

# USB 2.0 High-Speed (480 Mbps) and Audio Switches with Negative Signal Capability and 1.8-V Logic Compatibility

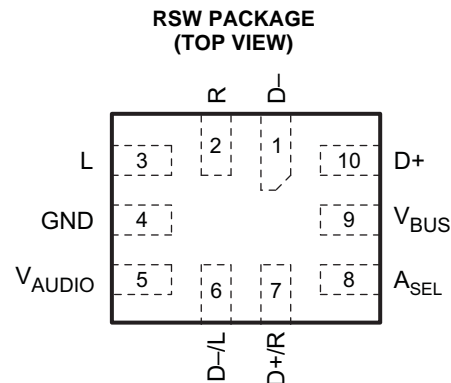
Check for Samples: [TS5USBA224](#)

## FEATURES

- **High-Speed USB Switch:**
  - 4  $\Omega$   $R_{\text{DS(on)}}$  Typical
  - 12.5 pF  $C_{\text{ON}}$  Typical
  - 650-MHz Bandwidth (–3 dB)
- **Audio Switch:**
  - 3  $\Omega$   $R_{\text{DS(on)}}$  Typical
  - Negative Rail Capability
  - Low THD: <0.05%
  - Internal Shunt Resistors for Click-and-Pop Reduction
  - Powered From  $V_{\text{AUDIO}}$  (2.7V to 5.5V)
- **1.8-V Compatible Control Input ( $A_{\text{SEL}}$  and  $V_{\text{BUS}}$ ) Threshold**
- **$I_{\text{OFF}}$  Supports Partial Powerdown Mode**
- **ESD Performance Tested Per JESD 22**
  - 2000-V Human-Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)
  - 200-V Machine Model (A115-A)

## APPLICATIONS

- Cellular Phones
- Personal Digital Assistants (PDAs)
- Portable Instrumentation
- Digital Still Cameras
- Portable Navigation Devices



## DESCRIPTION

The TS5USBA224 is a double-pole, double throw (DPDT) multiplexer that includes a low-distortion audio switch and a USB 2.0 High-Speed (480Mbps) switch in the same package. This configuration allows the system designer to use a common connector for audio and USB data. The audio switch is designed to allow audio signals to swing below ground which makes this common connector configuration possible.

The TS5USBA224 is powered up using  $V_{\text{AUDIO}}$ . When  $A_{\text{SEL}}=\text{High}$ , the audio path is selected regardless of the logic level at  $V_{\text{BUS}}$ . If  $A_{\text{SEL}}=\text{Low}$  and  $V_{\text{BUS}}=\text{High}$ , the USB path is selected. Otherwise if  $A_{\text{SEL}}=\text{Low}$  and  $V_{\text{BUS}}=\text{Low}$ , the audio path is selected.

The TS5USBA224 also features shunt resistors on the audio path to reduce clicks and pops that may be heard when the audio switches are selected.

## ORDERING INFORMATION

$T_A$	PACKAGE <sup>(1)</sup> <sup>(2)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	QFN 0.4-MM PITCH – RSW (Pb-Free)	Tape and reel	TS5USBA224RSWR	A5R

(1) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).

(2) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at [www.ti.com](http://www.ti.com).



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### SUMMARY OF TYPICAL CHARACTERISTICS

	USB PATH	AUDIO PATH
Number of switches	2	2
ON-state resistance ( $r_{on}$ )	4 $\Omega$	3 $\Omega$
ON-state resistance match ( $\Delta r_{on}$ )	< 0.3 $\Omega$	< 0.3 $\Omega$
ON-state resistance flatness ( $r_{on(flat)}$ )	N/A	1.5 $\Omega$
Turn-on/turn-off time ( $t_{on}/t_{off}$ )	< 2 $\mu$ s	< 4 $\mu$ s
Bandwidth (BW)	650 MHz	N/A
OFF isolation ( $O_{ISO}$ )	-22 dB	-83 dB
Crosstalk ( $X_{TALK}$ )	-31 dB	-83 dB
Total harmonic distortion (THD)	N/A	0.05%

### PIN DESCRIPTION TABLE

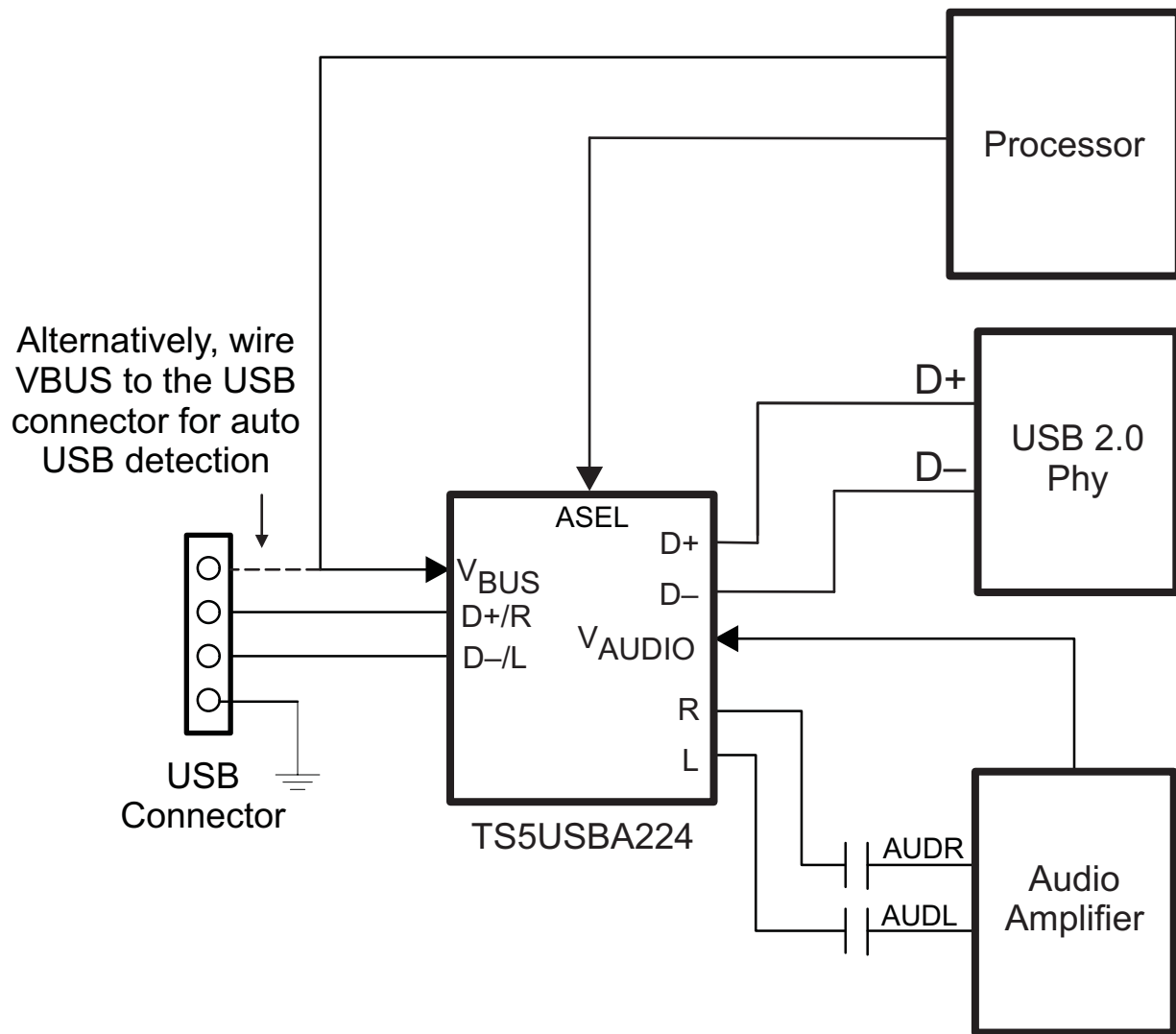
PIN			DESCRIPTION
NO.	NAME	TYPE	
1	D-	I/O	USB Data (Differential -)
2	R	I/O	Right Channel Audio
3	L	I/O	Left Channel Audio
4	GND	Ground	Ground
5	V <sub>AUDIO</sub>	Power	Supply Voltage
6	D-/L	I/O	USB/Audio Common Connector
7	D+/R	I/O	USB/Audio Common Connector
8	A <sub>SEL</sub>	Input	Control Input for Audio Path
9	V <sub>BUS</sub>	Input	Control Input for USB Path
10	D+	I/O	USB Data (Differential +)

FUNCTION TABLE

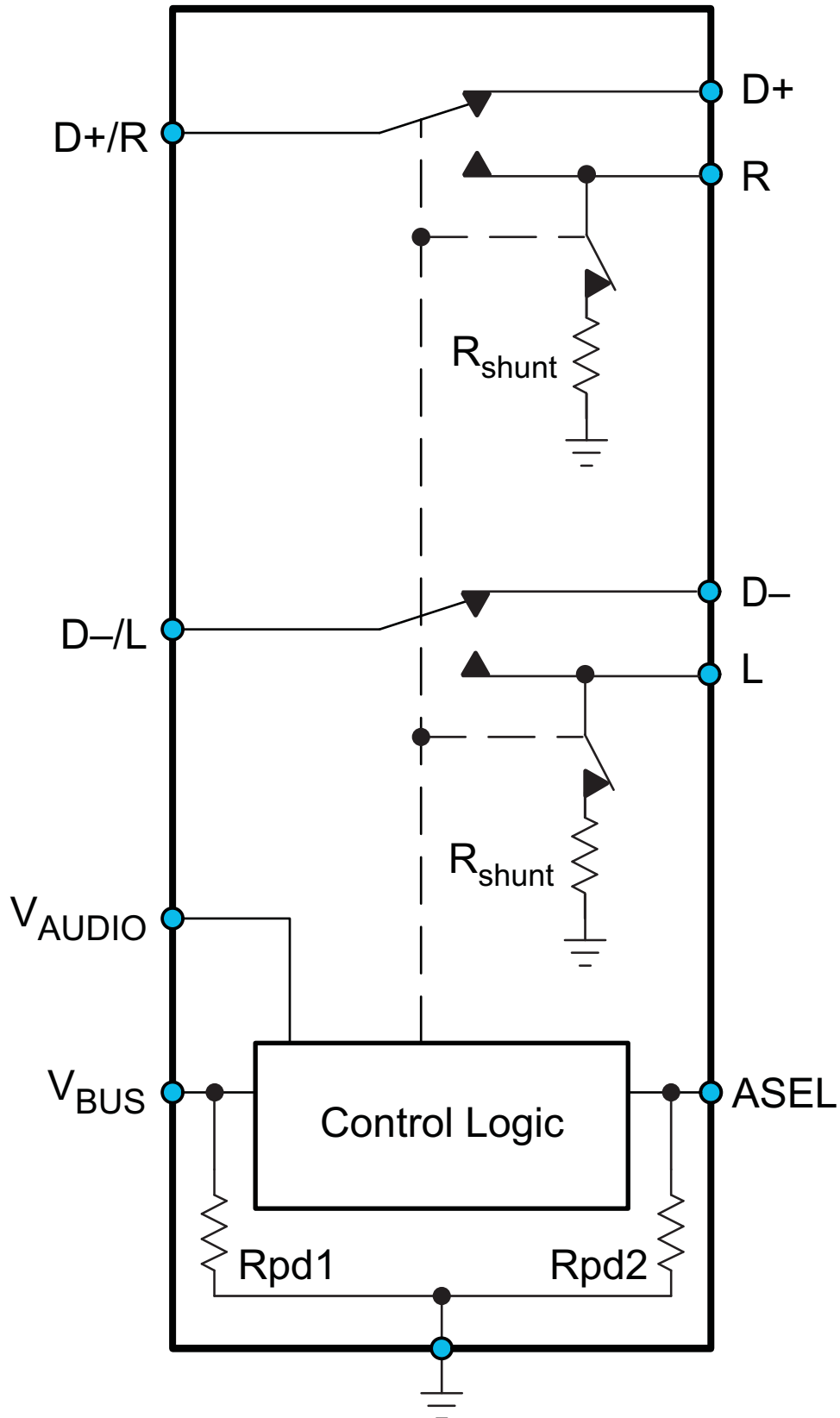
ASEL	V <sub>AUDIO</sub>	V <sub>BUS</sub>	L,R	D+, D-
L	L	L	OFF	OFF
L	L	H	OFF	OFF
L	H	L	ON	OFF
L	H	H	OFF <sup>(1)</sup>	ON
H	L	L	OFF	OFF
H	L	H	OFF	OFF
H	H	L	ON	OFF
H	H	H	ON	OFF

(1) 100Ω shunt resistors are enabled in this state.

TYPICAL APPLICATION BLOCK DIAGRAM



SWITCH BLOCK DIAGRAM



**ABSOLUTE MAXIMUM RATINGS<sup>(1)(2)</sup>**

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
V <sub>AUDIO</sub>	Supply voltage range <sup>(3)</sup>	-0.5	6.5	V
V <sub>D+</sub> V <sub>D-</sub>	Analog voltage Range <sup>(3)</sup>	-0.5	6.5	V
V <sub>R</sub> V <sub>L</sub>		V <sub>AUDIO</sub> - 6.5	V <sub>AUDIO</sub> + 0.5	V
I <sub>K</sub>	Analog port diode current	V <sub>D+</sub> , V <sub>D-</sub> < 0		mA
I <sub>D+</sub> , I <sub>D-</sub> I <sub>R</sub> , I <sub>L</sub>	ON-state switch current	V <sub>D+</sub> , V <sub>D-</sub> = 0 to V <sub>AUDIO</sub> , V <sub>R</sub> , V <sub>L</sub> V <sub>D+/R</sub> , V <sub>D-/L</sub> = V <sub>AUDIO</sub> - 5.5 V to V <sub>AUDIO</sub>		mA
I <sub>D+/R</sub> I <sub>D-/L</sub>	ON-state peak switch current <sup>(4)</sup>	-200	200	
V <sub>I</sub>	Digital input voltage range	-0.5	6.5	V
I <sub>IK</sub>	Digital logic input clamp current <sup>(3)</sup>	V <sub>I</sub> < 0		mA
I <sub>AUDIO</sub>	Continuous current through V <sub>AUDIO</sub>		100	mA
I <sub>GND</sub>	Continuous current through GND	-100		mA
T <sub>stg</sub>	Storage temperature range	-65	150	°C

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) The algebraic convention, whereby the most negative value is a minimum and the most positive value is a maximum.
- (3) All voltages are with respect to ground, unless otherwise specified.
- (4) Pulse at 1-ms duration <10% duty cycle.

**PACKAGE THERMAL IMPEDANCE<sup>(1)</sup>**

over operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	TYP	UNIT
θ <sub>JA</sub>	Package thermal impedance RSW package	175	°C/W

- (1) The package thermal impedance is calculated in accordance with JESD 51-7.

**ELECTRICAL CHARACTERISTICS**

T<sub>A</sub> = -40°C to 85°C, typical values are at V<sub>AUDIO</sub> = 3.3 V, T<sub>A</sub> = 25°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>USB SWITCH</b>					
V <sub>D+</sub> , V <sub>D-</sub>	Analog voltage range	0		5.5	V
r <sub>on</sub>	ON-state resistance	V <sub>AUDIO</sub> = 3 V, V <sub>BUS</sub> = 5 V, V <sub>ASEL</sub> = 0 V, V <sub>D+/D-</sub> = 0 V, 0.4 V, I <sub>ON</sub> = -8 mA		Switch ON	4 7 Ω
Δr <sub>on</sub>	ON-state resistance match between channels	V <sub>AUDIO</sub> = 3 V, V <sub>BUS</sub> = 5 V, V <sub>ASEL</sub> = 0 V, V <sub>D+/D-</sub> = 0 V, 0.4 V, I <sub>ON</sub> = -8 mA		Switch ON	0.3 Ω
I <sub>D+(OFF)</sub> I <sub>D-(OFF)</sub>	D+ ,D- OFF leakage current	V <sub>AUDIO</sub> = 3.6 V, V <sub>BUS</sub> = 0 V, V <sub>ASEL</sub> = 3.6 V, V <sub>D+</sub> , V <sub>D-</sub> = 0.3 V, V <sub>D+/R</sub> , V <sub>D-/L</sub> = 0.3 V		Switch OFF	±50 nA
I <sub>D+(ON)</sub> I <sub>D-(ON)</sub>	D+ ,D- ON leakage current	V <sub>AUDIO</sub> = 3.6 V, V <sub>BUS</sub> = 5 V, V <sub>ASEL</sub> = 0 V, V <sub>D+</sub> , V <sub>D-</sub> = 0.3 V, V <sub>D+/R</sub> = Open		Switch ON	±50 nA
<b>AUDIO SWITCH</b>					
V <sub>R</sub> , V <sub>L</sub>	Analog voltage range	V <sub>AUDIO</sub> - 5.5		V <sub>AUDIO</sub>	V
r <sub>on</sub>	ON-state resistance	V <sub>AUDIO</sub> = 3 V, V <sub>BUS</sub> = 0 V, V <sub>ASEL</sub> = 3 V, V <sub>L/R</sub> = -2 V, 0 V, 0.7 V, I <sub>ON</sub> = -26 mA		Switch ON	3 5 Ω
Δr <sub>on</sub>	ON-state resistance match between channels	V <sub>AUDIO</sub> = 3 V, V <sub>BUS</sub> = 0 V, V <sub>ASEL</sub> = 3 V, V <sub>L/R</sub> = 0.7 V, I <sub>ON</sub> = -26 mA		Switch ON	0.3 Ω
r <sub>on</sub> (flat)	ON-state resistance flatness	V <sub>AUDIO</sub> = 3 V, V <sub>BUS</sub> = 0 V, V <sub>ASEL</sub> = 3 V, V <sub>L/R</sub> = -2 V, 0 V, 0.7 V, I <sub>ON</sub> = -26 mA		Switch ON	1.5 2.5 Ω

**ELECTRICAL CHARACTERISTICS (continued)**

$T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ , typical values are at  $V_{\text{AUDIO}} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$r_{\text{SHUNT}}$	Shunt resistance	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 5\text{ V}$ , $V_{\text{ASEL}} = 0\text{ V}$ , $V_{\text{L/R}} = 0.7\text{ V}$ , $I_{\text{OSHUNT}} = 10\text{ mA}$	Switch OFF		100	200	$\Omega$
$I_{\text{L(OFF)}}$ $I_{\text{R(OFF)}}$	L, R OFF leakage current	$V_{\text{AUDIO}} = 3.6\text{ V}$ , $V_{\text{BUS}} = 5\text{ V}$ , $V_{\text{ASEL}} = 0\text{ V}$ , $V_{\text{R}}, V_{\text{L}} = 0.3\text{ V}$ , $V_{\text{AUDIO}-0.3\text{ V}}$ , $V_{\text{D+R}}, V_{\text{D-L}} = 0.3\text{ V}$ , $V_{\text{AUDIO}-0.3\text{ V}}$	Switch OFF			$\pm 50$	nA
$I_{\text{L(ON)}}$ $I_{\text{R(ON)}}$	L, R ON leakage current	$V_{\text{AUDIO}} = 3.6\text{ V}$ , $V_{\text{BUS}} = 0\text{ V}$ , $V_{\text{ASEL}} = 3.6\text{ V}$ , $V_{\text{D+R}}, \text{D-L} = 0.3\text{ V}$ , $V_{\text{R}}, V_{\text{L}} = 0.3\text{ V}$ , $V_{\text{AUDIO}-0.3\text{ V}}$ , $V_{\text{AUDIO}-0.3\text{ V}}$ $V_{\text{D+R}}, V_{\text{D-L}} = \text{Open}$	Switch ON			$\pm 50$	nA
<b>DIGITAL CONTROL INPUTS (<math>A_{\text{SEL}}</math>, <math>V_{\text{BUS}}</math>)</b>							
$V_{\text{IH}}$	Input logic high	$V_{\text{AUDIO}} = 2.7\text{ V to } 5.5\text{ V}$		1.2			V
$V_{\text{IL}}$	Input logic low	$V_{\text{AUDIO}} = 2.7\text{ V to } 5.5\text{ V}$				0.5	V
$I_{\text{IN}}$	Input leakage current	$V_{\text{AUDIO}} = 3.6\text{ V}$	$V_{\text{IN}} = 3.6\text{ V}$			$\pm 10$	$\mu\text{A}$
			$V_{\text{IN}} = 0\text{ V}$			$\pm 1$	
$r_{\text{PD1}}$	Internal pulldown resistance				3		$\text{M}\Omega$
$r_{\text{PD2}}$	Internal pulldown resistance				5		$\text{M}\Omega$

## DYNAMIC CHARACTERISTICS

 $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ , typical values are at  $V_{\text{AUDIO}} = 3.3\text{ V}$ ,  $T_A = 25^{\circ}\text{C}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>USB SWITCH</b>						
$t_{\text{ON}}$	Turn-on time	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 0\text{ V}$ to $5\text{ V}$ , $V_{\text{ASEL}} = 0\text{ V}$ , $V_{\text{D+R, D-L}} = 1\text{ V}$ , <a href="#">Figure 10</a>		2		$\mu\text{s}$
$t_{\text{OFF}}$	Turn-off time	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 5\text{ V}$ to $0\text{ V}$ , $V_{\text{ASEL}} = 0\text{ V}$ , $V_{\text{D+R, D-L}} = 1\text{ V}$ , <a href="#">Figure 10</a>		1		$\mu\text{s}$
$t_{\text{SK(O)}}$	Channel-to-channel skew	$f = 240\text{ MHz}$ , <a href="#">Figure 11</a>		35		ps
$t_{\text{SK(P)}}$	Skew of opposite transitions of same output	$f = t\ 240\text{ MHz}$ , <a href="#">Figure 11</a>		25		ps
$C_{\text{D+(OFF)}}$ $C_{\text{D-(OFF)}}$	D+, D-OFF capacitance	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 0\text{ V}$ , $A_{\text{SEL}} = 3\text{ V}$ , $f = 240\text{ MHz}$	Switch OFF	2.8		pF
$C_{\text{D+(ON)}}$ $C_{\text{D-(ON)}}$	D+, D- ON capacitance	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 5\text{ V}$ , $A_{\text{SEL}} = 0\text{ V}$ , $f = 240\text{ MHz}$	Switch ON	12.5		pF
$C_{\text{I}}$	Digital input capacitance	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 0\text{ V}$ , $A_{\text{SEL}} = 0\text{ V}$ , $f = 1\text{ MHz}$		2.2		pF
BW	Bandwidth	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 5\text{ V}$ , $V_{\text{ASEL}} = 0\text{ V}$ , <a href="#">Figure 12</a>	Switch ON	650		MHz
$O_{\text{ISO}}$	OFF Isolation	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 0\text{ V}$ , $V_{\text{ASEL}} = 3\text{ V}$ , $R_{\text{L}} = 50\ \Omega$ , $f = 240\text{ MHz}$ , <a href="#">Figure 14</a>	Switch OFF	-22		dB
$X_{\text{TALK}}$	Crosstalk	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 5\text{ V}$ , $V_{\text{ASEL}} = 0\text{ V}$ , $R_{\text{L}} = 50\ \Omega$ , $f = 240\text{ MHz}$ , <a href="#">Figure 13</a>	Switch ON	-31		dB
<b>AUDIO SWITCH</b>						
$t_{\text{ON}}$	Turn-on time	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 0\text{ V}$ or $5\text{ V}$ , $V_{\text{ASEL}} = 0\text{ V}$ to $3\text{ V}$ , $V_{\text{D+R, D-L}} = 1\text{ V}$ , <a href="#">Figure 10</a>		4		$\mu\text{s}$
$t_{\text{OFF}}$	Turn-off time	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 0\text{ V}$ , $V_{\text{ASEL}} = 3\text{ V}$ to $0\text{ V}$ , $V_{\text{D+R, D-L}} = 1\text{ V}$ , <a href="#">Figure 10</a>		1		$\mu\text{s}$
$C_{\text{L(OFF)}}$ $C_{\text{R(OFF)}}$	L, R OFF capacitance	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 5\text{ V}$ , $V_{\text{ASEL}} = 0\text{ V}$ , $f = 20\text{ kHz}$	Switch OFF	4.5		pF
$C_{\text{L(ON)}}$ $C_{\text{R(ON)}}$	L, R ON capacitance	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 0\text{ V}$ , $V_{\text{ASEL}} = 3\text{ V}$ , $f = 20\text{ kHz}$	Switch ON	15		pF
$O_{\text{ISO}}$	OFF Isolation	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 5\text{ V}$ , $V_{\text{ASEL}} = 0\text{ V}$ , $R_{\text{L}} = 50\ \Omega$ , $f = 20\text{ kHz}$ , <a href="#">Figure 14</a>	Switch OFF	-83		dB
$X_{\text{TALK}}$	Crosstalk	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 0\text{ V}$ , $V_{\text{ASEL}} = 3\text{ V}$ , $R_{\text{L}} = 50\ \Omega$ , $f = 20\text{ kHz}$ , <a href="#">Figure 13</a>	Switch ON	-83		dB
THD	Total harmonic distortion	$V_{\text{AUDIO}} = 3\text{ V}$ , $V_{\text{BUS}} = 0\text{ V}$ , $V_{\text{ASEL}} = 3\text{ V}$ , $f = 20\text{ Hz}$ to $20\text{ kHz}$ , $R_{\text{L}} = 600\ \Omega$ , $V_{\text{IN}} = 2\text{ Vpp}$		0.05		%
<b>SUPPLY</b>						
$V_{\text{AUDIO}}$	Power supply voltage			2.7	5.5	V
$I_{\text{AUDIO}}$	Positive supply current	$V_{\text{AUDIO}} = 3.6\text{ V}$ , $V_{\text{BUS}} = 0$ or $5\text{ V}$ , $V_{\text{ASEL}} = 0$ to $3.6\text{ V}$ , $I_{\text{OUT}} = 0$		6	10	$\mu\text{A}$
$I_{\text{OFF}}$	Power off leakage current	$V_{\text{AUDIO}} = 0\text{ V}$ , $V_{\text{D+R, D-L, D+, D-, L, R}} = 0$ to $5.5\text{ V}$			$\pm 10$	$\mu\text{A}$

TYPICAL CHARACTERISTICS

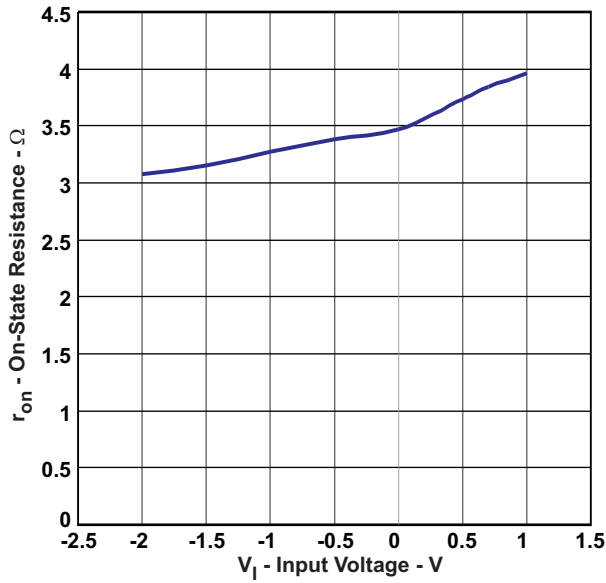


Figure 1. ON Resistance vs V<sub>1</sub> for Audio Switch

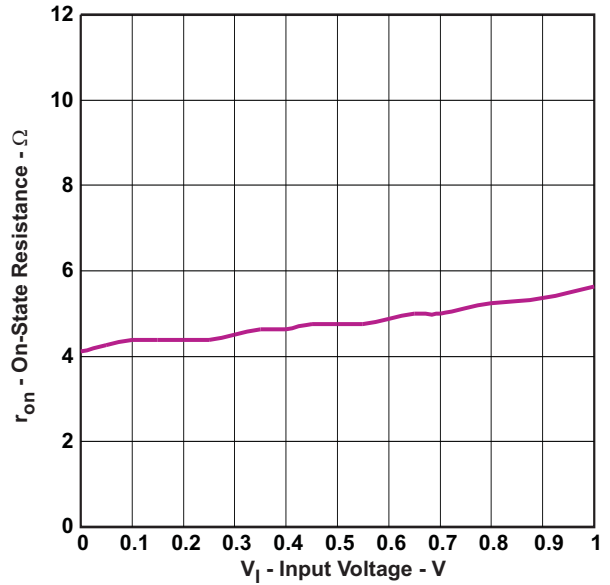


Figure 2. ON Resistance vs V<sub>1</sub> for USB Switch

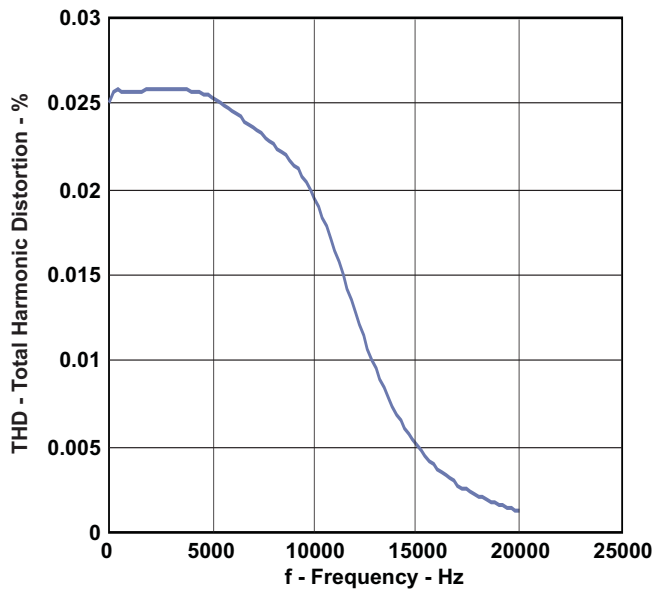


Figure 3. THD vs Frequency for Audio Switch

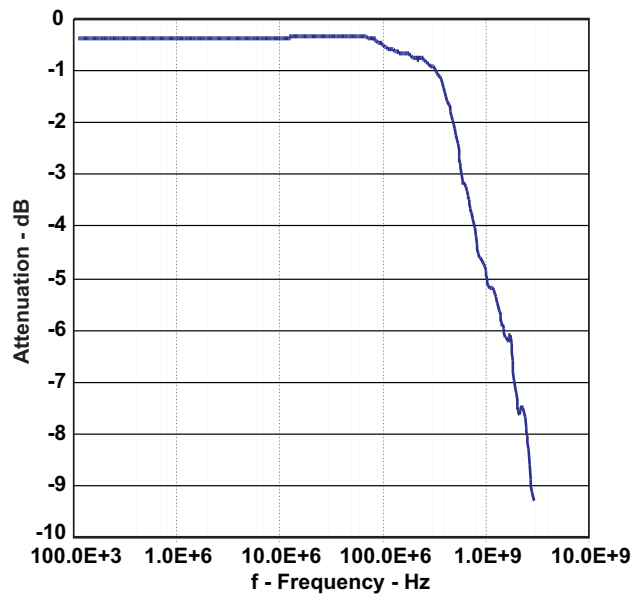


Figure 4. Gain vs Frequency for USB Switch

TYPICAL CHARACTERISTICS (continued)

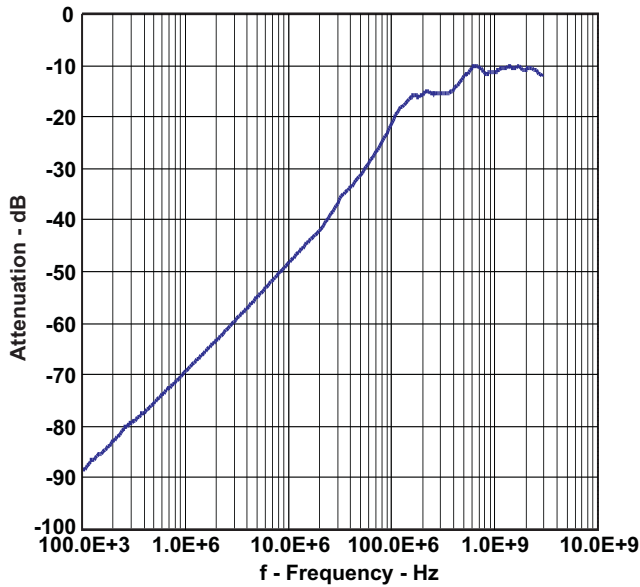


Figure 5. Off Isolation vs Frequency for Audio Switch

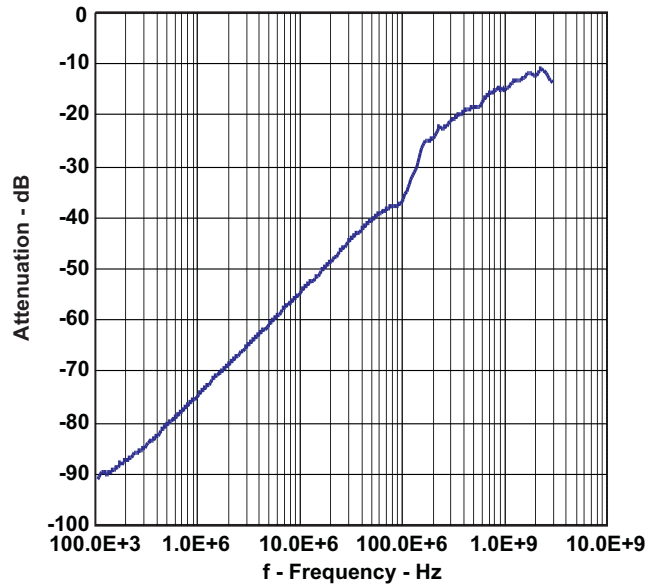


Figure 6. Off Isolation vs Frequency for USB Switch

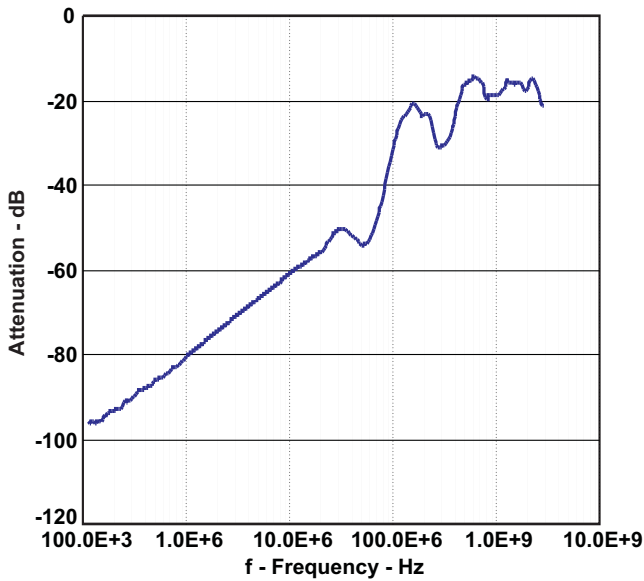


Figure 7. Cross Talk vs Frequency for Audio Switch

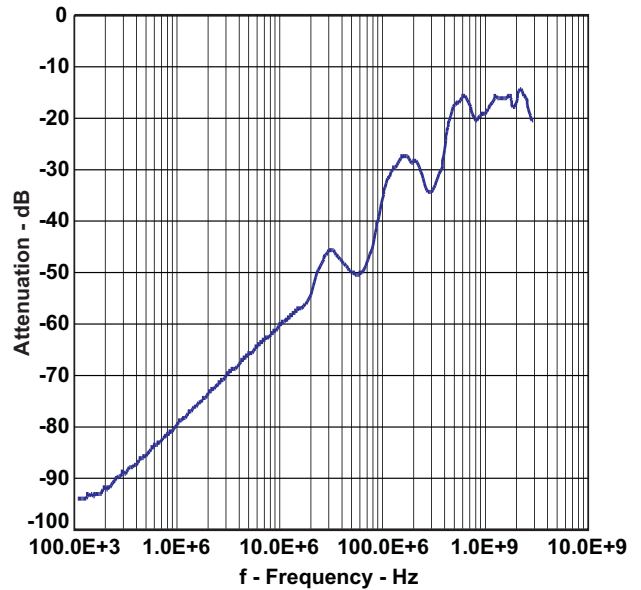


Figure 8. Cross Talk vs Frequency for USB Switch

### TYPICAL CHARACTERISTICS (continued)

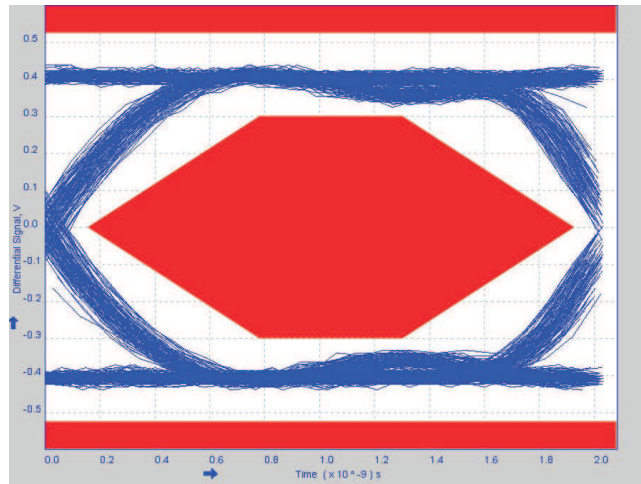
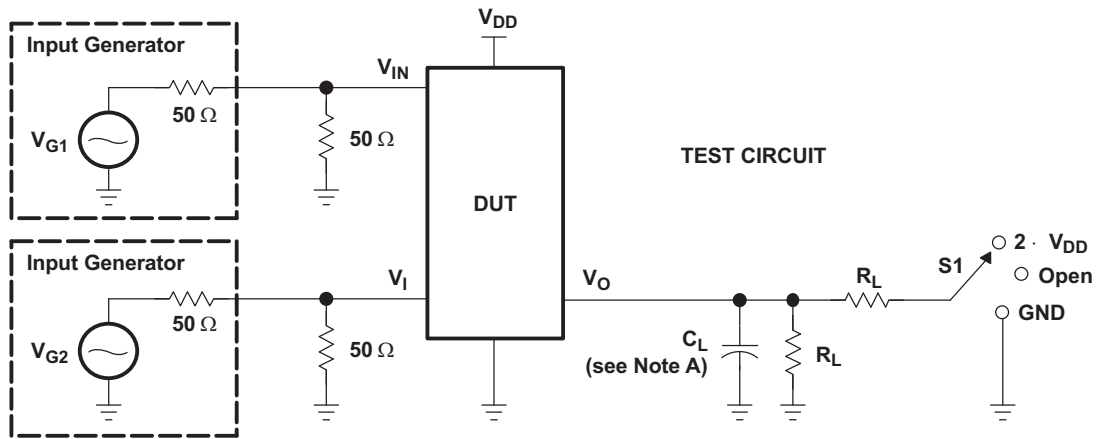
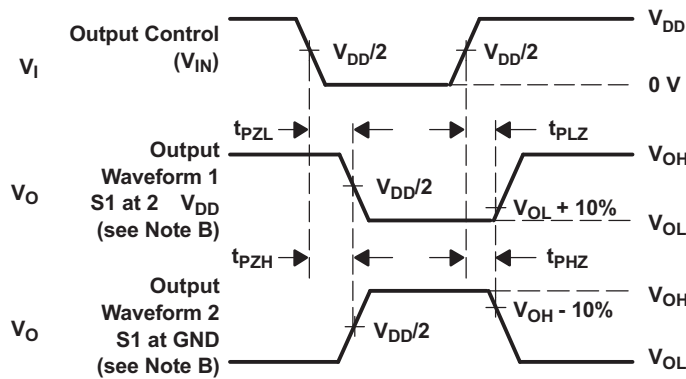


Figure 9. USB 2.0 Eye Pattern for USB Switch

PARAMETER MEASUREMENT INFORMATION  
(Enable and Disable Times)



TEST	$V_{AUDIO}(V_{DD})$	S1	$R_L$	$V_{in}$	$C_L$	$V_{\Delta}$
$t_{PLZ}/t_{PZL}$	3.3 V	$2 \cdot V_{DD}$	200 $\Omega$	GND	10 pF	0.3 V
$t_{PHZ}/t_{PZH}$	3.3 V	GND	200 $\Omega$	$V_{DD}$	10 pF	0.3 V

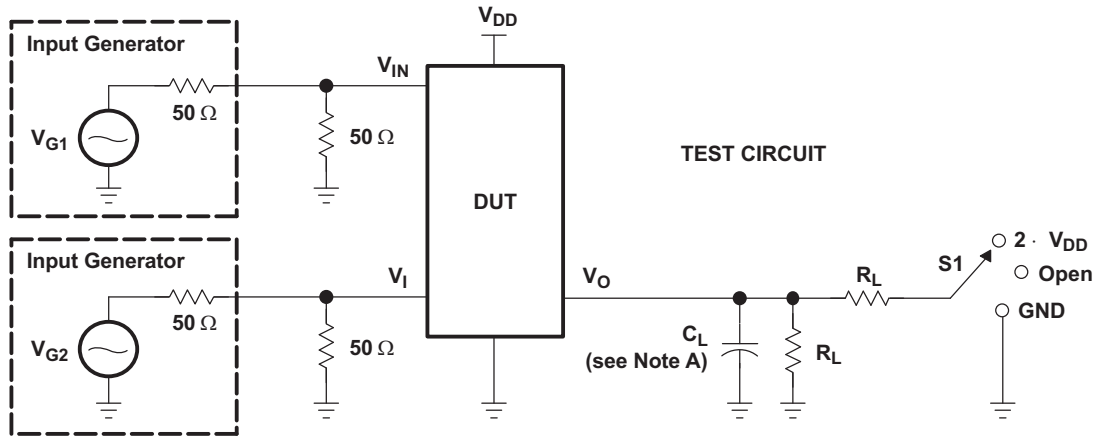


VOLTAGE WAVEFORMS  
ENABLE AND DISABLE TIMES

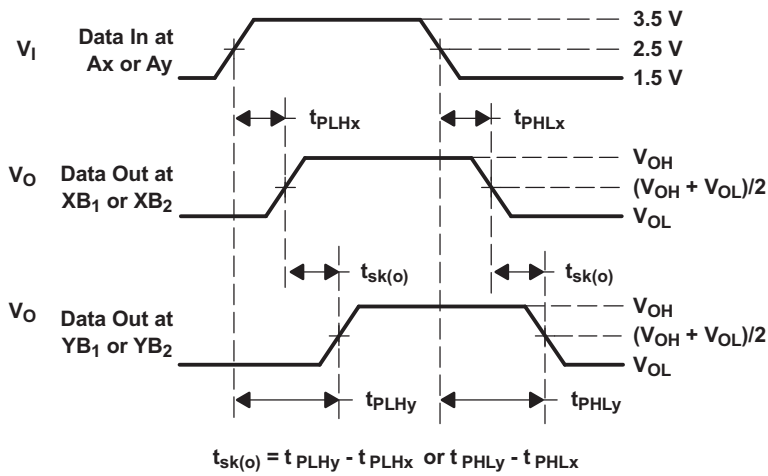
- NOTES: A.  $C_L$  includes probe and jig capacitance.  
 B. Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.  
 C. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 10$  MHz,  $Z_O = 50 \Omega$ ,  $t_r \leq 2.5$  ns,  $t_f \leq 2.5$  ns.  
 D. The outputs are measured one at a time, with one transition per measurement.  
 E.  $t_{PLZ}$  and  $t_{PHZ}$  are the same as  $t_{dis}$  or  $t_{OFF}$ .  
 F.  $t_{PZL}$  and  $t_{PZH}$  are the same as  $t_{en}$  or  $t_{ON}$ .

Figure 10. Test Circuit and Voltage Waveforms

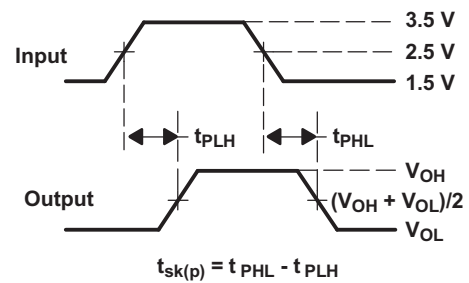
### PARAMETER MEASUREMENT INFORMATION (Skew)



TEST	V <sub>AUDIO</sub> (V <sub>DD</sub> )	S1	R <sub>L</sub>	V <sub>in</sub>	C <sub>L</sub>
t <sub>sk(o)</sub>	3.3 V ± 0.3 V	Open	200 Ω	V <sub>DD</sub> or GND	10 pF
t <sub>sk(p)</sub>	3.3 V ± 0.3 V	Open	200 Ω	V <sub>DD</sub> or GND	10 pF



**VOLTAGE WAVEFORMS  
OUTPUT SKEW (t<sub>sk(o)</sub>)**

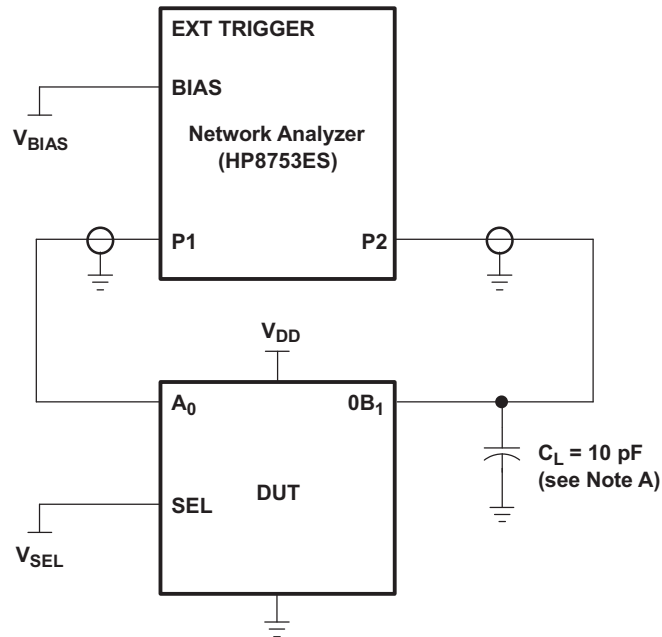


**VOLTAGE WAVEFORMS  
PULSE SKEW [t<sub>sk(p)</sub>]**

- NOTES: A. C<sub>L</sub> includes probe and jig capacitance.  
 B. 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.  
 C. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z<sub>O</sub> = 50 Ω, t<sub>r</sub> ≤ 2.5 ns, t<sub>f</sub> ≤ 2.5 ns.  
 D. The outputs are measured one at a time, with one transition per measurement.

**Figure 11. Test Circuit and Voltage Waveforms**

PARAMETER MEASUREMENT INFORMATION



A.  $C_L$  includes probe and jig capacitance.

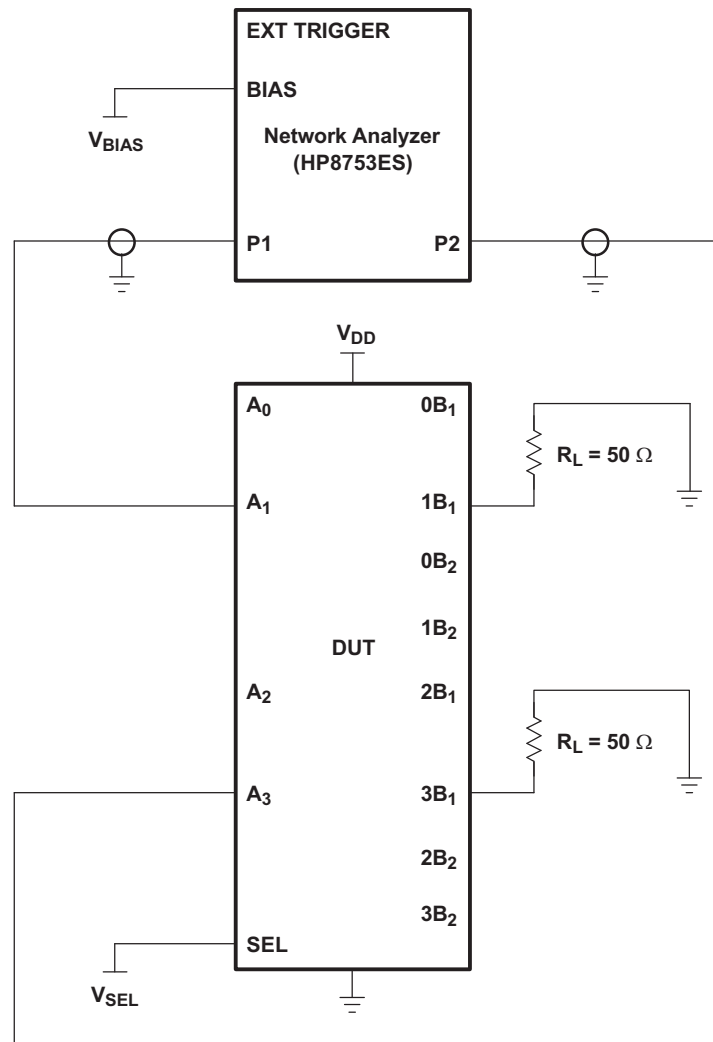
Figure 12. Test Circuit for Frequency Response (BW)

Frequency response is measured at the output of the ON channel. For example, when  $V_{SEL} = 0$  and  $A_0$  is the input, the output is measured at  $0B_1$ . All unused analog I/O ports are left open.

HP8753ES Setup

Average = 4  
 RBW = 3 kHz  
 $V_{BIAS} = 0.35 \text{ V}$   
 ST = 2 s  
 P1 = 0 dBm

## PARAMETER MEASUREMENT INFORMATION (continued)



- A.  $C_L$  includes probe and jig capacitance.
- B. A 50- $\Omega$  termination resistor is needed to match the loading of the network analyzer.

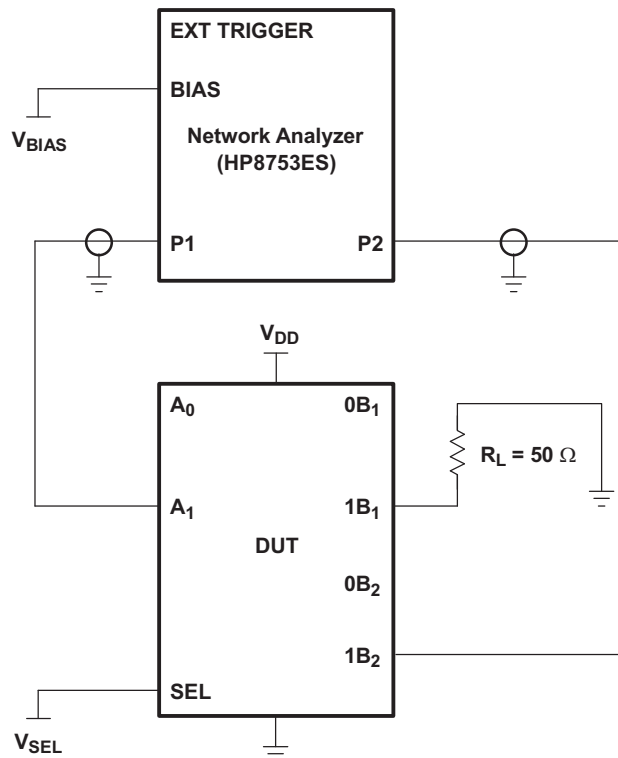
**Figure 13. Test Circuit for Crosstalk ( $X_{TALK}$ )**

Crosstalk is measured at the output of the nonadjacent ON channel. For example, when  $V_{SEL} = 0$  and  $A_1$  is the input, the output is measured at  $A_3$ . All unused analog input (A) ports are connected to GND, and output (B) ports are left open.

### HP8753ES Setup

Average = 4  
 RBW = 3 kHz  
 $V_{BIAS} = 0.35$  V  
 ST = 2 s  
 P1 = 0 dBm

PARAMETER MEASUREMENT INFORMATION (continued)



- A.  $C_L$  includes probe and jig capacitance.
- B. A 50- $\Omega$  termination resistor is needed to match the loading of the network analyzer.

**Figure 14. Test Circuit for OFF Isolation ( $O_{ISO}$ )**

OFF isolation is measured at the output of the OFF channel. For example, when  $V_{SEL} = GND$  and  $A_1$  is the input, the output is measured at  $1B_2$ . All unused analog input (A) ports are connected to ground, and output (B) ports are left open.

**HP8753ES Setup**

Average = 4  
 RBW = 3 kHz  
 $V_{BIAS} = 0.35\text{ V}$   
 ST = 2 s  
 P1 = 0 dBm

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TS5USBA224RSWR	ACTIVE	UQFN	RSW	10	3000	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	A5R	Samples

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSELETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

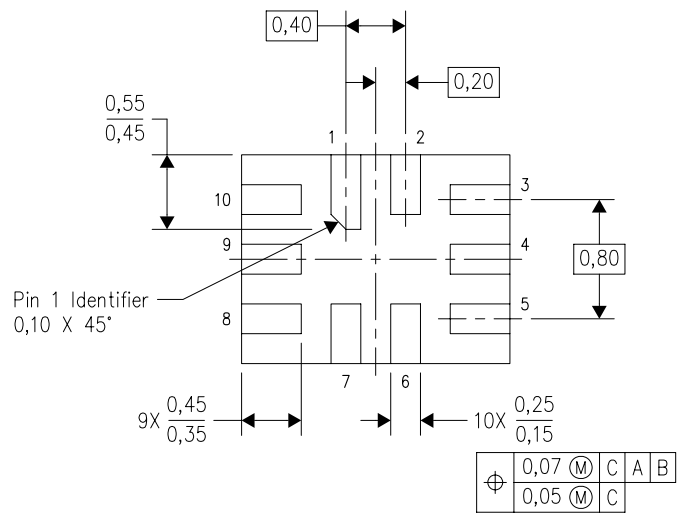
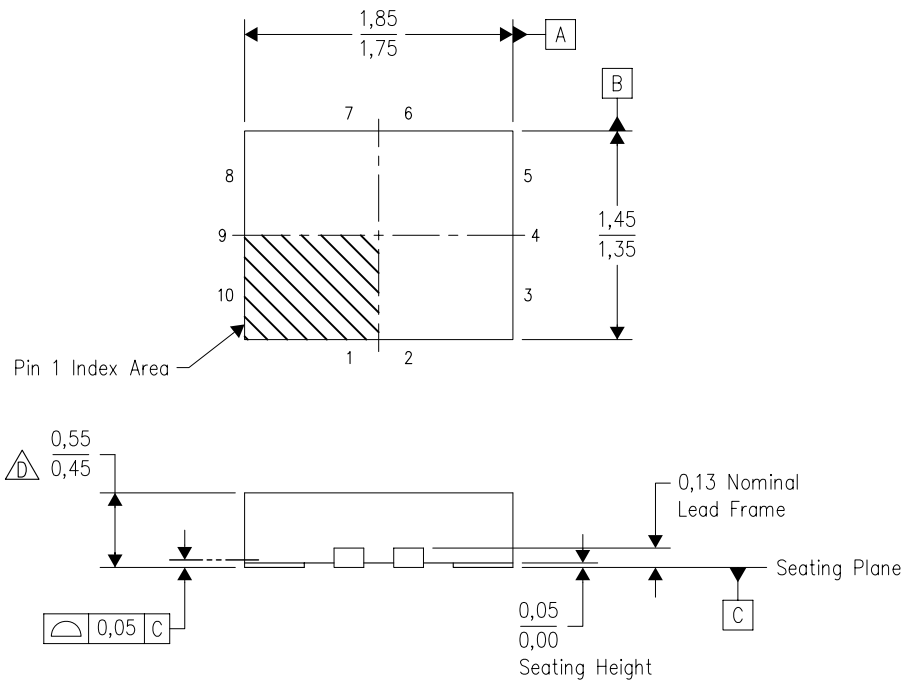
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RSW (R-PUQFN-N10)

PLASTIC QUAD FLATPACK NO-LEAD



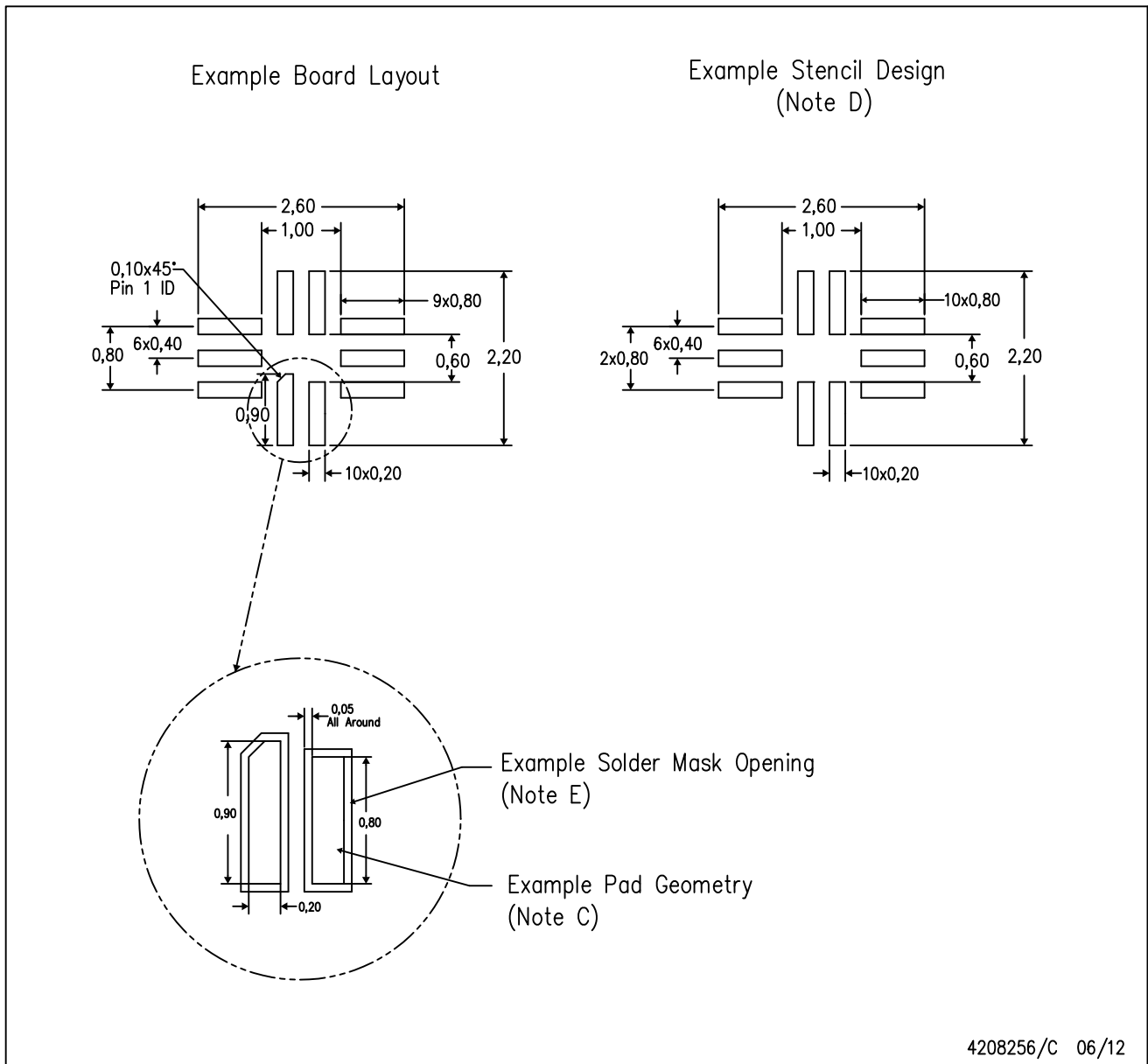
Bottom View

4208097/C 07/2008

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. QFN (Quad Flatpack No-lead) package configuration.
  -  This package complies to JEDEC MO-288 variation UDEE, except minimum package height.

RSW (R-PUQFN-N10)

PLASTIC QUAD FLATPACK NO-LEAD



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
  - Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.

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