=1MHz	-	4.0	-	pF

Switch AC Electrical Characteristics

Min and Max apply for T_A between -40 ℃ to 85 ℃ and TJ up to +125 ℃ (unless otherwise noted). Typical values are referenced to T_A=+25 ℃, V_{BAT}=3.8V.

Symbol	Parameter		Test Conditions	Min.	Typ.	Max.	Units
BW_{USB}	-3dB Bandwidth of USB channel			-	1300	-	MHz
O_{IRR}	OFF-Isolation	USB Mode	f=1MHz, R_S=50Ω, C_L=0	-	-70	-	dB
X_{TALK}	Active Channel Crosstalk D+ to D-	USB Mode	f=1MHz, R_S=50Ω, C_L=0	-	-70	-	dB
			f=240MHz, R_S=50Ω, C_L=0	-	-30	-	
$t_{SK(P)}$	Skew of Opposite Transitions of the Same Output (USB Mode)		tr=tf=750ps (10-90%) at 240MHz, C_L=0pF, R_L=50Ω	-	30	-	ps
t_{I2CRST}	Time When I^2C_SDA and I^2C_SCL Both LOW to Cause a Reset		-	15	-	-	ms
$t_{INTMASK}$	Time after INT Mask Cleared to "0" until INTB Goes LOW to Signal the Interrupt after Interruptible Event while INT Mask Bit Set to "1"		-	-	5	-	us
t_{SDPDET}	Time from V_{BUSIN} Valid to V_{BUSOUT} Valid with Charger FET Closed and USB Switches Closed for USB Standard Downstream Port		See Figure 6	-	200	-	ms
t_{CHGOUT}	Time from V_{BUSIN} Valid to V_{BUSOUT} Valid with Charger FET Closed for USB Charging Ports(CDP and DCP)		See Figure 4 and Figure 5	-	200	-	ms
t_{CARKIT}	Time from V_{BUSIN} Valid to Car Kit Type 1 or Type 2 Charger Detected		See Figure 8	-	130	-	ms
t_{IDDET}	Time from ID Not Floating to INTB LOW to Signal Accessory Attached that is ID Resistance-Based Only (V_{BUSIN} Not Valid)		See Figure 9	-	100	-	ms

I^2C Controller DC Electrical Characteristics

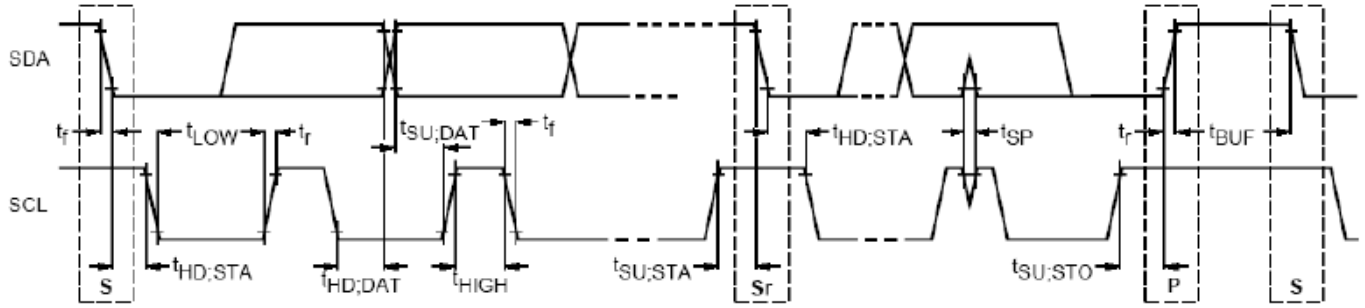
Symbol	Parameter		Fast Mode (400kHz)		Units
			Min.	Max.	
V_{IL}	Low-Level Input Voltage		-0.5	$0.3V_{DDIO}$	V
V_{IH}	High-Level Input Voltage		$0.7V_{DDIO}$	-	V
V_{HYS}	Hysteresis of Schmitt Trigger Inputs	V_{DDIO}>2V	$0.05V_{DDIO}$	-	V
		V_{DDIO}<2V	$0.1V_{DDIO}$	-	
V_{OL1}	Low-Level Output Voltage at 3mA Sink Current (Open-Drain)	V_{DDIO}>2V	0	0.4	V
		V_{DDIO}<2V	-	$0.2V_{DDIO}$	
I_{I2C}	Input Current of I^2C SDA and SCL Pins, Input Voltage 0.26V to2.34V		-10	10	μA
C_I	Capacitance for Each I/O Pin		-	10	pF

I^2C AC Electrical Characteristics

Symbol	Parameter	Fast Mode (400kHz)		Units
		Min.	Max.	
f_{SCL}	SCL Clock Frequency	0	400	kHz
t_{HDSTA}	Hold Time (Repeated) START Condition	0.6	-	μs
t_{LOW}	LOW Period of SCL Clock	1.3	-	μs
t_{HIGH}	HIGH Period of SCL Clock	0.6	-	μs
t_{SETSTA}	Set-up Time for Repeated START Condition	0.6	-	μs
t_{HDDAT}	Data Hold Time	0	0.9	μs
t_{SETDAT}	Data Set-up Time(1)	250	-	ns
t_r	Rise Time of SDA and SCL Signals(2)	-	300	ns
t_f	Fall Time of SDA and SCL Signals(2)	-	300	
t_{SETSTO}	Set-up Time for STOP Condition	0.6	-	μs
t_{BUF}	Bus-Free Time between STOP and START Conditions	1.3	-	μs
t_{SP}	Pulse Width of Spikes that Must Be Suppressed by the Input Filter	0	50	ns

Notes:

1. A fast-mode I²C-bus device can be used in a standard-mode I²C-bus system, but the requirement $t_{SETDAT} \geq 250ns$ must be met. This is automatically the case if the device does not stretch the LOW period of the SCL signal. If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line tr_max + t_{SETDAT} = 1000 + 250 = 1250ns (according to the standard-mode I²C bus specification) before the SCL line is released.
2. C_b equals the total capacitance of one BUS line in pF. If mixed with high-speed devices, faster fall times are allowed according to the I²C specification.



Definition of Timing for Full-Speed Mode Devices on the I²C Bus

Table 2. I²C Slave Address

Name	Size (Bits)	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Slave Address	8	0	1	0	0	1	0	1	R / $\overline{W}$

Table 3 Register Map

Address	Register	Type	Reset Value	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
01H	Device ID	Read	00000000	Version ID : 00011					Vendor ID(Pericom): 000		
02H	Control	Read/ Write	00011111	Reserved: -Read xxx -Write 000			Switch Open 0: Open all switches 1: Switch based on detection	Reserved: -Read 1 -Write 1	Manual Switch 0: Manual configuration 1: Automatic configuration	Reserved: -Read 1 -Write 1	Global Interrupt Mask 0: Does not Mask Interrupts 1: Mask Interrupts
03H	Interrupt	Read/ Clear	00000000	OVP&OCP Recovery 0: OVP and/or OCP event not recovered 1: OVP and/or OCP event recovered	OCP Event 0: No OCP event 1: OCP event	OVP Event 0: No OVP event 1: OVP event	Reserved -Read xxx, -Write 000 0: No Interrupt Reserved: -Read xxx, -Write 000			Detach 1: accessory detached	Attach 1: accessory attached
05H	Interrupt Mask	Read/ Write	00000000	OVP&OCP 0: No Interrupt Mask 1: Mask OVP&OCP Recovery interrupt	OCP 1: Mask OCP Event interrupt	OVP 1: Mask OVP Event interrupt	Reserved: -Read xxx, -Write 000 Reserved: -Read xxx, -Write 000			Detach 1: Mask Detach interrupt	Attach 1: Mask Attach interrupt

To be continued.

Register Map (Continuously.)

Address	Register	Type	Reset Value	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0AH	Device Type	Read	00000000	Reserved -Read x, -Write 0	USB Charging (DCP)	USB Charging (CDP)	Car Kit Charger	Reserved: -Read x, -Write 0	USB Data (SDP)	OTG	MHL
					0: No Detect						
					1: USB dedicated charging port (DCP) detected	1: USB charging downstream port (CDP) detected	1: USB Car Kit Charger detected	Reserved -Read x, -Write 0	1: USB standard downstream port (SDP) detected	1: USB OTG or Unidentified Devices detected	1: MHL detected
0BH	VBUS detect	Read/ Write	00000000	Reserved: -Read xxxxx, -Write 00000					0: VBUSIN detection enabled 1: VBUSIN detection disabled	Reserved-Read xx, -Write 00	
0EH	Charger Status	Read	00000000	Reserved: -Read xxx -Write 000			Apple Charger Type			Charger Type	
							0: No Detect			00: No connection	
							1: 2.4A Apple charger detected	1: 2A Apple charger detected	1: 1A Apple charger detected	01: Reserved Charger	
										10: Car Kit charger type1	
										11: Car Kit charger Type 2	
13H	Manual Switch	Read/ Write	00000000	D- Connection			D+ Connection			V_{BUS} Connection	
				000: Open D- switch 001: D- connected to DNH of USB port			000: Open D+ switch 001: D+ connected to DPH of USB port			00: Open VBUS switch 11: V_{BUSOUT} connected to V_{BUSIN}	
1BH[2]	Reset	Read/ Write	x0001000	Reserved: -Read xxxxxxx, -Write 0000000							**Reset** 0: No Reset 1: Reset (Always reads 0)
1DH	VBUS	Read	00000000	Reserved: -Read xxxxxx, -Write 000000						**V_{BUSIN}** Valid 0: V_{BUSIN} Not Valid 1: V_{BUSIN} Valid after 100ms	Reserved: -Read x, -Write 0

Note:

1. Register address 04H, 06H, 07H, 08H, 09H, 0BH, 0CH, 0DH, 0FH, 10H, 11H, 12H, 14H, 15H, 16H, 17H, 18H, 19H, 1AH, 1CH, 1EH, 1FH, 20H and 21H are reserved.
2. 1BH reset should not be applied during the cycle of the device detection. Normally, it would be applied at least 40ms after the device detection completed.

Functional Description

USB Port Accessory Detection List

Summarized below in Table 4 are the types of USB2.0 ports that PI3USB9281C can detect.

Table 4. ID and V_{BUSIN} Detection for USB Devices

V_{BUS}	D+	D-	USB switch	ID Resistance to GND (5)			Accessory Detected(1)
				Min.	Typ.	Max.	
x	x	x	Enable	GND	GND	GND	OTG
x	x	x	Disable	950Ω	1kΩ	1.05Ω	MHL
5V	x	x	Enable	190kΩ	200kΩ	210kΩ	Car Kit Type 1 Charger(2)
5V	x	x	Enable	419.9kΩ	442kΩ	464kΩ	Car Kit Type 2 Charger(2)
5V	2V	2.7V	Enable	3MΩ	Open	Open	1A Apple Charger
5V	2.7V	2V	Enable	3MΩ	Open	Open	2A Apple Charger
5V	2.7V	2.7V	Enable	3MΩ	Open	Open	2.4A Apple Charger
5V	(3)	(3)	Enable	3MΩ	Open	Open	USBBC1.2 DCP mode or Samsung FAST Charger (4)
5V	(3)	(3)	Enable	3MΩ	Open	Open	USB BC1.2 CDP Mode
5V	(3)	(3)	Enable	3MΩ	Open	Open	USB BC1.2 SDP Mode

Notes:

1. The accessory type is reported in the Device Type 1 (0Ah) and Charger Status (0Eh) registers with each valid accessory detection.
2. Follows the ANSI/CEA-936-A USB Car Kit specification.
3. The PI3USB9281C follows the Battery Charging 1.2 specification, which uses D+ and D- to determine what USB accessory is attached.
4. Samsung 1.2V fast charger will recognize as DCP attachment and enable the fast charging operation.
5. For devices with ID resistance other than those listed in Table 1, PI3USB9281C reports device attachment through I^2C to the embedded controller. The Unknown devices are mapped to OTG such that data switches are turned on to allow embedded controller to communicate and identify the unknown devices through USB protocols.

VBUSIN Detection Scheme

VBUSDET pin is used to indicate VBUSIN voltage level. The VBUSIN comparator stays awake in all cases including disable state (ENB=HIGH) and dead battery case (VBAT=0V). Tables below summarize the detection behavior for VBUSIN detection. All charger detections are disabled in disable state (ENB=HIGH). PI3USB9281C will undergo charger detection when the system is recovered from disable state (ENB = Transit from HIGH to LOW).

Table 5 VBUSDET outputs

VBUSIN Voltage level	VBUSDET
VBUSIN < 3.4V	High Impedance
VBUSIN ≧ 3.5V	Low

Table 6 Power supplies and control

Power supplies and control			Functionality		
VBUSIN	**VBAT Supply**	**ENB**	**VBUSDET**	**I^2C & Registers**	**BC1.2 Detection**
Low	Low	X(Don't care)	High Impedance	Reset	No charger plugin
High	Low	Low (Enabled)	Low with 30us wake up time	Normal operation	Charger detected
High	Low	High (Disabled)	Low with 30us wake up time	Reset	Detection disabled
High	High	Low (Enabled)	Low	Normal operation	Charger detected
High	High	High (Disabled)	Low	Reset	Detection disabled

Manual Mode Switch Control

In auto-mode, D+/D- data switches are turned on when there is VBUS. To manually control the on/off of D+/D- data switches, it can be controlled through setting register address: 0x13h to enter the manual switch mode. When manual mode is set, the switches are powered by VBAT when VBUS is absent. It helps ensure stable data connection during power role-swap.

USB Port Detection Flowchart

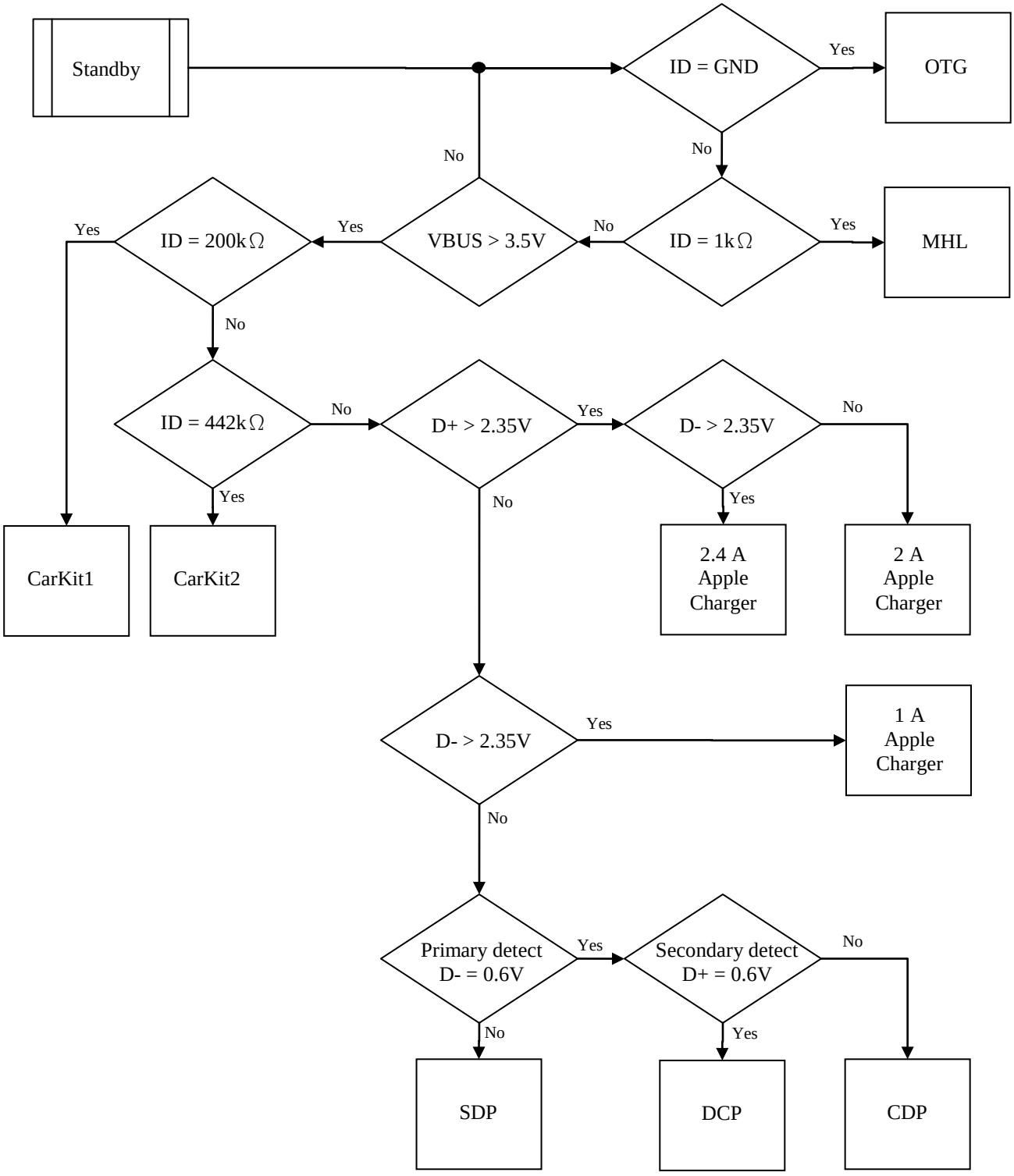


Figure 3. Accessory detection flowchart

USB Port Detection Timing

The following figures show the attach timing of the USB after insertion of accessories and the relationship between the INTB assertion and the VBUSDET assertion. PI3USB9281C has incorporated a V_{BUS} de-bounce circuit that waits a settle time of the USB cable.

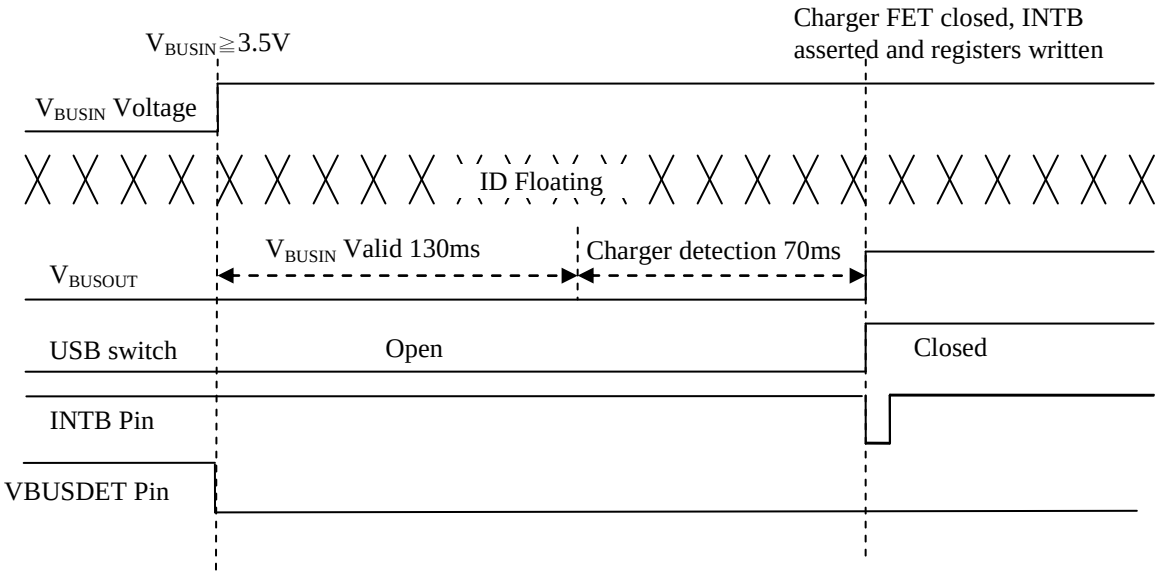


Figure 4. USB Charging Downstream Port (CDP) Attach Timing

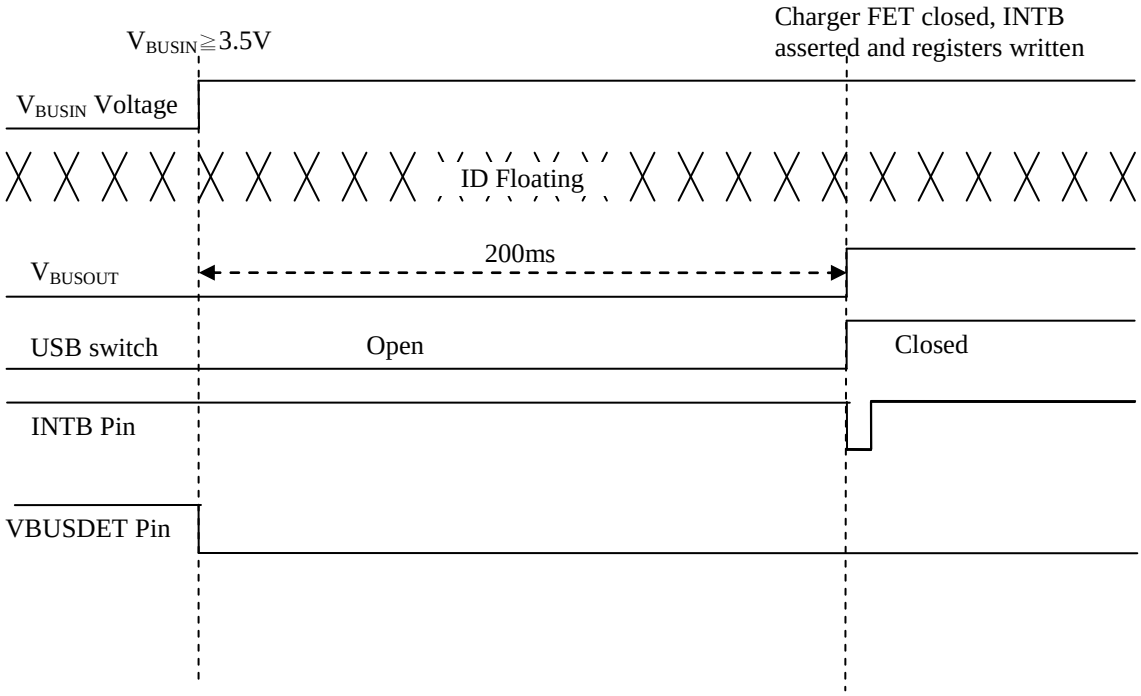


Figure 5. USB Dedicated Charging Port (DCP) Attach Timing

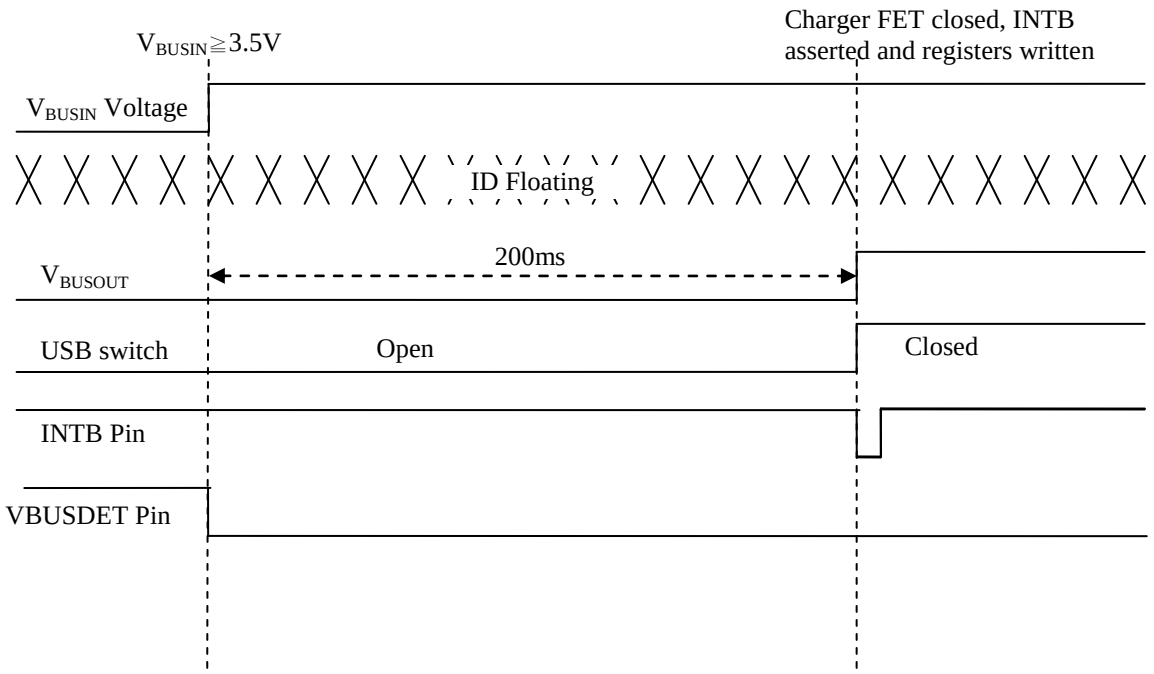


Figure 6. USB Standard Downstream Port (SDP) Attach Timing

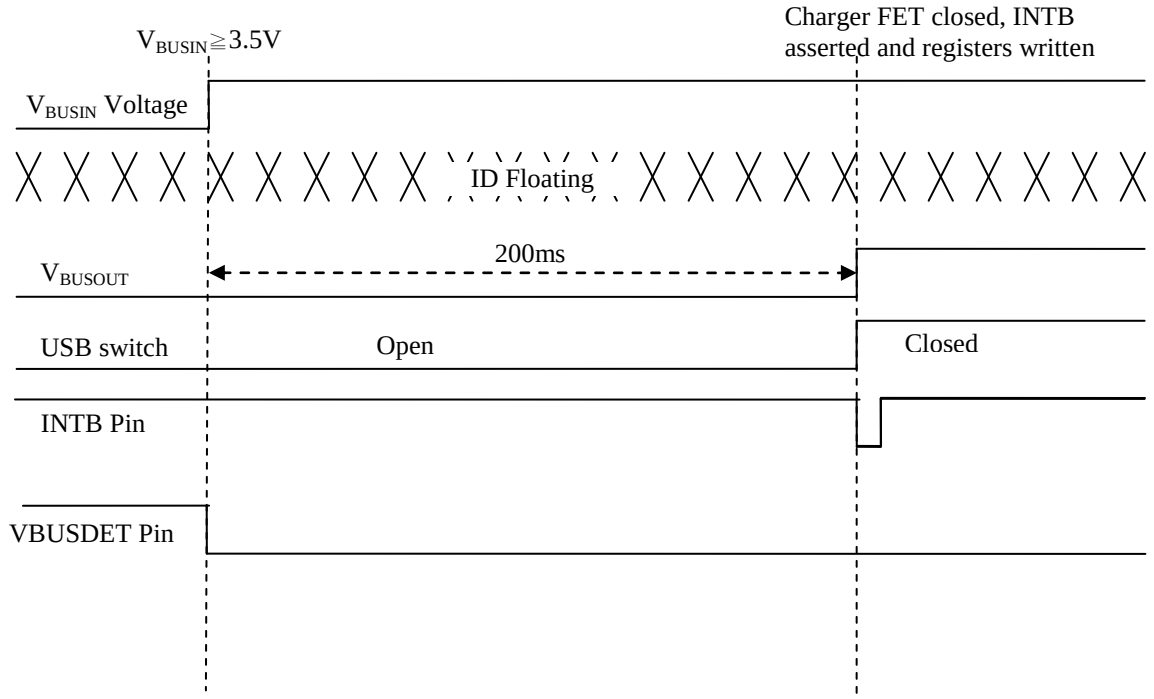


Figure 7. Apple Chargers (1A/2A/2.4A) Attach Timing

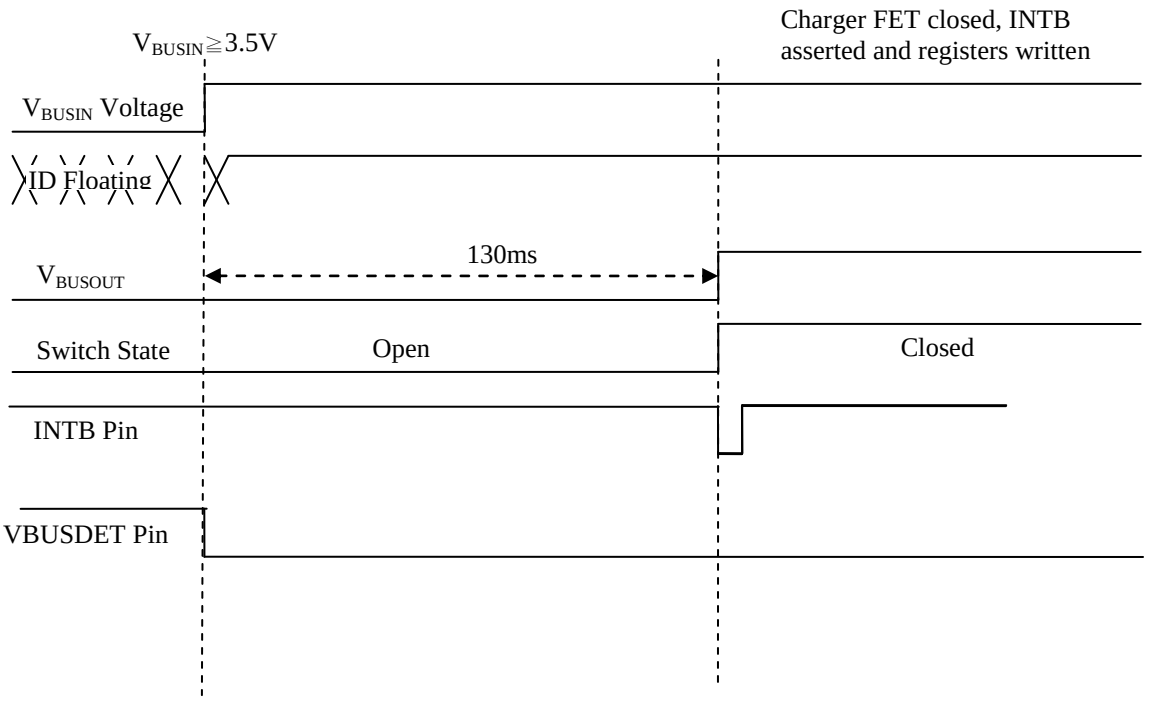


Figure 8. Car Kit Type 1 and 2 Timing

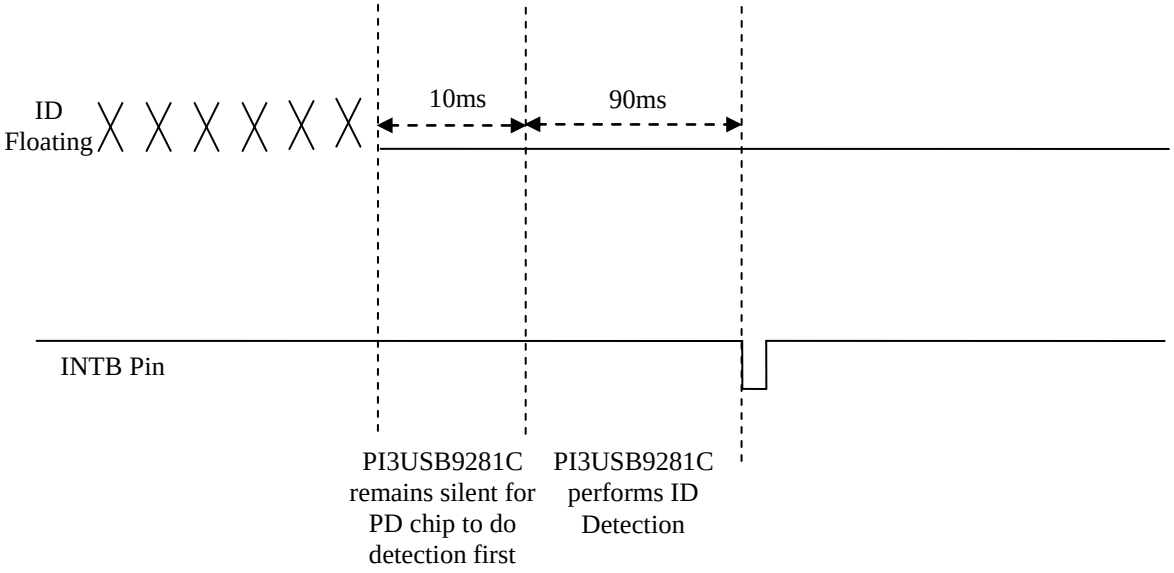
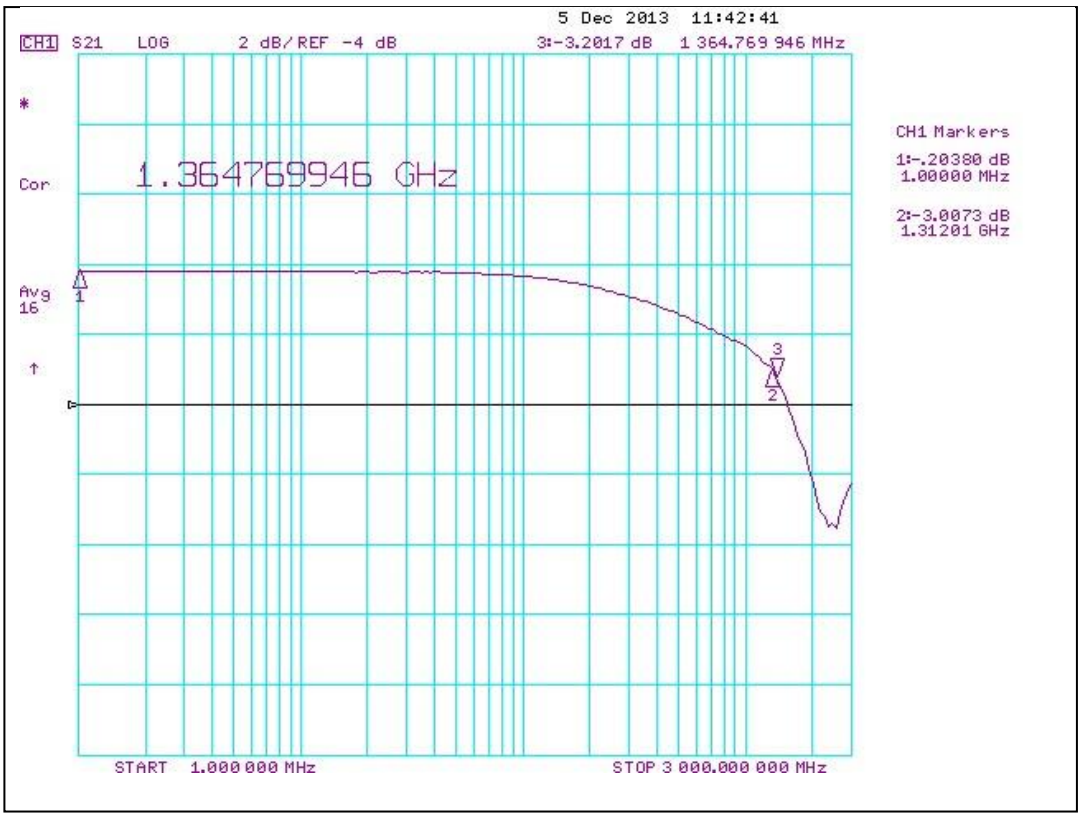


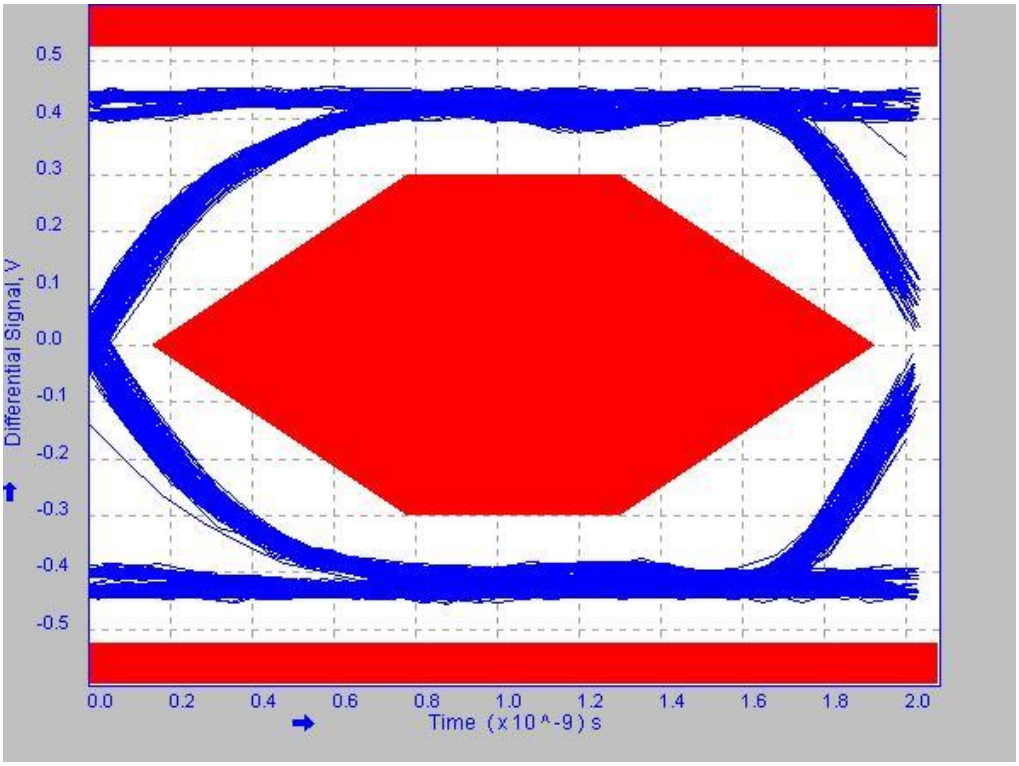
Figure 9. USB Power Delivery (PD) Cables and Other Accessories Detection Timing

TYPICAL CHARACTERISTICS

Frequency response curve for USB switch channel (D+ to DPH,3db BW=1.3G))

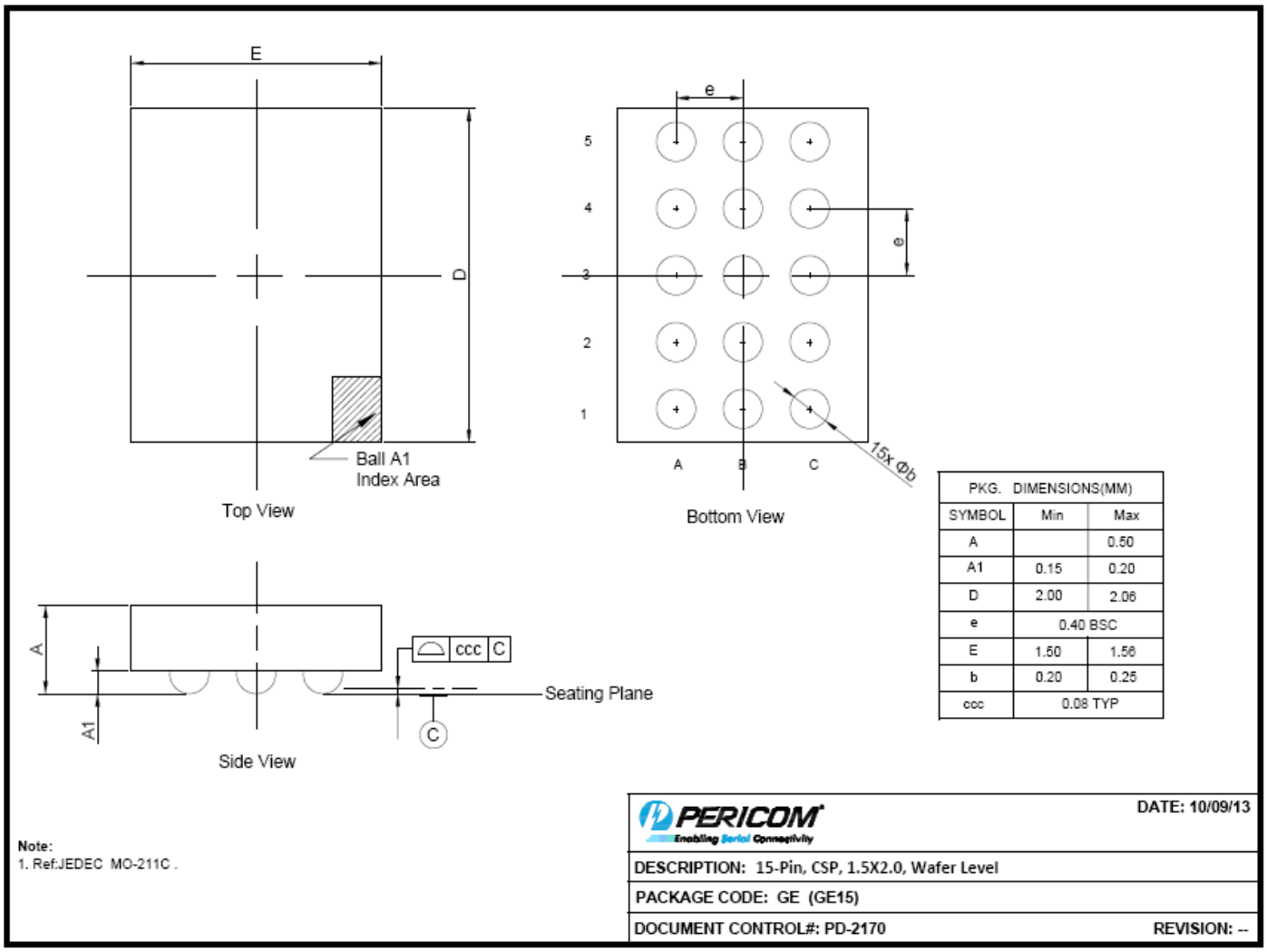


Eye diagram for USB 2.0 High Speed



Mechanical Information

CSP 1.5 x 2.0-15L



PKG. DIMENSIONS(MM)		
SYMBOL	Min	Max
A		0.60
A1	0.15	0.20
D	2.00	2.06
e	0.40 BSC	
E	1.50	1.56
b	0.20	0.25
ccc	0.08 TYP	

Note:
1. Ref:JEDEC MO-211C .

PERICOM Enabling Serial Connectivity

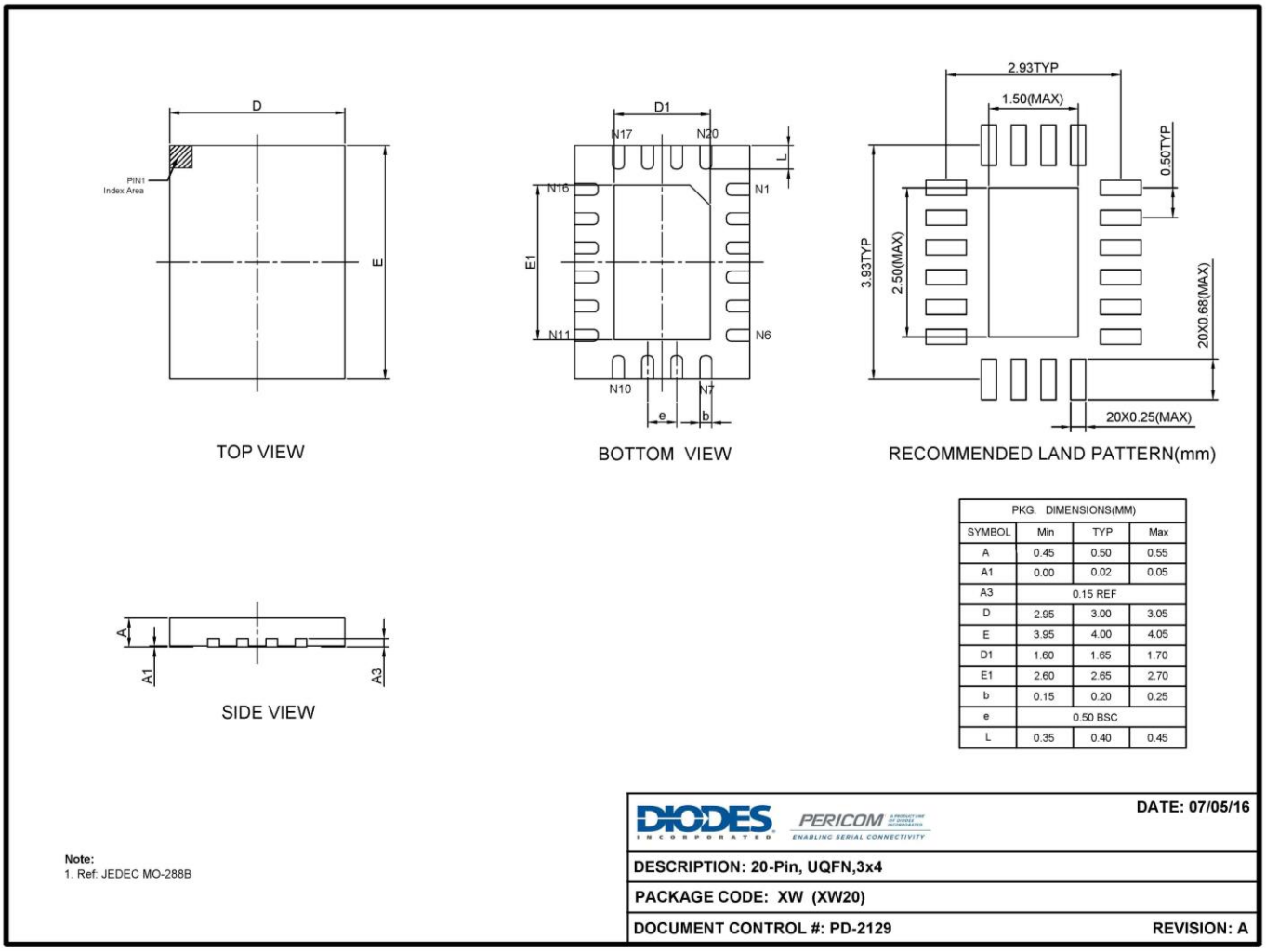
DATE: 10/09/13

DESCRIPTION: 15-Pin, CSP, 1.5X2.0, Wafer Level

PACKAGE CODE: GE (GE15)

DOCUMENT CONTROL#: PD-2170 REVISION: --

20-Lead UQFN (3×4×0.55mm)



Note: For latest package info, please check: http://www.pericom.com/support/packaging/packaging-mechanicals-and-thermal-characteristics/

Ordering Information

Part Numbers	Package Code	Package
PI3USB9281CGEE	GE	15-Pin, 1.5 x 2.0 (CSP)
PI3USB9281CGEEX	GE	15-Pin, 1.5 x 2.0 (CSP), Tape & Reel
PI3USB9281CXWE	XW	20-Pin, 3×4×0.5mm (UQFN)
PI3USB9281CXWEX	XW	20-Pin, 3×4×0.5mm (UQFN), Tape & Reel

Note:

- Thermal characteristics can be found on the company web site at www.pericom.com/packaging/
- E = Pb-free and Green
- Adding X Suffix= Tape/Reel