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

Check for Samples: TS5USBA224

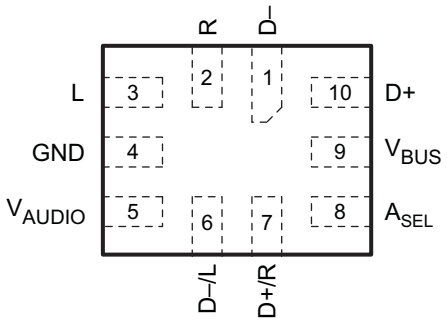
FEATURES

- **High-Speed USB Switch:**
  - **4 Ω R_{DSON} Typical**
  - **12.5 pF C_{ON} Typical**
  - **650-MHz Bandwidth (–3 dB)**
- **Audio Switch:**
  - **3 Ω R_{DSON} Typical**
  - **Negative Rail Capability**
  - **Low THD: <0.05%**
  - **Internal Shunt Resistors for Click-and-Pop Reduction**
  - **Powered From V_{AUDIO} (2.7V to 5.5V)**
- **1.8-V Compatible Control Input (A_{SEL} and V_{BUS}) Threshold**
- **I_{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**

RSW PACKAGE
(TOP VIEW)



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_{AUDIO}. When A_{SEL}=High, the audio path is selected regardless of the logic level at V_{BUS}. If A_{SEL}=Low and V_{BUS}=High, the USB path is selected. Otherwise if A_{SEL}=Low and V_{BUS}=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(1) (2)		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.
(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.

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 Ω	3 Ω
ON-state resistance match (Δr_{on})	< 0.3 Ω	< 0.3 Ω
ON-state resistance flatness ($r_{on(flat)}$)	N/A	1.5 Ω
Turn-on/turn-off time (t_{ON}/t_{OFF})	< 2 µs	< 4 µs
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

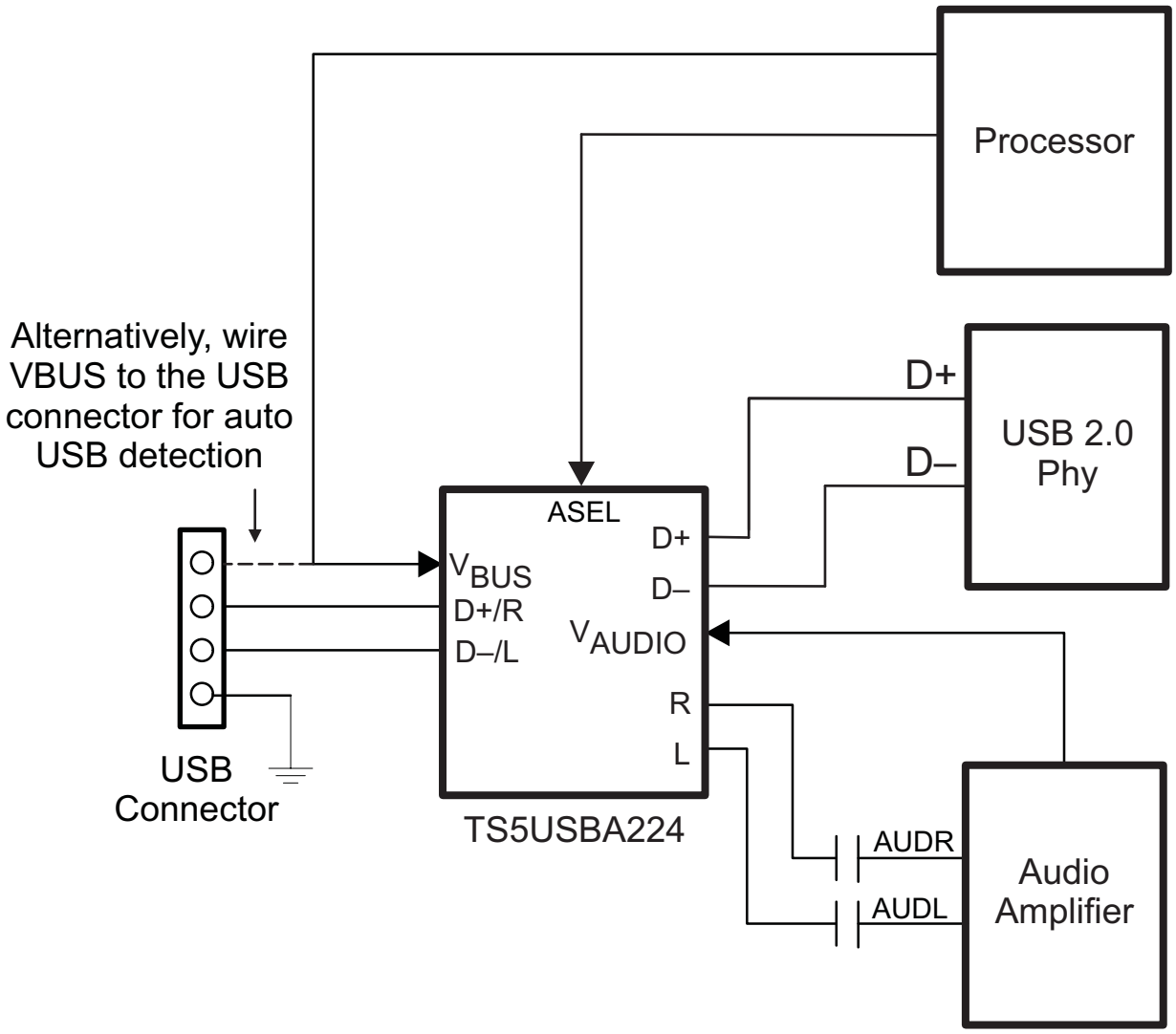
PIN			DESCRIPTION
NO.	NAME	TYPE	
1	D–	I/O	USB Data (Differential –)
2	R	I/O	Right Channel Audio
3	L	I/O	Left Channel Audio
4	GND	Ground	Ground
5	V_{AUDIO}	Power	Supply Voltage
6	D–/L	I/O	USB/Audio Common Connector
7	D+/R	I/O	USB/Audio Common Connector
8	A_{SEL}	Input	Control Input for Audio Path
9	V_{BUS}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

FUNCTION TABLE

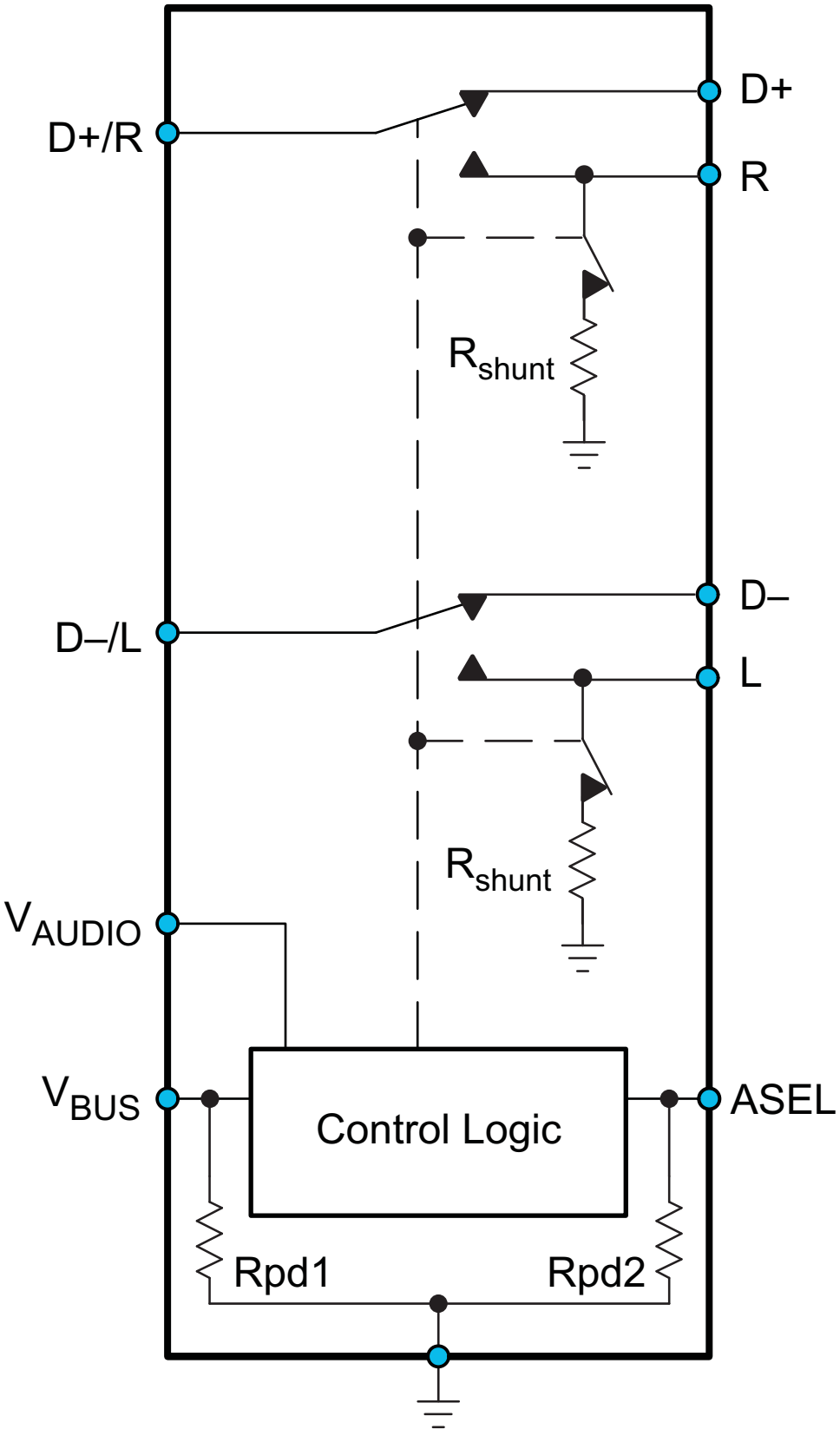
A_{SEL}	V_{AUDIO}	V_{BUS}	L,R	D+, D–
L	L	L	OFF	OFF
L	L	H	OFF	OFF
L	H	L	ON	OFF
L	H	H	OFF(1)	ON
H	L	L	OFF	OFF
H	L	H	OFF	OFF
H	H	L	ON	OFF
H	H	H	ON	OFF

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

TYPICAL APPLICATION BLOCK DIAGRAM



SWITCH BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS(1)(2)

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

			MIN	MAX	UNIT
V_{AUDIO}	Supply voltage range(3)		–0.5	6.5	V
V_{D+} $V_{D–}$	Analog voltage Range(3)		–0.5	6.5	V
V_R V_L			V_{AUDIO} – 6.5	V_{AUDIO} + 0.5	V
I_K	Analog port diode current	V_{D+}, $V_{D–}$ < 0	–50		mA
I_{D+}, $I_{D–}$ I_R, I_L	ON-state switch current	V_{D+}, $V_{D–}$ = 0 to V_{AUDIO}, V_R, V_L $V_{D+/R}$, $V_{D–/L}$ = V_{AUDIO} – 5.5 V to V_{AUDIO}	–100	100	mA
$I_{D+/R}$ $I_{D–/L}$	ON-state peak switch current(4)		–200	200	
V_I	Digital input voltage range		–0.5	6.5	V
I_{IK}	Digital logic input clamp current(3)	V_I < 0		–50	mA
I_{AUDIO}	Continuous current through V_{AUDIO}			100	mA
I_{GND}	Continuous current through GND		–100		mA
T_{stg}	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(1)

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

PARAMETER		TEST CONDITIONS	TYP	UNIT
θ_{JA}	Package thermal impedance	RSW package	175	°C/W

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

ELECTRICAL CHARACTERISTICS

T_A = –40°C to 85°C, typical values are at V_{AUDIO} = 3.3 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
USB SWITCH							
V_{D+},$V_{D–}$	Analog voltage range			0		5.5	V
r_{on}	ON-state resistance	V_{AUDIO} = 3 V, V_{BUS} = 5 V, V_{ASEL} = 0 V, $V_{D+/D–}$ = 0 V, 0.4 V, I_{ON} = –8 mA	Switch ON		4	7	Ω
Δr_{on}	ON-state resistance match between channels	V_{AUDIO} = 3 V, V_{BUS} = 5 V, V_{ASEL} = 0 V, $V_{D+/D–}$ = 0 V, 0.4 V, I_{ON} = –8 mA	Switch ON			0.3	Ω
$I_{D+(OFF)}$ $I_{D–(OFF)}$	D+ ,D- OFF leakage current	V_{AUDIO} = 3.6 V, V_{BUS} = 0 V, V_{ASEL} = 3.6 V, V_{D+} ,$V_{D–}$ = 0.3 V, $V_{D+/R}$,$V_{D–/L}$ = 0.3 V	Switch OFF			±50	nA
$I_{D+(ON)}$ $I_{D–(ON)}$	D+ ,D– ON leakage current	V_{AUDIO} = 3.6 V, V_{BUS} = 5 V, V_{ASEL} = 0 V, V_{D+} ,$V_{D–}$ = 0.3 V, $V_{D+/R}$ = Open	Switch ON			±50	nA
AUDIO SWITCH							
V_R,V_L	Analog voltage range			V_{AUDIO} – 5.5		V_{AUDIO}	V
r_{on}	ON-state resistance	V_{AUDIO} = 3 V, V_{BUS} = 0 V, V_{ASEL} = 3 V, $V_{L/R}$ = –2 V, 0 V, 0.7 V, I_{ON} = –26 mA	Switch ON		3	5	Ω
Δr_{on}	ON-state resistance match between channels	V_{AUDIO} = 3 V, V_{BUS} = 0 V, V_{ASEL} = 3 V, $V_{L/R}$ = 0.7 V, I_{ON} = –26 mA	Switch ON			0.3	Ω
$r_{on\ (flat)}$	ON-state resistance flatness	V_{AUDIO} = 3 V, V_{BUS} = 0 V, V_{ASEL} = 3 V, $V_{L/R}$ = –2 V, 0 V, 0.7 V, I_{ON} = –26 mA	Switch ON		1.5	2.5	Ω

ELECTRICAL CHARACTERISTICS (continued)

T_A = –40°C to 85°C, typical values are at V_{AUDIO} = 3.3 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
r_{SHUNT}	Shunt resistance	V_{AUDIO} = 3 V, V_{BUS} = 5 V, V_{ASEL} = 0 V, $V_{L/R}$ = 0.7 V, I_{OSHUNT} = 10 mA	Switch OFF		100	200	Ω
$I_{L(OFF)}$ $I_{R(OFF)}$	L , R OFF leakage current	V_{AUDIO} = 3.6 V, V_{BUS} = 5 V, V_{ASEL} = 0 V, V_R, V_L = 0.3 V, V_{AUDIO}–0.3 V, $V_{D+/R}$, $V_{D–/L}$ = 0.3 V, V_{AUDIO}–0.3V	Switch OFF			±50	nA
$I_{L(ON)}$ $I_{R(ON)}$	L , R ON leakage current	V_{AUDIO} = 3.6 V, V_{BUS} = 0 V, V_{ASEL} = 3.6 V,D+/R, D–L = 0.3 V, V_R, V_L = 0.3 V, V_{AUDIO}–0.3 V, V_{AUDIO}–0.3V $V_{D+/R}$, $V_{D–/L}$ =Open	Switch ON			±50	nA
DIGITAL CONTROL INPUTS (A_{SEL}, V_{BUS})							
V_{IH}	Input logic high	V_{AUDIO} = 2.7V to 5.5V		1.2			V
V_{IL}	Input logic low	V_{AUDIO} = 2.7V to 5.5V				0.5	V
I_{IN}	Input leakage current	V_{AUDIO} = 3.6V	VIN = 3.6V			±10	µA
			VIN = 0V			±1	
r_{PD1}	Internal pulldown resistance				3		MΩ
r_{PD2}	Internal pulldown resistance				5		MΩ

DYNAMIC CHARACTERISTICS

T_A = –40°C to 85°C, typical values are at V_{AUDIO} = 3.3 V, T_A = 25°C (unless otherwise noted)

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

TYPICAL CHARACTERISTICS

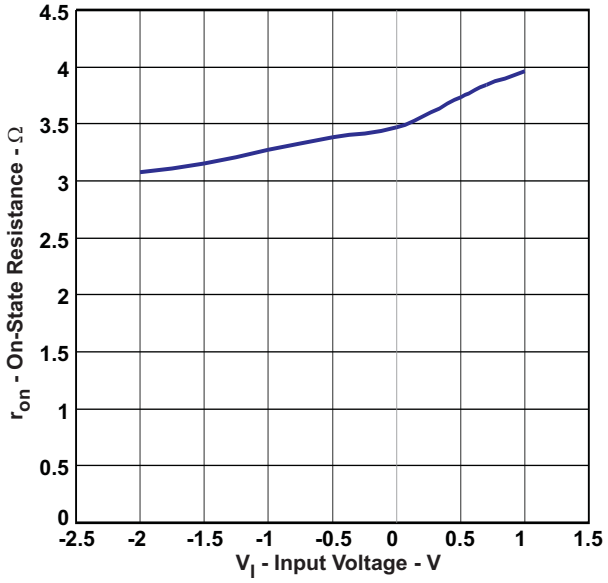


Figure 1. ON Resistance vs V_I for Audio Switch

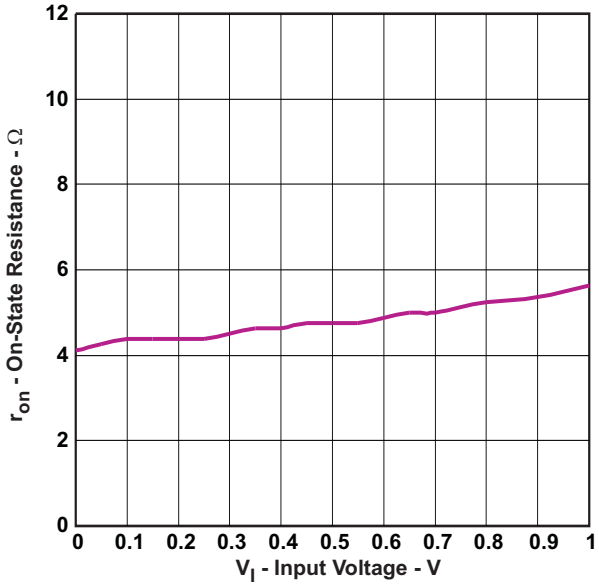


Figure 2. ON Resistance vs V_I for USB Switch

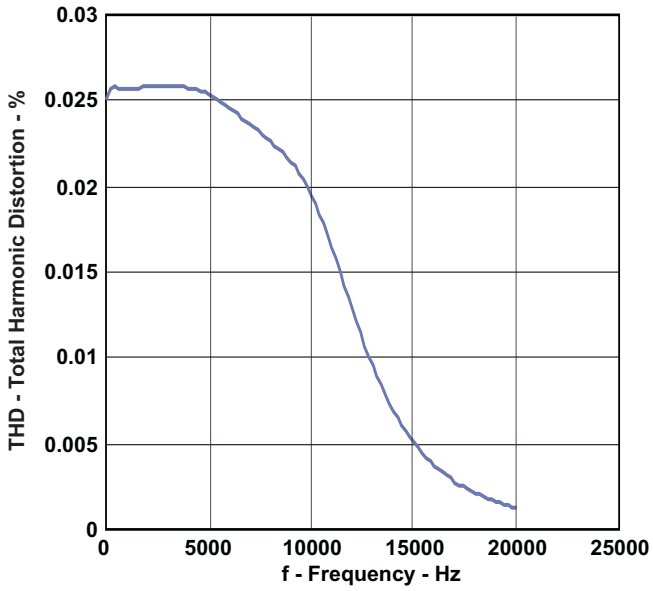


Figure 3. THD vs Frequency for Audio Switch

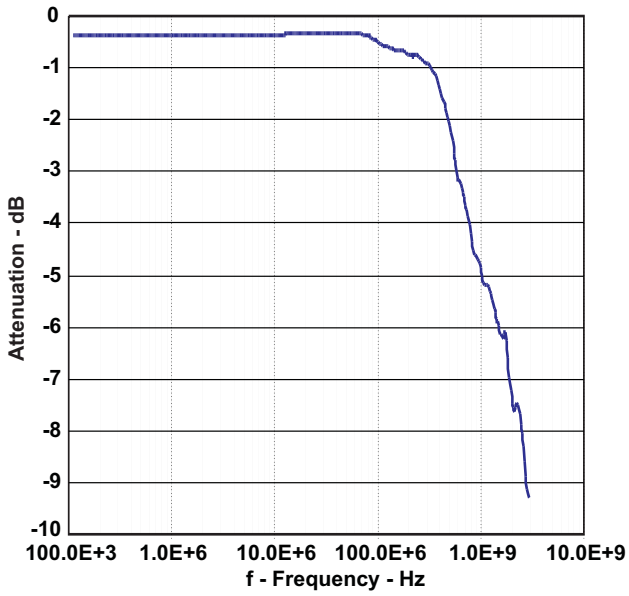


Figure 4. Gain vs Frequency for USB Switch

TYPICAL CHARACTERISTICS (continued)

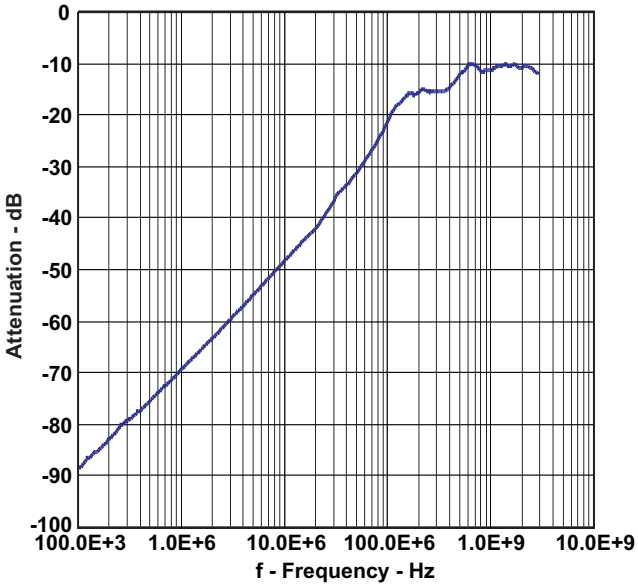


Figure 5. Off Isolation vs Frequency for Audio Switch

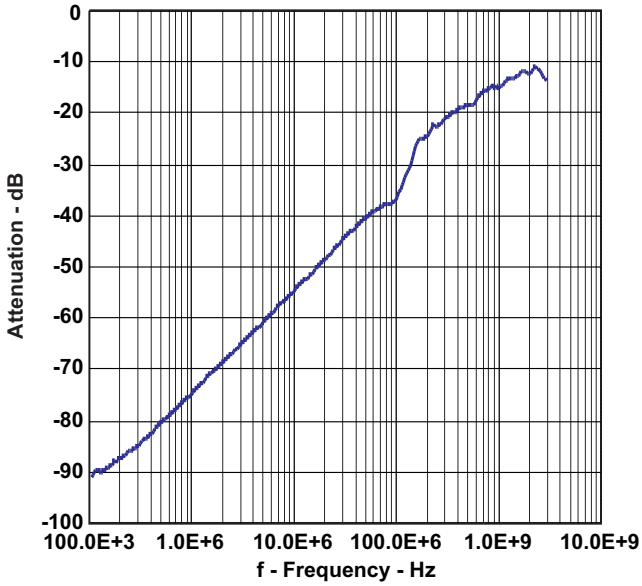


Figure 6. Off Isolation vs Frequency for USB Switch

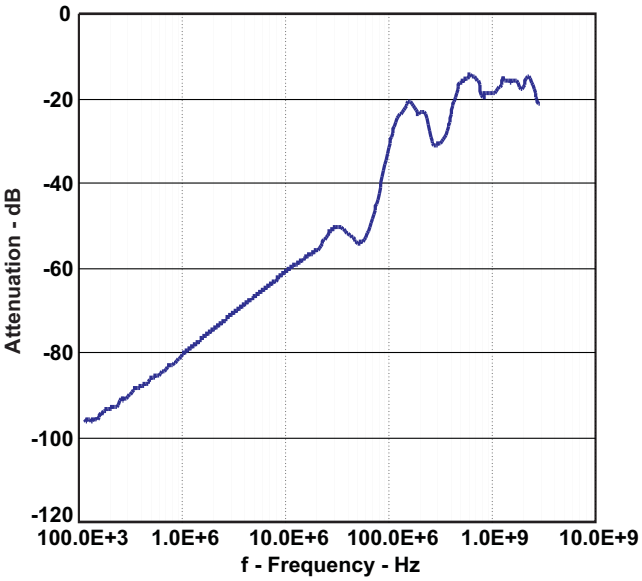


Figure 7. Cross Talk vs Frequency for Audio Switch

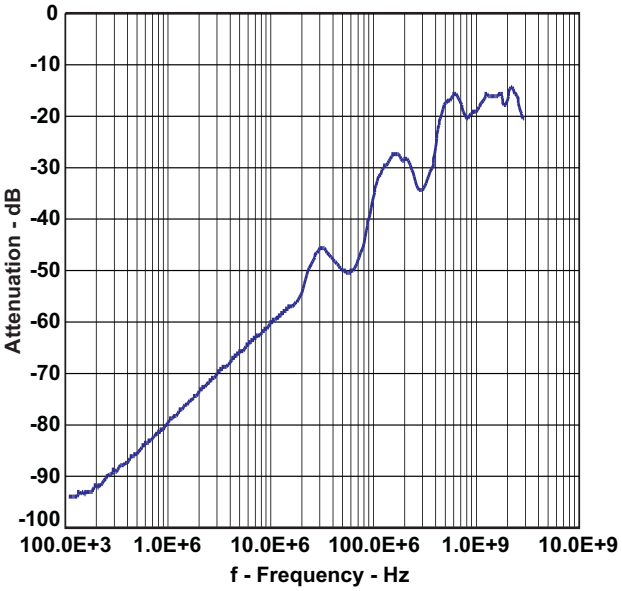


Figure 8. Cross Talk vs Frequency for USB Switch

TYPICAL CHARACTERISTICS (continued)

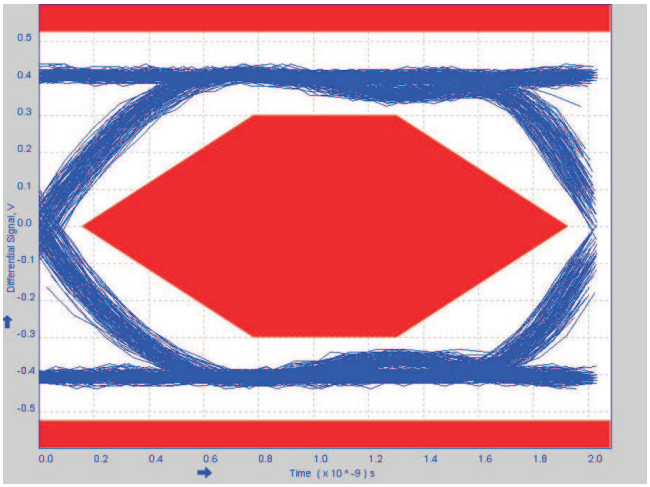
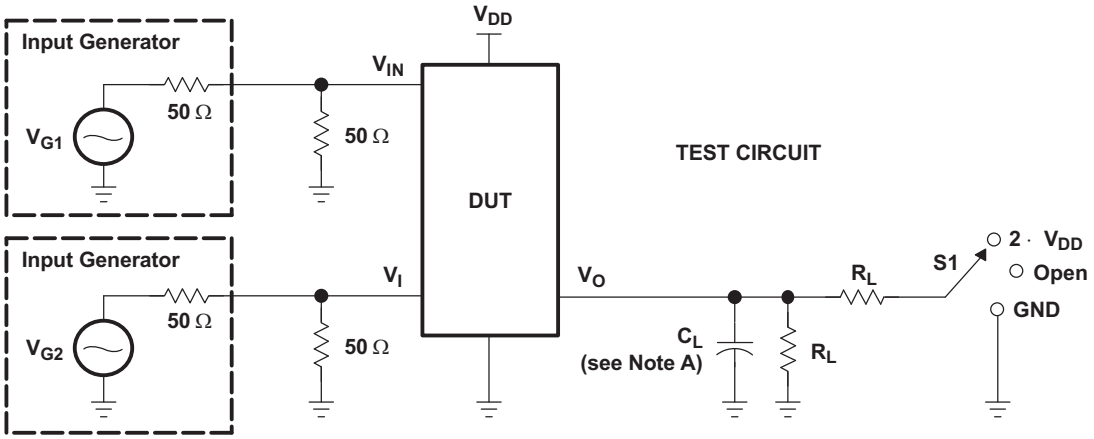
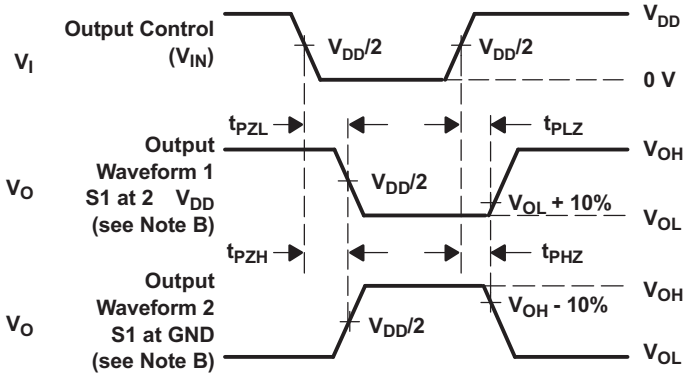


Figure 9. USB 2.0 Eye Pattern for USB Switch

PARAMETER MEASUREMENT INFORMATION
(Enable and Disable Times)



TEST	V_{AUDIO} (V_{DD})	S1	R_L	V_{in}	C_L	V_Δ
t_{PLZ}/t_{PZL}	3.3 V	2 · V_{DD}	200 Ω	GND	10 pF	0.3 V
t_{PHZ}/t_{PZH}	3.3 V	GND	200 Ω	V_{DD}	10 pF	0.3 V

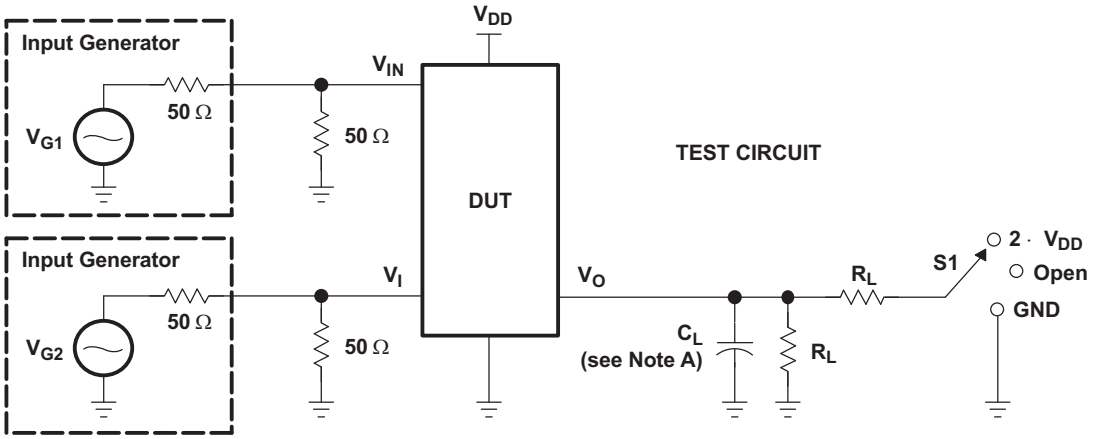


VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES

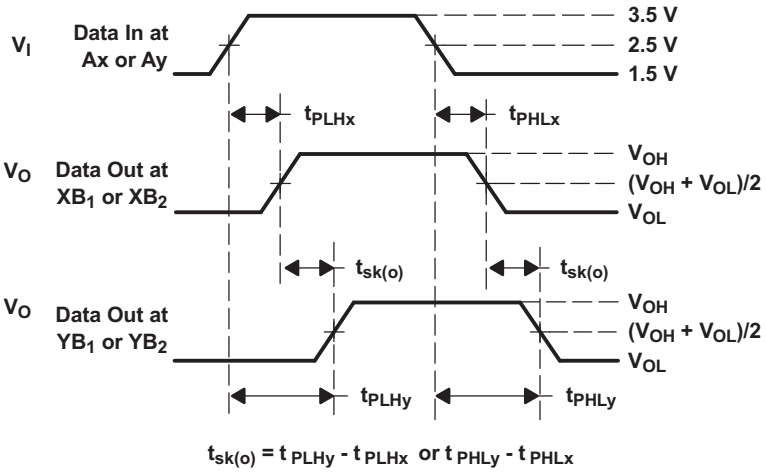
NOTES: A. C_L includes probe and jig capacitance.
B. Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.
C. All input pulses are supplied by generators having the following characteristics: PRR≤ 10 MHz, Z_O = 50 Ω, t_r ≤ 2.5 ns, t_f ≤ 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

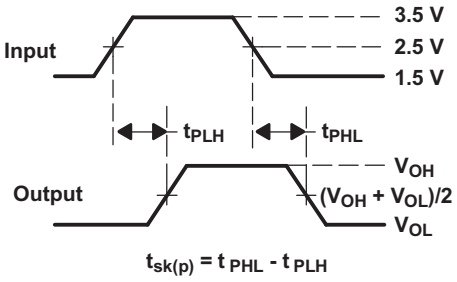
PARAMETER MEASUREMENT INFORMATION (Skew)



TEST	V_{AUDIO} (V_{DD})	S1	R_L	V_{in}	C_L
$t_{sk(o)}$	3.3 V ± 0.3 V	Open	200 Ω	V_{DD} or GND	10 pF
$t_{sk(p)}$	3.3 V ± 0.3 V	Open	200 Ω	V_{DD} or GND	10 pF



VOLTAGE WAVEFORMS
OUTPUT SKEW ($t_{sk(o)}$)

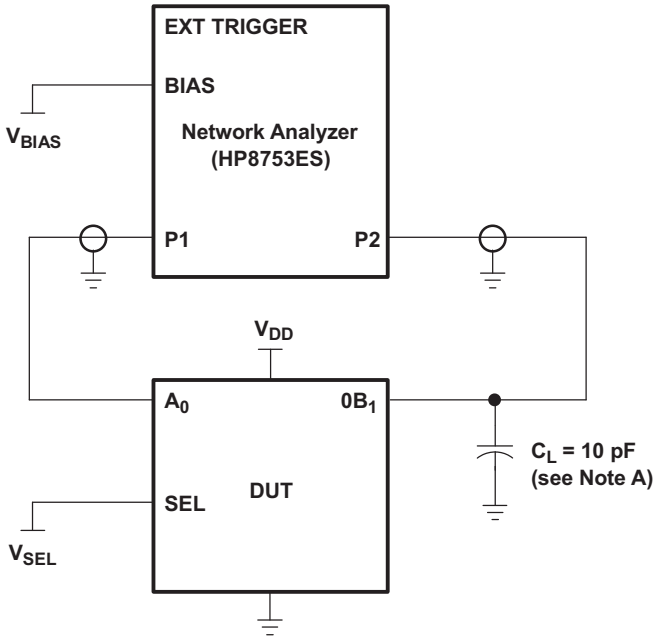


VOLTAGE WAVEFORMS
PULSE SKEW [$t_{sk(p)}$]

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 ≤ 10 MHz, Z_O = 50 Ω, t_r ≤ 2.5 ns, t_f ≤ 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.

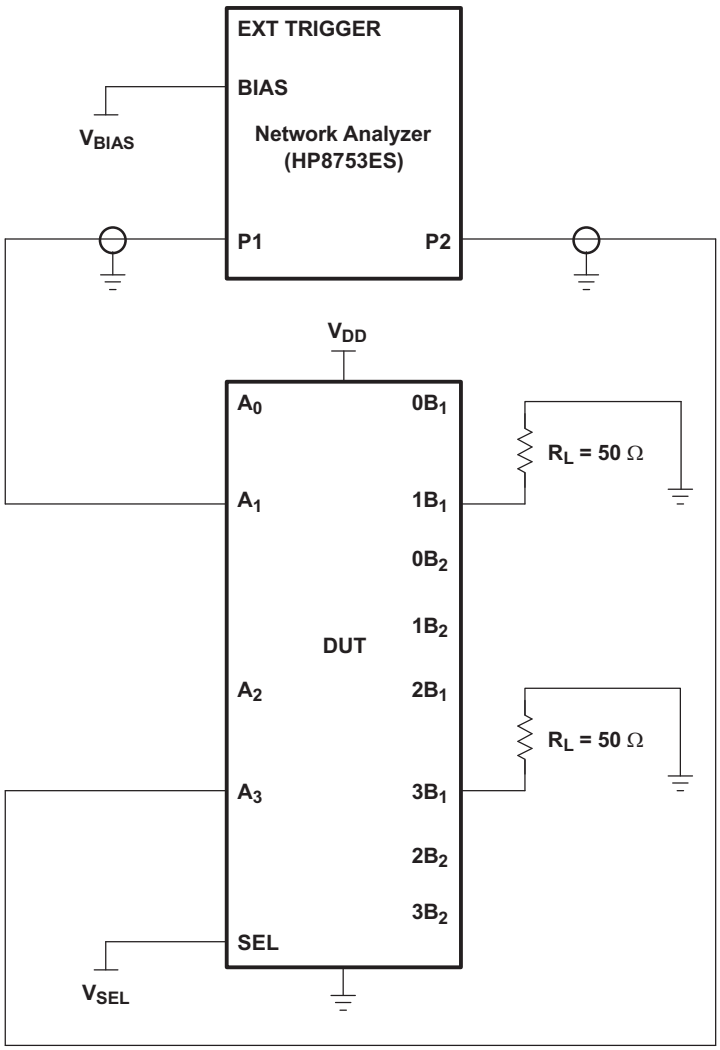
Figure 12. Test Circuit for Frequency Response (BW)

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 V
ST = 2 s
P1 = 0 dBM

PARAMETER MEASUREMENT INFORMATION (continued)



A. C_L includes probe and jig capacitance.

B. A 50-Ω termination resistor is needed to match the loading of the network analyzer.

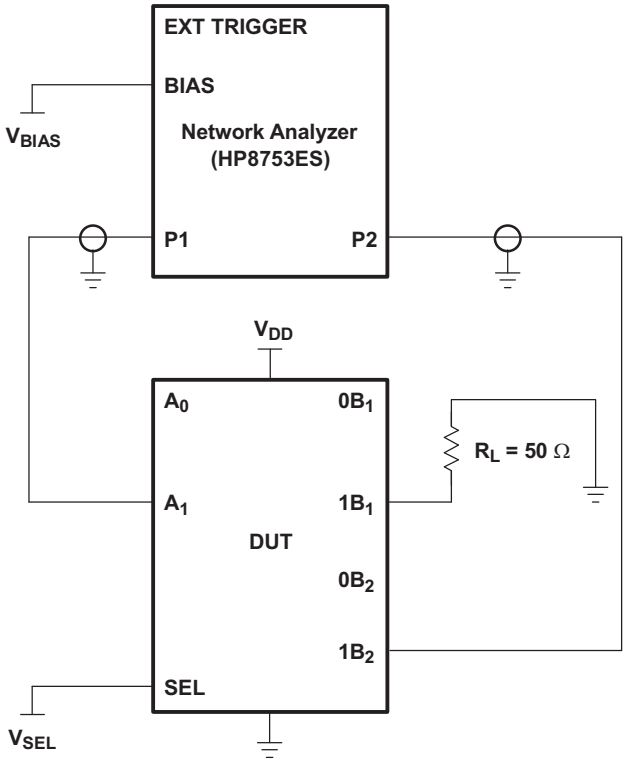
Figure 13. Test Circuit for Crosstalk (X_{TALK})

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-Ω 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 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	MSL Peak Temp (3)	Samples (Requires Login)
TS5USBA224RSWR	ACTIVE	UQFN	RSW	10	3000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	

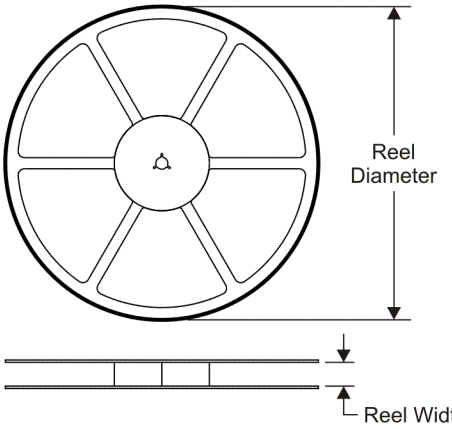
(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, 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.
OBSOLETE: 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)

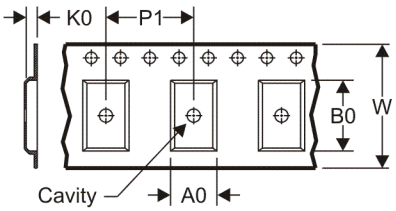
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

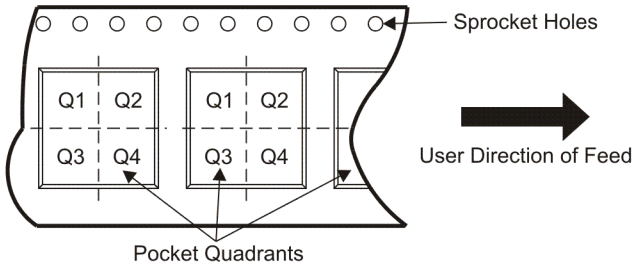


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

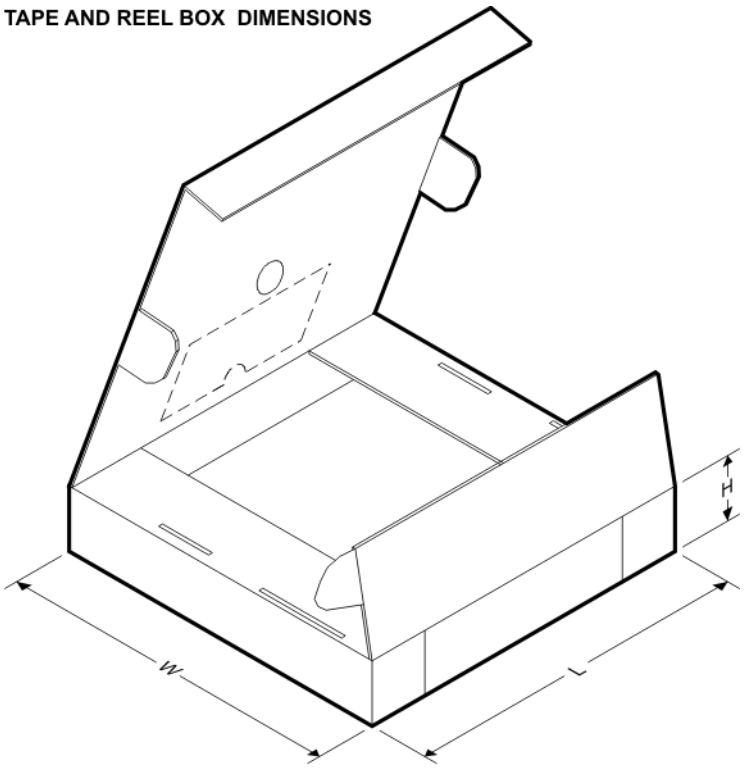
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TS5USBA224RSWR	UQFN	RSW	10	3000	180.0	8.4	1.59	2.09	0.72	4.0	8.0	Q1

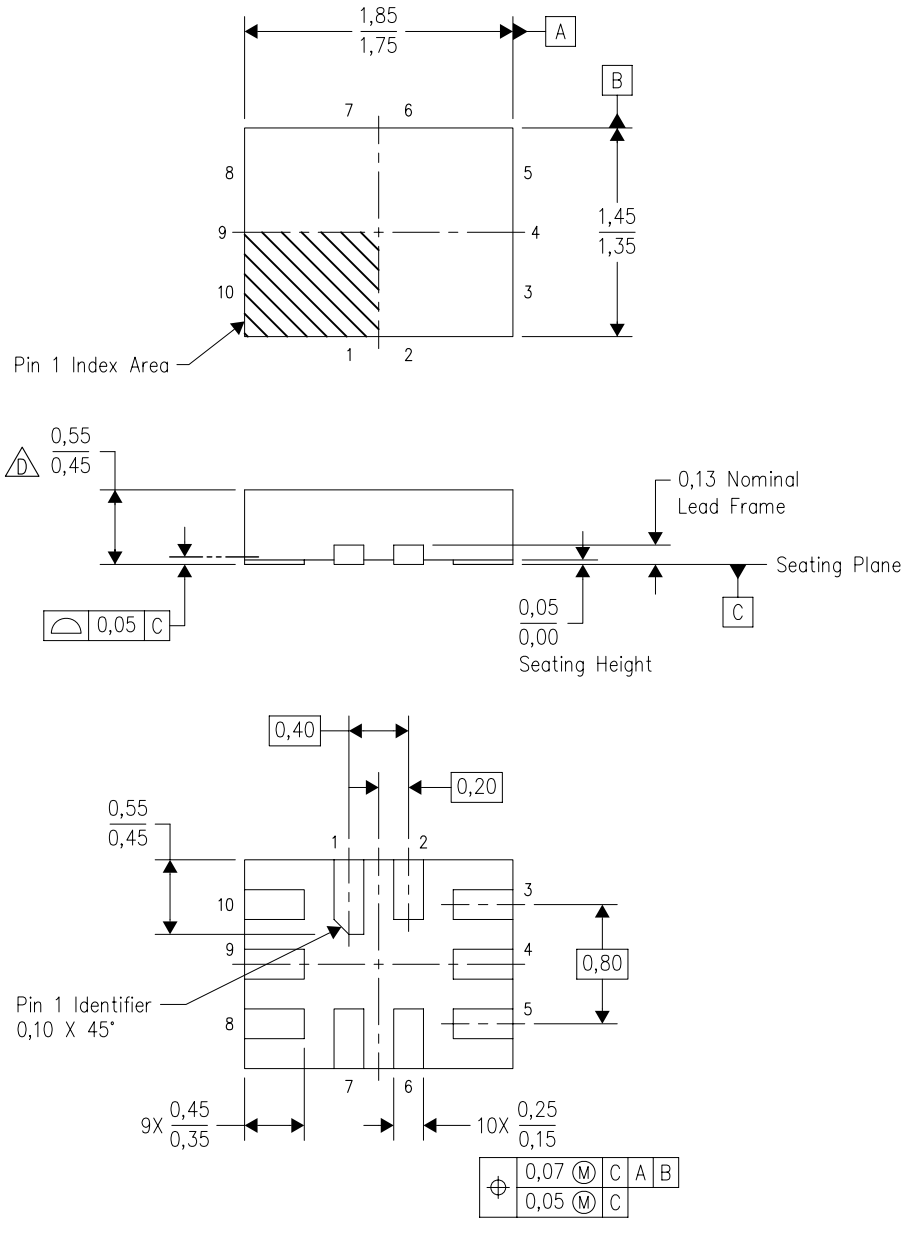
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TS5USBA224RSWR	UQFN	RSW	10	3000	202.0	201.0	28.0

RSW (R–PUQFN–N10) PLASTIC QUAD FLATPACK NO–LEAD



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.
D. This package complies to JEDEC MO–288 variation UDEE, except minimum package height.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DLP® Products	www.dlp.com	Communications and Telecom	www.ti.com/communications
DSP	dsp.ti.com	Computers and Peripherals	www.ti.com/computers
Clocks and Timers	www.ti.com/clocks	Consumer Electronics	www.ti.com/consumer-apps
Interface	interface.ti.com	Energy	www.ti.com/energy
Logic	logic.ti.com	Industrial	www.ti.com/industrial
Power Mgmt	power.ti.com	Medical	www.ti.com/medical
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
RFID	www.ti-rfid.com	Space, Avionics & Defense	www.ti.com/space-avionics-defense
RF/IF and ZigBee® Solutions	www.ti.com/lprf	Video and Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless-apps

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265