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

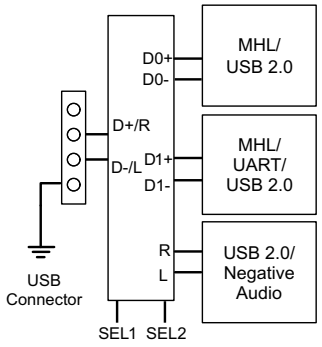
Check for Samples: TS3USBA225

FEATURES

- 2.7-V to 4.3-V Operating Power Supply (VCC)
- MHL/High-Speed USB (480Mbps) Switch:
  - VI/O Accepts Signals up to 4.3 V (Independent of VCC)
  - 6.5 Ω RDSON Typical
  - 3 pF CON Typical
  - 1.9 GHz Bandwidth (–3 dB)
- Audio Switch:
  - 2.5 Ω RDSON Typical
  - Negative Rail Capability –1.8 V to VCC
  - Low THD: < 0.05%
  - Internal Shunt Resistors for Click-and-Pop Reduction
- 1.8-V Compatible Control Input (SEL1 and SEL2) Threshold
- Minimized Current Consumption (~5 µA) in Power-Down Mode
- Power-Off Protection: All I/O Pins are High-Z when V_{CC}= 0 V
- 12-Pin QFN Package (2 × 1.7 mm, 0.4-mm pitch)
- ESD Performance Tested per JESD 22
  - 2000-V Human-Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)

APPLICATIONS

- Cell phones and Smartphones
- Tablet PCs
- Portable Instrumentation
- Digital Still Cameras
- Portable Navigation Devices (GPS)
- USB 2.0, MIPI (CSI/DSI), LVDS switching



DESCRIPTION

The TS3USBA225 is a double-pole, triple throw (DP3T) multiplexer that supports USB 2.0 High-Speed (480 Mbps) signals in all 3 differential channels. The first two high-speed channels also support Mobile High Definition Link (MHL) signaling with video data rates up to 720p, 60fps and 1080i, 30fps. One of the differential channels can also be used as an audio switch that is designed to allow audio signals to swing negatively. This configuration allows the system designer to use a common connector for audio and USB data.

The TS3USBA225 has a VCC range of 2.7 V to 4.3 V with the capability to pass true-ground audio signals down to –1.8 V. The device also supports a power-down mode that can be enabled when both SEL controls are low to minimize current consumption when no signal is transmitting. The TS3USBA225 also features internal shunt resistors on the audio path to reduce clicks and pops that may be heard when the audio switches are selected.

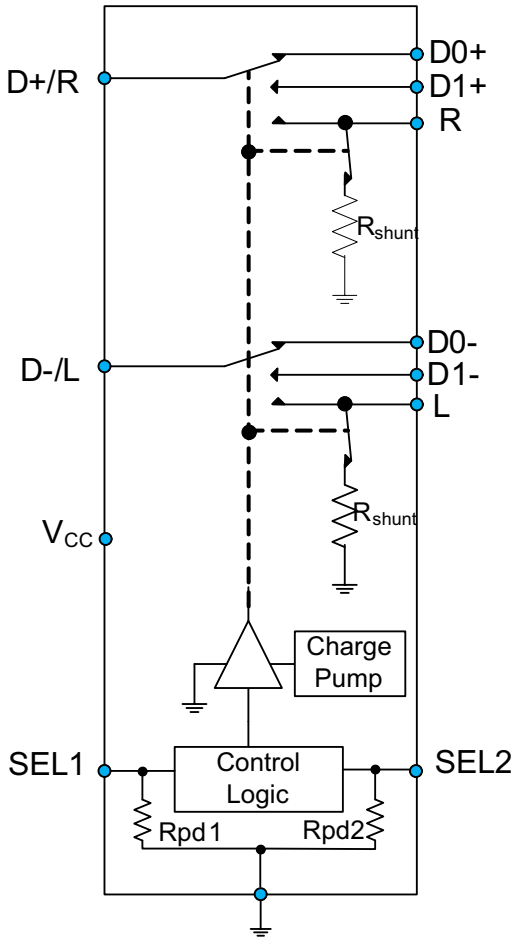
ORDERING INFORMATION

T_A	PACKAGE(1) (2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	QFN 0.4-mm pitch – RUT (Pb-Free)	Tape and reel	TS3USBA225RUTR	LQR

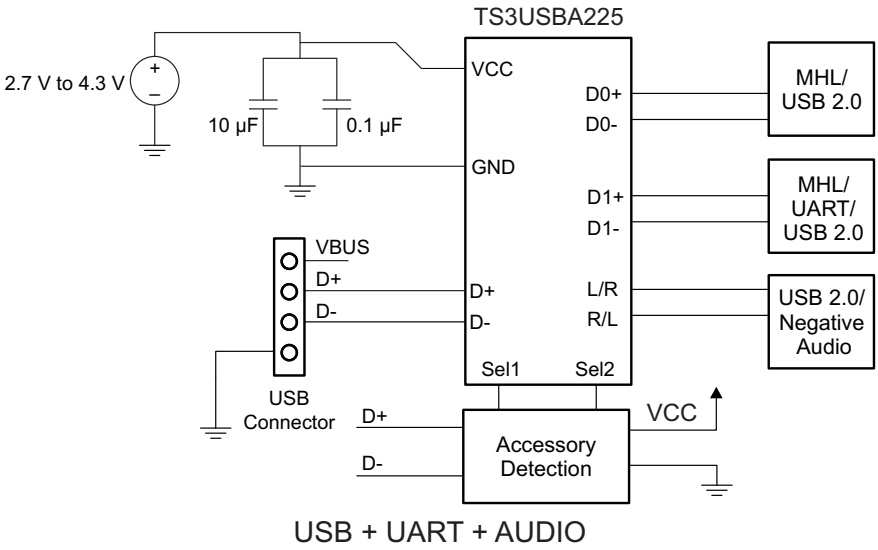
(1) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.
(2) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

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.

SWITCH BLOCK DIAGRAM

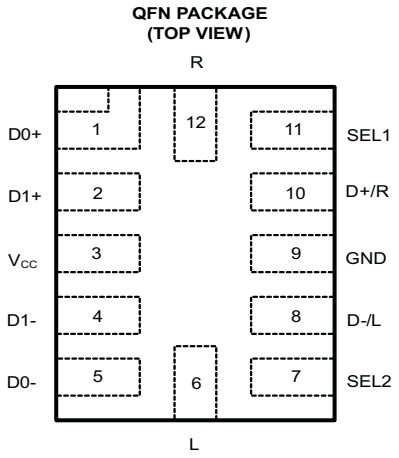


TYPICAL APPLICATION BLOCK DIAGRAM



USB + UART + AUDIO

PIN CONFIGURATION



12-Pin QFN Package (2x1.7 mm, 0.4mm pitch)

PIN DESCRIPTION TABLE

PIN			DESCRIPTION
NUMBER	NAME	TYPE	
1	D0+	I/O	MHL/USB/UART Data 1 (Differential +)
2	D1+	I/O	MHL/USB/UART Data 2 (Differential +)
3	VCC	Power	Power supply
4	D1–	I/O	MHL/USB/UART Data 2 (Differential –)
5	D0–	I/O	MHL/USB/UART Data 1 (Differential –)
6	L	I/O	USB-/Left Channel Audio
7	SEL2	Input	Control Input Select Line 2. The default state for SEL2 is LOW.
8	D–/L	I/O	MHL/USB/UART/Audio Common Connector
9	GND	Ground	Ground
10	D+/R	I/O	MHL/USB/UART/Audio Common Connector
11	SEL1	Input	Control Input Select Line 1. The default state for SEL1 is LOW.
12	R	I/O	USB+/Right Channel Audio

FUNCTION TABLE

SEL1	SEL2	V_{CC}	L,R	D0+, D0-	D1+, D1-	Mode
X	X	L	OFF	OFF	OFF	Hi-Z Mode
L	L	H	OFF	OFF	OFF	Power-Down Mode
L	H	H	OFF(1)	ON	OFF	MHL/USB Mode 1
H	L	H	ON	OFF	OFF	USB/Audio Mode
H	H	H	OFF(1)	OFF	ON	MHL/USB Mode 2

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

SUMMARY OF TYPICAL CHARACTERISTICS

	USB PATH	USB/AUDIO PATH
Number of switches	4	2
ON-state resistance (r_{on})	6.5 Ω	2.5 Ω
ON-state resistance match (Δr_{on})	0.1 Ω	0.1 Ω
ON-state resistance flatness ($r_{on(flat)}$)	2 Ω	1.5 Ω
ON-state capacitance ($C_{I/O}$,on)	3 pF	3.5 pF
Bandwidth (BW)	1.9 GHz	1.2 GHz
Total harmonic distortion (THD)	N/A	0.05%

ABSOLUTE MAXIMUM RATINGS(1)(2)

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

			MIN	MAX	UNIT
V_{CC}	Supply voltage range(3)		–0.3	4.6	V
V_{D0+}, V_{D0-}, V_{D1+}, V_{D1-}	High speed differential signal voltage range(3)		–0.3	4.6	V
V_R, V_L	Audio signal voltage range		– 1.9	V_{CC}	V
I_K	Analog port diode current	$V_{I/O+}$,$V_{I/O-}$< 0	–50		mA
V_I	Digital input voltage range (SEL1, SEL2)		–0.3	4.6	V
I_{IK}	Digital logic input clamp current(3)	V_I < 0	–50		
I_{CC}	Continuous current through VCC			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.

RECOMMENDED OPERATING CONDITIONS

			MIN	MAX	UNIT
V_{CC}	Supply voltage range		2.7	4.3	V
V_{D0+}, V_{D0-}, V_{D1+}, V_{D1-}	High speed differential signal voltage range		0	4.3	V
V_R, V_L	Audio signal voltage range		– 1.8	V_{CC}	V
I_K	Analog port diode current	$V_{I/O+}$,$V_{I/O-}$< 0	–50		mA
V_I	Digital input voltage range (SEL1, SEL2)		0	4.3	V
T_A	Operating free-air temperature		–40	85	°C

ELECTRICAL CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
MHL/USB SWITCH							
r_{on}	ON-state resistance	V_{CC} = 3.0 V	$V_{I/O+,I/O-}$= 0.4 V, I_{ON} = 15 mA		6.5	7.5	Ω
Δr_{on}	ON-state resistance match between channels	V_{CC} = 3.0 V	$V_{I/O+,I/O-}$= 1.7 V, I_{ON} = 15 mA		0.1		Ω
$r_{on\ (flat)}$	ON-state resistance flatness	V_{CC} = 3.0 V	$V_{I/O+,I/O-}$= 0 to 1.7 V, I_{ON} = 15 mA		0.5		Ω
I_{OZ}	OFF leakage current	V_{CC} = 3.6 V	Switch OFF , $V_{I/O+,I/O-}$= 0 to 3.6 V, 1789553 $V_{D+/R,\ D-/L}$ = 0 V			1	µA
USB/AUDIO SWITCH							
r_{on}	ON-state resistance	V_{CC} = 3.0 V	SEL1=High, SEL2=Low, $V_{L/R}$ = -2V, 0V, 0.7V, I_{ON} = -26 mA		2.5	3.5	Ω
Δr_{on}	ON-state resistance match between channels	V_{CC} = 3.0 V	SEL1=High, SEL2=Low, $V_{L/R}$ = 0.7V, I_{ON} = -26 mA		0.1		Ω
$r_{on\ (flat)}$	ON-state resistance flatness	V_{CC} = 3.0 V	SEL1=High, SEL2=Low, $V_{L/R}$ = -2V, 0V, 0.7V, I_{ON} = -26 mA		0.1		Ω
r_{SHUNT}	Shunt resistance	V_{CC} = 2.7 V to 4.3 V	Switch OFF, $V_{L/R}$ = 0.7V, I_{SHUNT} = 10 mA		100	200	Ω
DIGITAL CONTROL INPUTS (SEL1, SEL2)							
V_{IH}	Input logic high	V_{CC} = 2.7 V to 4.3 V		1.3			V
V_{IL}	Input logic low	V_{CC} = 2.7 V to 4.3 V				0.4	V
I_{IN}	Input leakage current	V_{CC} = 2.7 V to 4.3 V	V_{IN} = 4.3V			±3	µA
			V_{IN} = 0V			±0.1	
r_{PD1}, r_{PD2}	Internal pulldown resistance	V_{CC} = 2.7 V to 4.3 V			3		MΩ

DYNAMIC CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
MHL/USB SWITCH							
t_{pd}	Propagation Delay	V_{CC} = 2.7V or 3.3V			0.25		ns
t_{ON}	Turn-on time	RL = 50Ω, CL = 35pF	V_{CC} = 2.7V			60	ns
t_{OFF}	Turn-off time	RL = 50Ω, CL = 35pF	V_{CC} = 2.7V			20	ns
$t_{SK(O)}$	Channel-to-channel skew	V_{CC} = 2.7V or 3.3V		15			ps
$t_{SK(P)}$	Skew of opposite transitions of same output	V_{CC} = 2.7V or 3.3V		15			ps
$C_{I/O+(OFF)}$ $C_{I/O-(OFF)}$	OFF capacitance	V_{CC} = 2.7V or 3.3V, $V_{D0+/D0-}$=0 or 3.3V	Switch OFF		1		pF
$C_{I/O+(ON)}$ $C_{I/O-(ON)}$	ON capacitance	V_{CC} =2.7V or 3.3V, $V_{D0+/D0-}$= 0 or 3.3V	Switch ON		3		pF
C_I	Digital input capacitance	V_{CC} =2.7V or 3.3V, V_I = 0 or 3.3V 2.5					pF
BW	Bandwidth	V_{CC} =2.7V or 3.3V, R_L = 50Ω	Switch ON		1.9		GHz
O_{ISO}	OFF Isolation	V_{CC} =2.7V or 3.3V, R_L = 50Ω, f = 240 MHz	Switch OFF		-35		dB
X_{TALK}	Crosstalk	V_{CC} =2.5V or 3.3V, R_L = 50Ω, f = 240 MHz	Switch ON		-45		dB
USB/AUDIO SWITCH							
t_{ON}	Turn-on time	R_L = 50Ω, C_L = 35pF	V_{CC} = 2.7V		40		µs
t_{OFF}	Turn-off time	R_L = 50Ω, C_L = 35pF	V_{CC} = 2.7V		15		ns
$C_{L(OFF)}$, $C_{R(OFF)}$	L , R OFF capacitance	V_{CC} = 2.7V to 4.3V, f = 20 kHz	Switch OFF		1.0		pF
$C_{L(ON)}$, $C_{R(ON)}$	L, R ON capacitance	V_{CC} = 2.7V to 4.3V, f = 20 kHz	Switch ON		3.5		pF
O_{ISO}	OFF Isolation	V_{CC} = 3.3V, R_L = 50Ω, f = 20 kHz	Switch OFF		-85		dB
X_{TALK}	Crosstalk	V_{CC} = 3.3V, R_L = 50Ω, f = 20 kHz	Switch ON		-95		dB
THD	Total harmonic distortion	V_{CC} = 3.3V, SEL1=High, SEL2=Low, f = 20Hz to 20kHz, R_L = 600Ω, V_{IN} = 2Vpp	Switch ON		0.05%		
SUPPLY							
V_{CC}	Power supply voltage			2.7		4.3	V
I_{CC}	Positive supply current	V_{CC} = 2.7V, 3.6V, V_{IN}=VCC or GND, VI/O=0V, Switch ON or OFF			25	50	µA
$I_{CC, PD}$	Positive supply current (Power-Down Mode)	V_{CC} = 2.7V, 3.6V, VIN=VCC or GND, VI/O=0V, SEL1 and SEL2 = Low			3	5	µA
I_{OFF}	Power off leakage current	V_{CC} = 0V, VD+/R, D-/L, D0+, D0-, D1+, D1-, L, R = 0 to 4.3V			±0.1		µA

TYPICAL CHARACTERISTICS

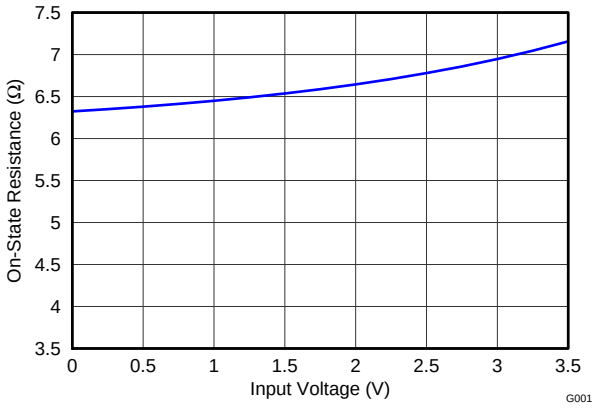


Figure 1. ON Resistance vs V_I for MHL/USB Switch

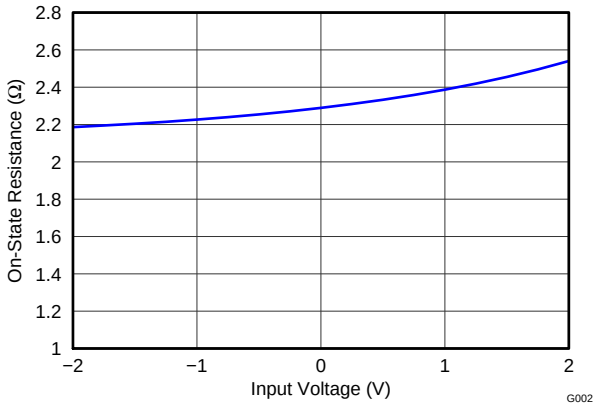


Figure 2. ON Resistance vs V_I for USB/Audio Switch

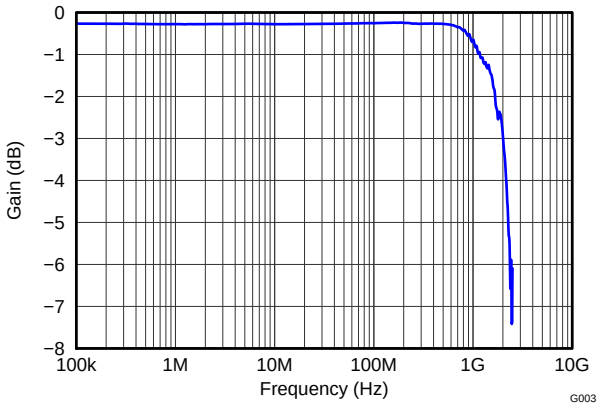


Figure 3. Gain vs Frequency for MHL/USB Switch

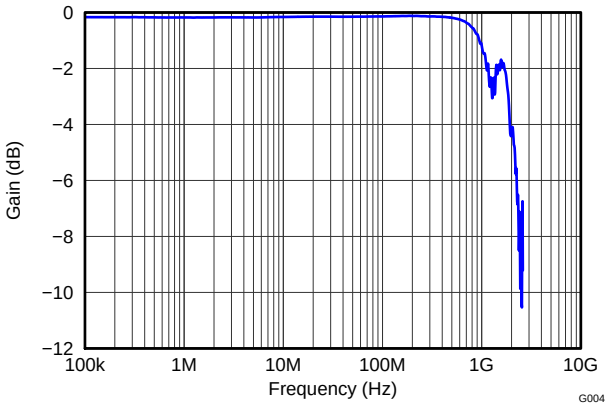


Figure 4. Gain vs Frequency for USB/Audio Switch

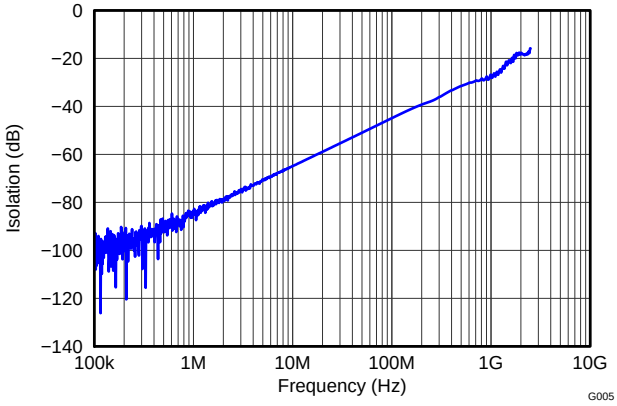


Figure 5. Off Isolation vs Frequency for MHL/USB Switch

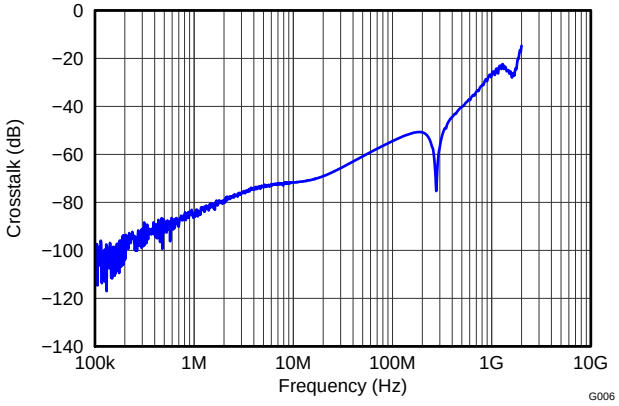


Figure 6. Cross Talk vs Frequency for MHL/USB Switch

TYPICAL CHARACTERISTICS (continued)

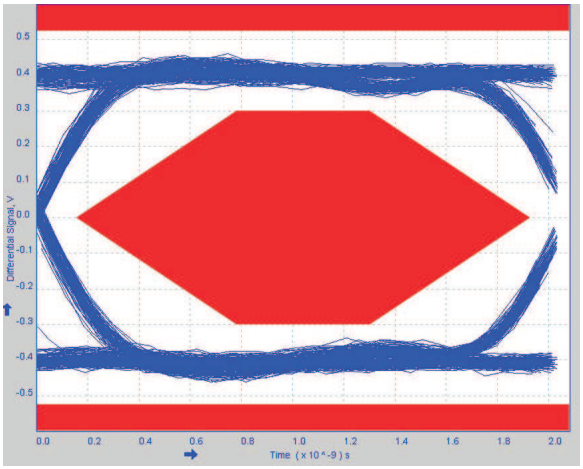


Figure 7. Eye Pattern: 480-Mbps USB 2.0 Eye Pattern (No Switch)

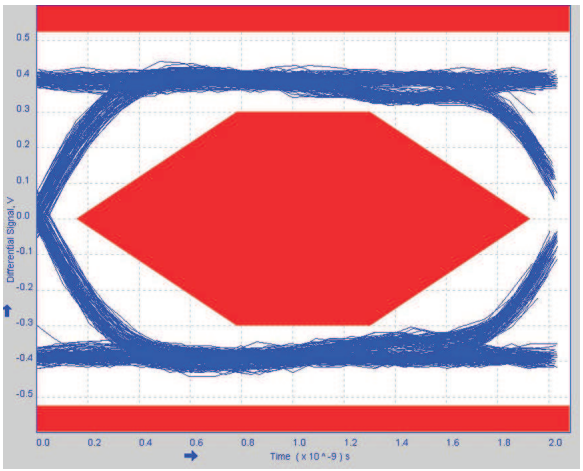


Figure 8. Eye Pattern: 480-Mbps USB 2.0 Eye Pattern for USB Switch

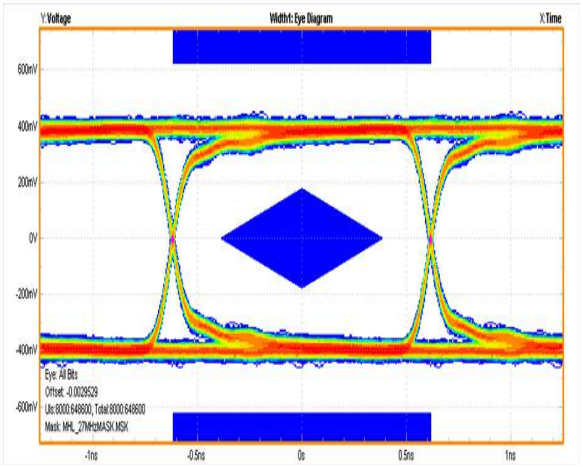


Figure 9. MHL Eye Pattern: 480p 60fps (No Switch)

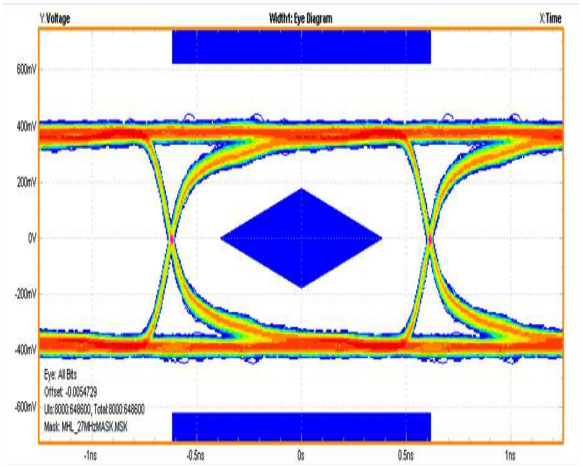


Figure 10. MHL Eye Pattern: 480p 60fps (With Switch)

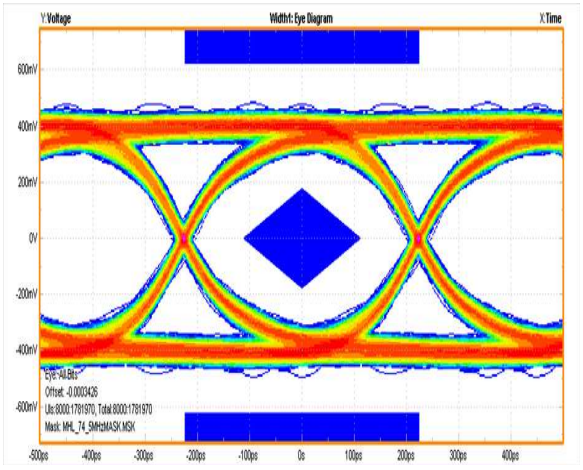


Figure 11. MHL Eye Pattern: 720p 60fps, 1080i 30fps (No Switch)

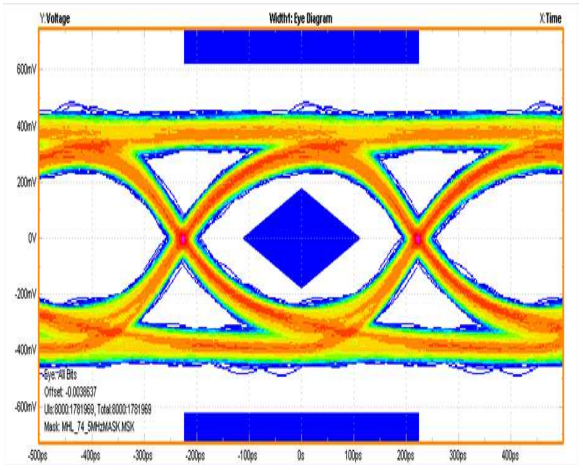


Figure 12. MHL Eye Pattern: 720p 60fps, 1080i 30fps (With Switch)

REVISION HISTORY

Changes from Original (October 2011) to Revision A **Page**

- Added MHL specification to datasheet. 1
- Updated Application Block Diagrams. 1
- Updated Switch Block Diagram 2
- Updated Typical Application Block Diagram 2
- Added MHL Eye Pattern graphics. 8

Changes from Revision A (April 2012) to Revision B **Page**

- Updated Application Block Diagrams. 1
- Updated MIN value in the ABSOLUTE MAXIMUM RATINGS table for V_R, V_L. 4
- Updated MIN value in the RECOMMENDED OPERATING CONDITIONS table for V_R, V_L. 4

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
TS3USBA225RUTR	ACTIVE	UQFN	RUT	12	3000	Green (RoHS & no Sb/Br)	CU NIPDAU | CU NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	(LQ7 ~ LQR)	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.
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.

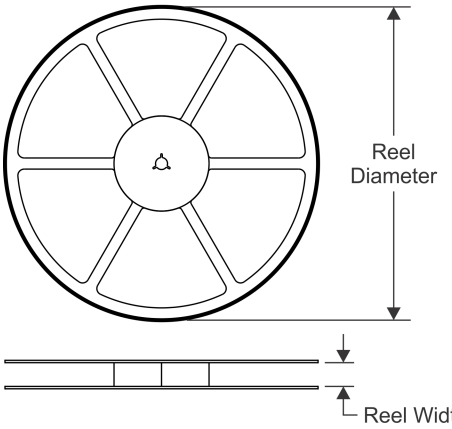
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

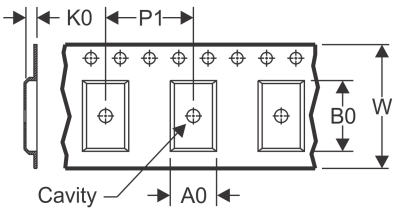
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

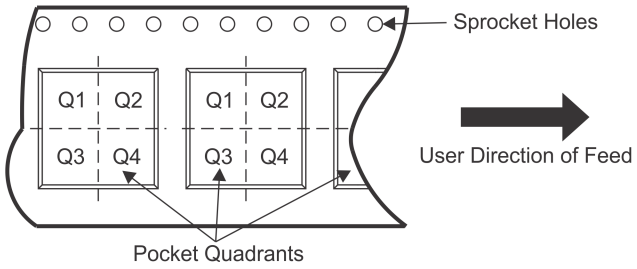


TAPE DIMENSIONS



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

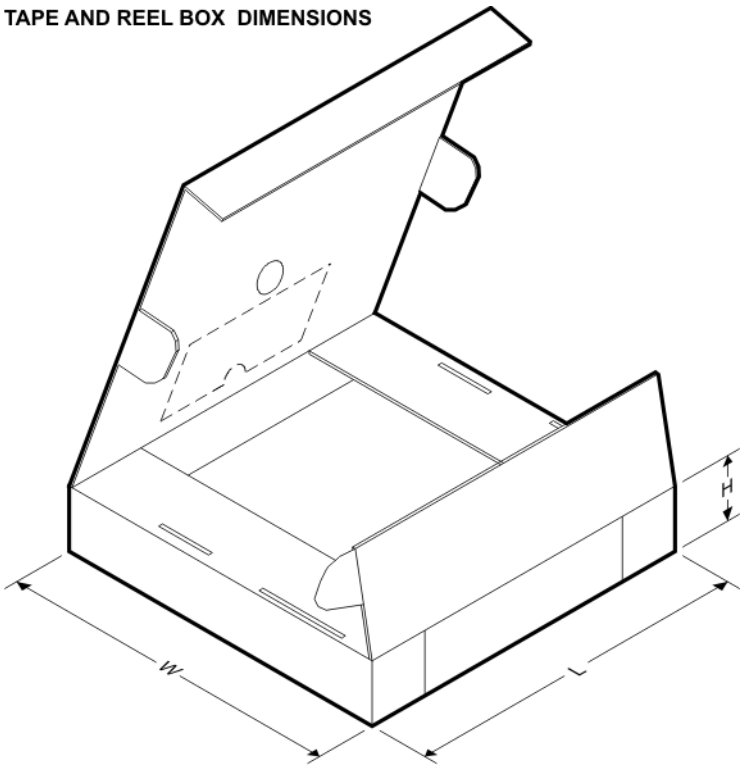
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TS3USBA225RUTR	UQFN	RUT	12	3000	180.0	8.4	1.95	2.3	0.75	4.0	8.0	Q1
TS3USBA225RUTR	UQFN	RUT	12	3000	180.0	9.5	1.9	2.3	0.75	4.0	8.0	Q1

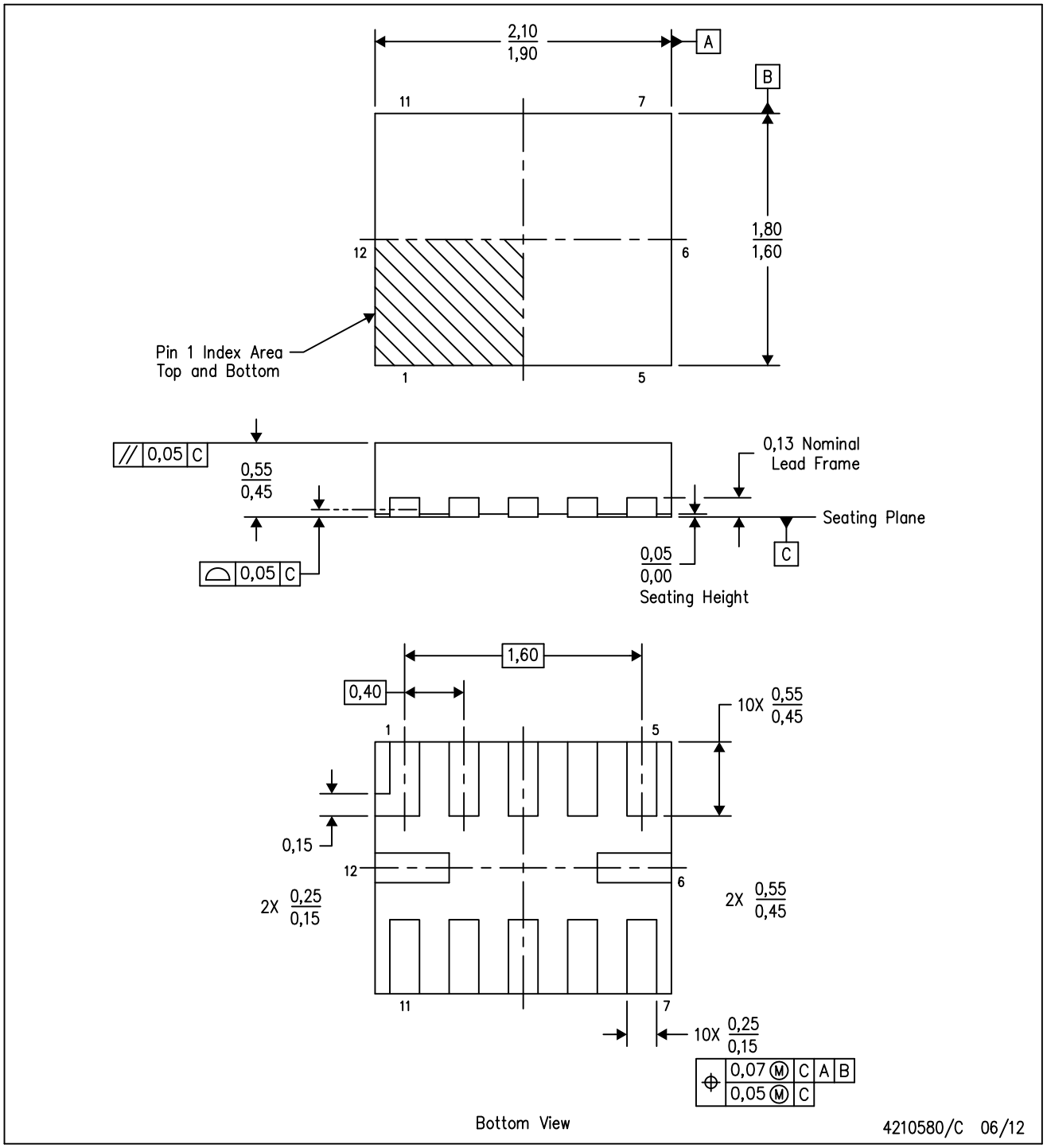
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

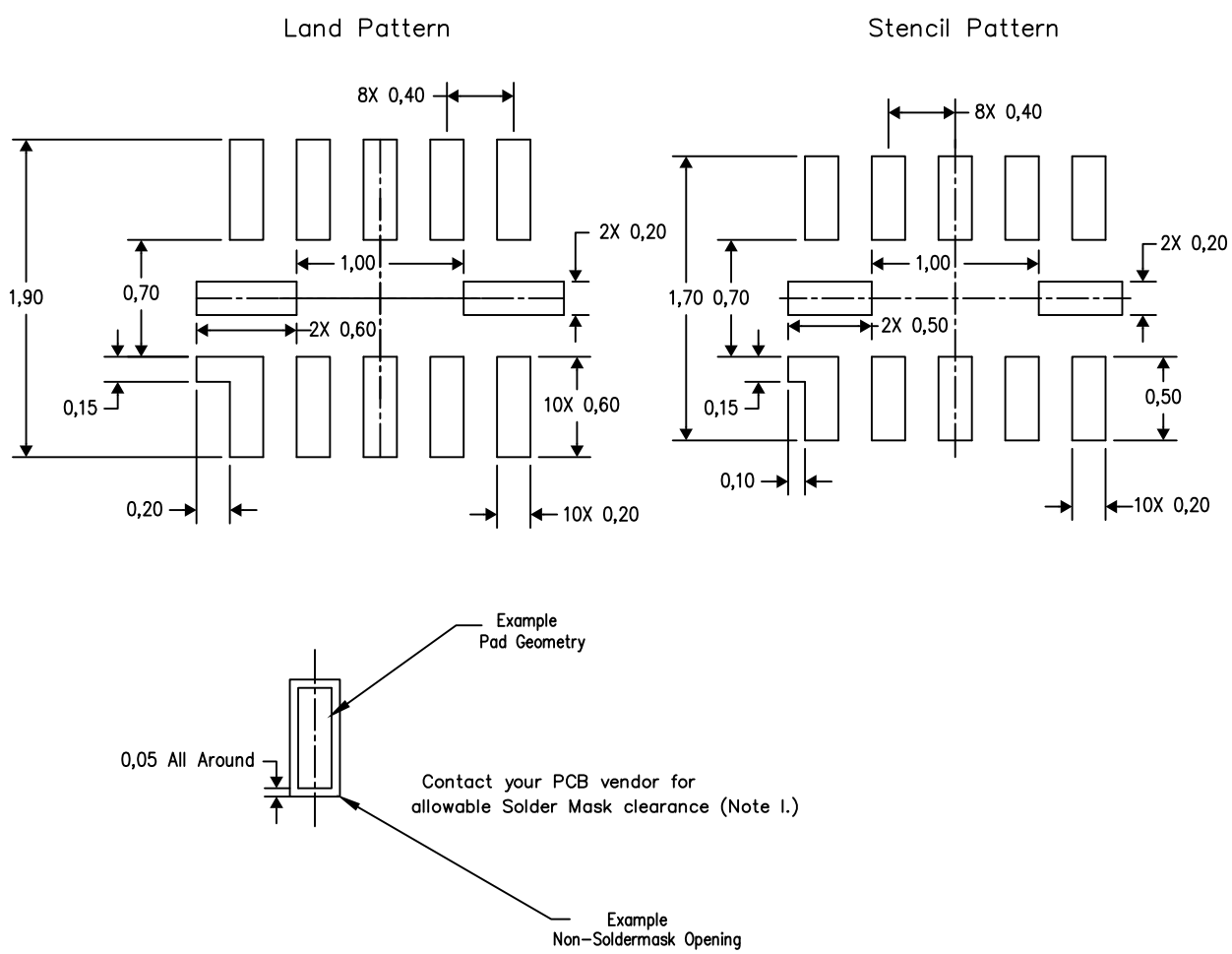
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TS3USBA225RUTR	UQFN	RUT	12	3000	202.0	201.0	28.0
TS3USBA225RUTR	UQFN	RUT	12	3000	184.0	184.0	19.0

RUT (R–PUQFN–N12) PLASTIC QUAD FLATPACK NO–LEAD



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.

RUT (R–PUQFN–N12) PLASTIC QUAD FLATPACK NO–LEAD



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.
E. Maximum stencil thickness 0,1016 mm (4 mils). All linear dimensions are in millimeters.
F. 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.
G. Over–printing land for larger area ratio is not advised due to land width and bridging potential. Exersize extreme caution.
H. Suggest stencils cut with lasers such as Fiber Laser that produce the greatest positional accuracy.
I. Component placement force should be minimized to prevent excessive paste block deformation.

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