

**PI3USB31532Q**

**10Gbps USB Type-C DP2.1/USB3 6:4 Crossbar Switch**

**Description**

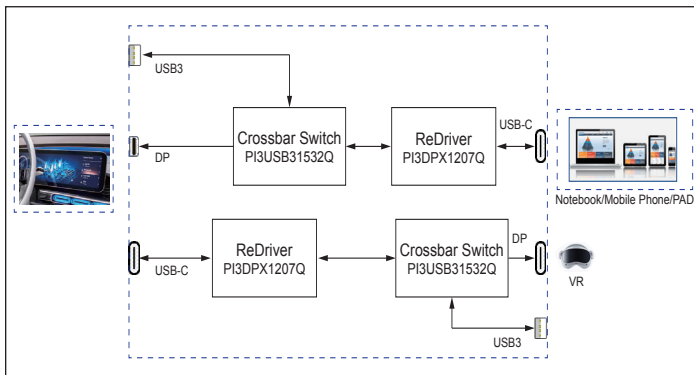
The DIODES PI3USB31532Q is a 6:4 differential channels, bidirectional, 10Gbps crossbar switch solution for routing USB 3.2 and/or DP 2.1 signals through USB Type-C® connector. It supports either one lane of USB 3.2 Gen 2, one lane of USB 3.2 Gen 2 and two channels of DP 2.1 UHBR10, or four channels of DP 2.1 UHBR10 to the USB Type-C connector.

In addition, AUX± channels are also switch to the USB Type-C sideband pins, SBU1 and SBU2. The PI3USB31532Q offers excellent signal integrity for high-speed signals and low-power dissipation.

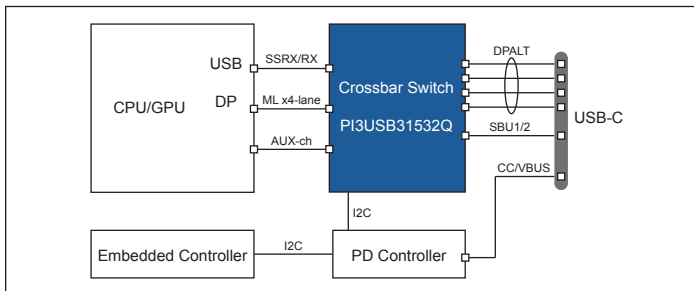
**Application(s)**

- Smart Cockpit
- Rear Seat Entertainment

**Application Diagram**



**Figure 1. RSE Application**



**Figure 2. Smart Cockpit Application**

**Features**

- Six Differential Channels to Two/Four Differential Channels Bidirectional Crossbar Switch
- 10Gbps USB 3.2 Gen 2 Super Speed and DP 2.1 UHBR10 Switching to USB Type-C Connector
- Supports Either Pin Control or I<sup>2</sup>C Control to Configure the Switch
- Low Insertion Loss: -1.7dB @ 10Gb/s
- Return Loss: -15dB @ 10Gb/s
- CrossTalk: -38dB @ 10Gb/s
- Off Isolation: -22dB @ 10Gb/s
- -3dB Bandwidth: 8.3GHz
- Multiplexes One of the Following to USB Type-C Connector:
  - USB 3.2 Gen 2 Signal Only
  - One Lane of USB 3.2 Gen 2 Signal and Two Channels of DP 2.1 UHBR10
  - Four Channels of DP2.1 UHBR10
- With DP 2.1 UHBR10 Operating, AUX+ and AUX- are switch to SBU Pins
- Power Supply: 3.3V
- AEC-Q100 Grade 2, -40°C to 105°C
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. “Green” Device (Note 3)
- The PI3USB31532Q 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/>
- Packaging (Pb-free & Green):
  - 40-contact, TQFN (ZLC)

**Ordering Information**

Ordering Code	Packaging Code	Package Description
PI3USB31532Q2ZLCEX	ZLC	40-Pin, 3mm x 6mm (TQFN) (W-QFN3060-40)

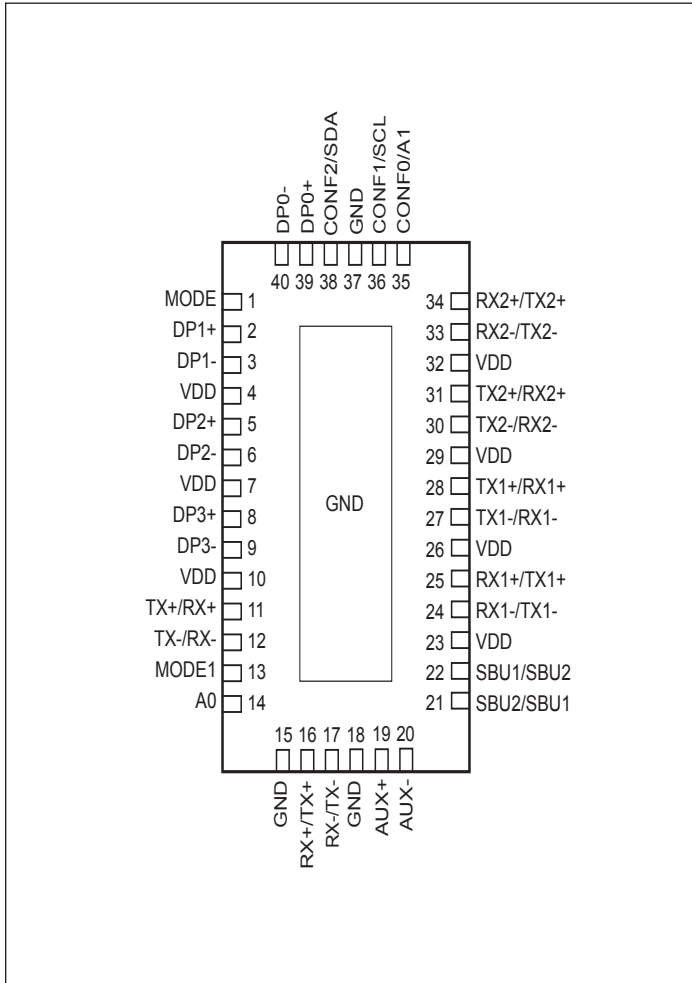
**Notes:**

- Q = Automotive Compliant
- 2 = AEC-Q100 Grade Level
- E = Pb-free and Green
- X suffix = Tape/Reel

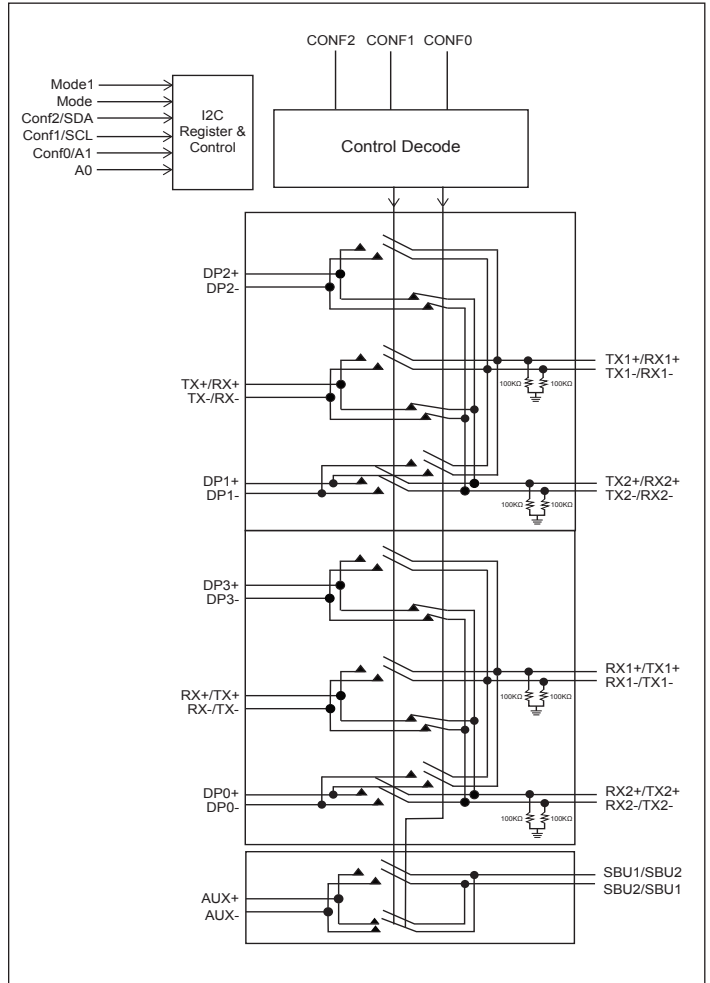
**Notes:**

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



## Block Diagram



**Note:**

1. The first pinout name (such as *RX2+* in *RX2+/TX2+*) is for source reference schematic in page 4.
2. The second pinout name (such as *TX2+* in *RX2+/TX2+*) is for sink reference schematic in page 5.

## Pin Description

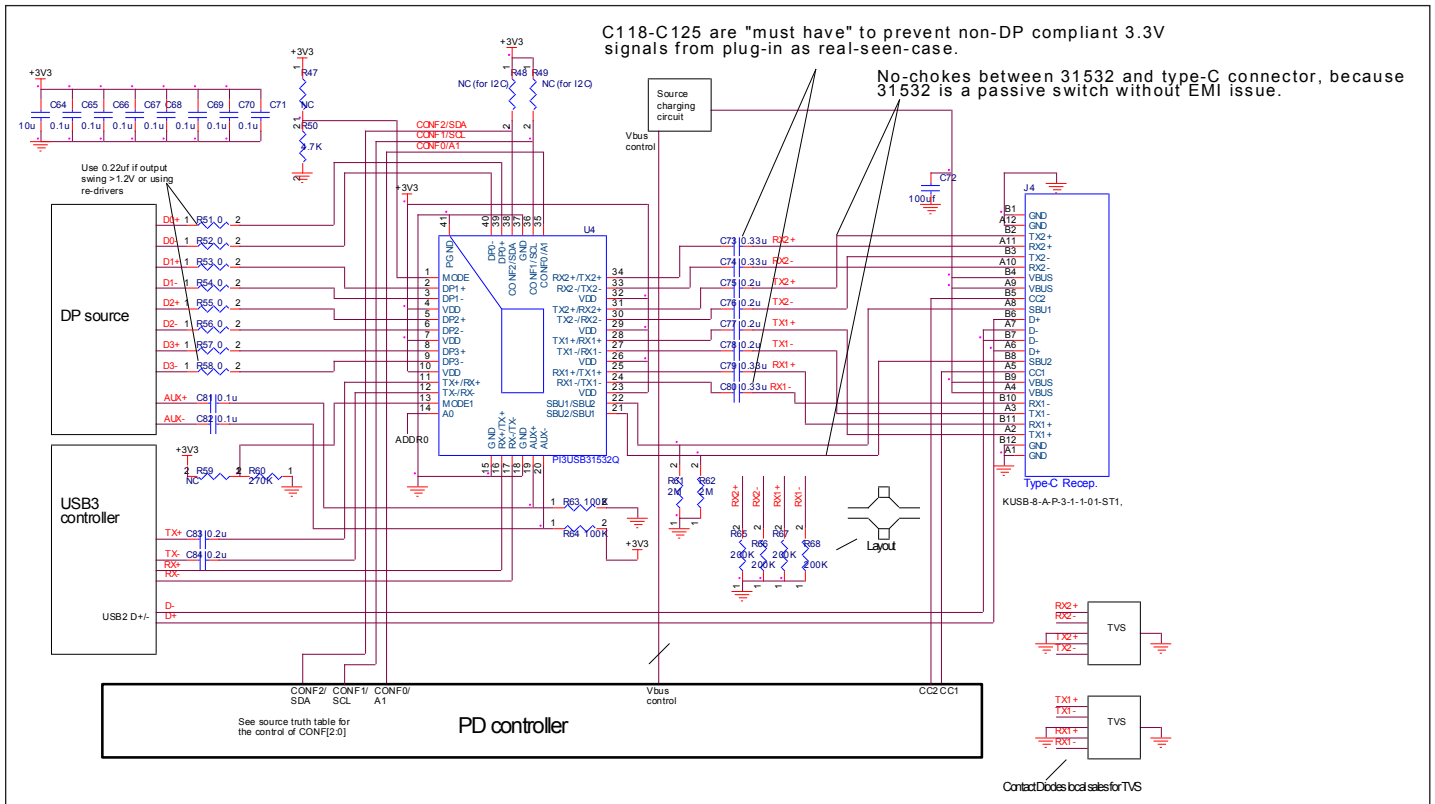
Pin#	Pin Name	Type	Description
4, 7, 10, 23, 26, 29, 32	VDD	Power	3.0V to 3.6V power supply. All VDD pins must be tied to external power.
11, 12	TX+/RX+, TX-/RX-	I/O	Differential USB 3.2 Gen 2 Transmit signal (source application) or differential USB 3.2 Gen 2 Receive signal (sink application). Connected internally with 100kΩ pulldown to GND.
16, 17	RX+/TX+, RX-/TX-	I/O	Differential USB 3.2 Gen 2 Receive signal (source application) or differential USB 3.2 Gen 2 Transmit signal (sink application). Connected internally with 100kΩ pulldown to GND.
39, 40	DP0+, DP0-	I/O	Differential DP0 signal.
2, 3	DP1+, DP1-	I/O	Differential DP1 signal.
5, 6	DP2+, DP2-	I/O	Differential DP2 signal.
8, 9	DP3+, DP3-	I/O	Differential DP3 signal.
19, 20	AUX+, AUX-	I/O	Differential Auxiliary signal for DP.
22, 21	SBU1, SBU2	I/O	Sideband signal at Type-C connector.
25, 24	RX1+/TX1+, RX1-/TX1-	I/O	Differential Receive signal 1 at Type-C connector (source application) or differential Transmit signal 1 at Type-C connector (sink application).
28, 27	TX1+/RX1+, TX1-/RX1-	I/O	Differential Transmit signal 1 at Type-C connector (source application) or differential Receive signal 1 at Type-C connector (sink application).
31, 30	TX2+/RX2+, TX2-/RX2-	I/O	Differential Transmit signal 2 at Type-C connector (source application) or differential Receive signal 2 at Type-C connector (sink application).
34, 33	RX2+/TX2+, RX2-/TX2-	I/O	Differential Receive signal 2 at Type-C connector (source application) or differential Transmit signal 2 at Type-C connector (sink application).
22	SBU1/SBU2	I/O	Sideband signal 1 (source application) or side band signal 2 (sink application) at Type-C connector.
21	SBU2/SBU1	I/O	Sideband signal 2 (source application) or side band signal 1 (sink application) at Type-C connector.
1	MODE	I	Control mode selection MODE = 1, I2C control = 0, pin control through CONF[2:0]
35, 36, 38	CONF[2:0]	I	Switch configuration selection pin when MODE = 0, refer to <i>Switch Selection Truth Table</i> for detail. When MODE = 1, these pins are part of the I2C interface as SDA/SCL/A1.
38	SDA	I/O	Serial in data of I2C when MODE = 1.
36	SCL	I	I2C clock input pin when MODE = 1.
35	A1	I	A[1] of A[1:0] I2C selectable address when MODE = 1.
14	A0	I	A[0] of A[1:0] I2C selectable address when MODE = 1.
15, 18, 37, Center Pad	GND	Power	Ground supply.
13	MODE1	I	When MODE 1 = 0, I2C I/O is 1.8V interface. When MODE 1 = 1, I2C I/O is 3.3V interface.

**Configuration Table for Source Application (V1.0a)**

			Type-C USB 3.2 Gen 1/Gen 2 only		V1.0a DP ALT Spec Receptacle DFP_D pin Assignment			
Switch	Open	Open	USB 3.2 Gen 1/Gen 2	USB 3.2 Gen 1/Gen 2 Flip	C, E (Table 3-1)	C, E Flip (Table 3-2)	D, F (Table 3-1)	D, F flip (Table 3-2)
Conf[2:0]	000	001	100	101	4 Lanes of DP 2.1 UHBR10	4 Lanes of DP 2.1 UHBR10 flip	USB 3.2 Gen 1/ Gen 2 +2 Lanes of DP 2.1 UHBR10	USB 3.2 Gen 1/Gen 2 +2 Lanes of DP 2.1 UHBR10 Flip
TX	x	x	TX1	TX2	x	x	TX1	TX2
RX	x	x	RX1	RX2	x	x	RX1	RX2
DP0	x	x	x	x	RX2	RX1	RX2	RX1
DP1	x	x	x	x	TX2	TX1	TX2	TX1
DP2	x	x	x	x	TX1	TX2	x	x
DP3	x	x	x	x	RX1	RX2	x	x
AUX+	x	x	x	x	SBU1	SBU2	SBU1	SBU2
AUX-	x	x	x	x	SBU2	SBU1	SBU2	SBU1

000 = switch open with power down

001 = switch open only, no power down



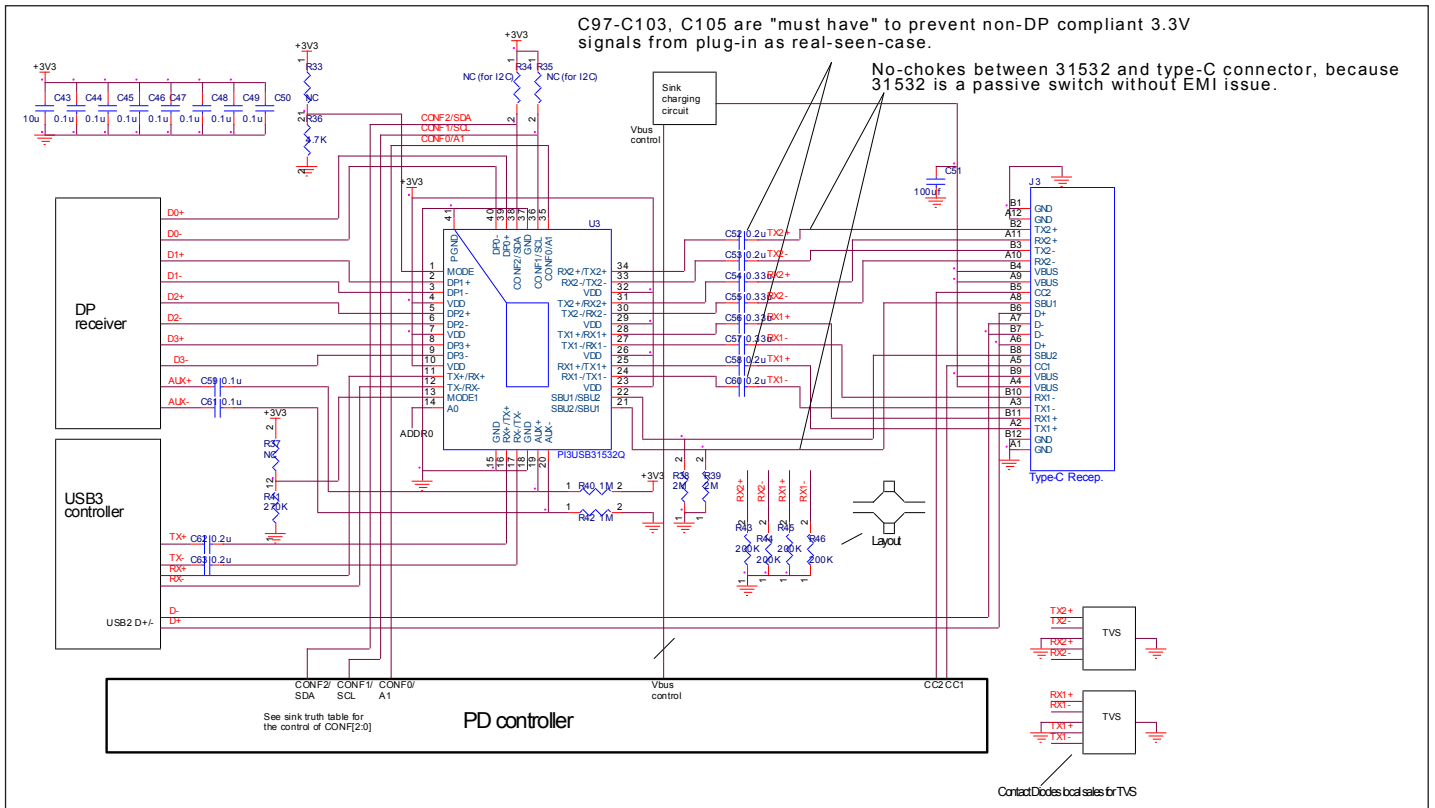
**PI3USB31532Q Reference Schematic for Source Application**

**Configuration Table for Sink Application (V1.0a)**

			Type-C USB 3.2 Gen 1/Gen 2 Only		V1.0a DP ALT Spec Receptacle UFP_D pin Assignment			
Switch	Open	Open	USB 3.2 Gen 1/Gen 2	USB 3.2 Gen 1/Gen 2 Flip	C (Table 3-3)	C Flip (Table 3-4)	D (Table 3-3)	D Flip (Table 3-4)
Conf[2:0]	000	001	100	101	4 Lanes of DP 2.1 UHBR10	4 Lanes of DP 2.1 UHBR10 flip	USB 3.2 Gen 1/ Gen 2 +2 Lanes of DP 2.1 UHBR10	USB 3.2 Gen 1/Gen 2 +2 Lanes of DP 2.1 UHBR10 Flip
TX	x	x	TX1	TX2	x	x	TX1	TX2
RX	x	x	RX1	RX2	x	x	RX1	RX2
DP0	x	x	x	x	TX2	TX1	TX2	TX1
DP1	x	x	x	x	RX2	RX1	RX2	RX1
DP2	x	x	x	x	RX1	RX2	x	x
DP3	x	x	x	x	TX1	TX2	x	x
AUX+	x	x	x	x	SBU2	SBU1	SBU2	SBU1
AUX-	x	x	x	x	SBU1	SBU2	SBU1	SBU2

000 = switch open with power down

001 = switch open only, no power down



**PI3USB31532Q Reference Schematic for Sink Application**

## I2C Control

### \*\* I2C Function Reference:

"THE I2C-BUS SPECIFICATION, VERSION 2.1"

### I2C Control Register:

	Register Bits							
	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Slave address (First byte is slave address)	1	0	1	0	1	A1	A0	0/1 (W/R)
Vendor ID (Second byte is vendor ID, read only)	0	0	0	0	0	0	0	0
Selection control (Third byte is for selection control, read/write)	0	0	0	0	0	conf[2]	conf[1]	conf[0]

### Note:

1. Bit7 - Bit3 = Version ID (00000) in (01H)
2. Bit2 - Bit0 = Pericom Vendor ID (000) in (01H)
3. A0, A1 are hardware selectable (pin35, pin36)
4. conf[2]/conf[1]/conf[0] are written into the register by the master PI3USB31532Q will decode Bit2 - Bit0 in (02h) for I2C control (Pin1/MODE = 1). Default power-up state is 000.

## Bus Transactions

Data transfers follow the format shown in Figure 3. After the START condition (S), a slave address is sent. This address is 7 bits long followed by an eighth bit, which is a data direction bit (R/W)—a 'zero' indicates a transmission (WRITE), and a 'one' indicates a request for data (READ). A data transfer is always terminated by a STOP condition (P) generated by the master. However, if a master still wishes to communicate on the bus, it can generate a repeated START condition (S) and address another slave without first generating a STOP condition. Various combinations of read/write formats are then possible within such a transfer.

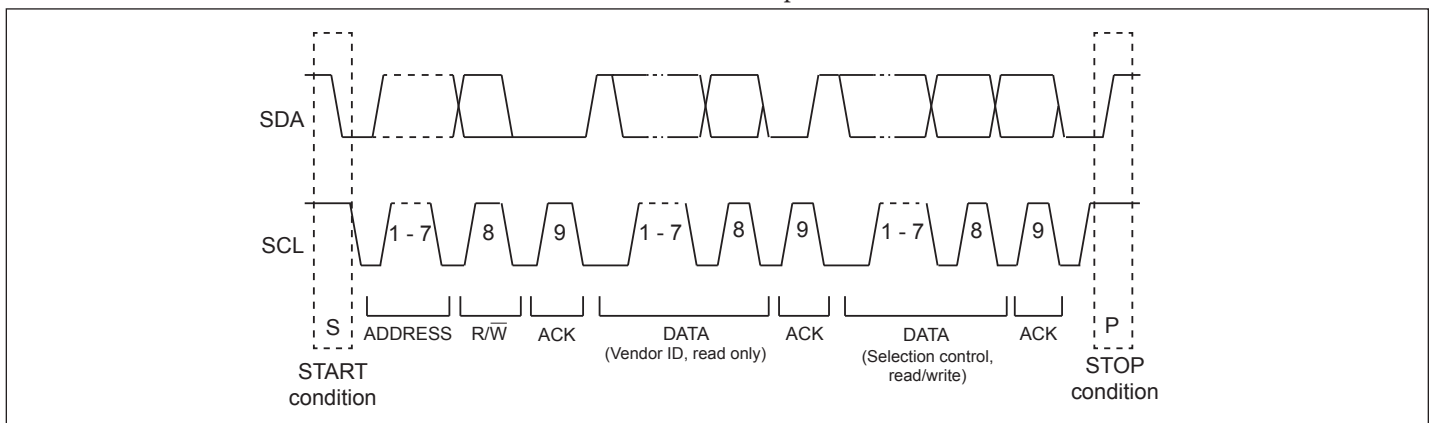
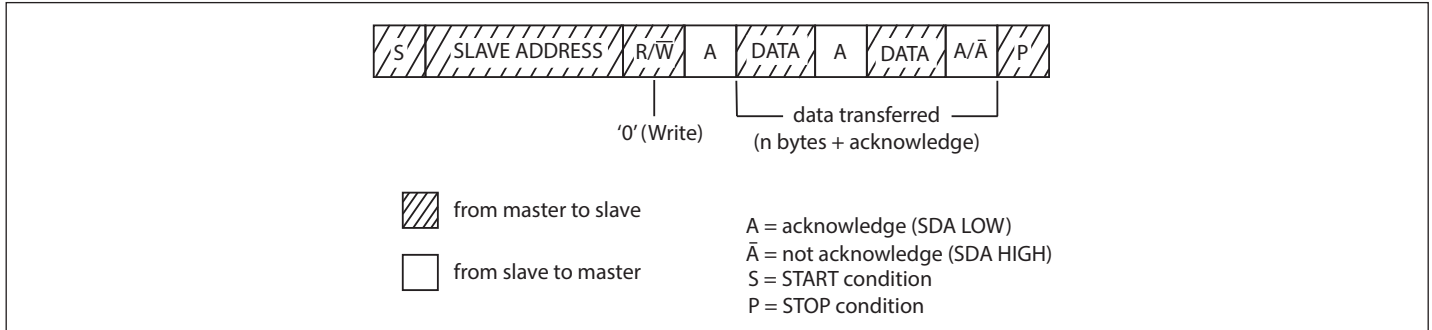
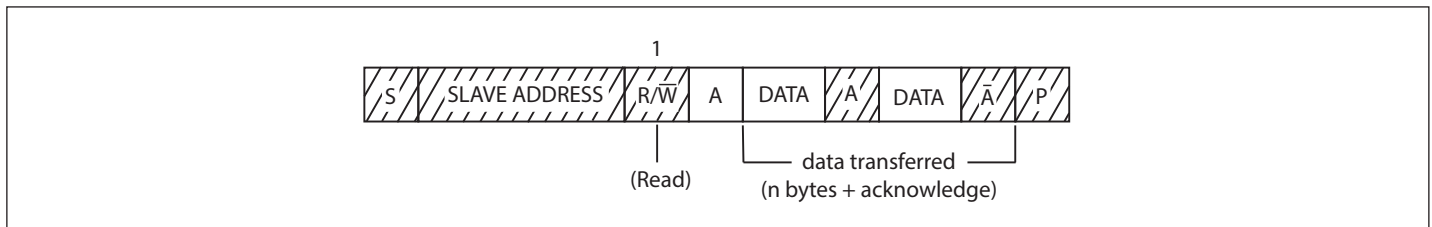


Figure 3. A Complete Data Transfer

Data is transmitted to the PI3USB31532Q registers using the Write mode as shown in Figure 4. Data is read from the PI3USB31532Q registers using the Read mode as shown in Figure A4.



**Figure 4. Write to Control Register**



**Figure A4. Read to Control Register**

The example of PD-I2C Control for PI3USB31532Q, A0=0, A1=0.

	PD-I2C Controlled Registers for PI3USB31532Q		
	DP	USB3.2	USB3.2 + DP
Non Flip	Start → 10101000 → 00000000 → 00000010 → stop	Start → 10101000 → 00000000 → 00000100 → stop	Start → 10101000 → 00000000 → 00000110 → stop
Flip	Start → 10101000 → 00000000 → 00000011 → stop	Start → 10101000 → 00000000 → 00000101 → stop	Start → 10101000 → 00000000 → 00000111 → stop

## Maximum Ratings

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

Supply Voltage to Ground Potential, $V_{DD} = 3.3V$ .....	-0.3V to 4.3V
Control DC Input.....	-0.3V to $V_{DD}+0.3V$
Junction Temperature .....	125°C
Storage Temperature.....	-65°C to +150°C
Channel DC Input for USB, DP.....	-0.3V to 1.2V
Channel DC Input for AUX .....	-0.35V to $V_{DD}$
ESD, HBM.....	±2000V
ESD, CDM.....	±1000V

**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

Parameter	Min.	Typ.	Max.	Unit
Ambient Operating Temperature	-40		+105	°C
Power Supply Voltage (Measured in Respect to GND)	3.0	3.3	3.6	V

## Static Characteristics

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{DD}$	Supply Voltage		3.0	3.3	3.6	V
$I_{DD}$	VDD Supply Current	$V_{DD} = 3.3V$ all Conf[2:0] states except [000]		350	400	μA
		$V_{DD} = 3.3V$ Conf[2:0] = 000		10	30	μA
$I_{OFF}$	I/O Leakage When Power is Off	$V_{DD} = 0V$ $V_{IO}(USB\ 3.2\ Gen\ 2) = 0V$ $V_{IO}(DP\ 2.1) = 0V$ $V_{IO}(AUX) = 0V\ to\ 3.6V$ $V_{IO}(SBU) = 0V\ to\ 3.6V$			50	μA

### Control pin (MODE, MODE1)

$I_{IH}$	High-Level Digital Input Current	$V_{IH} = V_{DD}$ $V_{DD} = 3.6V$			5	μA
$I_{IL}$	Low-Level Digital Input Current	$V_{IL} = GND$ $V_{DD} = 3.6V$			5	μA
$V_{IH}$	High-Level Digital Input Voltage	$V_{DD} = 3.6V$	$0.75 \times V_{DD}$			V
$V_{IL}$	Low-Level Digital Input Voltage	$V_{DD} = 3.6V$			0.6	V



**PI3USB31532Q**

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
<b>Control/I2C pin (A0, A1, SDA, SCL, when MODE = H, MODE1 = H)</b>						
$I_{IH}$	High-Level Digital Input Current	$V_{IH} = VDD$ $VDD = 3.6V$			5	$\mu A$
$I_{IL}$	Low-Level Digital Input Current	$V_{IL} = GND$ $VDD = 3.6V$			5	$\mu A$
$V_{IH}$	High-Level Digital Input Voltage	$VDD = 3.6V$	$0.75 \times VDD$			V
$V_{IL}$	Low-Level Digital Input Voltage	$VDD = 3.6V$			0.6	V
<b>Control/I2C pin (A0, A1, SDA, SCL, when MODE = H, MODE1 = L)</b>						
$I_{IH}$	High-Level Digital Input Current	$V_{IH} = VDD$ $VDD = 3.6V$			5	$\mu A$
$I_{IL}$	Low-Level Digital Input Current	$V_{IL} = GND$ $VDD = 3.6V$			5	$\mu A$
$V_{IH}$	High-Level Digital Input Voltage	$VDD = 3.6V$	1.2			V
$V_{IL}$	Low-Level Digital Input Voltage	$VDD = 3.6V$			0.4	V
<b>Control pin (CONF[2:0], when MODE = L)</b>						
$I_{IH}$	High-Level Digital Input Current	$V_{IH} = VDD$ $VDD = 3.6V$			5	$\mu A$
$I_{IL}$	Low-Level Digital Input Current	$V_{IL} = GND$ $VDD = 3.6V$			5	$\mu A$
$V_{IH}$	High-Level Digital Input Voltage	$VDD = 3.6V$	1.2			V
$V_{IL}$	Low-Level Digital Input Voltage	$VDD = 3.6V$			0.4	V
<b>I/O pin (TX+, TX-, RX+, RX-, TX1+, TX1-, RX1+, RX1-, TX2+, TX2-, RX2+, RX2-DP0+, DP0-, DP1+, DP1-, DP2+, DP2-, DP3+, DP3-) (AUX+, AUX-, SBU1, SBU2)</b>						
$C_{OFF}$	USB 3.2 Gen 2/DP 1.4 switch OFF capacitance	$VIO = GND$ $f = 1MHz$		1.2		pF
$C_{ON}$	USB 3.2 Gen 2/DP 1.4 switch ON capacitance	$VIO = GND$ $f = 1MHz$		2.3		pF
$C_{OFF}$	AUX+/AUX- switch OFF capacitance	$VIO = GND$ $f = 1MHz$		4.0		pF
$C_{ON}$	AUX+/AUX- switch ON capacitance	$VIO = GND$ $f = 1MHz$		7.0		pF
$I_{OZL}$	I/O leakage for TX_to_TX1/TX2, RX_to_RX1/RX2 DPx_to_TX/RX(x = 0, 1, 2, 3) AUX_to_SBUy(y = 1, 2)	$VDD = 3.6V,$ $VIO (USB 3.2 Gen 2) = 0V,$ $VIO (DP 2.1) = 0V,$ $VIO (AUX) = 0V$		1	5	$\mu A$

**PI3USB31532Q**

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$I_{OZH}$	I/O leakage for TX_to_TX1/TX2, RX_to_RX1/RX2 DPx_to_TX/RX(x = 0, 1, 2, 3) AUX_to_SBUy(y = 1, 2)	VDD = 3.6V, VIO (USB 3.2 Gen 2) = 1.2V, VIO (DP 2.1) = 1.2V, VIO (AUX) = 4.0V		1	15	$\mu A$
<b>Linear Region for Analog Switch</b>						
$V_{p\_IO}$	Linear Region for Analog Switch TX_to_TX1/TX2, RX_to_RX1/RX2 DPx_to_TX/RX(x = 0, 1, 2, 3)	VDD = 3.3V, Ipass = 10mA	1.4	1.6		V
$V_{p\_IOSB}$	Linear Region for Analog Switch AUX_to_SBUx(x = 1, 2)	VDD = 3.3V, Ipass = 10mA	4.0	4.2		V

### Dynamic Characteristics

Min and Max apply for  $T_A$  between  $-40^{\circ}C$  to  $105^{\circ}C$ . Typical values are referenced to  $T_A = 25^{\circ}C$ .

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Units
tstartup	Startup Time	Supply voltage valid or (*) the device is powered up & channel is turn on to its specified characteristics VDD = 3V		10	20	$\mu s$
trcfg	Reconfiguration Time	Conf[2:0] change to channel specified operating characteristics		1	2	
tpd	Propagation Delay 1	From input port to output port USB/DP		80		ps
tpd	Propagation Delay 2	From input port to output port AUX		150		ps
tsk	Skew Time 1	From input port to output USB/DP Bit to bit skew		10		ps
tsk	Skew Time 2	From input port to output AUX Bit to bit skew		20		ps
VI_usb_dp	USB/DP Input Signal	USB/DP switch analog signal	-0.3		1.2	V
VI_aux	AUX+/AUX- Input Signal	AUX switch analog signal	-0.35		VDD	V

\* Conf[2:0] changes from [000] to [001]/[010]/[011]/[100]/[101]/[110]/[111]

## Switch AC Electrical Characteristics

Min and Max apply for  $T_A$  between  $-40^{\circ}\text{C}$  to  $105^{\circ}\text{C}$  and  $T_j$  up to  $+125^{\circ}\text{C}$  (unless otherwise noted). Typical values are referenced to  $T_A = +25^{\circ}\text{C}$ ,  $V_{DD} = 3.3\text{V}$ .

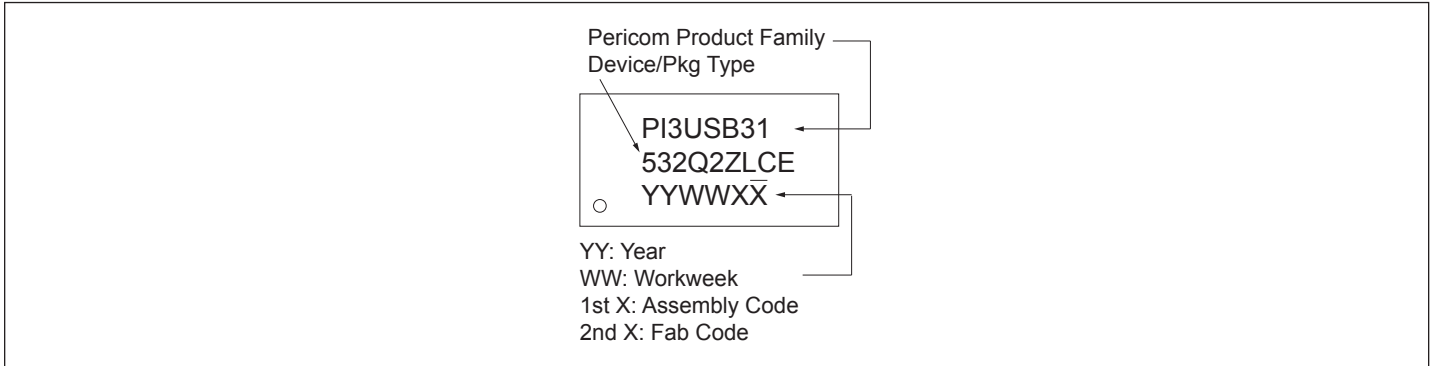
Symbol	Parameter	Frequency/Vcom		Typ.	Units
BW_USB	-3dB bandwidth of USB 3.2 Gen 2			8.3	GHz
BW_DP	-3dB bandwidth of DP 2.1			6.9	GHz
$I_L$	Differential Insertion Loss	5GHz/0V	USB 3.2 Gen 2	-1.7	dB
		5Ghz/0V	DP 2.1	-2.3	
		4.05GHz/ 0V	DP 1.4	-1.6	
$R_L$	Differential Return Loss	5GHz/0V	USB 3.2 Gen 2	-15	
		5Ghz/0V	DP 2.1	-12	
		4.05GHz/ 0V	DP 1.4	-14	
Xtalk	Differential Crosstalk	5GHz/0V	USB 3.2 Gen 2	-38	
		5Ghz/0V	DP 2.1	-30	
		4.05GHz/ 0V	DP 1.4	-33	
Xoff	Off Isolation	5GHz/0V	USB 3.2 Gen 2/DP 2.1	-22	
		4.05GHz/ 0V	DP 1.4	-25	

## I<sup>2</sup>C Electrical Characteristics

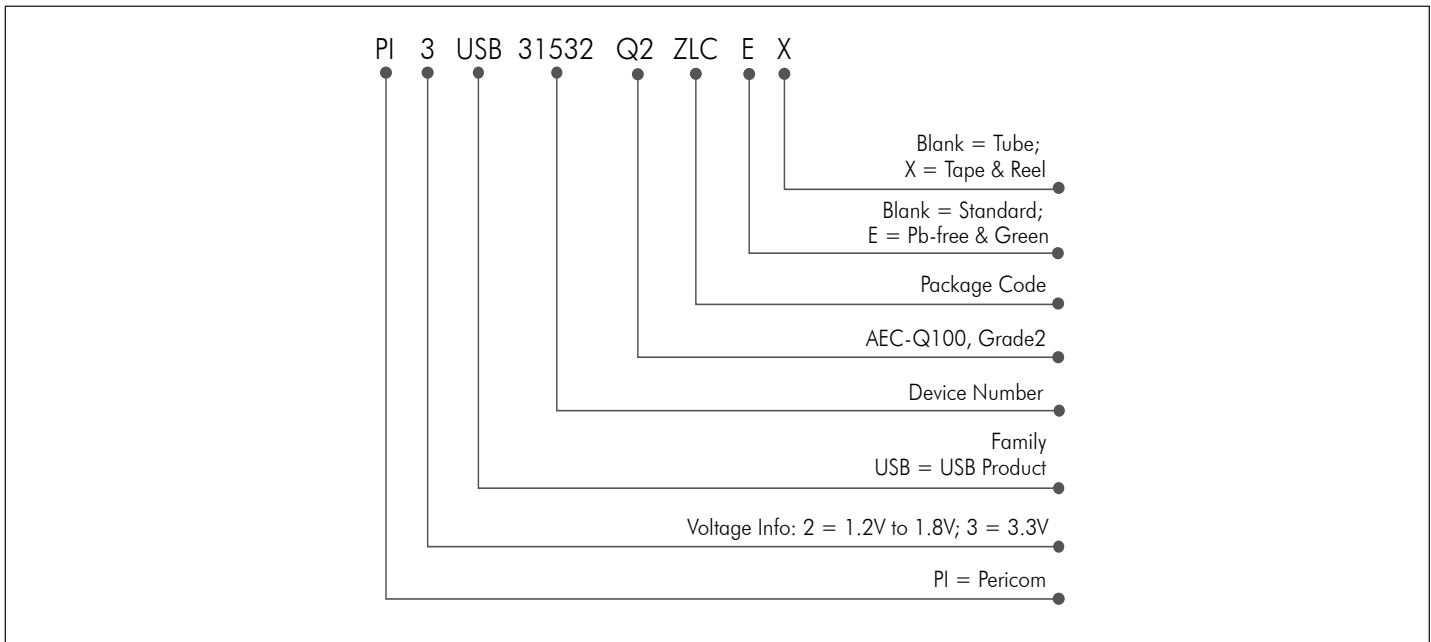
Symbol	Parameter	Standard Mode (100kHz)		Fast Mode (400kHz)		Fast Mode Plus (1MHz)		Units
		Min	Max	Min	Max	Min	Max	
$f_{SCL}$	SCL Clock Frequency	0	100	0	400	0	1000	kHz
$t_{HD:STA}$	Hold Time (repeated) START Condition	4.0		0.6		0.26		$\mu\text{s}$
$t_{LOW}$	LOW Period of the SCL Clock	4.7		1.3		0.5		$\mu\text{s}$
$t_{HIGH}$	HIGH Period of the SCL Clock	4.0		0.6		0.26		$\mu\text{s}$
$t_{SET:STA}$	Setup Time for a Repeated START Condition	4.7		0.6		0.26		$\mu\text{s}$
$t_{HD:DAT}$	Data Hold Time	0	3.45	0	0.9	0	0.33	$\mu\text{s}$
$t_{SET:DAT}$	Data Setup Time	250		100		50		ns
$t_f$	Fall Time of both SDA and SCL Signals		300		300		120	ns
$t_r$	Rise Time of both SDA and SCL Signals		1000		300		120	ns
$t_{SET:STO}$	Setup Time for STOP Condition	4.0		0.6		0.26		$\mu\text{s}$

**PI3USB31532Q**

**Part Marking**

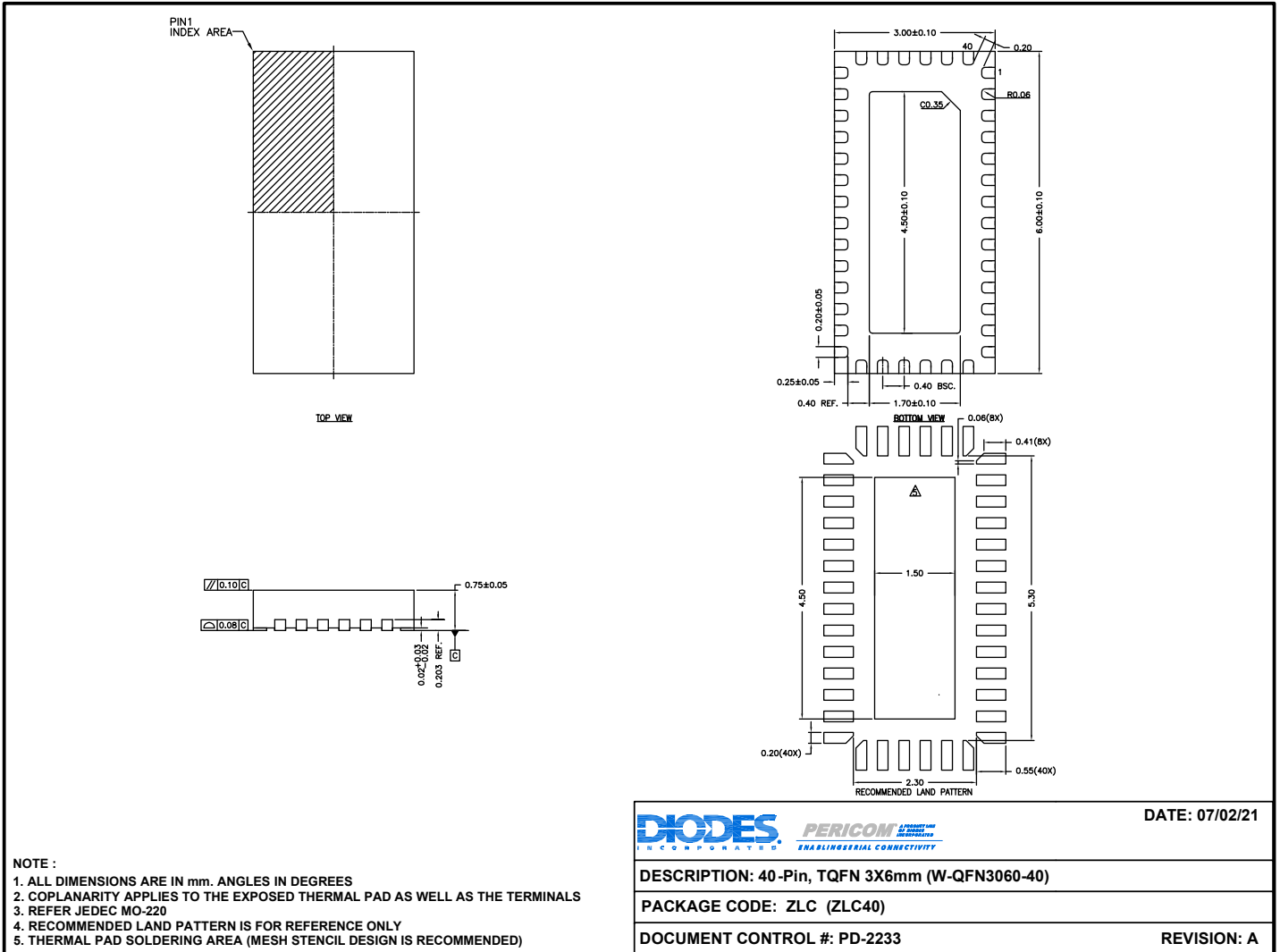


**Device Naming Information**



**Packaging Mechanical**

**40-TQFN (ZLC)**



21-1406

For latest package information:

See <http://www.diodes.com/design/support/packaging/pericom-packaging/packaging-mechanicals-and-thermal-characteristics/>.

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