A Product Line of
Diodes Incorporated

PI5USB216EQ

USB 2.0 Signal Conditioner, BC 1.2 CDP

Description

The PI5USB216EQ is an USB2.0 Signal conditioner to boost the signals and insert pre-emphasis to compensate the ISI signal loss in the channels before and after the conditioner. Patent-pending Design to maintain stable common mode with symmetrical Boost/Pre-emphasis on D+/D-.

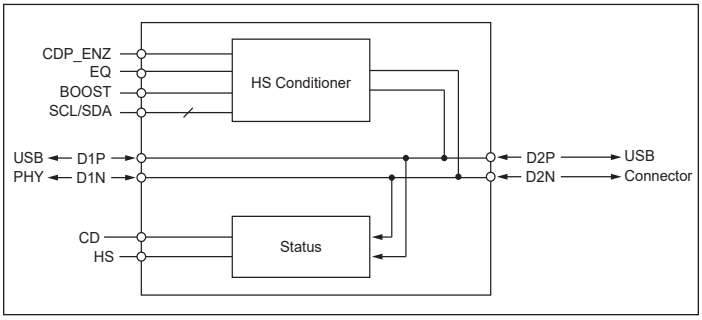
The PI5USB216EQ can be used in USB Host or Device application, far from USB PHY or far from connector application. Boost/Pre-emphasis and Receiver Equalization levels can be configured through pin or I2C mode depending on the channel conditions. Device Attach and High-Speed handshake success are also detected and reported.

The PI5USB216EQ is compatible with the USB On-The-Go (OTG) and battery charging (BC 1.2) protocols. The Integrated BC 1.2 battery charging controller can be enabled via a control pin.

Application(s)

- Automotive Infotainment and Clusters
- Automotive Head Units
- Active Cables, Cable Extenders, Backplanes

Functional Block Diagram



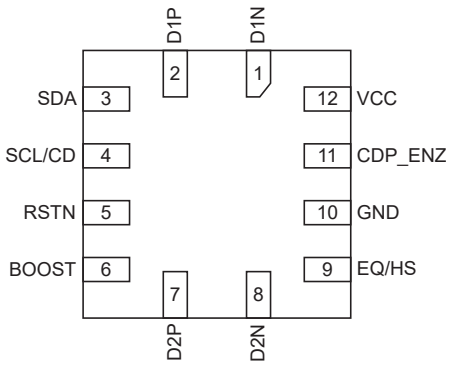
Features

- AEC-Q100 Qualified for Automotive Applications
  - Device Temperature Grade 2: -40°C to 105°C
- Wide Supply Voltage Range: 2.3V to 5.5V
- USB Ports 5.5V Tolerance
- Low Power Consumption in Disconnect and Shutdown Mode
- Compatible with USB2.0, OTG 2.0 and BC 1.2
- Integrated BC 1.2 CDP Battery Charging Controller
- Host or Device Agnostic
- Boost/Pre-emphasis Level and Receiver Equalization Programming through Pin Mode or I2C Mode
- Symmetrical Boost/Pre-emphasis on D+/D- to Maintain Stable Common Mode
- Device Attach and High-Speed Detections
- Supports up to 5m Cable Length
- Supports up to 10m Cable Length with Two PI5USB216EQ
- ESD Performance: 2KV HBM, 1KV CDM
- Packaging (Pb-free & Green):
  - 12-contact, X2QFN (XUA)
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)
- The PI5USB216EQ is suitable for automotive applications requiring specific change control; this part is AEC-Q100 qualified, PPAP capable, and manufactured in IATF 16949 certified facilities.
  https://www.diodes.com/quality/product-definitions/

Notes:

1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.
4. Automotive products are AEC-Q100 qualified and are PPAP capable. Refer to https://www.diodes.com/quality/.

Pin Configuration



Pin Description

Pin Number	Pin Name	Type	Description
1, 2	D1N, D1P	I/O	USB High speed port
3	SDA	I/O	500kΩ internal pulled high and 1.8MΩ internal pulled down. In I2C mode: Bidirectional I2C data pin; Connected to a pull-up resistor During power up, pulled up SDA and SCL/CD with Rpu (<10kΩ) to enter I2C mode OR floating to enter Pin mode In Pin mode: Do not connect
4	SCL/CD	I/O	In I2C mode: I2C Clock pin During power up, pulled up SDA and SCL/CD with Rpu (<10kΩ) to enter I2C mode OR floating to enter Pin mode (500kΩ pull-down during RSTN rising) In Pin mode: Output CD, Flag indicating that a USB device is attached. Asserted from an unconnected state upon detection of DP or DM pull up resistor. De-asserted upon detection of disconnect.
5	RSTN	I	Device disable/enable. Low – Device is at RESET and in shutdown, and High – Normal operation. 500kΩ internal pulled high and 1.8MΩ internal pulled down. Recommend 0.1-uF external capacitor to GND to ensure clean power on reset if not driven. If the pin is driven, it must be held low until the supply voltage for the device reaches within specifications.
6	BOOST	I	USB High Speed Boost selection. Select via external pull down resistor. Sampled upon de-assertion of RSTN. Does not recognize real time adjustments.
7, 8	D2P, D2N	I/O	USB High speed port

Pin Number	Pin Name	Type	Description
9	EQ/HS	I/O	<u>In I2C mode:</u> No function <u>In Pin mode:</u> At reset: 3-level input signal EQ. Receiver Equalization selection. High Equalization (pin is pulled high) Medium Equalization (pin is left floating) Low Equalization (pin is pulled low) After Reset: Output signal HS. Flag indicating that channel is in High Speed mode. Asserted upon: 1. Detection of USB-IF High Speed test fixture from an unconnected state followed by transmission of USB TEST_PACKET pattern. 2. Detection of High Speed a successful High Speed handshake
10	GND	Power	Ground
11	CDP_ENZ	I	Set CDP_ENZ is low to enable BC 1.2 CDP controller. Internal pullup 500kΩ
12	VCC	Power	Supply Power

Maximum Ratings

(Above which useful life may be impaired. For user guidelines, not tested.)

Storage Temperature .....–55°C to +125°C
Supply Voltage .....–0.5V to +6.0V
USB IO Voltage .....–0.5V to +6.0V
Control Input Voltage.....–0.5V to +6.0V
Output Current 10mA
ESD: HBM Mode 2000V

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 Operating Conditions

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Units
V_{CC}	Supply Voltage		2.3		5.5	V
T_A	Ambient Temperature		-40		85	°C

DC Electrical Characteristics

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Units
Power						
I_{ACTIVE}	High-speed (HS) active current	USB channel in HS mode with traffic		22	30	mA
I_{IDLE}	High-speed idle current	USB channel in HS mode without traffic		14	22	mA
I_{SUSPE}	High-speed suspend current	USB channel in HS Suspend mode		0.55	1.5	mA
I_{FS_LS}	Full/Low speed current	USB channel in FS/LS mode		0.6	1.5	mA
I_{DISC}	Disconnect current	No USB attachment		0.7	1.5	mA
I_{RSTN}	Disable current	RSTB = 0V		13	80	µA
I_{LKG_FS}	Pin fail-safe leakage current for SDA, SCL/CD, DxP/N, RSTN, EQ/HS, CDP_ENZ	VCC = 0V, Tested Pin = 5.5V			40	µA
RSTN						
V_{IH}	High-level input voltage		1.05		5.5	V
V_{IL}	Low-level input voltage		0		0.4	V
I_{IH}	High-level input current	VRSTN = VCC	-15		15	µA
I_{IL}	Low-level input current	VRSTN = 0V	-20		20	µA
EQ						
V_{IH}	High-level input voltage		1.6			V
V_{IF}	Floating-level input voltage		1.0		1.5	V
V_{IL}	Low-level input voltage				0.8	V
I_{IH}	High-level input current	VEQ = VCC	-5		5	uA
I_{IL}	Low-level input current	VEQ = 0V	-5		5	uA

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Units
CDP_ENZ						
V_{IH}	High-level input voltage		1.05		5.5	V
V_{IL}	Low-level input voltage		0		0.4	V
I_{IH}	High-level input current	VCDP_ENZ = VCC	-5		5	uA
I_{IL}	Low-level input current	VCDP_ENZ = GND	-20		20	uA
BOOST						
R_{BOOST}	Setting 0				160	Ω
	Setting 1		1.5		2	kΩ
	Setting 2		3.4		3.96	kΩ
	Setting 3		7.5			kΩ
CD, HS						
V_{OH}	High-level output voltage	Iout = 50uA, VCC > 3.0V	2.5			V
		Iout = 25uA, VCC = 2.3V	1.8			
V_{OL}	Low-level output voltage	Iout = 50uA			0.4	V
SCL, SDA						
C_{I2CBUS}	I2C Bus capacitance		4		150	pF
V_{IH}	SDA and SCL input high level voltage		1.05		5.5	V
V_{IL}	SDA and SCL input low level voltage		0		0.3	V
I_{SDAO}	SDA low level output current	SDA = 0.4V	1.5			mA
fSCL	SCL clock frequency				1000	KHz
DxP, DxM						
C_{IO}	Capacitance to GND	240MHz, Device off		2.4		pF

Switching Characteristics

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Units
F_{BR}	DxP/M bit rate				480.24	Mbps
t_{RISE}	DxP/M rise time	10% - 90%; VCC = 5.5V; Max BOOST	100			ps
t_{FALL}	DxP/M fall time	90% - 10%; VCC = 5.5V; Max BOOST	100			ps
t_{RSTN_PW}	Minimum width to detect a valid RSTN signal assert when the pin is actively driven		20			µs
t_{STABLE}	VCC stable before RSTN de-assertion		100			µs
t_{VCC_RAMP}	VCC ramp time		0.2		100	ms

Detail Description

Overview

The PI5USB216EQ is an USB2.0 High-Speed (HS) Signal conditioner to boost the signals and insert pre-emphasis to compensate the ISI signal loss in the channels before and after. PI5USB216EQ will not alter the signals of USB Low Speed (LS), Full Speed (FS), On-The-Go (OTG) and Battery Charging (BC), while HS signals are compensated. Boost/Pre-emphasis level and Receiver Equalization can be programmed by I2C or pin mode.

BOOST/PRE-EMPHASIS

The BOOST pin of PI5USB216EQ is used to configure the level of BOOST/PRE-EMPHASIS in pin mode and initialize the corresponding register in I2C mode. Amplitude boost compensates the amplitude loss due to the long channel before PI5USB216EQ, and pre-emphasis compensates the high frequency loss due to the low-pass long channel after PI5USB216EQ. The four settings can be selected by an external pulldown resistor at this pin and it will be sampled a short moment after RSTN rising.

BOOST Pin Connection	Register Default Value	Boost/Pre-Emphasis Level
Setting 0 (<160 Ω)	0000	Lowest
Setting 1 (~1.8 kΩ)	0101	Lower Mid
Setting 2 (~3.6 kΩ)	1010	Higher Mid
Setting 3 (>7.5 kΩ)	1111	Highest

Receiver Equalization

The EQ pin of PI5USB216EQ is used to configure the level of Receiver Equalization in pin mode and initialize the corresponding register in I2C mode. The three settings can be selected by connecting the pin to VCC/Floating/GND during RSTN and it will be sampled a short moment after RSTN rising. After RSTN, the pin will function as an output for HS detection.

EQ Pin Connection	Register Default Value	Receiver Equalization Level
VCC	10	High
Floating	01	Mid
GND	00	Lowest

BC 1.2 Charging Controller

The PI5USB216EQ can serve USB BC 1.2 host charging controller functionality if the host itself does not provide. When CDP_ENZ is low, the PI5USB216EQ supports CDP charging downstream port functionality. CDP_ENZ has an internal 500k pull up resistor when the pin is left open, CDP controller will be disable.

Pin 11 (CDP_ENZ)	CDP
High	Disable
Low	Enable

I2C Mode

PI5USB216EQ supports 1MHz up-to-1.2V I2C for device configuration and status readback. This controller is enabled after SCL and SDA pins are sampled high shortly after de-assertion of RSTN. Otherwise, pin mode is enabled. In I2C mode, the registers can be accessed by I2C read/write transaction to 7-bit slave address 0x2C.

Address	Register	Type	Reset Value	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
00h	Reserved	RW	00000000b	Reserved							
01h	Control	RW	xx00xx00b	Receiver Equalization Level 00 (Lowest) 01 10 11 (Highest) Default value set by EQ pin sampling during startup		Boost/Pre-emphasis Level Coarse 00 (Lowest) 01 10 11 (Highest) Default value set by BOOST pin sampling during startup		Fine 00 (Lowest) 01 10 11 (Highest)		Receiver Sensitivity Level 00 (Lowest) 01 10 11 (Highest) Default value is 00	
02h	Device ID	R	10110000b	Device ID: 10110					Revision: 000		

Device Functional Modes

Low Speed (LS) Mode/Full Speed (FS) Mode

PI5USB216EQ automatically detects a LS/FS connection and does not enable signal compensation. In pin mode, CD pin is asserted high.

High Speed (HS) Mode

PI5USB216EQ automatically detects a HS connection and will enable signal compensation. In pin mode, CD and HS pins are asserted high.

OTG Mode/B.C.1.2 Mode

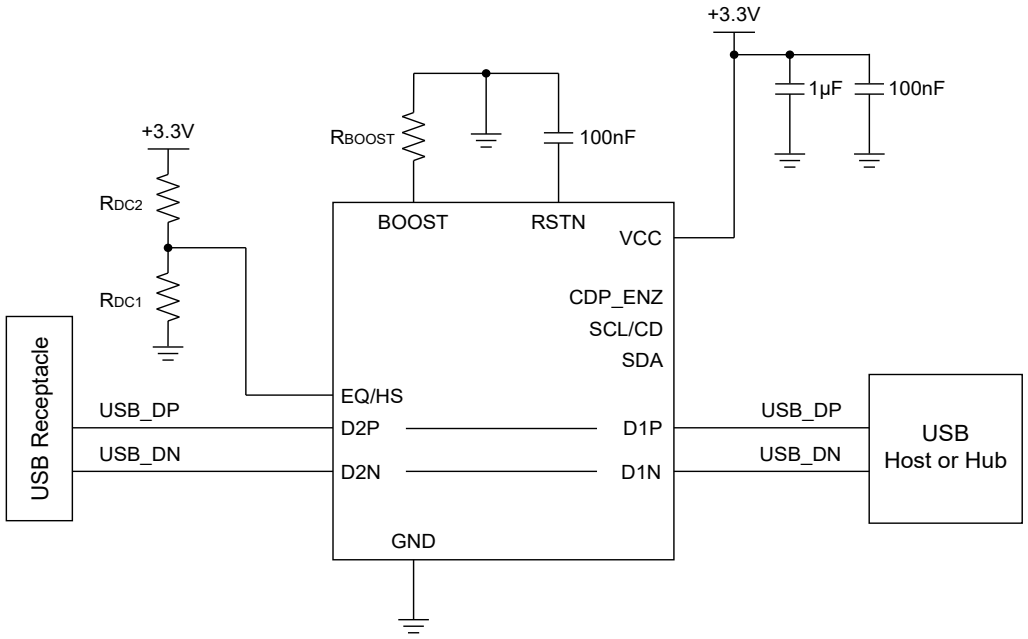
PI5USB216EQ does not enable signal compensation for OTG or B.C.1.2 signals. In pin mode, CD pin is asserted low.

Shutdown Mode

PI5USB216EQ is disabled when its RSTN pin is asserted low. In shutdown mode the USB channel is still fully operational, but there is neither signal compensation nor any indication from the CD or HS pin as to the status of the channel.

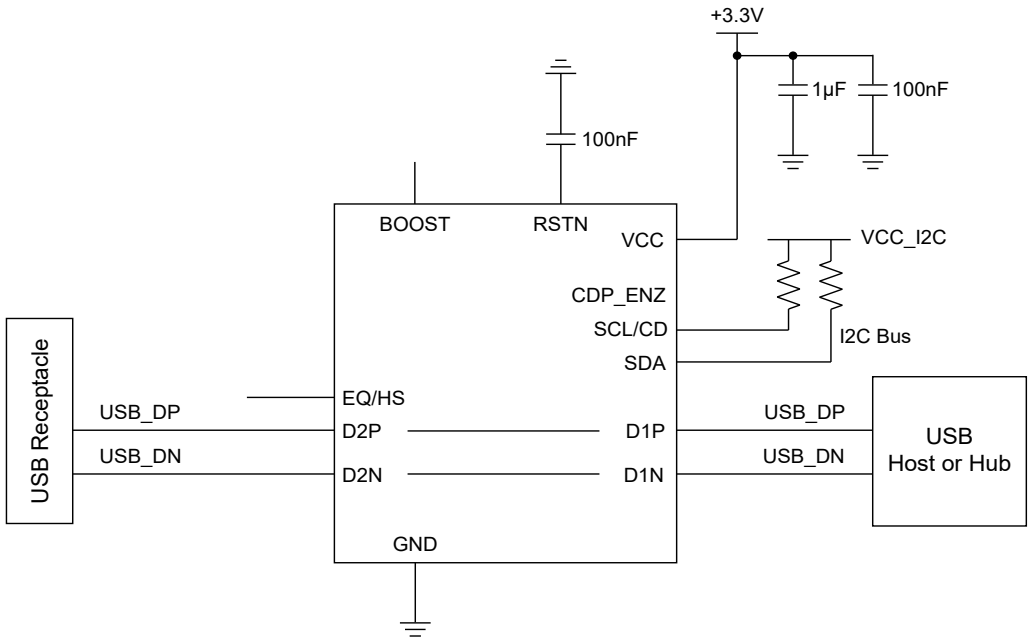
Application Diagram

Pin Mode



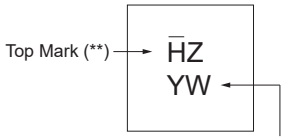
D2P must be shorted to D1P on PCB.
D2N must be shorted to D1N on PCB.

I2C Mode



D2P must be shorted to D1P on PCB.
D2N must be shorted to D1N on PCB.

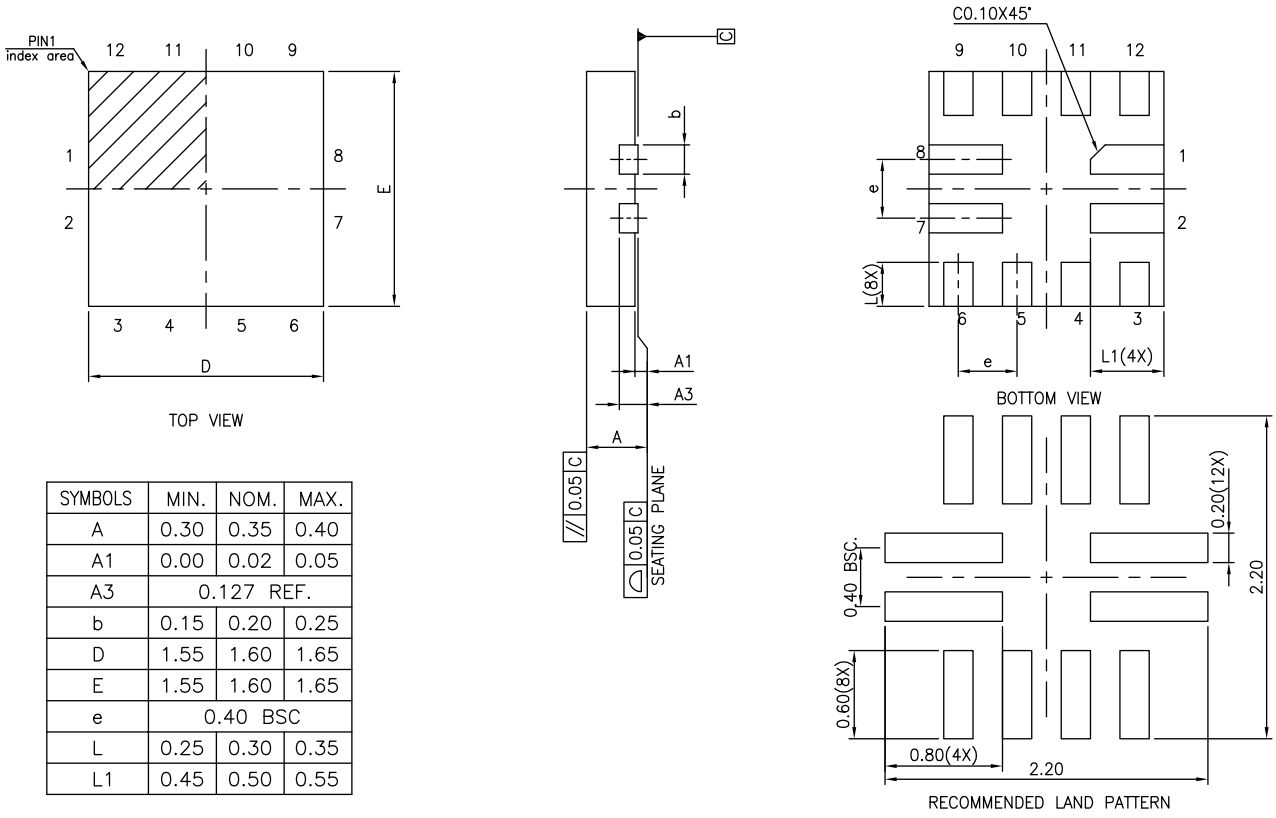
Part Marking



Y: Date Code (Year)
W: Date Code (Workweek)
Note: Date Code per MA-1251
Line above first character denotes Pin 1 indicator, Lead-free and Green

Packaging Mechanical

12-X2QFN (XUA)



SYMBOLS	MIN.	NOM.	MAX.
A	0.30	0.35	0.40
A1	0.00	0.02	0.05
A3		0.127 REF.	
b	0.15	0.20	0.25
D	1.55	1.60	1.65
E	1.55	1.60	1.65
e		0.40 BSC	
L	0.25	0.30	0.35
L1	0.45	0.50	0.55

NOTE :
1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
2. REFER JEDEC MO-288
3. RECOMMENDED LAND PATTERN IS FOR REFERENCE ONLY.

DATE: 04/21/22

DESCRIPTION: X2-QFN1616-12

PACKAGE CODE: XUA (XUA12)

DOCUMENT CONTROL #: PD-2167 REVISION: B

For latest package info.

please check: http://www.diodes.com/design/support/packaging/pericom-packaging/packaging-mechanicals-and-thermal-characteristics/

Mechanical Data

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish - Ni/Pd/Au Plated Leads. Solderable per MIL-STD-202, Method 208 e4
- Weight: 0.042 grams (Approximate)

Ordering Information

Orderable Part Number	Package Code	Package Description
PI5USB216EQ2XUAEX	XUA	X2-QFN1616-12

Notes:

1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.
4. Q = Automotive Compliant
5. 2 = AEC-Q100 Grade Level
6. E = Pb-free and Green
7. X suffix = Tape/Reel

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