PERICOM®

PI3USB411

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

Features

- Bandwidth for USB ports > 1.2Gbps
- Low THD for Audio ports < 0.02%
- ESD > 2kV HBM
- Low I_{CC} = 800µA
- Wide V_{CC} operating range: 2.7V to 4.2V ±10%
- Packaging: Pb-free & Green, 16-contact TDFN (ZJ16)

Description

PI3USB411 integrates two unique Pericom technology solutions into a single IC package. PI3USB411 offers the customer 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, the PI3USB411 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 the PI3USB411 device. Two channels are targeted for high speed USB2.0 signals (Dx), and two channels are targeted for low THD audio signals (Ax). Due to its passive nature, all paths will allow bi-directional traffic.

Block Diagram
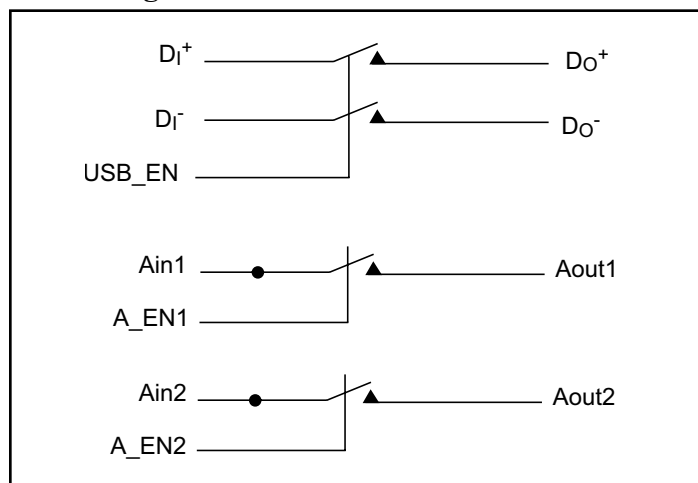
Pin Description
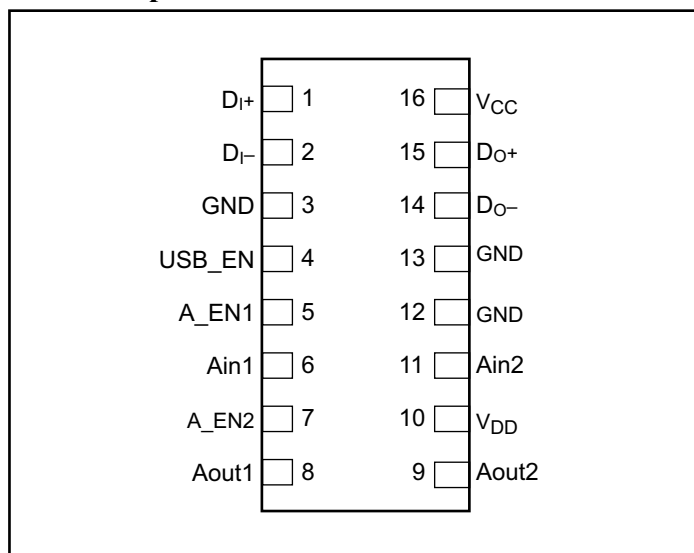
Truth Table

USB_EN	Function
0	$D_I = D_O$
1	$D_I = D_O$ = Hi-Z

A_ENx	Function
0	Ainx = Aoutx
1	Ainx = Aoutx = Hi-Z

Note: x = 1, 2

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 +4.4V
DC Input Voltage .... −0.5V to +5.5V
DC Output Current 120mA
Power Dissipation 0.5W

Note: Stresses greater than those listed under MAXIMUM RAT-INGS 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, 4, 14, 15)
($T_A = -40°C$ to $+85°C$, $V_{CC} = 3.3V \pm 10\%$)

Paramenter	Description	Test Conditions [1]		Min.	Typ.[2]	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_{IK}	Clamp Diode Voltage	V_{CC} = Max., $I_{IN} = -18mA$			-0.7	-1.2	
I_{IH}	Input HIGH Current	V_{CC} = Max., $V_{IN} = VCC$				±5	μA
I_{IL}	Input LOW Current	V_{CC} = Max., $V_{IN} = GND$				±5	
R_{ON}	Switch On-Resistance[3]	V_{CC} = Min., $1.25V \leq V_{IN} \leq V_{CC}$, $I_{IN} = -40mA$			4	6.5	Ω
$R_{FLAT(ON)}$	On-Resistance Flatness[4]	V_{CC} = Min., V_{IN} @ 1.5V and V_{CC} I_{IN} = -40mA			1.0		
ΔR_{ON}	On-Resistance match from center ports to any other port[4]	V_{CC} = Min., $1.5V \leq V_{IN} \leq V_{CC}$, I_{IN} = -40mA			0.9	2	

Capacitance for USB 2.0 Switching ($T_A = 25°C$, f = 1 MHz) (only related to pins 1, 2, 4, 14, 15)

Parameters[4]	Description	Test Conditions[1]	Typ.[2]	Max.	Units
C_{IN}	Input Capacitance		2.0	3.0	pF
C_{OFF}	Port I Capacitance, Switch OFF	$V_{IN} = 0V$	4.0	6	
C_{ON}	Switch Capacitance, Switch ON		7.5	9.5	

Notes for Page 2:
1. For max. or min. conditions, use appropriate value specified under Electrical Characteristics for the applicable device type.
2. Typical values are at $V_{CC} = 3.3V$, $T_A = 25°C$ ambient and maximum loading.
3. 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.
4. This parameter is determined by device characterization but is not production tested.

Dynamic Electrical Characteristics Over the Operating Range

(T_A = –40°C to +85°C, V_{CC} = 3.3V ±10%, GND = 0V) (Only related to pins 1, 2, 4, 14, 15)

Parameters[1]	Description	Test Conditions[3]	Typ.[4]	Units
X_{TALK}	Crosstalk	R_L = 100Ω, f = 250 MHz	-31	dB
O_{IRR}	OFF Isolation		-39	
BW	Bandwidth -3dB	R_L = 100Ω	700	MHz

Switching Characteristics (Only related to pins 1, 2, 4, 14, 15)

Parameters	Description	Test [3] Conditions	Min.	Typ.[4]	Max.	Units
t_{PD}	Propagation Delay[2]			0.25		
t_{PZH}, t_{PZL}	Line Enable Time - USB_EN to D_I, D_O		0.5		15.0	
t_{PHZ}, t_{PLZ}	Line Disable Time - USB_EN to D_I, D_O		0.5		9.0	ns
$t_{SK(p)}$	Skew between opposite transitions of the same output (t_{PHL} - t_{PLH}) [2]			0.1	0.2	

Power Supply Characteristics

Parameter	Description	Test Conditions[3]	Min.	Typ.	Max.	Units
I_{CC}	Power Supply Current	V_{CC} = Max, V_{IN} = GND or V_{CC}			800	µA

Notes for Page 3:
1. Guaranteed by design.
2. 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.
3. For max. or min. conditions, use appropriate value specified under Electrical Characteristics for the applicable device type.
4. Typical values are at V_{CC} = 3.3V, T_A = 25C ambient and maximum loading.

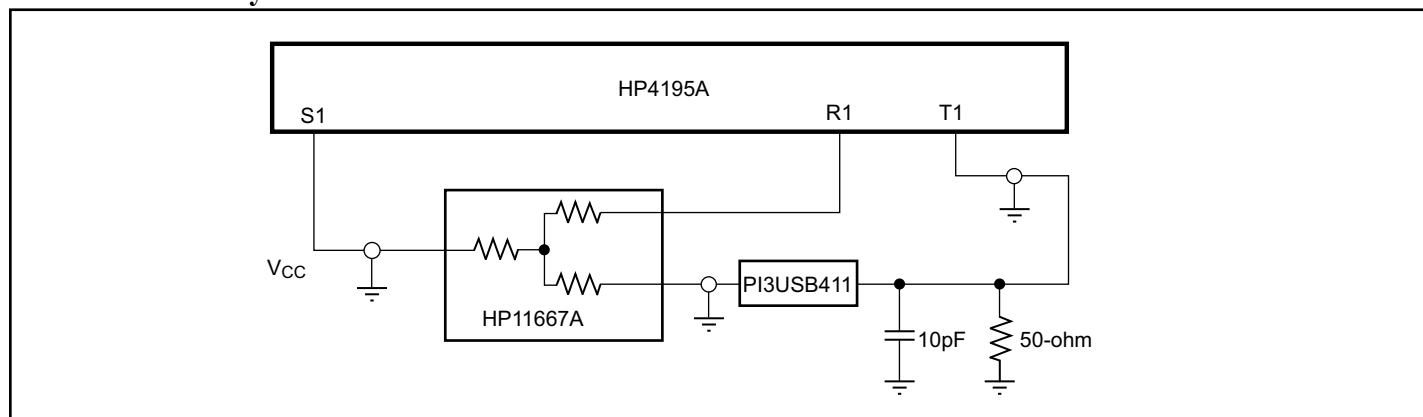## Test Circuit for Electrical Characteristics
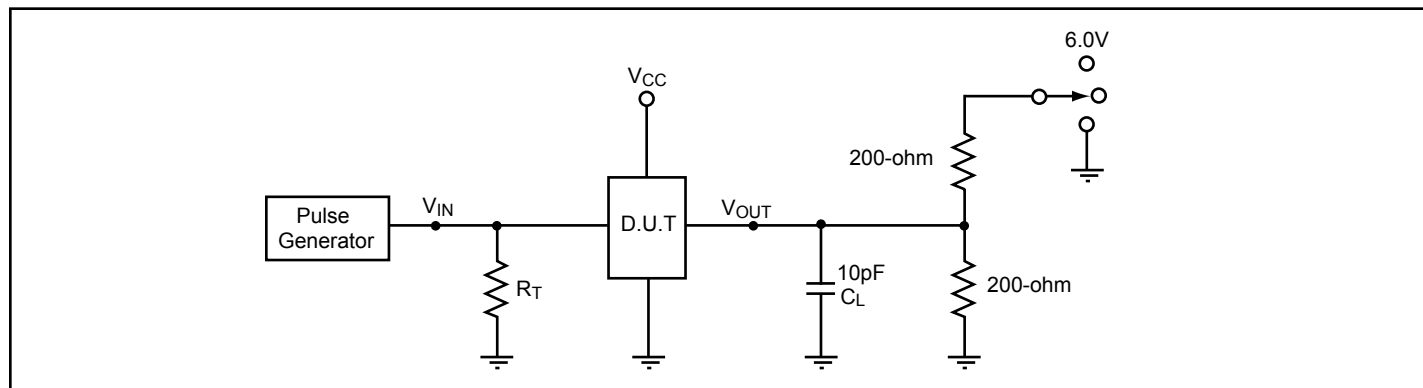
Notes:

- 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 ≤ MHz, $Z_O = 50\Omega$, $t_R \leq 2.5ns$, $t_F \leq 2.5ns$.
- 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
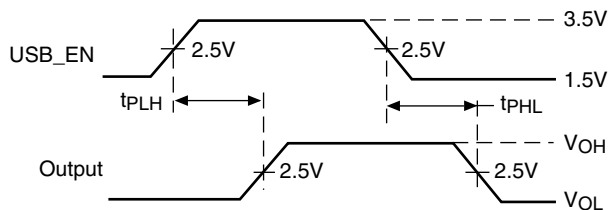
Voltage Waveforms Propagation Delay Times

USB_EN — 2.5V ... 2.5V — 3.5V / 1.5V

t_{PLH} t_{PHL}

Output — 2.5V ... 2.5V — V_{OH} / V_{OL}
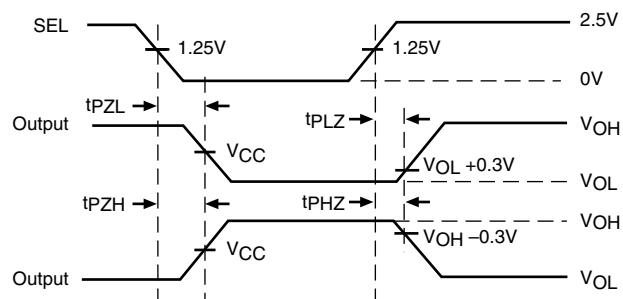
Voltage Waveforms Enable and Disable Times

SEL — 1.25V ... 1.25V — 2.5V / 0V

Output — t_{PZL} ... t_{PLZ} — V_{CC}, V_{OH}, V_{OL} +0.3V, V_{OL}

Output — t_{PZH} ... t_{PHZ} — V_{CC}, V_{OH}, V_{OH} −0.3V, V_{OL}

Input — 3.5V / 2.5V / 1.5V

t_{PLH} t_{PHL}

Output — V_{OH} / 2.5V / V_{OL}

$t_{SK(p)} = |\, t_{PHL} - t_{PLH}\, |$
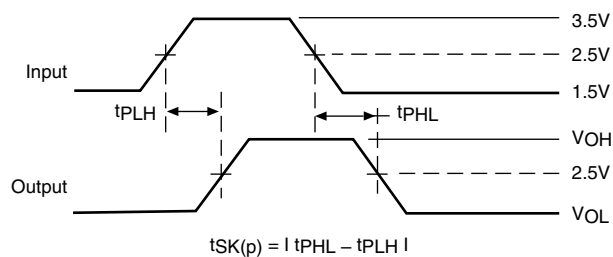
Pulse Skew - $t_{SK(p)}$

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

DC Electrical Characteristics +3V Supply

(V_{CC} = 2.7V to 4.2V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at 3V and +25°C.)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Analog Switch						
Analog Signal Range	VA_{INX} or VA_{OUTX}		-0.3		V_{CC}	V
On-Resistance	R_{ON}	V_{CC} = 2.7V, IA_{IN} = 100mA, VA_{OUT} = 0 to V_{CC}		0.6	0.8	
On-Resistance Match Between Channels	ΔR_{ON}	V_{CC} = 2.7V, IA_{IN} = 100mA, VA_{OUT} = 1.5V		0.01	0.06	Ω
On-Resistance Flatness	R_{ONF}	V_{CC} = 2.7V, I_{AIN} = 100mA, VA_{OUT} = 0 to V_{CC}			0.25	
Off Leakage Current	I_{OFF}	V_{CC} = 3.3V, VA_{OUT} = 3V, 0.3V, VA_{IN} = 0.3V, 3V	-400		400	nA
On Leakage Current	$I_{(ON)}$	V_{CC} = 3.3V, VA_{OUT} = 3V, 0.3V, VA_{IN} = 0.3V, 3V, or floating	-160		160	
Digital I/O (Pin 5 and Pin 7)						
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	µA
Power Supply						
Power-Supply Range	V_{CC}		2.7		4.6	V

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

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Turn-On Time	t_{ON}	V_{CC} = 2.7V, VA_{OUT} = 1.5V, R_L = 50Ω, C_L = 35pF, *See Test Circuit Figure 1 & 2.*		15	25	ns
Turn-Off Time	t_{OFF}	V_{CC} = 2.7V, VA_{OUT} = 1.5V, R_L = 50Ω, C_L = 35pF, *See Test Circuit Figure 1 & 2.*		4	10	
Charge Injection	Q	VA_{IN} = 0, R_S = 0, C_L = 1nF, *See Test Circuit Figure 3.*		55		pC
Off-Isolation	O_{IRR}	C_L = 5pF, R_L = 50Ω, f = 100kHz, VA_{IN} = 1 V_{RMS}, , *See Test Circuit Figure 4.*		-75		dB
Crosstalk	X_{TALK}	C_L = 5pF, R_L = 50Ω, f = 100kHz, VA_{IN} = 1 V_{RMS}, *See Test Circuit Figure 5.*		-90		
3dB Bandwidth	f_{3dB}	*See Test Circuit Figure 8.*		60		MHz

Capacitance (only related to pins 5, 6, 7, 8, 9, 11)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Off Capacitance	$C_{(OFF)}$	f = 1MHz, *See Test Circuit Figure 6.*		35		pF
On Capacitance	$C_{(ON)}$	f = 1MHz, *See Test Circuit Figure 7.*		95		

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

Figure 1. AC Test Circuit
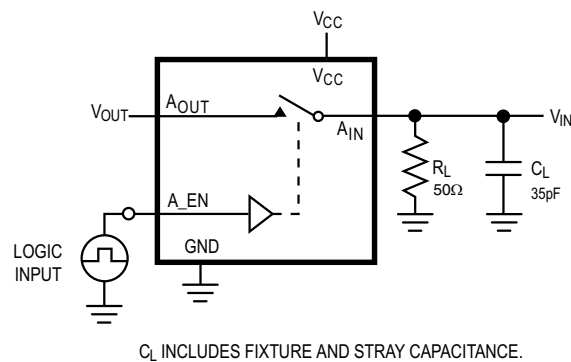
Note:
1. Unused input (NC or NO) must be grounded.
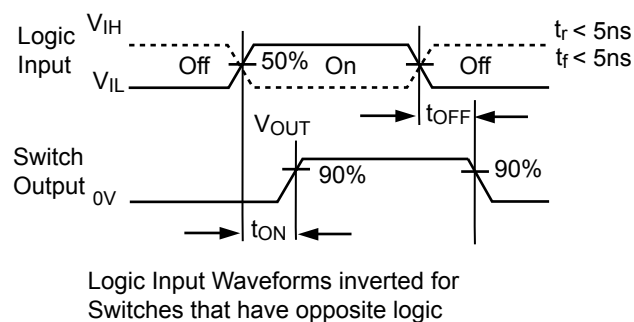
Figure 2. AC Waveforms
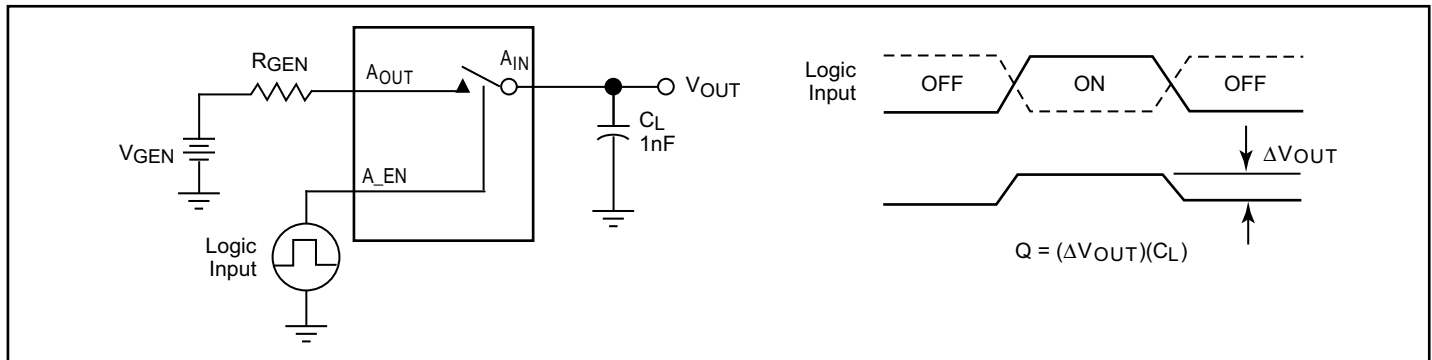
Figure 3. Charge Injection Test
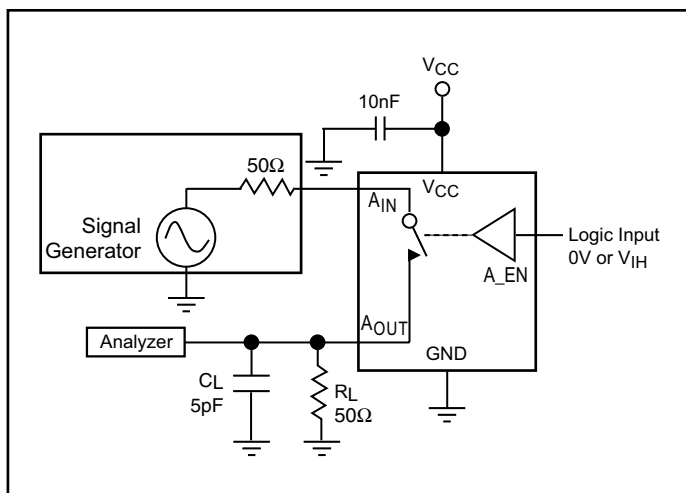
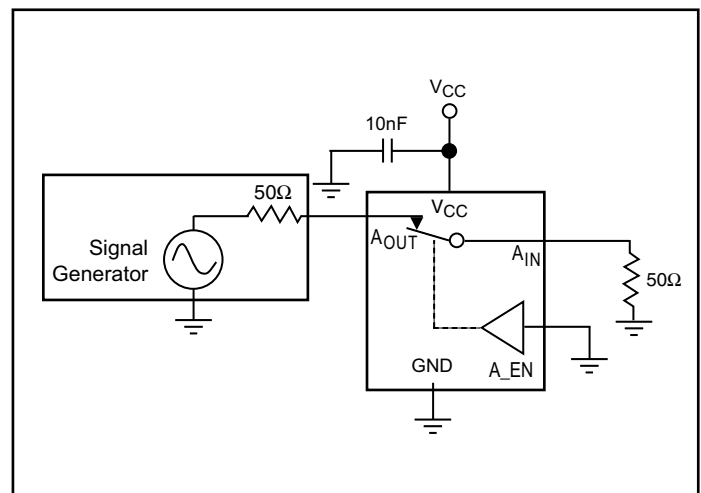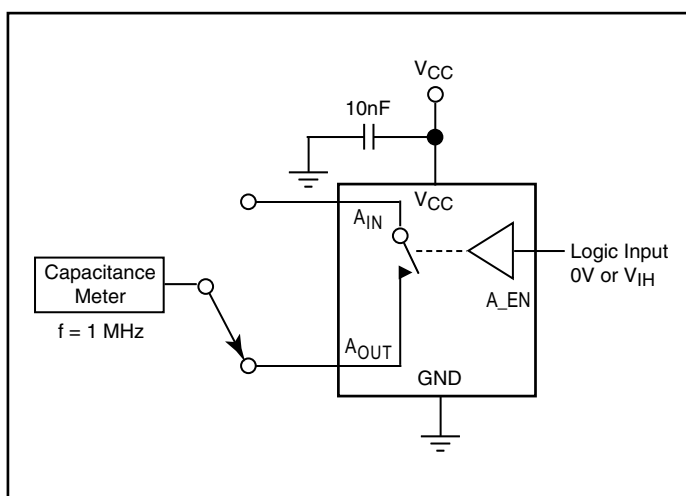**Figure 4. Off Isolation**

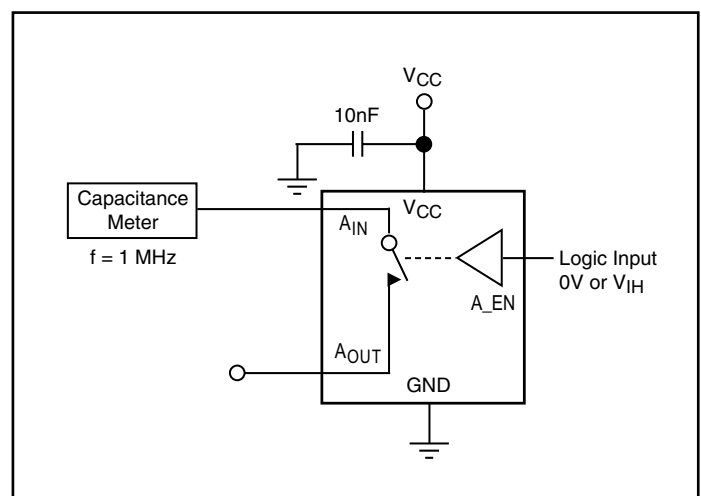**Figure 5. Crosstalk**

Figure 6. Channel Off Capacitance
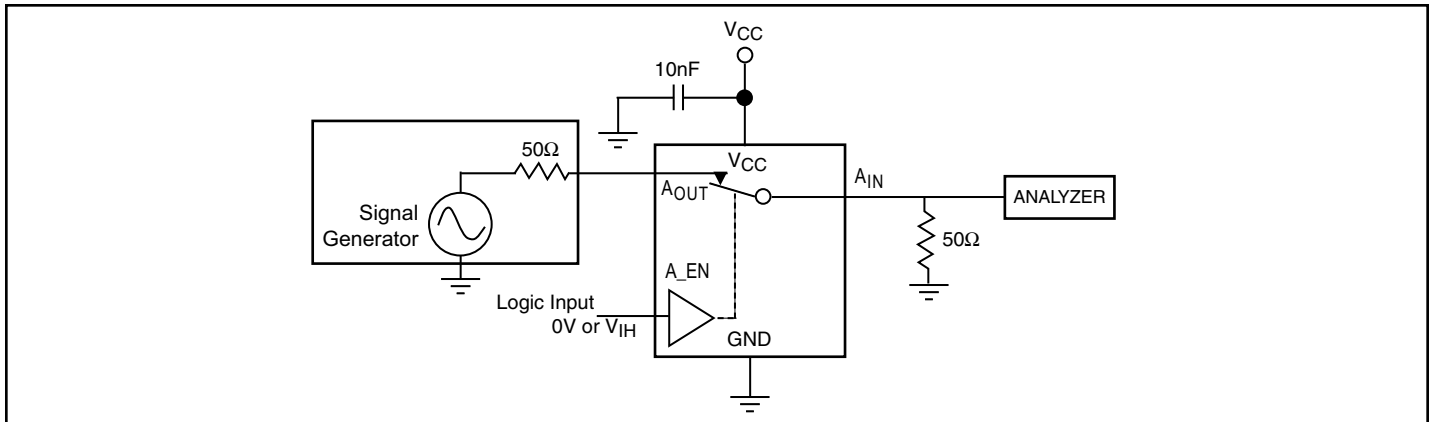

Figure 7. Channel On Capacitance

Figure 8. Bandwidth
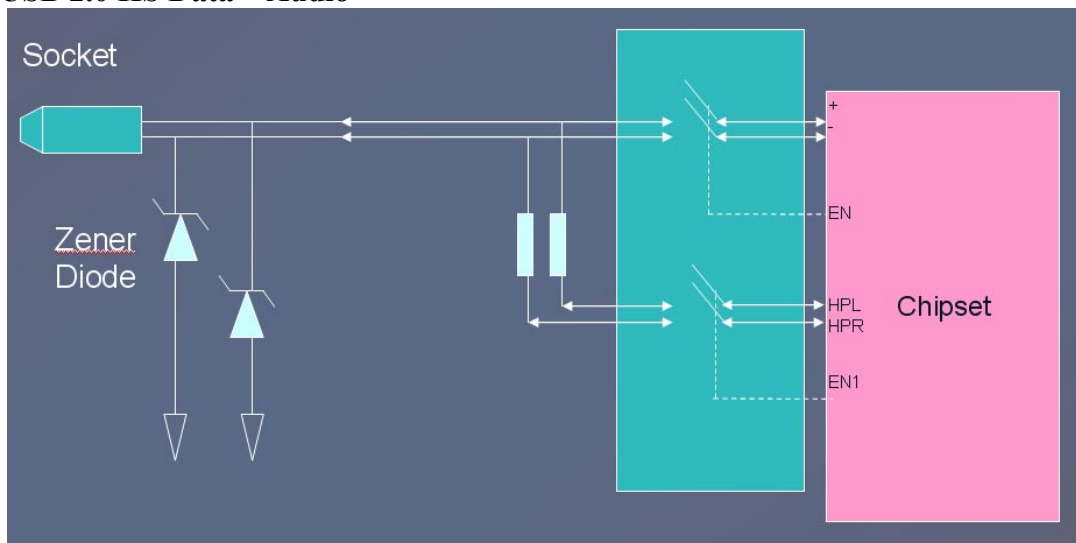
Application Information

USB 2.0 HS Data + Audio

Figure 9. Application of handheld device combining audio and USB data on single port

USB 2.0 Signals + High Fidelity Audio Signals
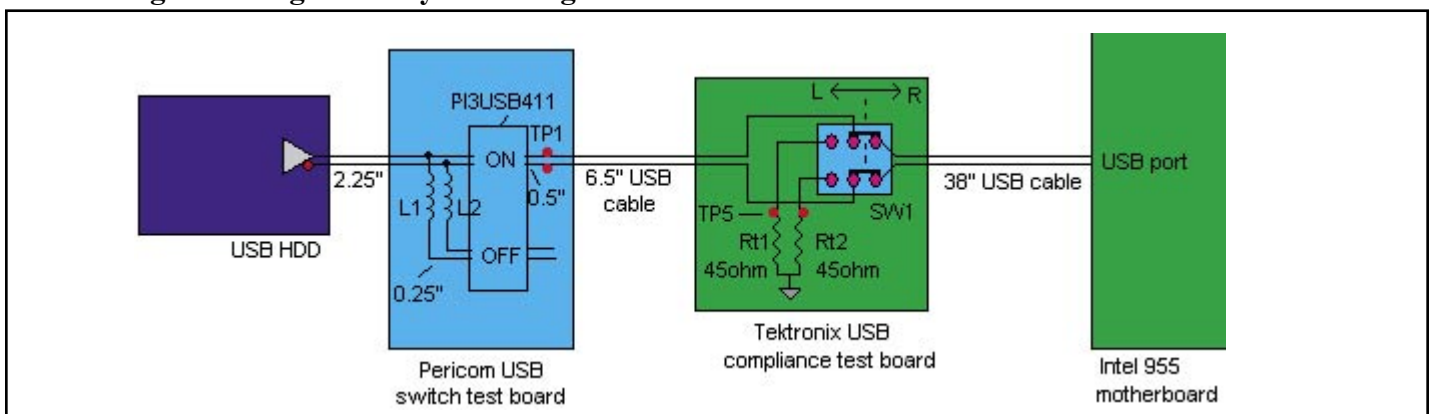
Figure 10: USB 2.0 high-Speed (480Mbps) Signal Test Set-up
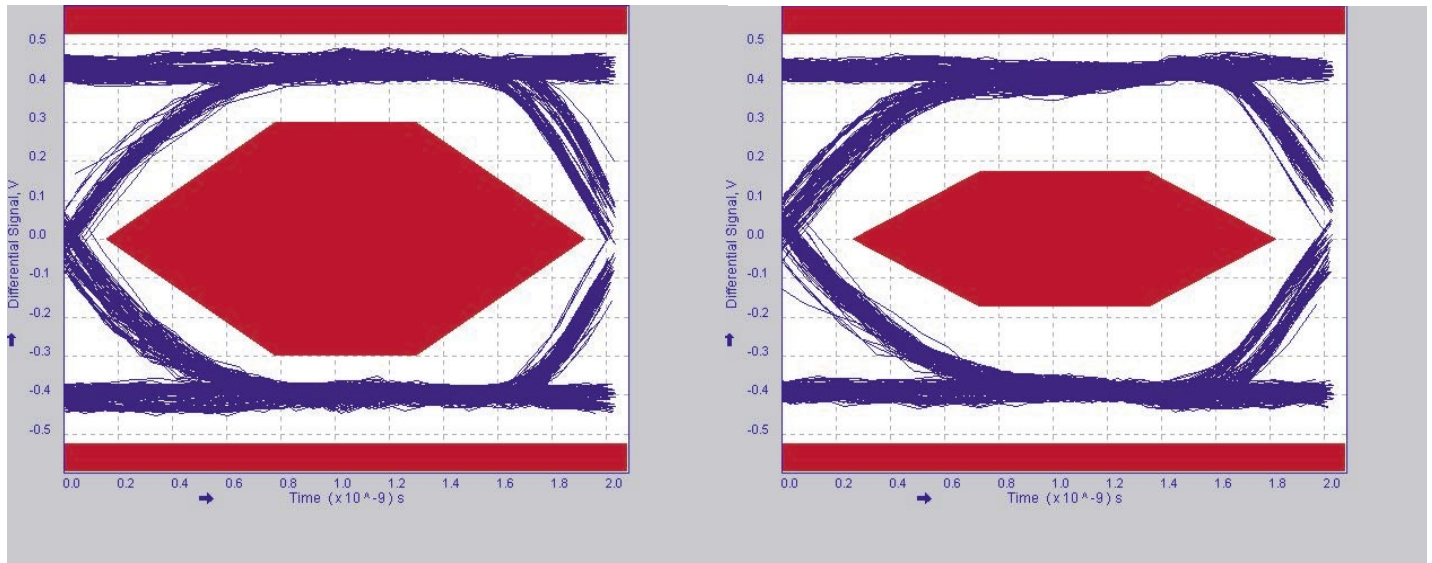
Figure 11: USB 2.0 High-Speed (480Mbps) TP1, left eye, and TP5, right eye, tested with no PI3USB411 in the signal path
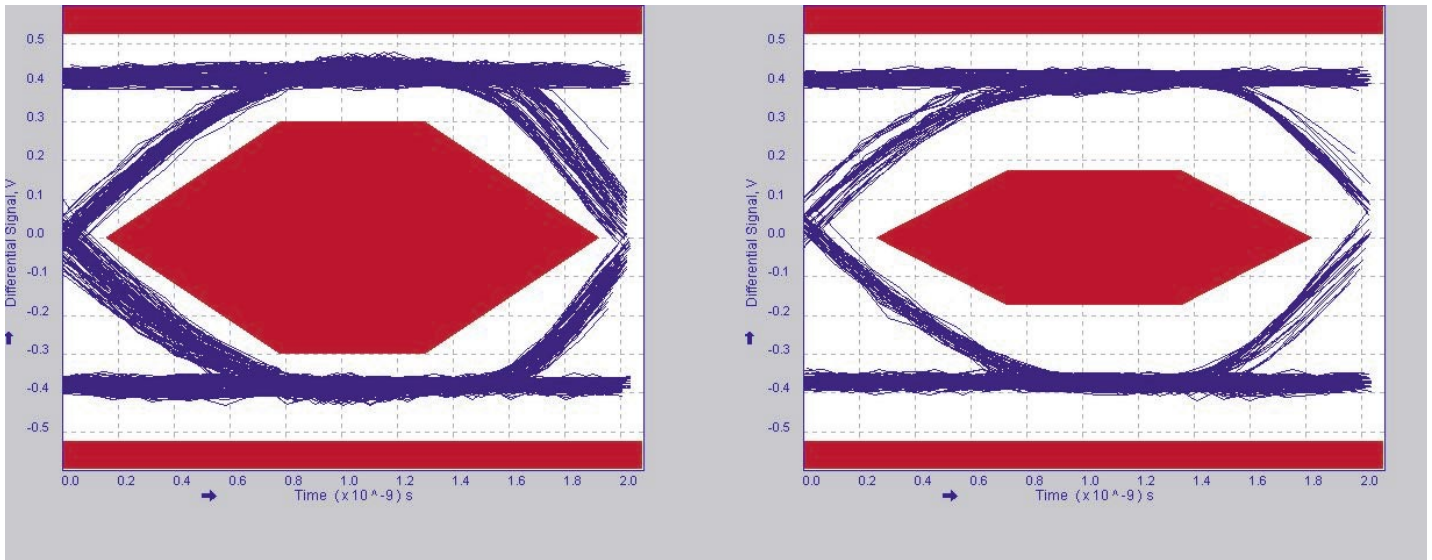
Figure 12: USB 2.0 High-Speed (480Mbps) TP1, left eye, and TP5, right eye, tested with only USB data signals connected (Audio signals are left not connected with no inductors.
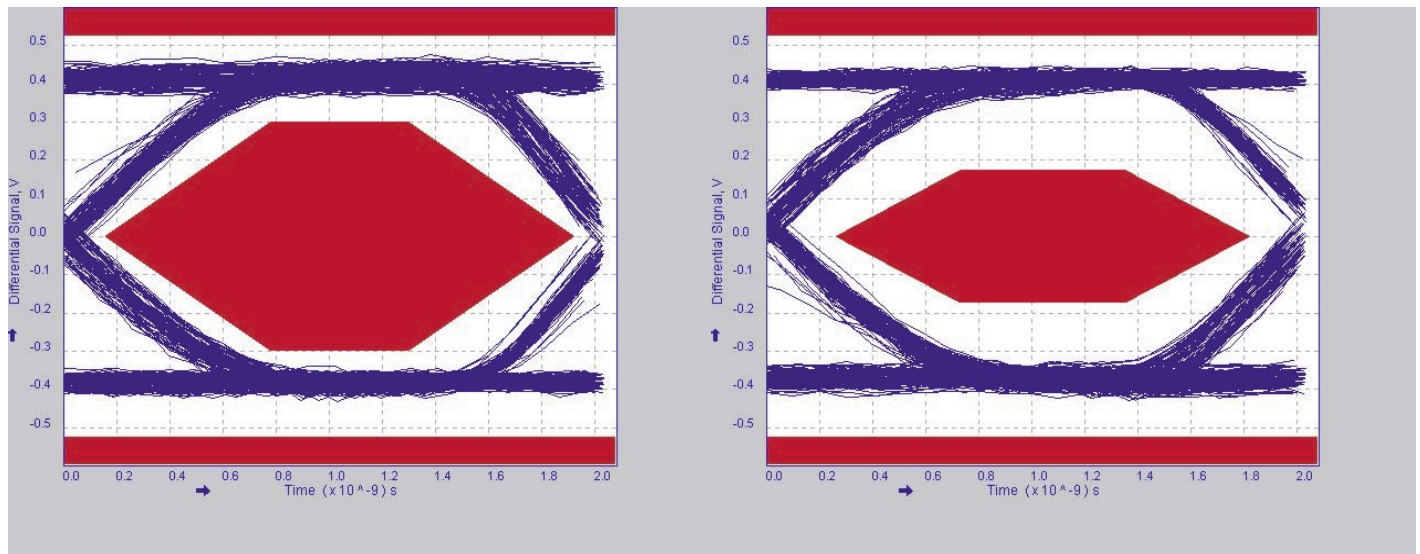
Figure 13: USB 2.0 High-Speed (480Mbps) TP1, left eye, and TP5, right eye, tested with PI3USB411 in the signal path with Analog signals "Off" and 9.3uH Inductors for L1 and L2
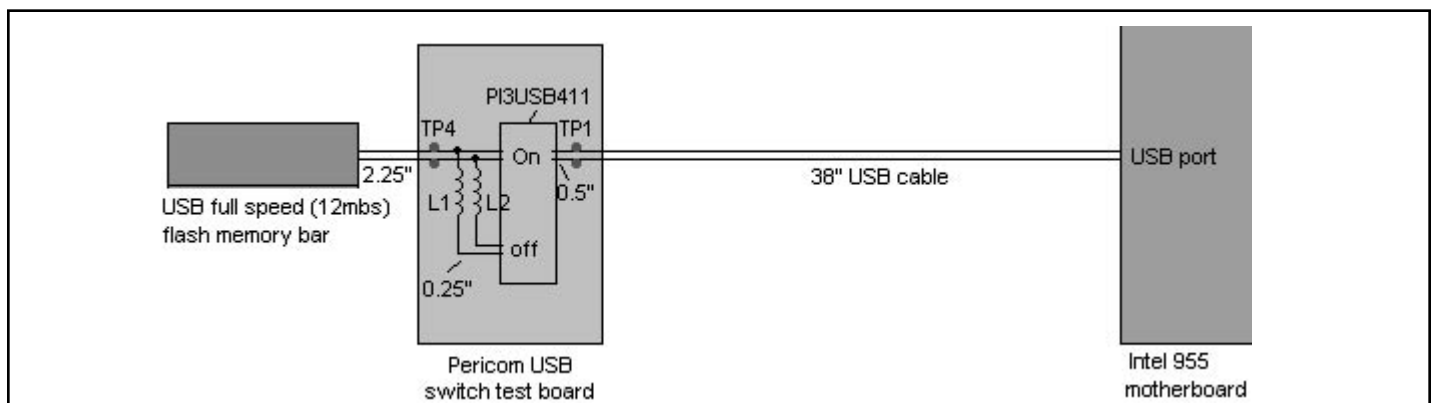

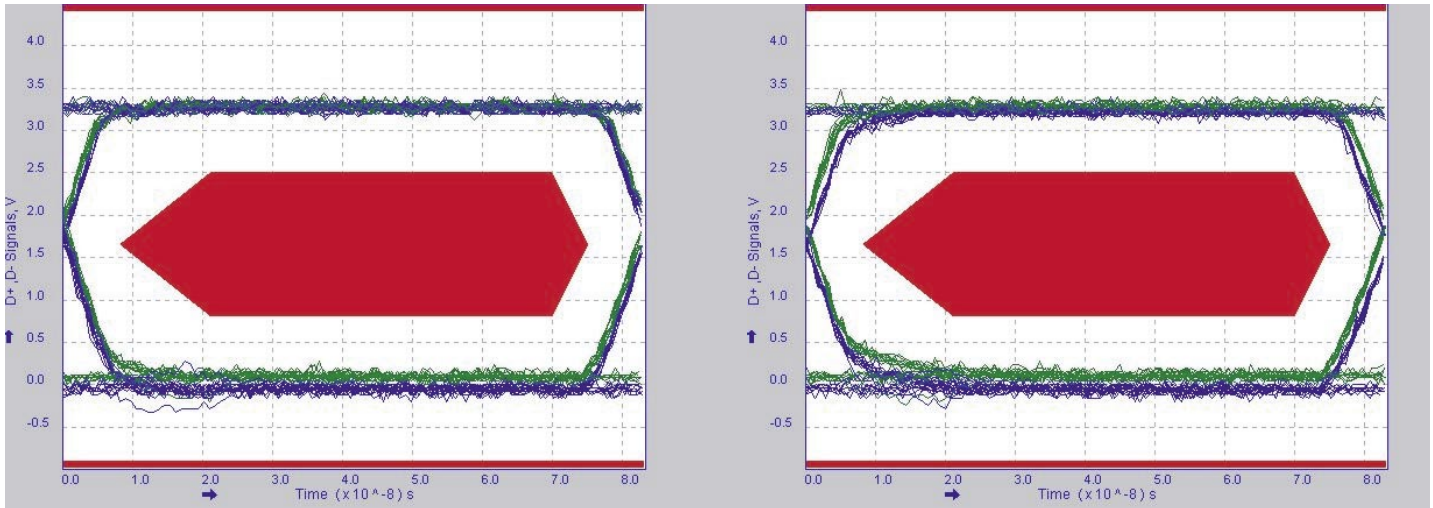**Figure 14:** USB 2.0 full-Speed (12Mbps) Signal Test Set-up

Figure 15: USB 2.0 Full-Speed (12Mbps) TP1, left eye, and TP4, right eye, tested with no PI3USB411 in the signal path
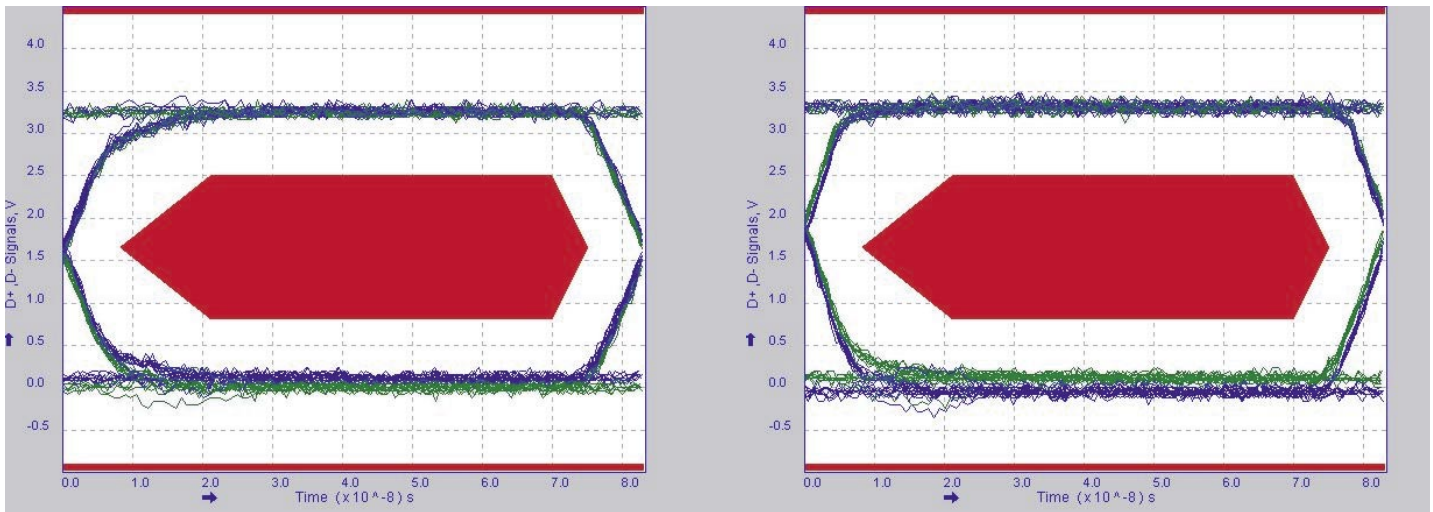

Figure 16: USB 2.0 Full-Speed (12Mbps) TP1, left eye, and TP4, right eye, tested with only USB data signals connected (Audio signals are left not connected with no inductors).
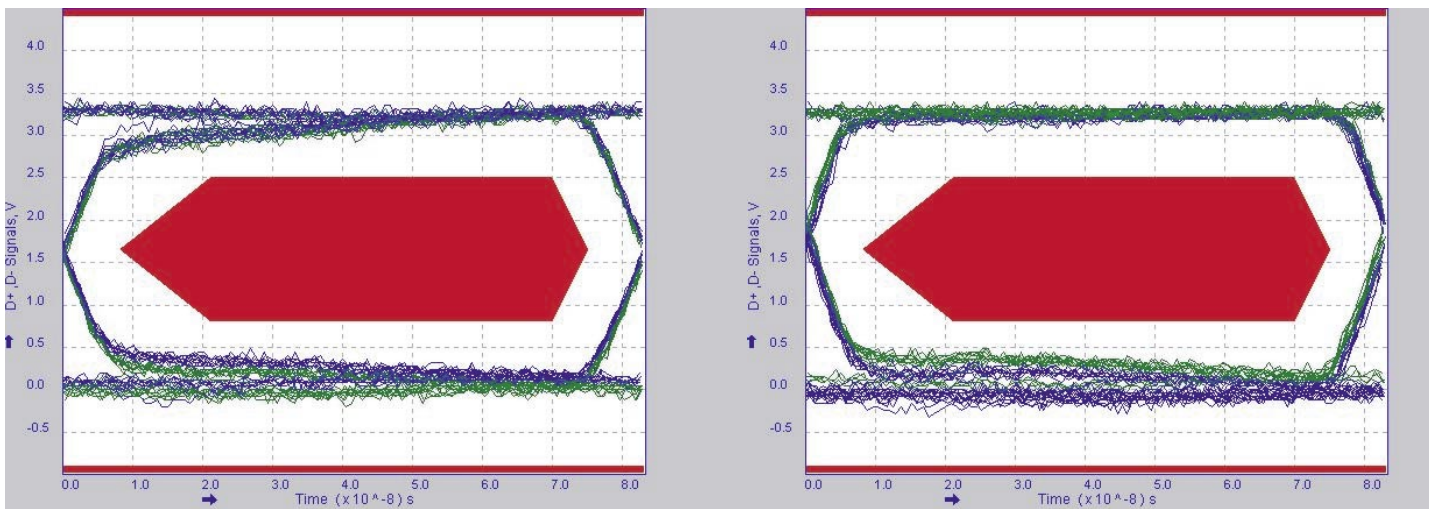

Figure 17: USB 2.0 Full-Speed (12Mbps) TP1, left eye, and TP4, right eye, tested with PI3USB411 in the signal path with Analog signals "Off" and 9.3uH Inductors for L1 and L2
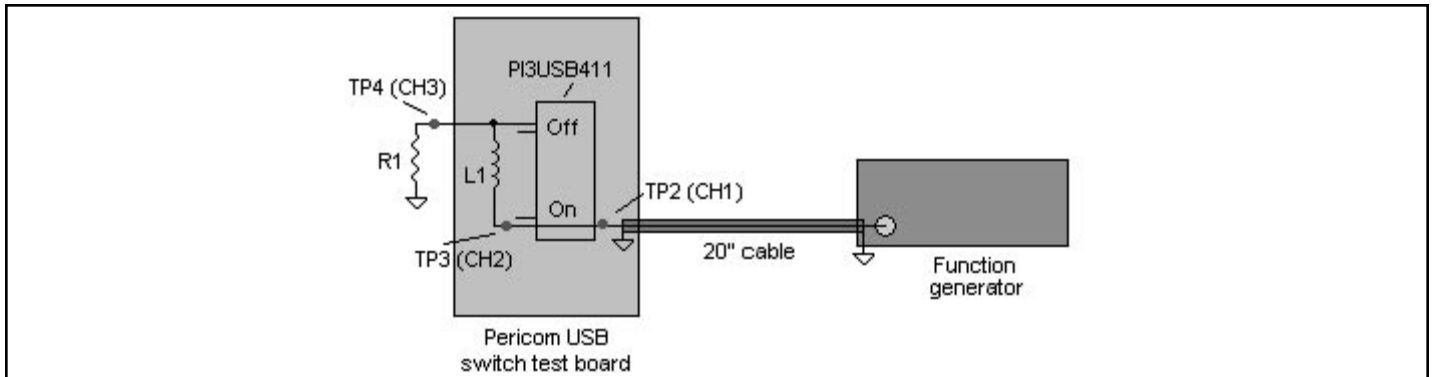
Figure 18: High Fidelity Audio Signal Test Setup.

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 termina-
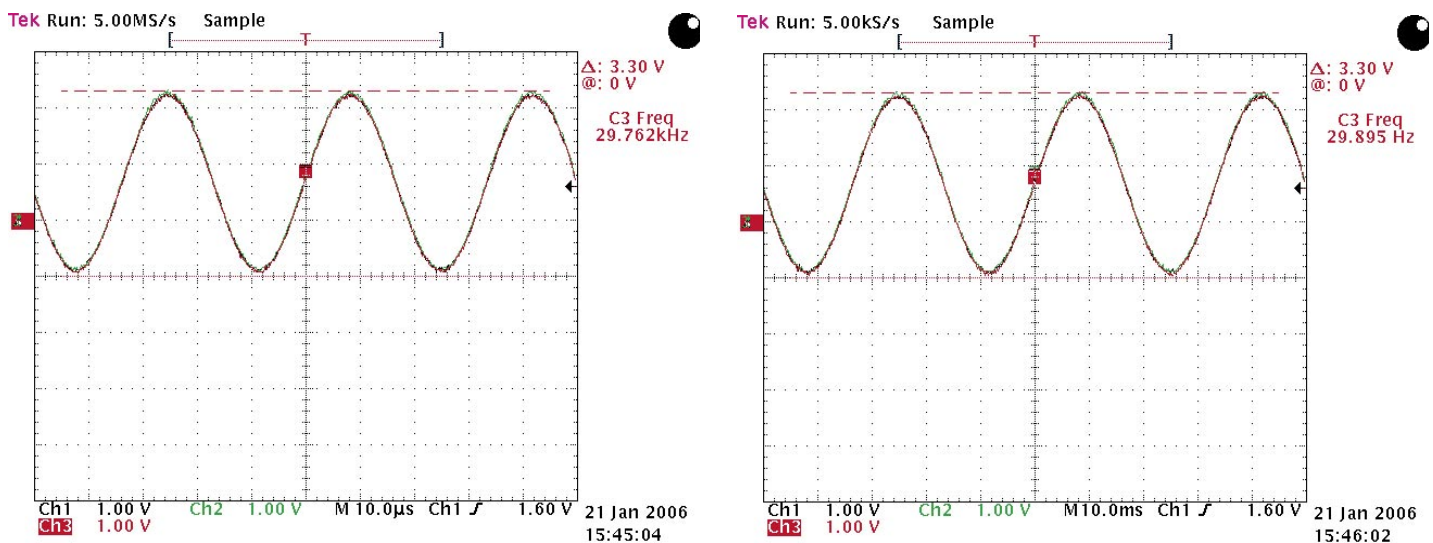

Figure 19: See Figure 18 for test setup. R1=12K and the sine wave on the left plot is 30kHz, while the sine wave on the right is 30Hz. Channel 1 (black)=TP2, Channel 2 (green)=TP3, Channel 3(red)=TP4

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
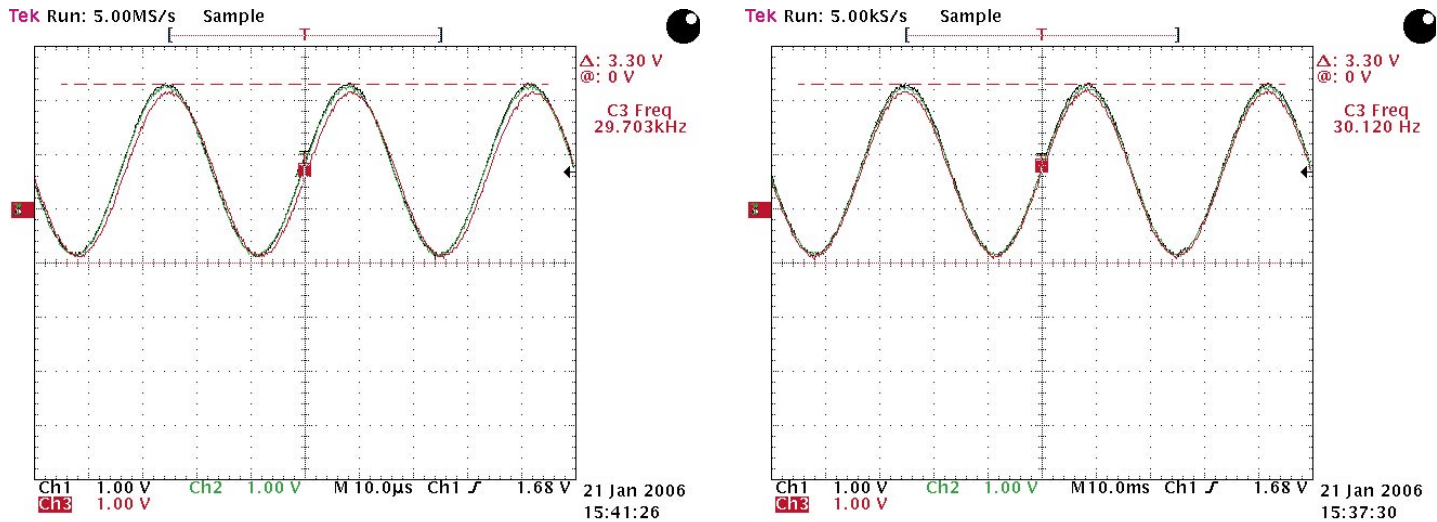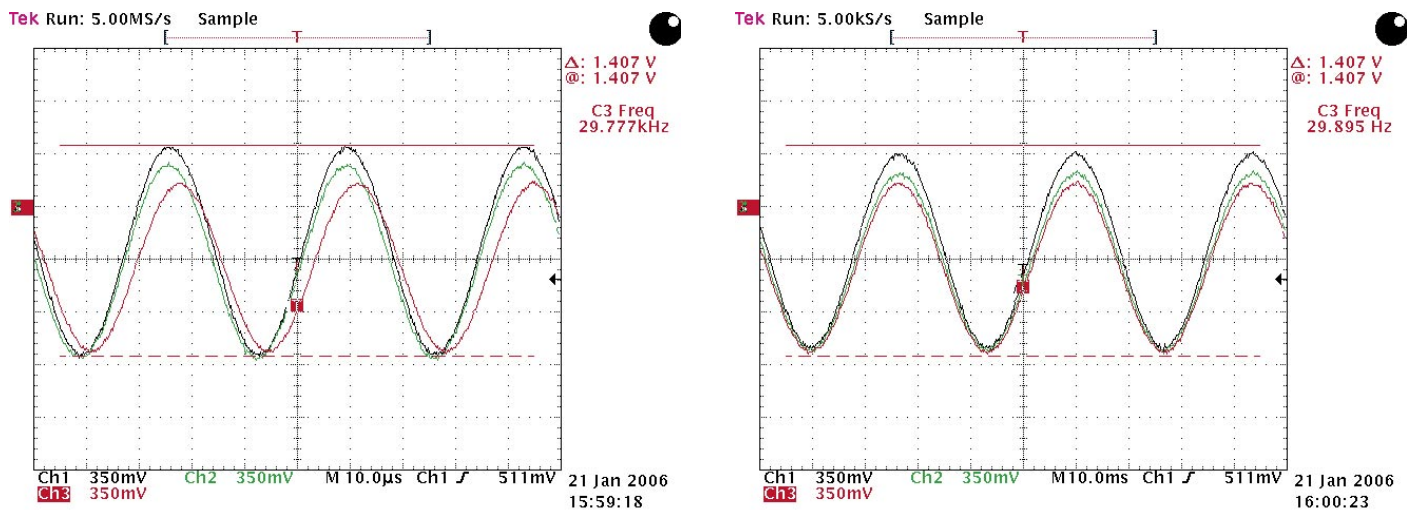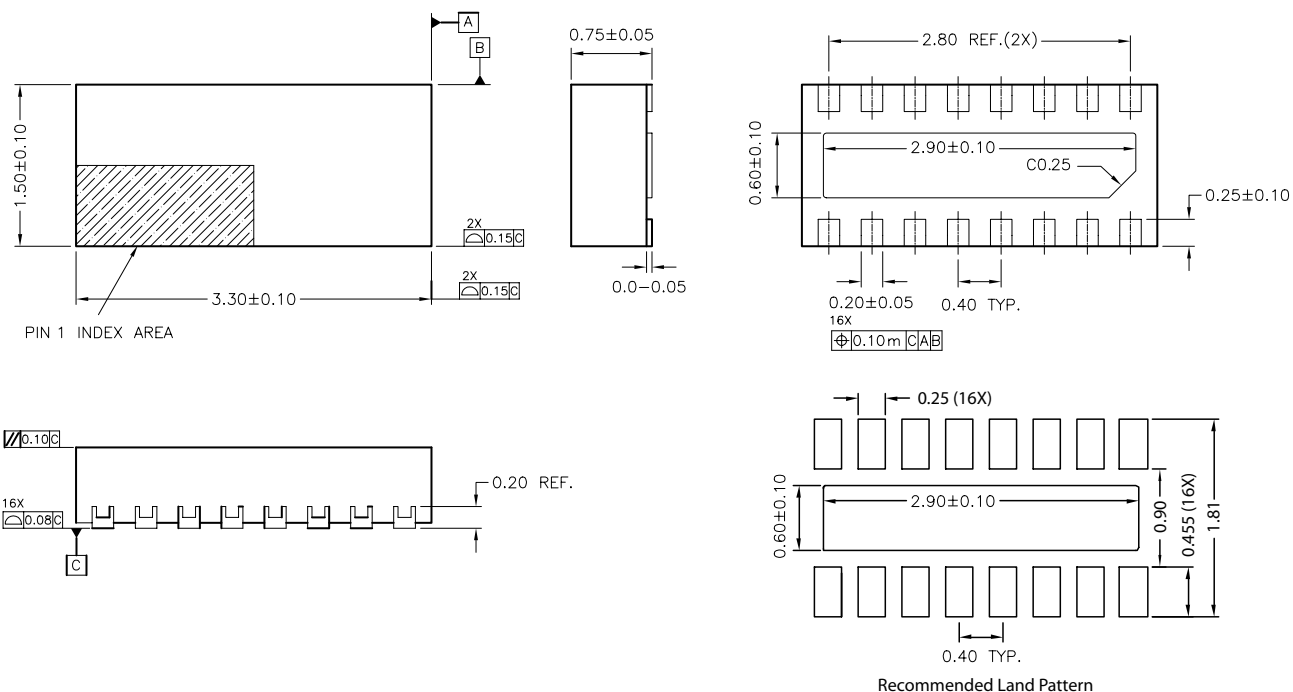
Packaging Information - 16-contact TDFN

0.75±0.05

2.80 REF.(2X)

1.50±0.10

2.90±0.10

C0.25

0.60±0.10

0.25±0.10

3.30±0.10

0.0−0.05

0.20±0.05
16X

0.40 TYP.

⊕ 0.10m C A B

PIN 1 INDEX AREA

2X
⌴ 0.15 C

2X
⌴ 0.15 C

A
B

0.25 (16X)

0.20 REF.

16X
⌴ 0.08 C

0.10 C

0.60±0.10

2.90±0.10

0.90

0.455 (16X)

1.81

0.40 TYP.

Recommended Land Pattern

Notes:
1) All dimensions are in millimeters
2) Ref JEDEC: MO-229 (Ref.)
3) Bilateral coplanarity zone applies to the exposed heat sink slug as well as the terminals

PERICOM
Semiconductor Corporation

DATE: 03/30/06

DESCRIPTION: 16-contact, Thin Dual-in-line Flat No-Lead (TDFN)

PACKAGE CODE: ZJ (ZJ16)

DOCUMENT CONTROL #: PD-2042

REVISION: B

Ordering Information

Ordering Code	Package Code	Package Description	Top Mark
PI3USB411ZJE	ZJ	Pb-free & Green, 16-contact TDFN	U1

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

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