



### 3.3V, USB 2.0 High Speed Signal Switch w/ Low THD Channels for Two Audio Signals

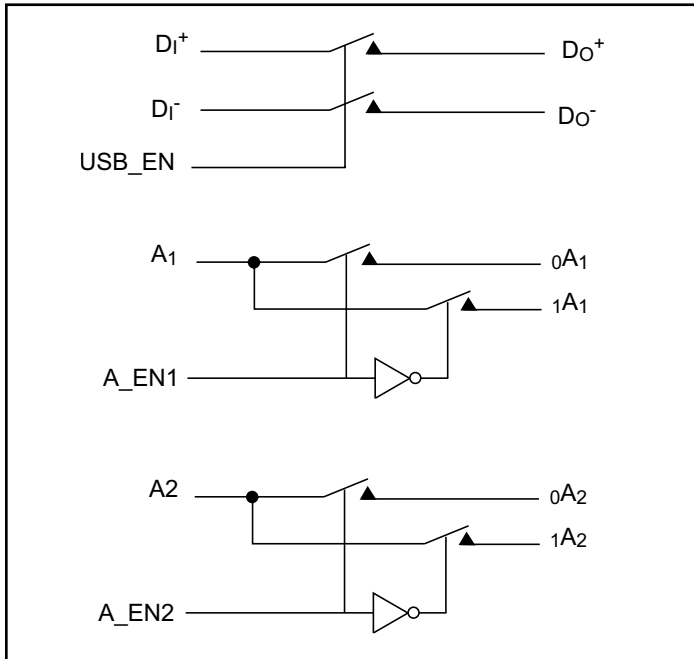
#### Features

- BW for USB ports > 1.2Gbps
- Low THD for Audio ports < 0.02%
- ESD > 2kV HBM
- Low I<sub>CC</sub> = 800uA
- Wide V<sub>CC</sub> operating range: 2.7V to 4.2V ±10%
- Audio signal Crosstalk @ 100kHz is -90dB
- Audio signal Off-isolation @ 100kHz is -75dB
- USB signal off-isolation @ 480 Mbps is -39dB
- Packaging: (Pb-free & Green): 16-contact TDFN (ZJ)

#### Description

PI3USB412 integrates two unique Pericom technology solutions into a single IC package. It offers the user a solution that switches both high speed differential signals, with high bandwidth performance, as well as low THD audio signals. For handheld applications where both a USB data transfer port and a port for an external headset is required, Pericom's PI3USB412 solution can offer the ability to combine the two ports into one. With a single port, design engineers are faced with an issue of switching two completely different types of signals. One signal is a high speed differential signal, where bandwidth is the largest concern, and the second signal is an audio signal, where low THD is the largest concern. Pericom's solution offers multiple channels within our PI3USB412 device. Two channels are targeted for high speed USB 2.0 signals (Dx), and two channels are targeted for low THD audio signals (Ax). The two low THD audio signals are developed in a mux configuration. Thus, the user can have two internal sources going to a single audio output.

#### Block Diagram



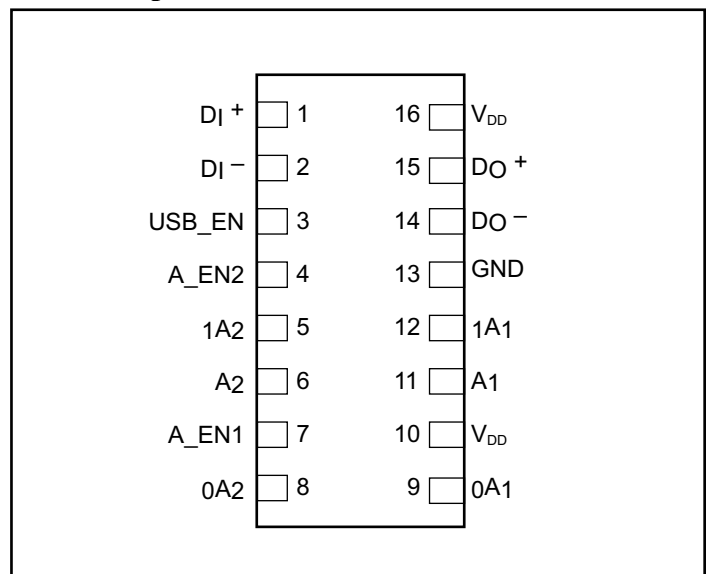
#### Truth Table

USB_EN	Function
0	D <sub>I</sub> = D <sub>O</sub>
1	D <sub>I</sub> = D <sub>O</sub> = Hi-Z

A_EN <sub>x</sub>	Function
0	A <sub>X</sub> = 0A <sub>X</sub>
1	A <sub>X</sub> = 1A <sub>X</sub>

Note: x = 1, 2

#### Pin Description





### Maximum Ratings

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

Storage Temperature .....	-65°C to +150°C
Supply Voltage to Ground Potential .....	-0.5V to +4.6V
DC Input Voltage .....	-0.5V to $V_{CC} + 0.5V$
DC Output Current .....	120mA
Power Dissipation .....	0.5W

**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.

### DC Electrical Characteristics for USB 2.0 Switching over Operating Range

(only related to pins 1, 2, 3, 14, 15)

( $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $V_{CC} = 3.3V \pm 10\%$ )

Parameter	Description	Test Conditions <sup>(1)</sup>	Min.	Typ. <sup>(2)</sup>	Max.	Units
$V_{IH}$	Input HIGH Voltage	Guaranteed HIGH level	$V_{CC} = 4.2V$	2.0		V
			$V_{CC} = 3.3V$	1.6		
$V_{IL}$	Input LOW Voltage	Guaranteed HIGH level			0.8	V
$V_{IK}$	Clamp Diode Voltage	$V_{CC} = \text{Max.}, I_{IN} = -18\text{mA}$		-0.7	-1.2	
$I_{IH}$	Input HIGH Current	$V_{CC} = \text{Max.}, V_{IN} = V_{CC}$			$\pm 5$	
$I_{IL}$	Input LOW Current	$V_{CC} = \text{Max.}, V_{IN} = \text{GND}$			$\pm 5$	
$R_{ON}$	Switch On-Resistance <sup>(3)</sup>	$V_{CC} = \text{Min.}, 1.25V \leq V_{IN} \leq V_{CC}, I_{IN} = -40\text{mA}$		4	6.5	$\Omega$
$R_{FLAT(ON)}$	On-Resistance Flatness <sup>(4)</sup>	$V_{CC} = \text{Min.}, V_{IN} @ 1.5V \text{ and } V_{CC}, I_{IN} = -40\text{mA}$		1.0		
$\Delta R_{ON}$	On-Resistance match from center ports to any other port <sup>(4)</sup>	$V_{CC} = \text{Min.}, 1.5V \leq V_{IN} \leq V_{CC}, I_{IN} = -40\text{mA}$		0.9	2	

### Capacitance for USB 2.0 Switching ( $T_A = 25^\circ\text{C}$ , $f = 1\text{ MHz}$ ) (only related to pins 1, 2, 3, 14, 15)

Parameters <sup>(4)</sup>	Description	Test Conditions <sup>(1)</sup>	Typ. <sup>(2)</sup>	Max.	Units
$C_{IN}$	Input Capacitance	$V_{IN} = 0V$	2.0	3.0	pF
$C_{OFF}$	Port I Capacitance, Switch OFF		4.0	6.0	
$C_{ON}$	Switch Capacitance, Switch ON		7.5	9.5	

#### Notes for Page 2:

- For max. or min. conditions, use appropriate value specified under Electrical Characteristics for the applicable device type.
- Typical values are at  $V_{CC} = 3.3V$ ,  $T_A = 25^\circ\text{C}$  ambient and maximum loading.
- Measured by the voltage drop between  $D_I$  and  $D_O$  pins at indicated current through the switch. On-resistance is determined by the lower of the voltages on the two ( $D_I$  &  $D_O$ ) pins.
- This parameter is determined by device characterization but is not production tested.

**Dynamic Electrical Characteristics Over the Operating Range**(T<sub>A</sub> = -40°C to +85°C, V<sub>CC</sub> = 3.3V ±10%, GND = 0V) (only related to pins 1, 2, 3, 14, 15)

Parameters	Description	Test Conditions	Typ. <sup>(4)</sup>	Units
X <sub>TALK</sub>	Crosstalk	R <sub>L</sub> = 100Ω, f = 250 MHz	-31	dB
O <sub>IRR</sub>	OFF Isolation		-39	
BW	Bandwidth -3dB	R <sub>L</sub> = 100Ω	700	MHz

**Switching Characteristics** (only related to pins 1, 2, 3, 14, 15)

Parameters	Description	Test <sup>(3)</sup> Conditions	Min.	Typ. <sup>(4)</sup>	Max.	Units
t <sub>PD</sub>	Propagation Delay <sup>(2)</sup>			0.25		ns
t <sub>PZH</sub> , t <sub>PZL</sub>	Line Enable Time - USB_EN to D <sub>N</sub>		0.5		15.0	
t <sub>PHZ</sub> , t <sub>PLZ</sub>	Line Disable Time - USB_EN to D <sub>N</sub>		0.5		9.0	
t <sub>SK(p)</sub>	Skew between opposite transitions of the same output (t <sub>PHL</sub> - t <sub>PLH</sub> ) <sup>(2)</sup>			0.1	0.2	

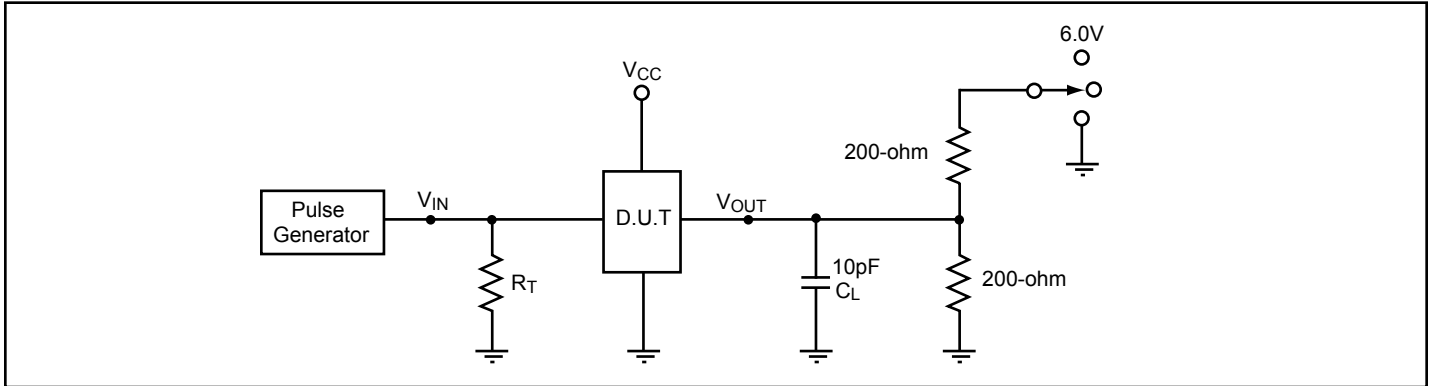
**Power Supply Characteristics**

Parameters	Description	Test Conditions <sup>(3)</sup>	Min.	Typ.	Max.	Units
I <sub>CC</sub>	Quiescent Power Supply Current	V <sub>CC</sub> = Max., V <sub>IN</sub> = GND or V <sub>CC</sub>			800	μA

**Notes for Page 3:**

- Guaranteed by design.
- The switch contributes no propagational delay other than the RC delay of the On-Resistance of the switch and the load capacitance. The time constant for the switch alone is of the order of 0.25ns for 10pF load. Since this time constant is much smaller than the rise/fall times of typical driving signals, it adds very little propagational delay to the system. Propagational delay of the bus switch when used in a system is determined by the driving circuit on the driving side of the switch and its interactions with the load on the driven side.
- For max. or min. conditions, use appropriate value specified under Electrical Characteristics for the applicable device type.
- Typical values are at V<sub>CC</sub> = 3.3V, T<sub>A</sub> = 25C ambient and maximum loading.

**Test Circuit for Electrical Characteristics**



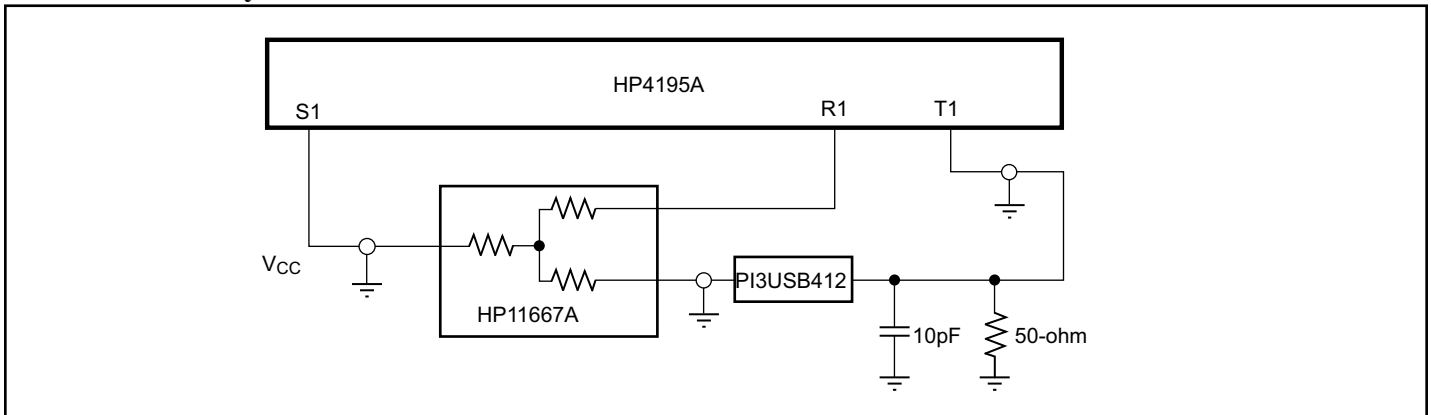
**Notes:**

- $C_L$  = Load capacitance: includes jig and probe capacitance.
- $R_T$  = Termination resistance: should be equal to  $Z_{OUT}$  of the Pulse Generator
- Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control.  
Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.
- All input impulses are supplied by generators having the following characteristics:  $PRR \leq \text{MHz}$ ,  $Z_O = 50\Omega$ ,  $t_R \leq 2.5\text{ns}$ ,  $t_F \leq 2.5\text{ns}$ .
- The outputs are measured one at a time with on transition per measurement.

**Switch Positions**

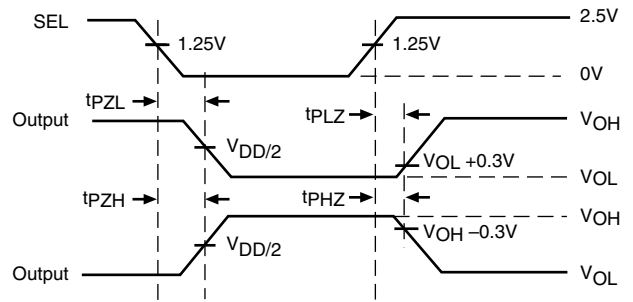
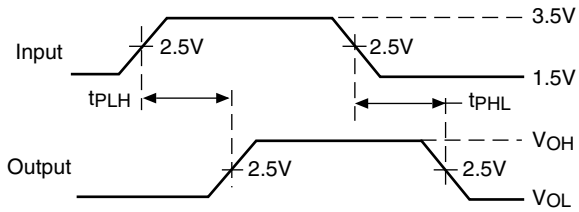
Test	Switch
$t_{PLZ}$ , $t_{PZL}$ (output on O-side)	6.0V
$t_{PHZ}$ , $t_{PZH}$ (output on O-side)	GND
Prop Delay	Open

**Test Circuit for Dynamic Electrical Characteristics**



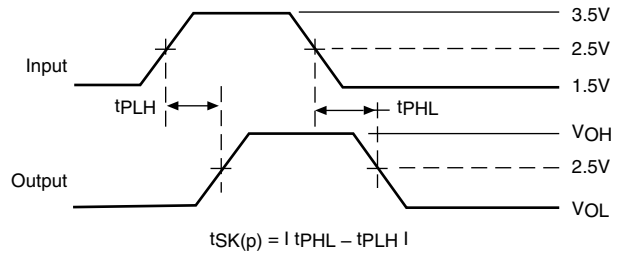


Switching Waveforms



Voltage Waveforms Propagation Delay Times

Voltage Waveforms Enable and Disable Times



$$t_{SK(p)} = |t_{PHL} - t_{PLH}|$$

Pulse Skew -  $t_{SK(p)}$



**Audio Switch** (only related to pins 4, 5, 6, 7, 8, 9, 11, 12)

### DC Electrical Characteristics +3V Supply

( $V_{CC} = 2.7V$  to  $3.3V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $3V$  and  $+25^{\circ}C$ .)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
<b>Analog Switch</b>						
Analog Signal Range	$V_{1AX}, V_{0AX}, V_{AX}$		-0.3		$V_{CC}$	V
$1AX$ On-Resistance	$R_{ON(0AX)}$	$V_{CC} = 2.7V, I_{AX} = 100mA, V_{0AX} = 0$ to $V_{CC}$		0.6	0.8	$\Omega$
$0AX$ On-Resistance	$R_{ON(1AX)}$	$V_{CC} = 2.7V, I_{AX} = 100mA, V_{1AX} = 0$ to $V_{CC}$		0.6	0.8	
On-Resistance Match Between Channels	$\Delta R_{ON}$	$V_{CC} = 2.7V, I_{AX} = 100mA, V_{0AX}$ or $V_{1AX} = 1.5V$		0.01	0.06	
$0AX$ On-Resistance Flatness	$R_{ONF(0AX)}$	$V_{CC} = 2.7V, I_{AX} = 100mA, V_{0AX} = 0$ to $V_{CC}$			0.25	
$1AX$ On-Resistance Flatness	$R_{ONF(1AX)}$	$V_{CC} = 2.7V, I_{AX} = 100mA, V_{1AX} = 0$ to $V_{CC}$			0.15	
$1AX$ or $AX$ Off Leakage Current	$I_{OFF(1AX)}$ or $I_{OFF(0AX)}$	$V_{CC} = 3.3V, V_{0AX}$ or $V_{1AX} = 3V, 0.3V, V_{AX} = 0.3V, 3V$	-400		400	
$AX$ On Leakage Current	$I_{AX(ON)}$	$V_{CC} = 3.3V, V_{1AX}$ or $V_{0AX} = 3V, 0.3V, V_{AX} = 0.3V, 3V$ , or floating	-160		160	
<b>Digital I/O</b>						
Input Logic High	$V_{IH}$		1.3			V
Input Logic Low	$V_{IL}$				0.6	
Input Hysteresis	$V_H$	$V_{CC} = 3.3V$		200		mV
Input Leakage Current	$I_{A\_EN}$	$V_{A\_EN} = 0$ or $V_{CC}$	-0.5		0.5	$\mu A$
<b>Power Supply</b>						
Power-Supply Range	$V_{CC}$		2.7		4.6	V

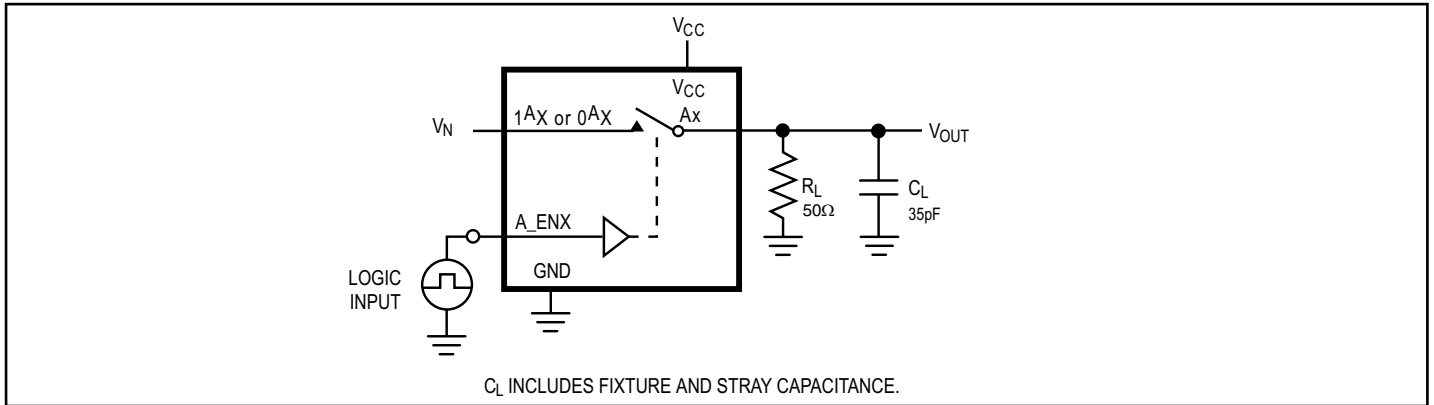

**Switch and AC Characteristics** (only related to pins 4, 5, 6, 7, 8, 9, 11, 12)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Turn-On Time	$t_{ON}$	$V_{CC} = 2.7V$ , $V_{1AX}$ or $V_{0AX} = 1.5V$ , $R_L = 50\Omega$ , $C_L = 35pF$ , <i>See Test Circuit Figure 1 &amp; 2.</i>		15	25	ns
Turn-Off Time	$t_{OFF}$	$V_{CC} = 2.7V$ , $V_{1AX}$ or $V_{0AX} = 1.5V$ , $R_L = 50\Omega$ , $C_L = 35pF$ , <i>See Test Circuit Figure 1 &amp; 2.</i>		4	10	
Break-Before-Make Delay	$t_{BBM}$	$V_{CC} = 2.7V$ , $V_{1AX}$ or $V_{0AX} = 1.5V$ , $R_L = 50\Omega$ , $C_L = 35pF$ , <i>See Test Circuit Figure 3.</i>			20	
Charge Injection	Q	$A_X = 0$ , $R_S = 0$ , $C_L = 1nF$ , <i>See Test Circuit Figure 4.</i>		55		pC
Off-Isolation	$O_{IRR}$	$C_L = 5pF$ , $R_L = 50\Omega$ , $f = 100kHz$ , $V_{AX} = 1 V_{RMS}$ , <i>See Test Circuit Figure 5.</i>		-75		dB
Crosstalk	$X_{TALK}$	$C_L = 5pF$ , $R_L = 50\Omega$ , $f = 100kHz$ , $V_{AX} = 1 V_{RMS}$ , <i>See Test Circuit Figure 6.</i>		-90		
3dB Bandwidth	$f_{3dB}$	<i>See Test Circuit Figure 9.</i>		60		MHz

**Capacitance**

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
$0A_X$ Off Capacitance	$C_{(OFF)}$	$f = 1 MHz$ , <i>See Test Circuit Figure 7.</i>		35		pF
$1A_X$ Off Capacitance	$C_{(OFF)}$	$f = 1 MHz$ , <i>See Test Circuit Figure 7.</i>		35		
$0A_X$ On Capacitance	$C_{(ON)}$	$f = 1 MHz$ , <i>See Test Circuit Figure 8.</i>		95		
$1A_X$ On Capacitance	$C_{(ON)}$	$f = 1 MHz$ , <i>See Test Circuit Figure 8.</i>		95		

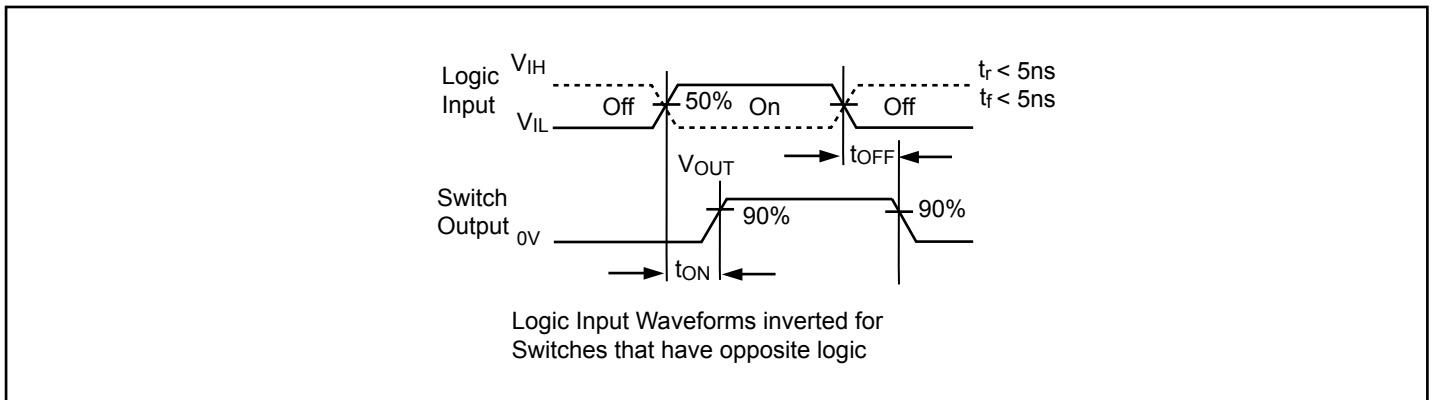
**Test Circuits and Timing Diagrams** (only related to pins 5, 6, 7, 8, 9, 11, 12)



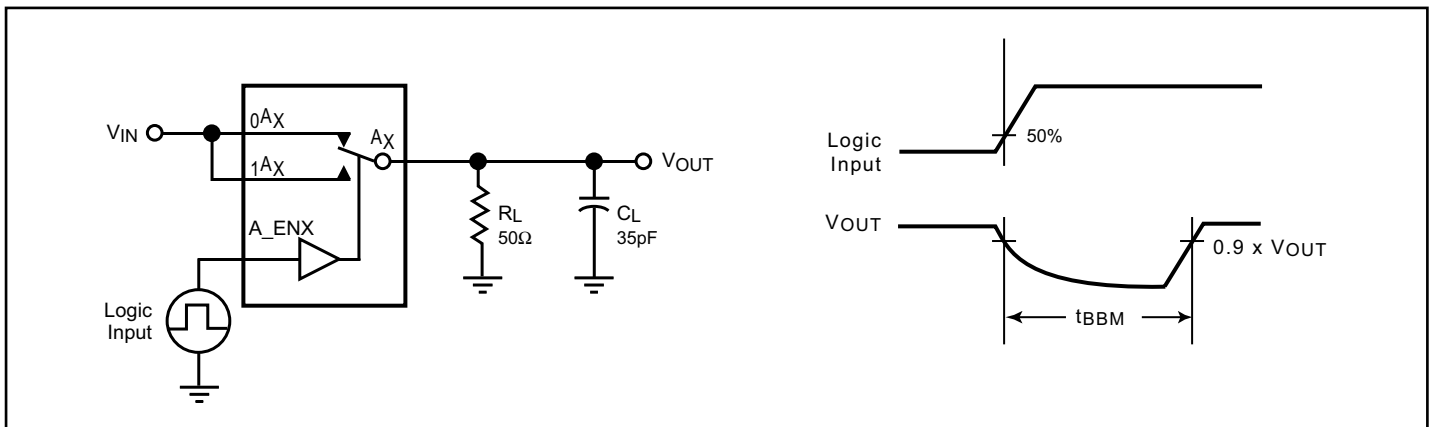
**Note:**

1. Unused input must be grounded.

**Figure 1. AC Test Circuit**



**Figure 2. AC Waveforms**



**Figure 3. Break Before Make Interval Timing**



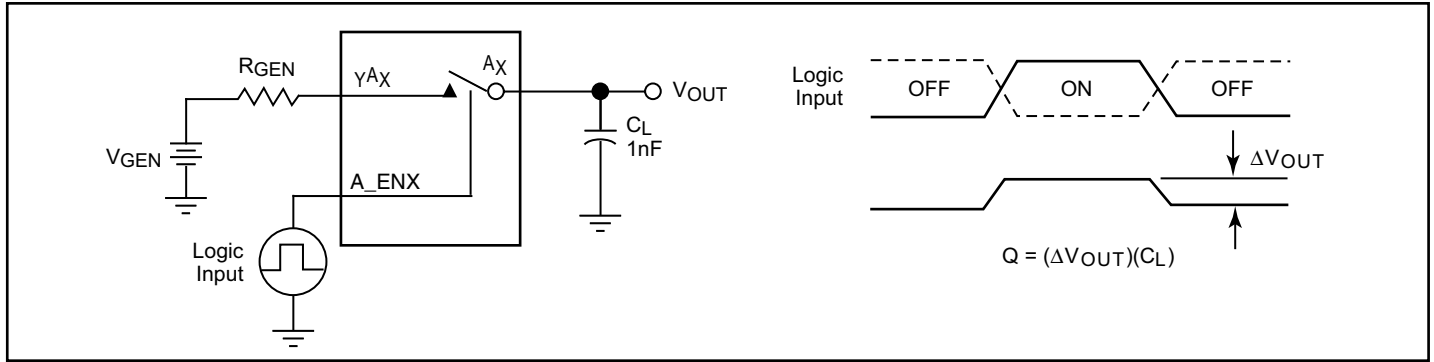


Figure 4. Charge Injection Test

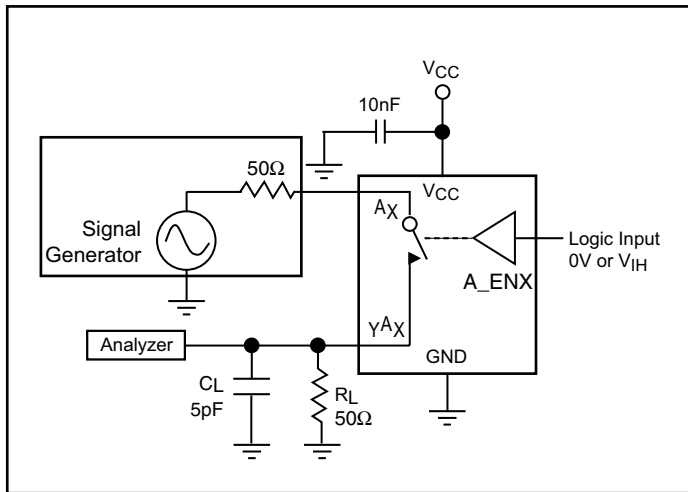


Figure 5. Off Isolation

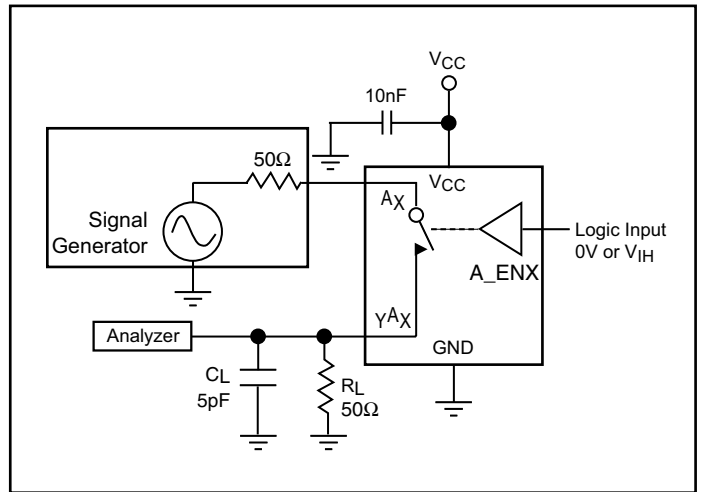


Figure 6. Crosstalk

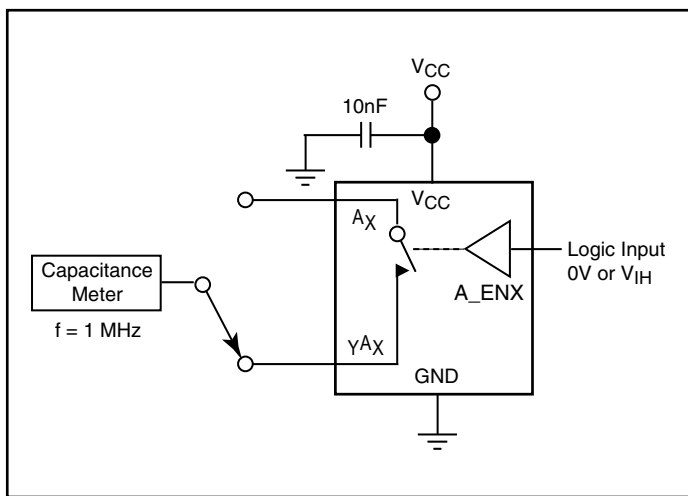


Figure 7. Channel Off Capacitance

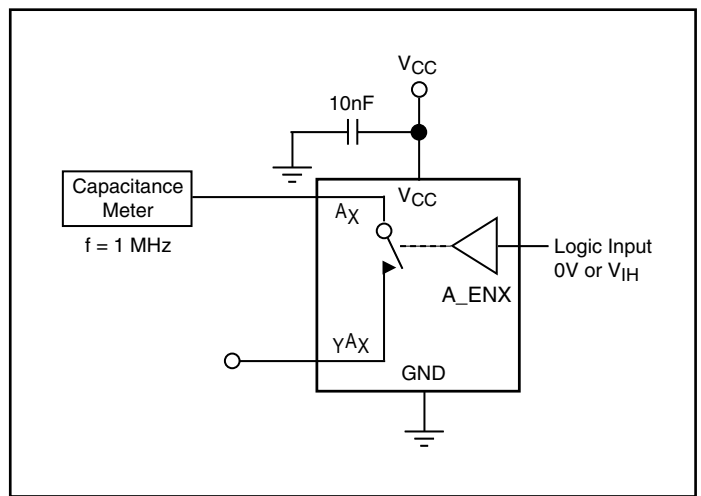


Figure 8. Channel On Capacitance

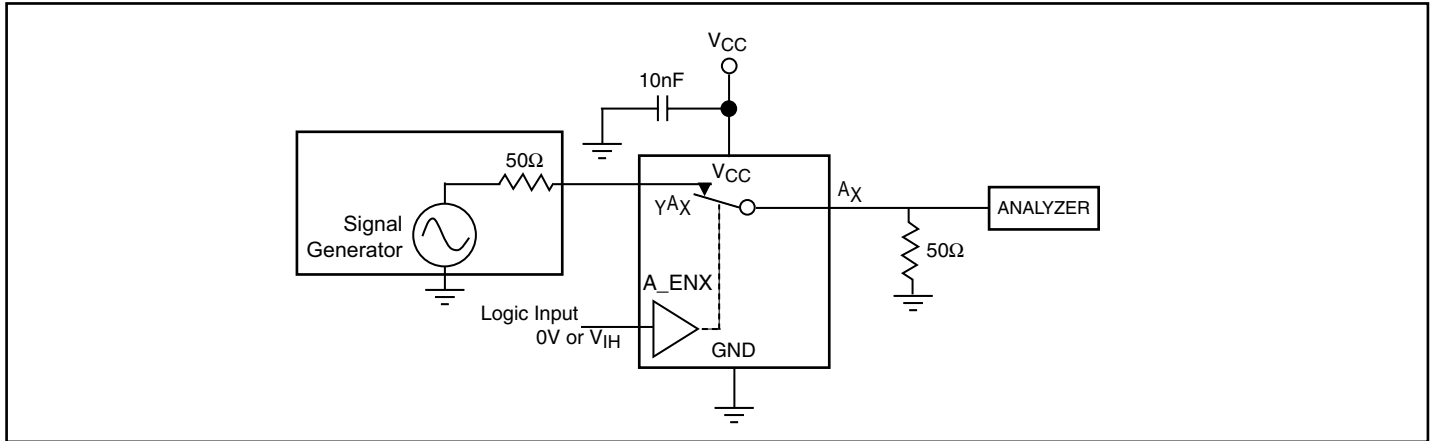
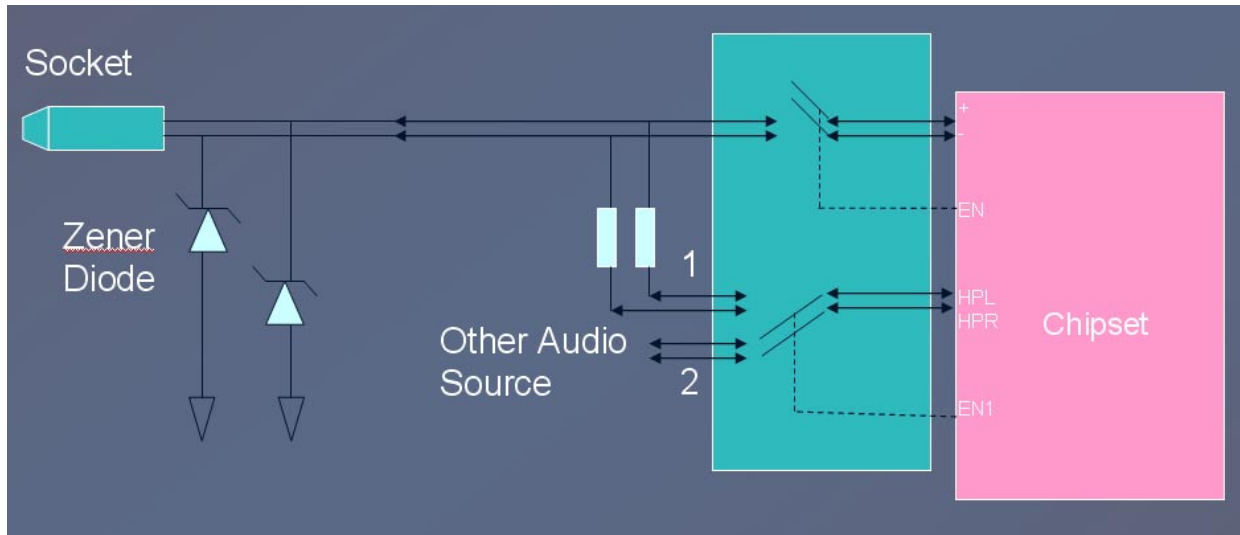


Figure 9. Bandwidth

### Application Information

#### USB 2.0 HS Data + Audio



#### USB 2.0 Signals + High Fidelity Audio Signals

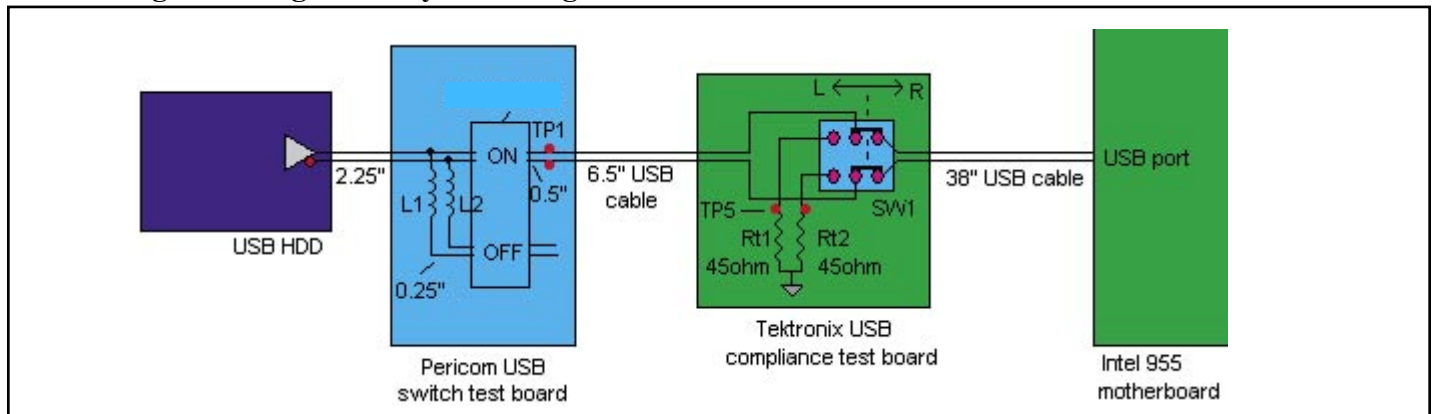
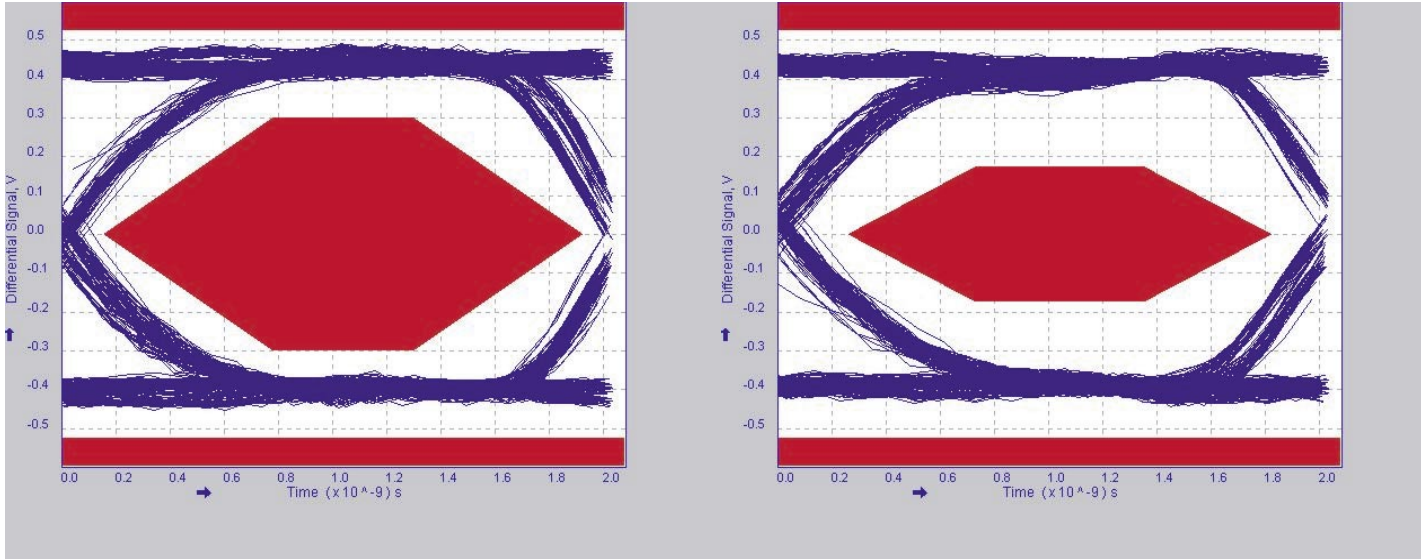
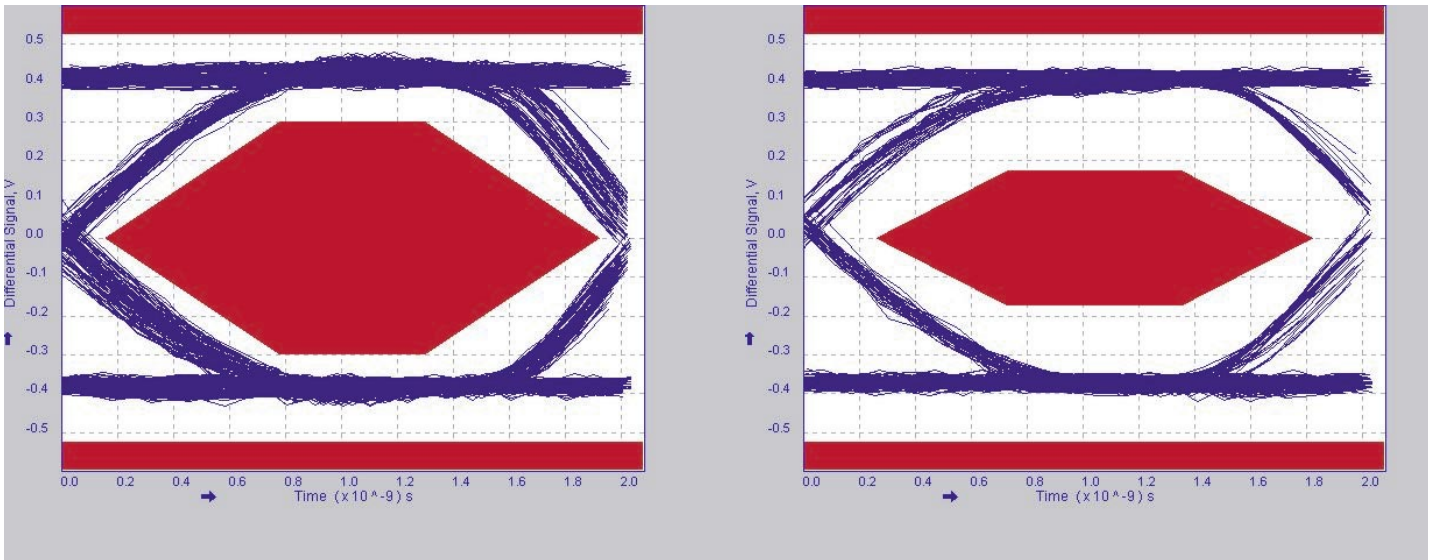


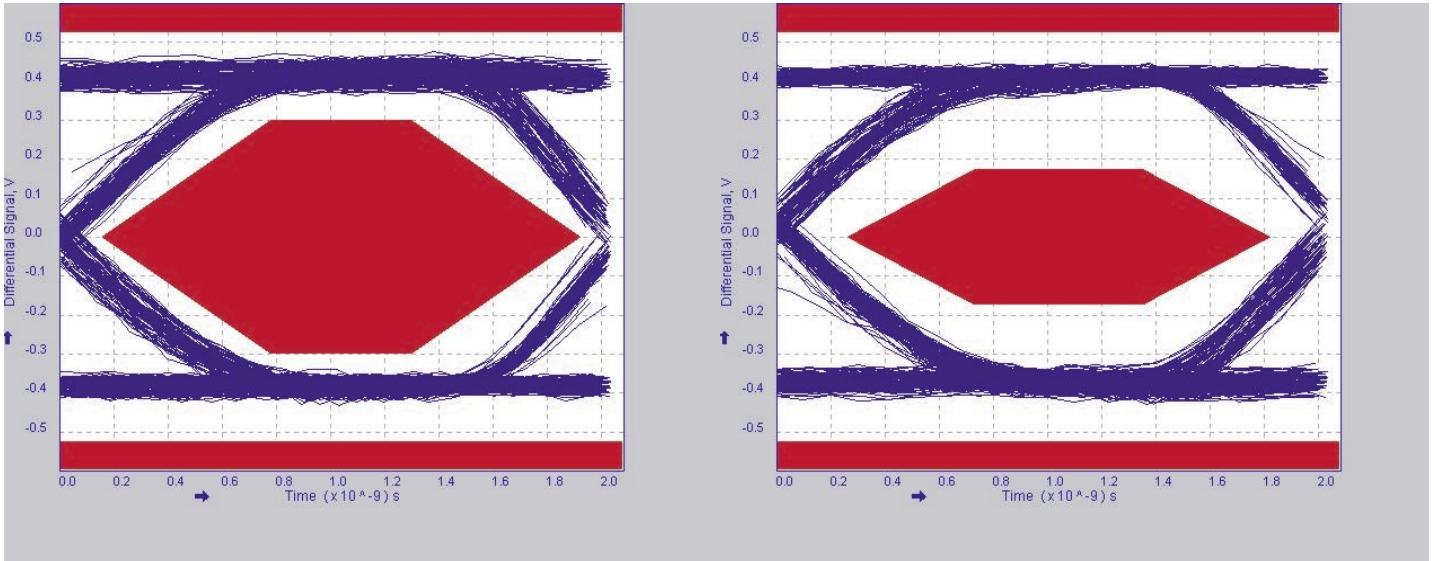
Figure 10: USB 2.0 high-Speed (480Mbps) Signal Test Set-up



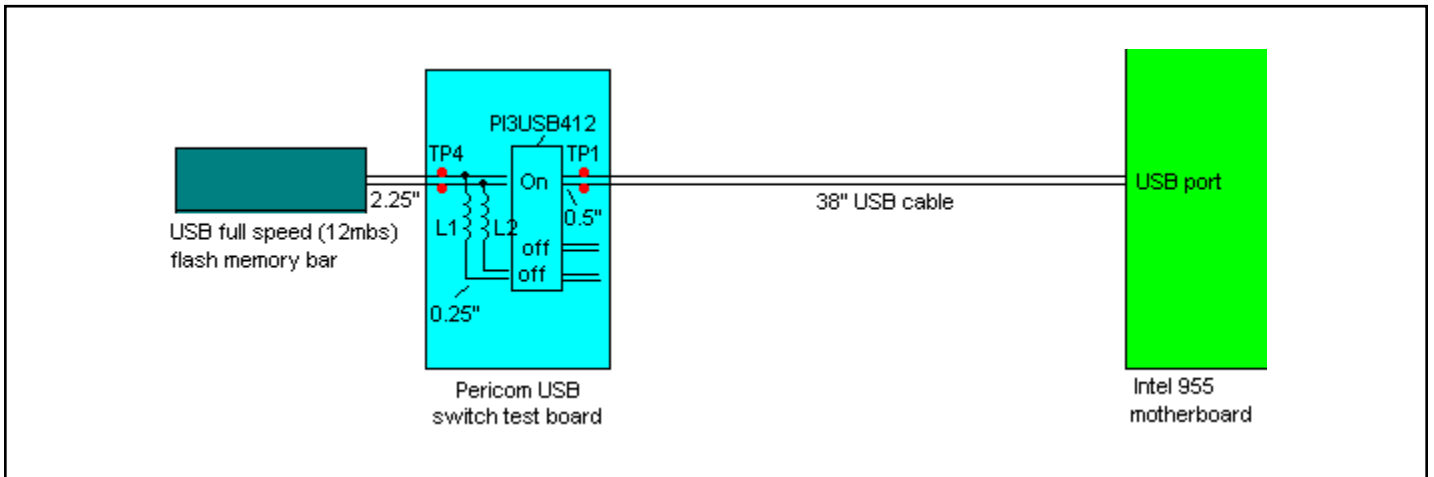
**Figure 11:** USB 2.0 High-Speed (480Mbps) TP1, left eye, and TP5, right eye, tested with no PI3USB412 in the signal path



**Figure 12:** USB 2.0 High-Speed (480Mbps) TP1, left eye, and TP5, right eye, tested with only USB data signals connected (Audio signals are left not connected with no inductors).



**Figure 13:** USB 2.0 High-Speed (480Mbps) TP1, left eye, and TP5, right eye, tested with PI3USB412 in the signal path with Analog signals “Off” and 9.3uH Inductors for L1 and L2



**Figure 14:** USB 2.0 full-Speed (12Mbps) Signal Test Set-up



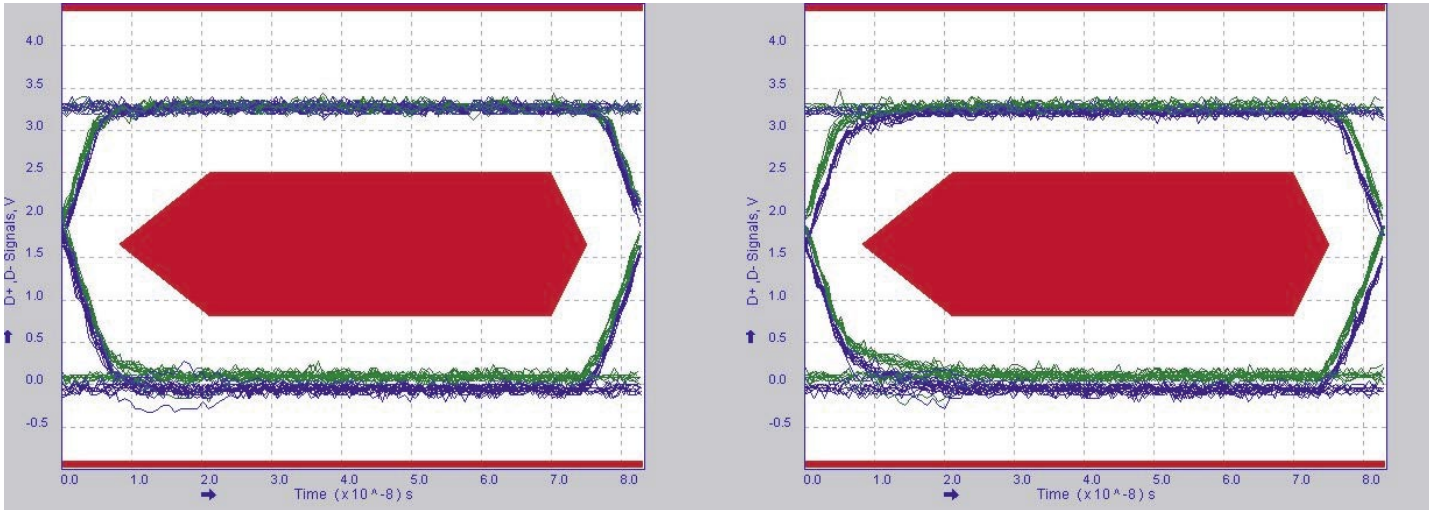


Figure 15: USB 2.0 Full-Speed (12Mbps) TP1, left eye, and TP4, right eye, tested with no PI3USB412 in the signal path

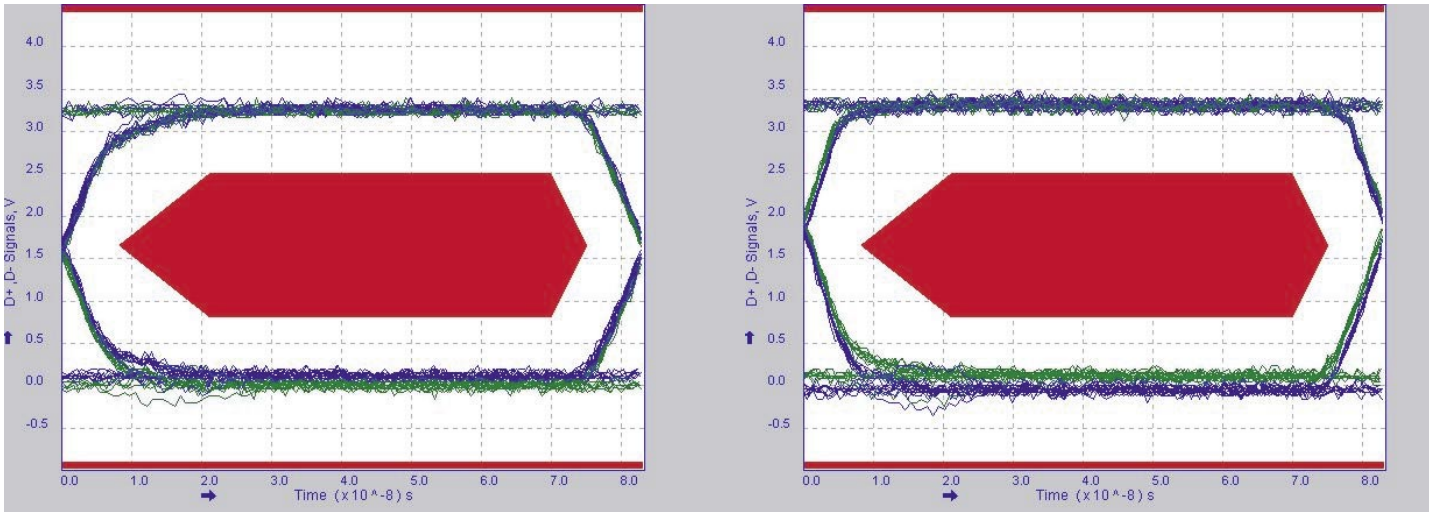


Figure 16: USB 2.0 Full-Speed (12Mbps) TP1, left eye, and TP4, right eye, tested with only USB data signals connected (Audio signals are left not connected with no inductors).

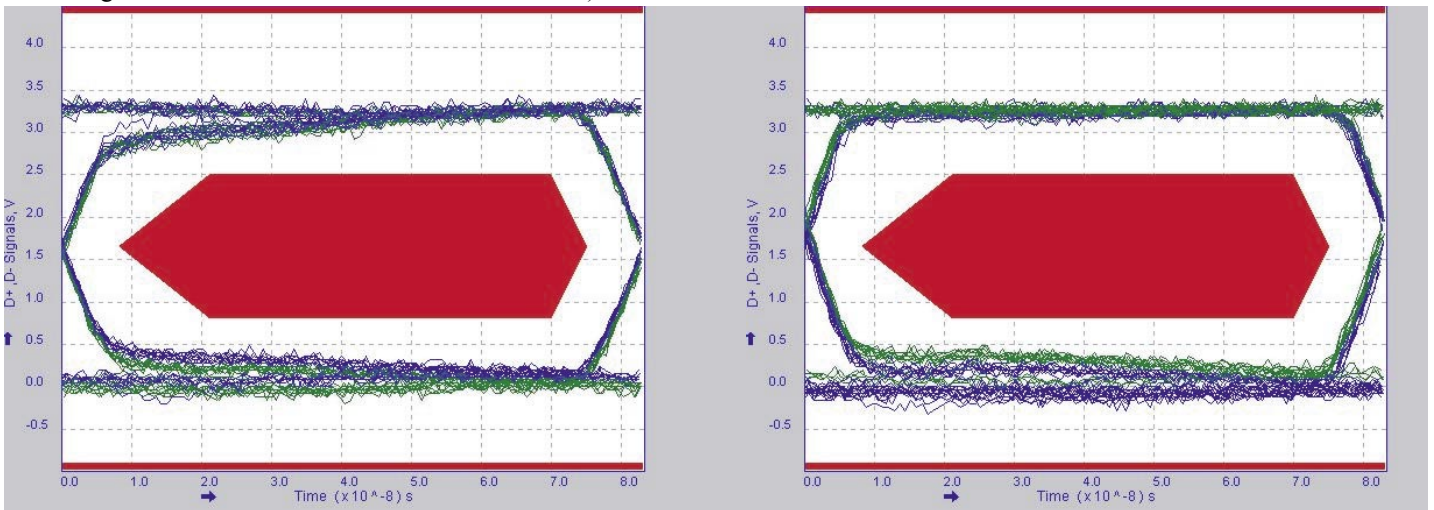
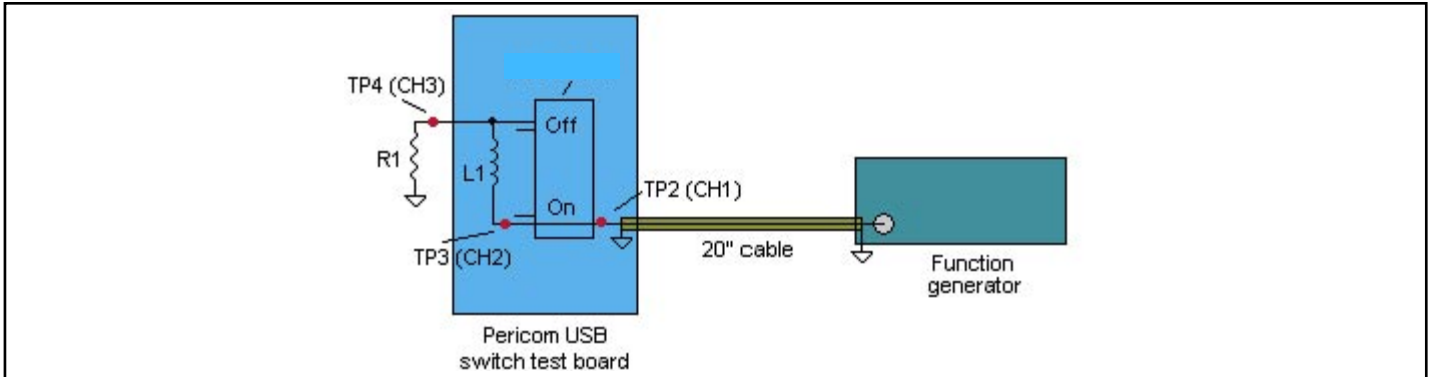
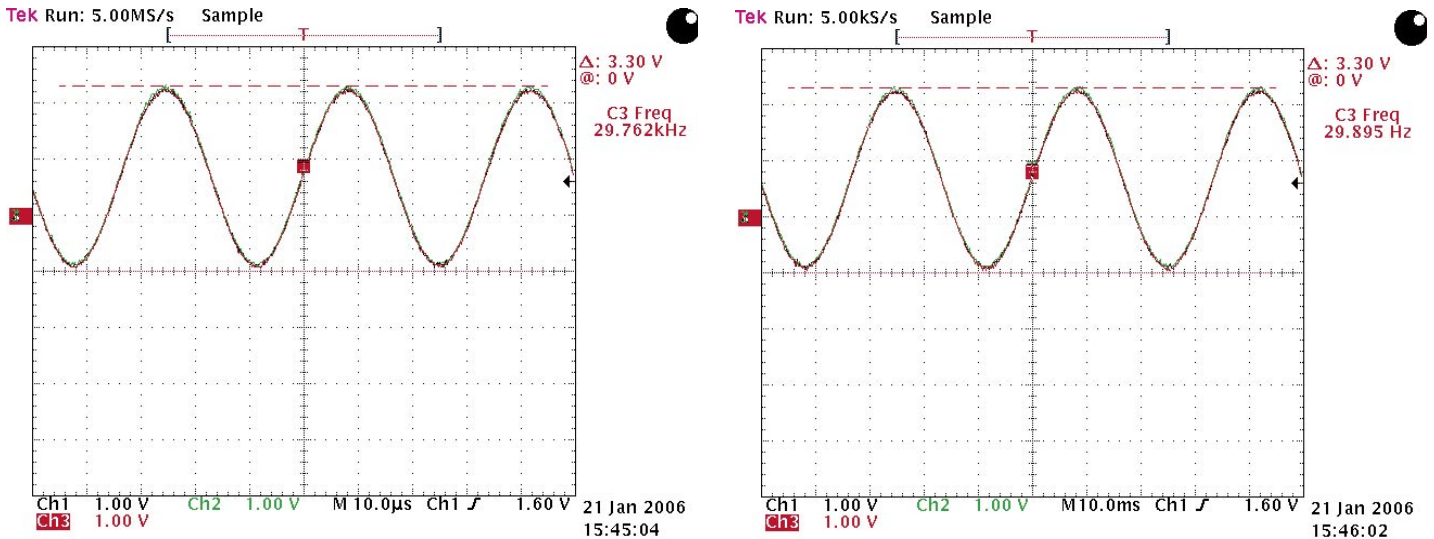


Figure 17: USB 2.0 Full-Speed (12Mbps) TP1, left eye, and TP4, right eye, tested with PI3USB412 in the signal path with Analog signals "Off" and 9.3uH Inductors for L1 and L2

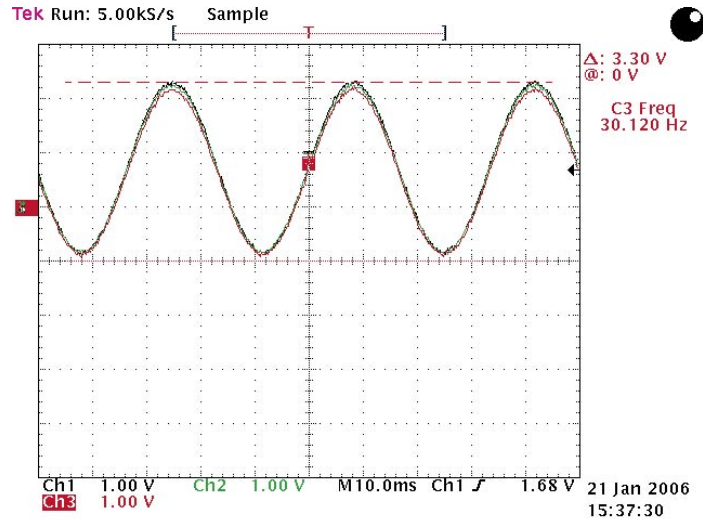
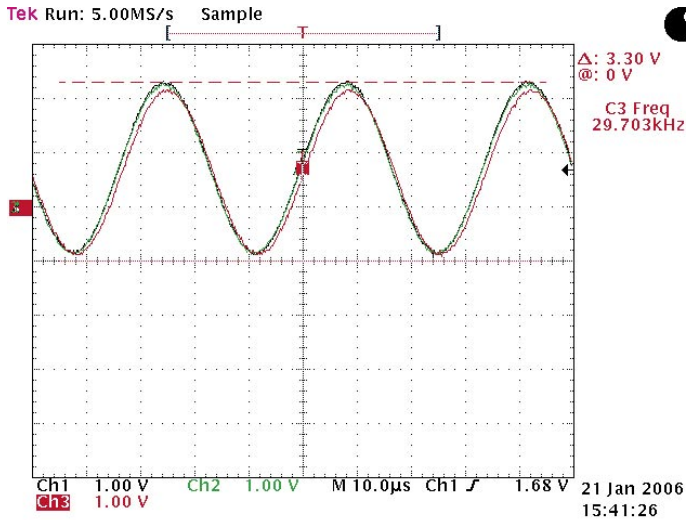


**Figure 18:** High Fidelity Audio Signal Test Setup.

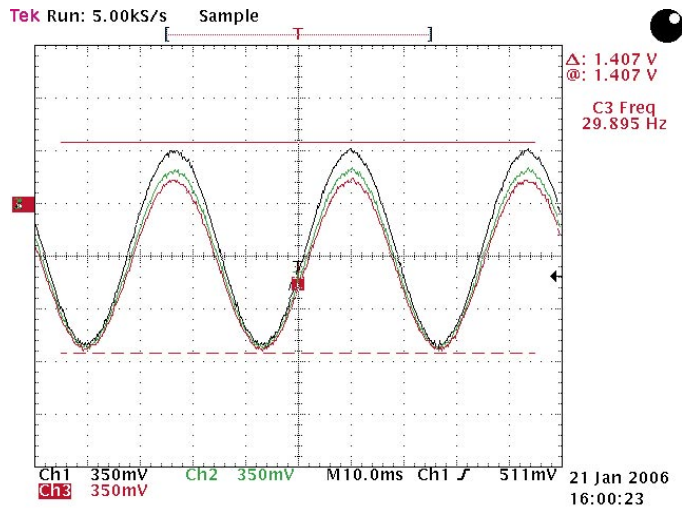
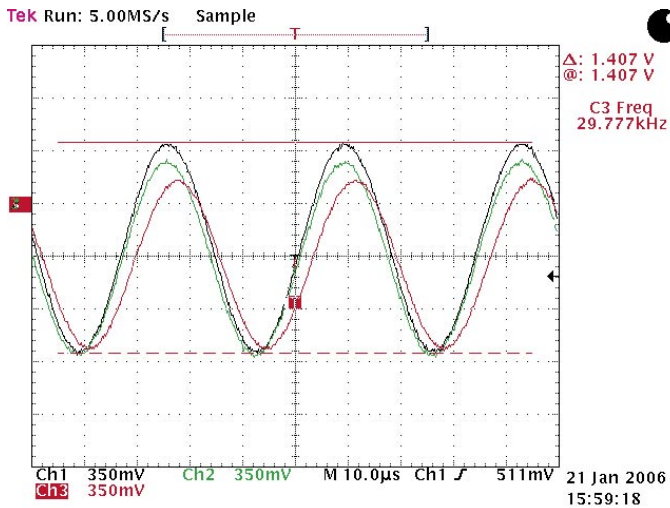
In Figure 18, the test flow is to send a sine wave signal from 30Hz to 30KHz from the Function Generator (HP8116A) to the Pericom Test Board. Pericom took measurements on three test points using a Tektronix Scope (TDS694C). The three test points were TP2 (Channel 1 on Scope), TP3 (Channel 2 on Scope), and TP4 (Channel 3 on Scope). R1 represents the termination of the headset speaker.



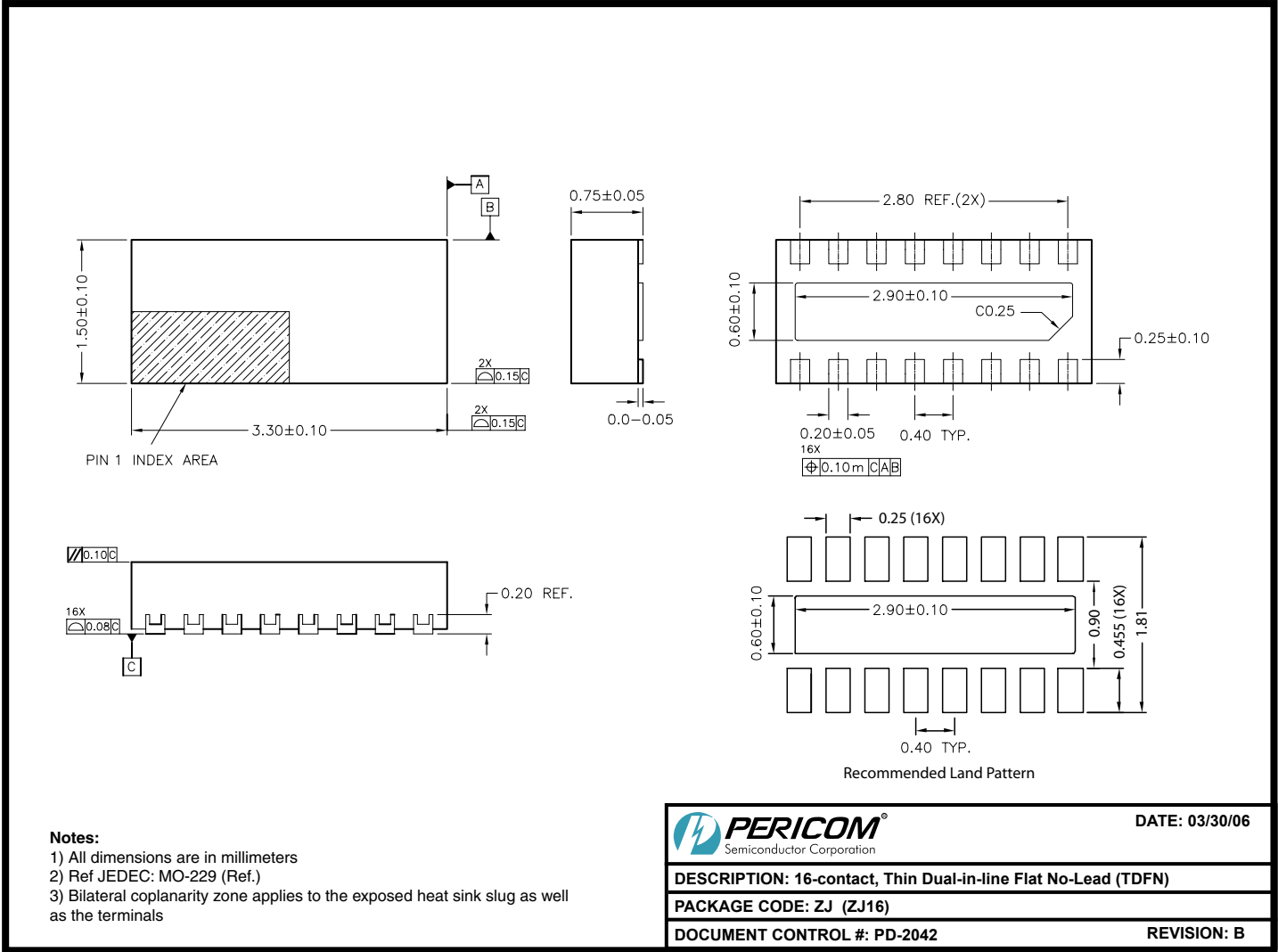
**Figure 19:** See Figure 18 for test setup. R1=12K and the sine wave on the left plot is 30KHz, while the sine wave on the right is 30Hz. Channel 1 (black)=TP2, Channel 2 (green)=TP3, Channel 3 (red)=TP4



**Figure 20:** R1=15-ohm, left→30kHz, right→30hz, channel 1 (black)=TP2, channel 2 (green)=TP3, channel 3(red)=TP4



**Figure 21:** R1=4 Ohm and the sine wave on the left plot is 30KHz, while the sine wave on the right is 30Hz. Channel 1 (black)=TP2, Channel 2 (green)=TP3, Channel 3(red)=TP4



### Ordering Information

Ordering Code	Package Code	Package Description	Package Top Mark
PI3USB412ZJEX	ZJ	Pb-free & Green, 16-contact TDFN	U2E

**Notes:**

- Thermal characteristics can be found on the company web site at [www.pericom.com/packaging/](http://www.pericom.com/packaging/)
- E = Pb-free and Green
- Adding an X suffix = Tape/Reel