DPDT USB 2.0 High-Speed (480Mbps) and Mobile High-Definition Link (MHL) Switch

Check for Samples: TS3USB3000

FEATURES

- **V_{CC} Range 2.7V to 4.3V**
- **Mobile Hi-definition Link (MHL) Switch**
  - **Bandwidth (-3dB) 6.1 GHz**
  - **Ron (Typ) 5.7 Ω**
  - **Con (Typ) 1.6 pF**
- **USB Switch**
  - **Bandwidth (-3dB) 6.1 GHz**
  - **Ron (Typ) 4.6 Ω**
  - **Con (Typ) 1.4 pF**
- **Current Consumption 30 µA Typ**
- **Special Features**
  - **I_{OFF} Protection Prevents Current Leakage in Powered Down State (V_{CC} and V_{BUS} = 0 V)**
  - **1.8-V Compatible Control Inputs (SEL, $\overline{OE}$)**
  - **Over-Voltage Tolerance (OVT) on all I/O Pins up to 5.5V Without External Components**
- **ESD Performance**
  - **3.5 kV Human Body Model (A114B, Class II)**
  - **1 kV Charged Device Model (C101)**
- **10-pin QFN Package (2.0x1.5 mm, 0.5 mm Pitch)**

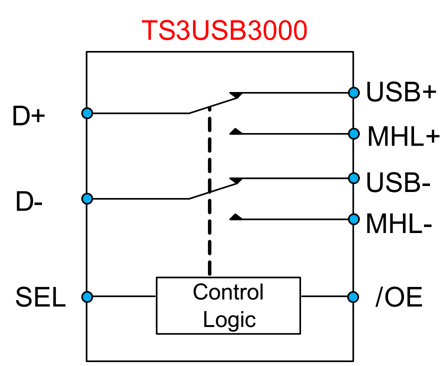
DESCRIPTION

The TS3USB3000 is a double-pole, double throw (DPDT) multiplexer that includes a high speed Mobile High-Definition Link (MHL) switch and an USB 2.0 High-Speed (480Mbps) switches in the same package. These configurations allow the system designer to use a common USB or Mico-USB connector for both MHL video signals and USB data.

The TS3USB3000 has a VCC range of 2.7V to 4.3V and supports over-voltage tolerance (OVT) feature, which allows the I/O pins to withstand over-voltage conditions (up to 5.5V). The power-off protection feature forces all I/O pins to be in high impedance mode when power is not present, allowing full isolation of the signals lines under such condition without excessive leakage current. The select pins of TS3USB3000 are compatible with 1.8V control voltage, allowing them to be directly interfaced with the General Purpose I/O (GPIO) from a mobile processor.

The TS3USB3000 comes with a small 10-pin QFN package with only 2.0mm x 1.5mm is size, which makes it a perfect candidate to be used in mobile applications.

SWITCH DIAGRAM

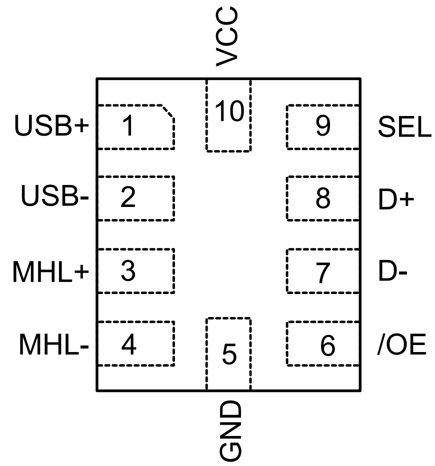


ORDERING INFORMATION

T_A	PACKAGE		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	QFN– RSE	Tape and reel	TS3USB3000RSER	DSJ

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.

PIN DESCRIPTION



Pin Description Table

PIN			DESCRIPTION
NO.	NAME	TYPE	
1	USB+	I/O	USB Data (Differential +)
2	USB–	I/O	USB Data (Differential –)
3	MHL+	I/O	MHL Data (Differential +)
4	MHL–	I/O	MHL Data (Differential –)
5	GND	Ground	Ground
6	$\overline{\text{OE}}$	Input	Output Enable (Active Low)
7	D–	I/O	Data Switch Output (Differential –)
8	D+	I/O	Data Switch Output (Differential +)
9	SEL	Input	Output Select
10	VCC	Power	Supply

FUNCTION TABLE

SEL	$\overline{\text{OE}}$	SWITCH STATUS
X	High	Both USB and MHL switches in High-Z
Low	Low	D+/D– to USB+/USB–
High	Low	D+/D– to MHL+/MHL–

SUMMARY OF TYPICAL CHARACTERISTICS

	MHL PATH	USB PATH
Number of switches	2	2
ON-state resistance (r_{on})	5.7 Ω	4.6 Ω
ON-state resistance match (Δ_{ron})	<0.1 Ω	<0.1 Ω
ON-state capacitance ($C_{I/O}$,on)	1.6 pF	1.4 pF
Bandwidth (BW)	6.1 GHz	6.1 GHz

TYPICAL APPLICATION

Figure 1 represents a typical application of the TS3USB3000 MHL switch. The TS3USB3000 is used to switch signals between the USB path, which goes to the baseband or application processor, or the MHL path, which goes to the HDMI to MHL bridge. The TS3USB3000 has internal 6MΩ pull-down resistors on SEL and $\overline{OE}$. The pull-down on SEL ensure the USB channel is selected by default. The pull-down on $\overline{OE}$ enables the switch when power is applied. The TS5A3157 is a separate SPDT switch that is used to switch between MHL's CBUS and the USB ID line that is needed for USB OTG (USB On-The-Go) application.

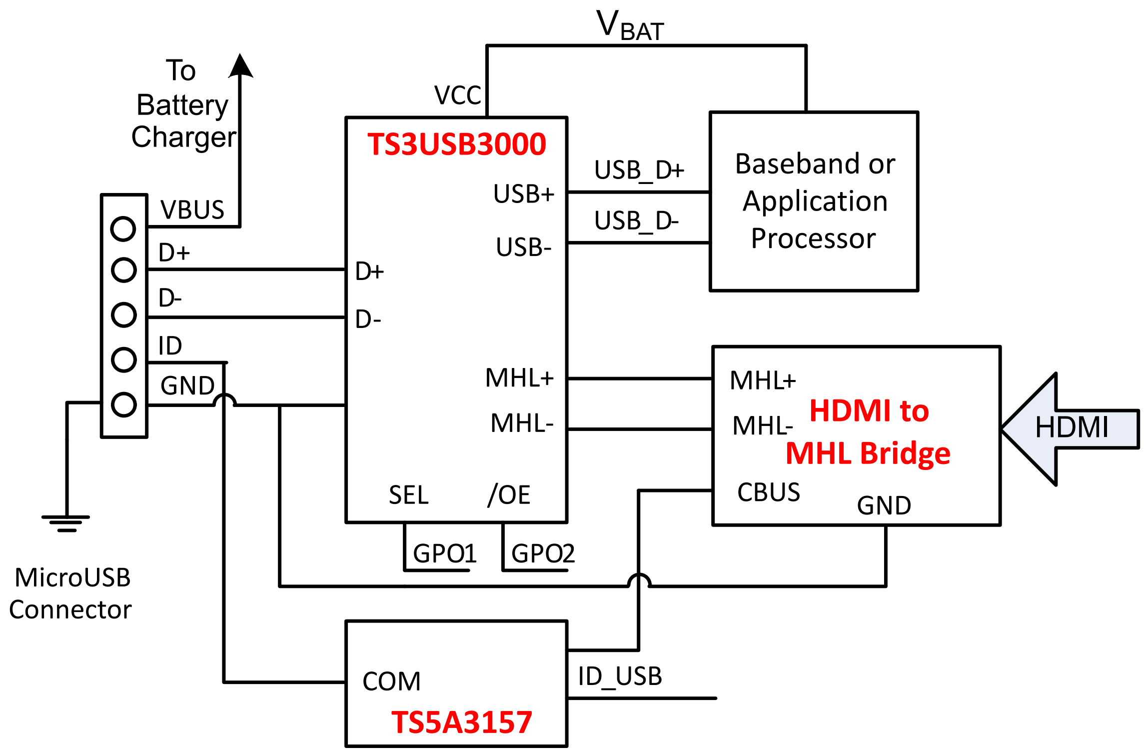


Figure 1. Typical TS3USB3000 Application

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	5.5	V
$V_{I/O}$	Input/Output DC voltage range[3]		–0.3	5.5	V
I_K	Input/Output port diode current	VI/O < 0	–50		mA
V_I	Digital input voltage range (SEL, /OE)		–0.3	5.5	V
I_{IK}	Digital logic input clamp current[3]	VI < 0	–50		mA
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 above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.
(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.

PACKAGE THERMAL IMPEDANCE[1]

			TYP	UNIT
θ_{JA}	Package thermal impedance	RSE package	243	°C/W

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

RECOMMENDED OPERATING CONDITIONS

		MIN	MAX	UNIT
V_{CC}	Supply voltage range	2.7	4.3	V
$V_{I/O\ (USB)}$ $V_{I/O\ (MHL)}$	Analog voltage range	0	3.6	V
V_I	Digital input voltage range (SEL, $\overline{OE}$)	0	VCC	V
T_{RAMP} (V_{CC})	Power supply ramp time requirement (V_{CC})	100	1000	µs/V
T_A	Operating free-air temperature	-40	85	ºC

ELECTRICAL CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
MHL SWITCH							
R_{ON}	ON-state resistance	V_{CC} = 2.7V	$V_{I/O}$ = 1.65V, I_{ON} = –8mA		5.7	9.0	Ω
ΔR_{ON}	ON-state resistance match between + and – paths	V_{CC} = 2.7V	$V_{I/O}$ = 1.65V, I_{ON} = –8mA		0.1		Ω
$R_{ON (FLAT)}$	ON-state resistance flatness	V_{CC} = 2.7V	$V_{I/O}$ = 1.65V to 3.45V, I_{ON} = –8mA		1		Ω
I_{OZ}	OFF leakage current	V_{CC} = 4.3V	Switch OFF, $V_{MHL+/MHL–}$ = 1.65V to 3.45V, $V_{D+/D–}$ = 0V	–2		2	µA
I_{OFF}	Power-off leakage current	V_{CC} = 0V	Switch ON or OFF, $V_{MHL+/MHL–}$ = 1.65V to 3.45V, $V_{D+/D–}$ = NC	–10		10	µA
I_{ON}	ON leakage current	V_{CC} = 4.3V	Switch ON, $V_{MHL+/MHL–}$ = 1.65V to 3.45V, $V_{D+/D–}$ = NC	–2		2	µA
USB SWITCH							
R_{ON}	ON-state resistance	V_{CC} = 2.7V	$V_{I/O}$ = 0.4V, I_{ON} = –8 mA		4.6	7.5	Ω
ΔR_{ON}	ON-state resistance match between + and – paths	V_{CC} = 2.7V	$V_{I/O}$ = 0.4V, I_{ON} = –8 mA		0.1		Ω
$R_{ON (FLAT)}$	ON-state resistance flatness	V_{CC} = 2.7V	$V_{I/O}$ = 0V to 0.4V, I_{ON} = –8 mA		1		Ω
I_{OZ}	OFF leakage current	V_{CC} = 4.3V	Switch OFF, $VU_{SB+/USB–}$ = 0V to 3.6V, $V_{D+/D–}$ = 0V	–2		2	µA
I_{OFF}	Power-off leakage current	V_{CC} = 0V	Switch ON or OFF, $V_{USB+/USB–}$ = 0V to 3.6V, $V_{D+/D–}$ = NC	–10		10	µA
I_{ON}	ON leakage current	V_{CC} = 4.3V	Switch ON, $V_{USB+/USB–}$ = 0V to 3.6V, $V_{D+/D–}$ = NC	–2		2	µA
DIGITAL CONTROL INPUTS (SEL, $\overline{OE}$)							
V_{IH}	Input logic high	V_{CC} = 2.7V to 4.3V		1.3			V
V_{IL}	Input logic low	V_{CC} = 2.7V to 4.3V				0.6	V
I_{IN}	Input leakage current	V_{CC} = 4.3V, $_{VI/O}$ = 0V to 3.6V, $_{VIN}$ = 0 to 4.3V		–10		10	µA

DYNAMIC CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
t_{pd}	Propagation Delay		$R_L = 50\Omega$, $C_L = 5$ pF, $V_{CC} = 2.7$ V to 4.3 V		100		ps
t_{ON}	Turn-on time (SEL to Output)					400	ns
t_{OFF}	Turn-off time (SEL to Output)					400	ns
$t_{ZH, ZL (MHL)}$	MHL Enable Time ($\overline{OE}$ to Output)	$V_{I/O} = 3.3$ V or 0 V			100		µs
$t_{HZ, LZ (MHL)}$	MHL Disable Time ($\overline{OE}$ to Output)				200		ns
$t_{ZH, ZL (USB)}$	USB Enable Time ($\overline{OE}$ to Output)	$V_{I/O} = 0.8$ V or 0 V			100		µs
$t_{HZ, LZ (USB)}$	USB Disable Time ($\overline{OE}$ to Output)				200		ns
$t_{SK(P)}$	Skew of opposite transitions of same output				20		ps
$C_{ON(MHL)}$	MHL path ON capacitance	$V_{CC} = 3.3$ V, $V_{I/O} = 0$ or 3.3 V, f = 240 MHz	Switch ON		1.6	2.0	pF
$C_{ON(USB)}$	USB path ON capacitance		Switch ON		1.4	2.0	pF
$C_{OFF(MHL)}$	MHL path OFF capacitance	$V_{CC} = 3.3$ V, $V_{I/O} = 0$ or 3.3 V f = 240 MHz	Switch OFF		1.4	2.0	pF
$C_{OFF(USB)}$	USB path OFF capacitance		Switch OFF		1.6	2.0	pF
C_I	Digital input capacitance	$V_{CC} = 3.3$ V, $V_I = 0$ or 2 V			2.2		pF
O_{ISO}	OFF Isolation	$V_{CC} = 2.7$ V to 4.3 V, $R_L = 50\ \Omega$, f = 240 MHz	Switch OFF		-34		dB
X_{TALK}	Crosstalk	$V_{CC} = 2.7$ V to 4.3 V, $R_L = 50\ \Omega$, f = 240 MHz	Switch ON		-37		dB
$B_{W(MHL)}$	MHL path –3dB bandwidth	$V_{CC} = 2.7$ V to 4.3 V, $R_L = 50\ \Omega$, f = 240 MHz	Switch ON		6.1		GHz
$B_{W(USB)}$	USB path –3dB bandwidth	$V_{CC} = 2.7$ V to 4.3 V, $R_L = 50\ \Omega$,	Switch ON		6.1		GHz
SUPPLY							
V_{CC}	Power supply voltage			2.7		4.3	V
I_{CC}	Positive supply current	$V_{CC} = 4.3$ V, $V_{IN} = V_{CC}$ or GND, $V_{I/O} = 0$ V, Switch ON or OFF			30	50	µA
$I_{cc, HZ}$	Power supply current in high-Z mode	$V_{CC} = 4.3$ V, $V_{IN} = V_{CC}$ or GND, $V_{I/O} = 0$ V, Switch ON or OFF, $\overline{OE}$ = H			5	10	µA

PARAMETER MEASUREMENT INFORMATION

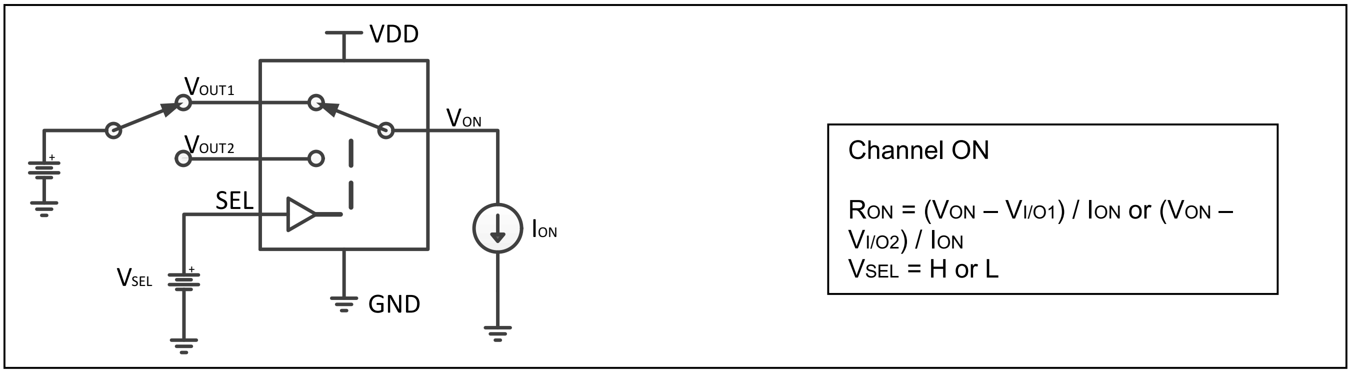


Figure 2. ON State Resistance (R_{ON})

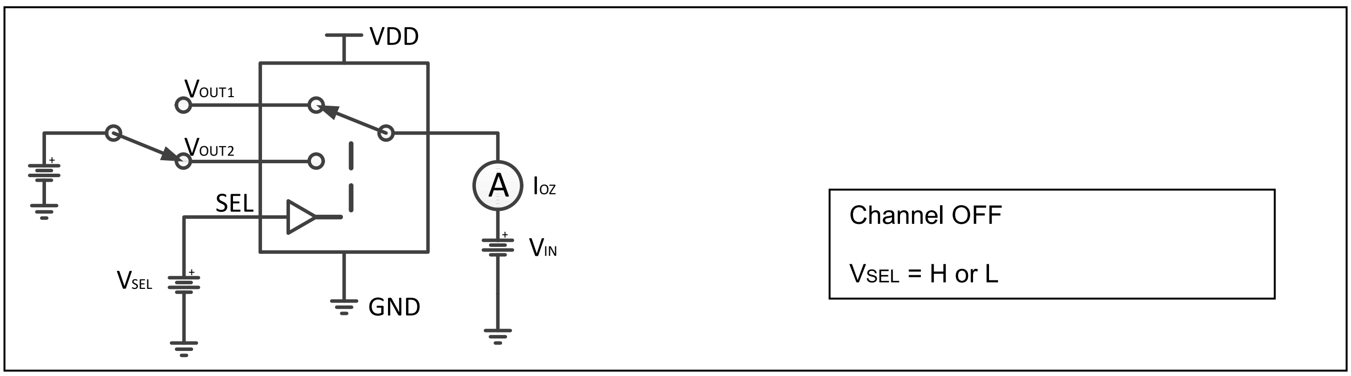


Figure 3. OFF Leakage Current (I_{OZ})

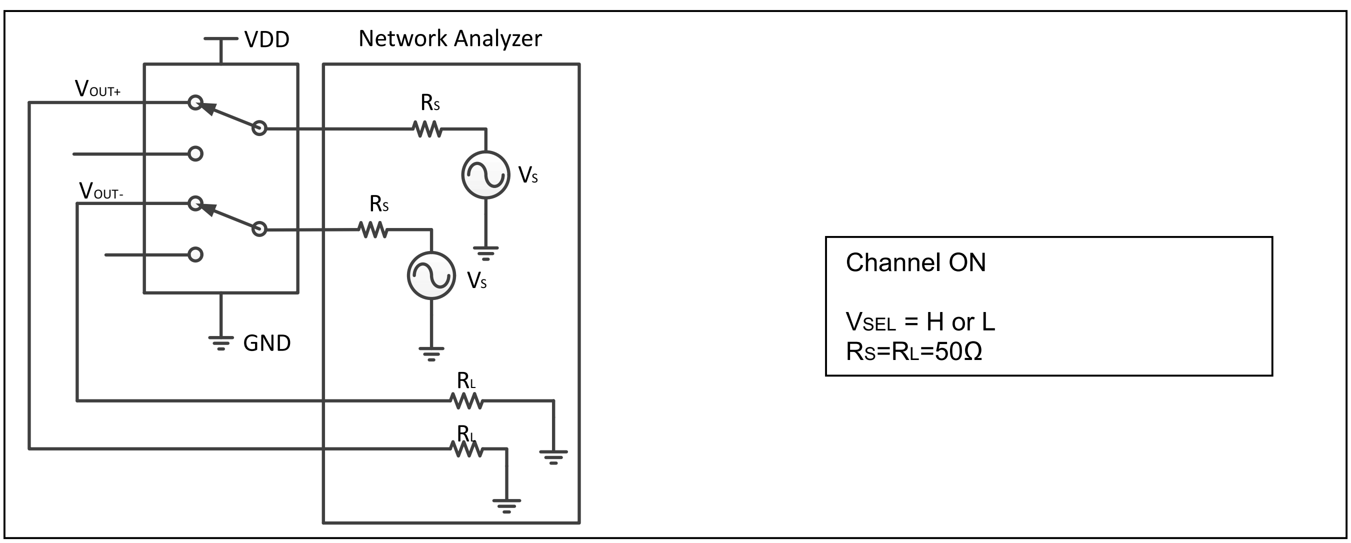


Figure 4. Bandwidth (BW)

TYPICAL CHARACTERISTICS

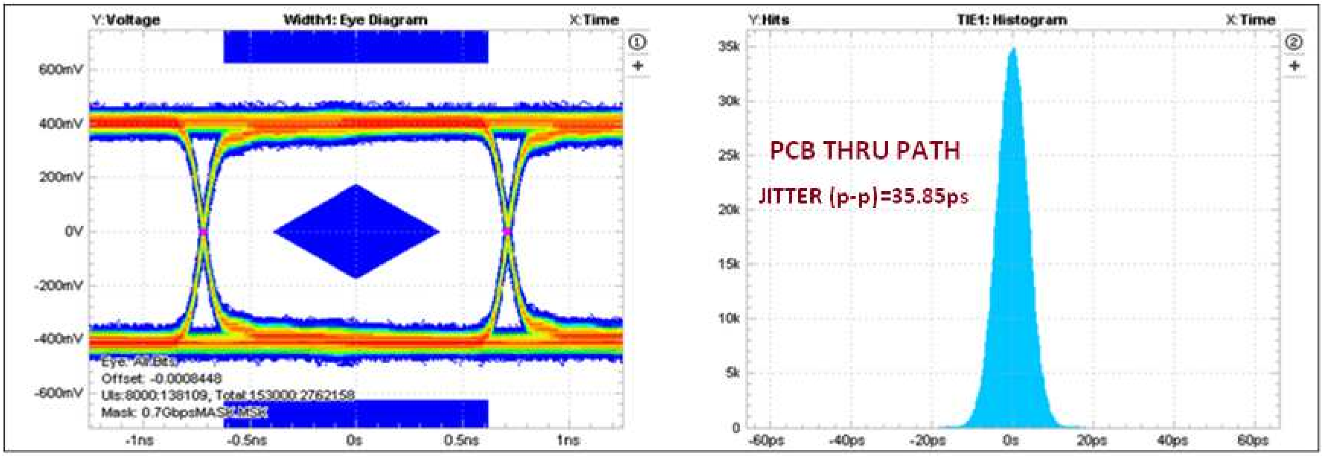
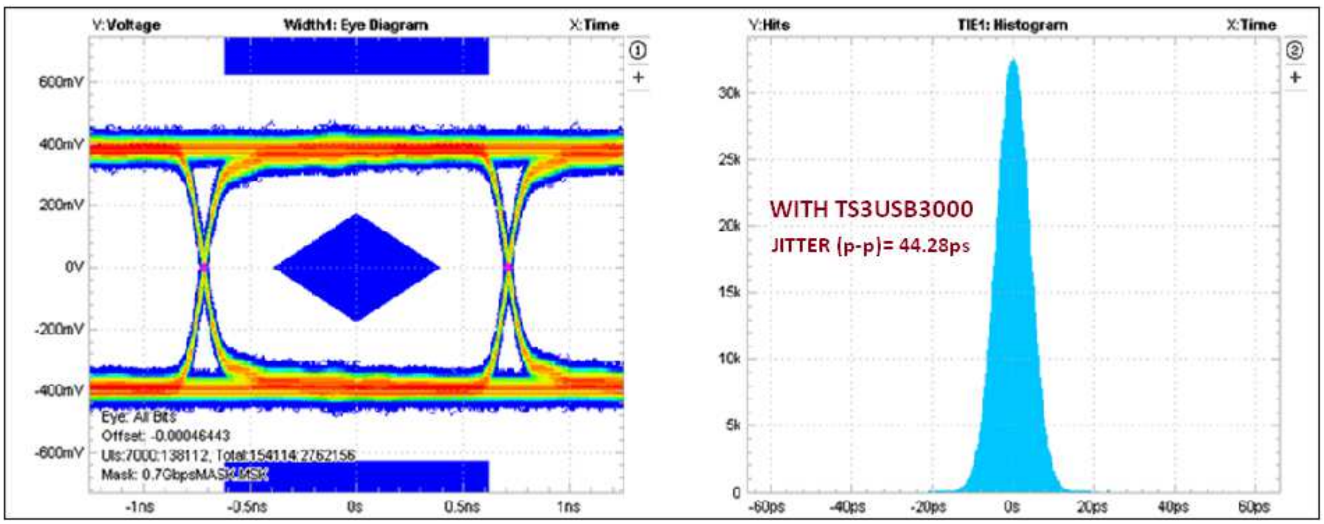


Figure 5. Eye Pattern and Time Interval Error Histogram: 0.7 Gbps With No Device



The TS3USB3000 contributes only 8.4ps of peak-to-peak jitter for 0.7 Gbps data rate.

Figure 6. Eye Pattern and Time Interval Error Histogram: 0.7 Gbps for MHL Switch

TYPICAL CHARACTERISTICS (continued)

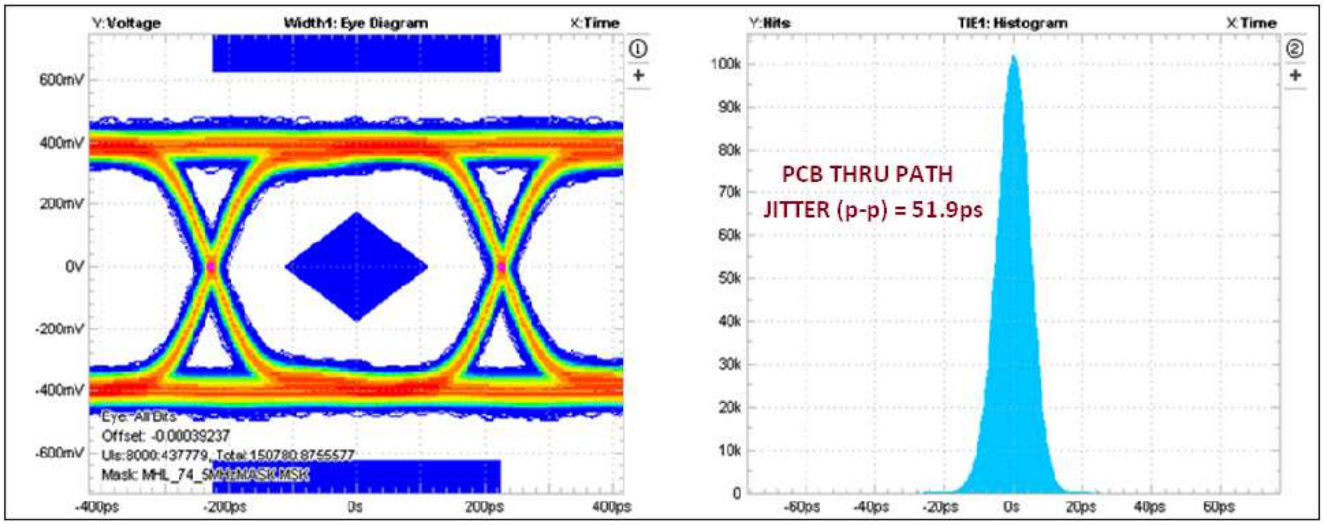
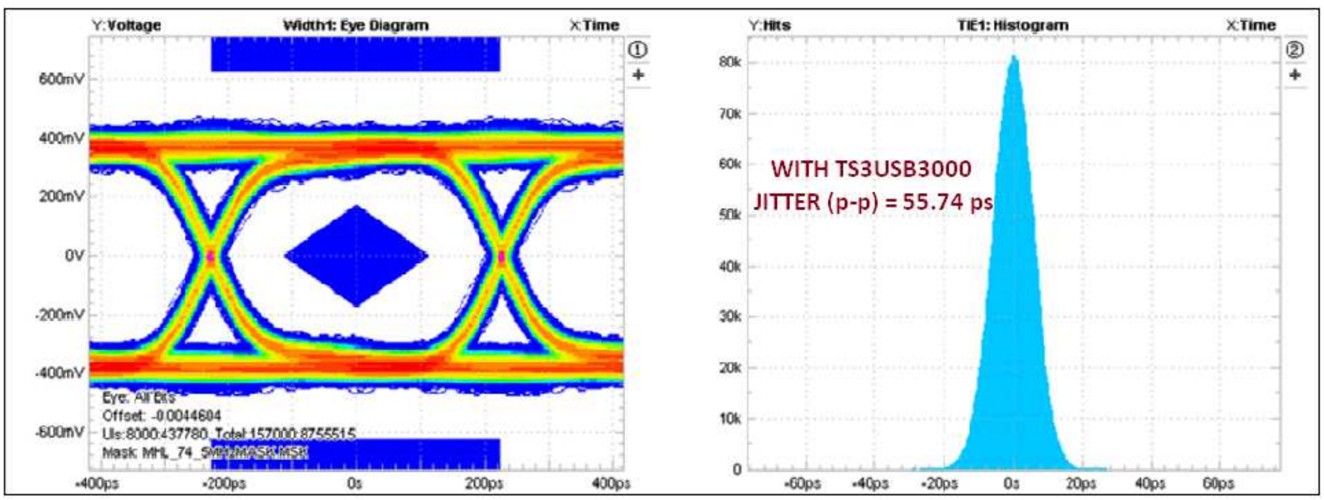


Figure 7. Eye Pattern and Time Interval Error Histogram: 2.2 Gbps With No Device



The TS3USB3000 contributes only 3.8ps of peak-to-peak jitter for 2.2 Gbps data rate.

Figure 8. Eye Pattern and Time Interval Error Histogram: 2.2 Gbps for MHL Switch

TYPICAL CHARACTERISTICS (continued)

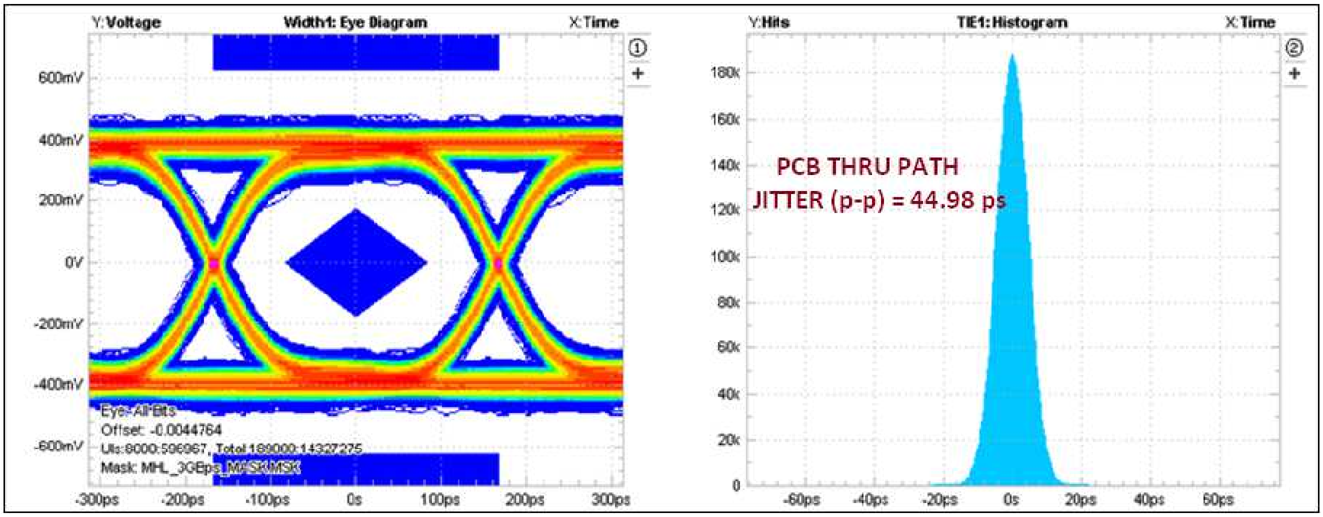
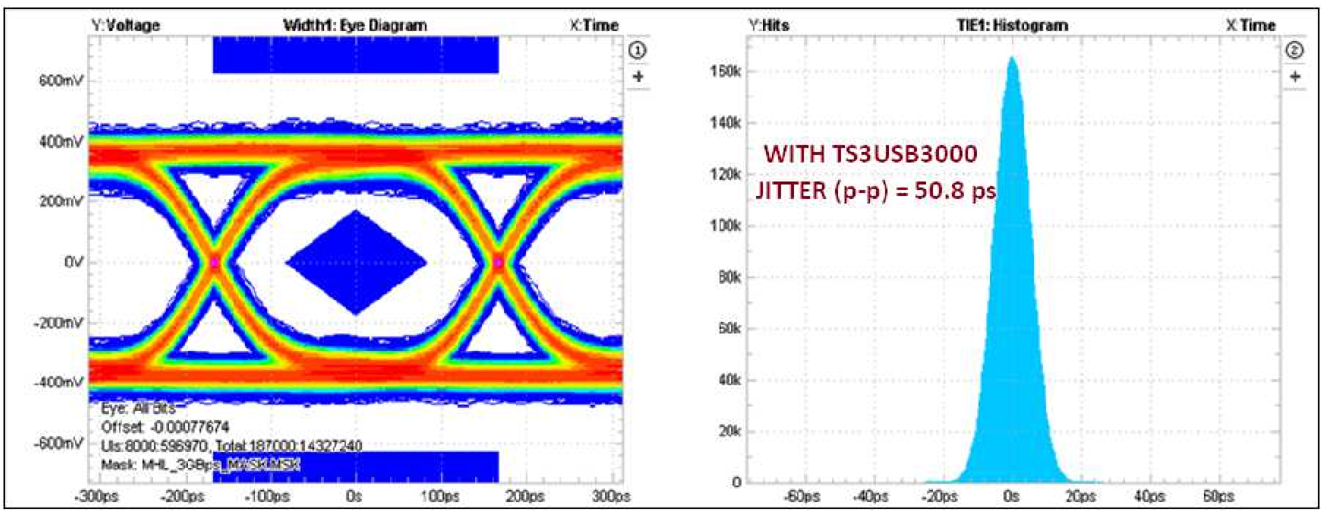


Figure 9. Eye Pattern and Time Interval Error Histogram: 3.0 Gbps With No Device



The TS3USB3000 contributes only 5.8ps of peak-to-peak jitter for 3.0 Gbps data rate.

Figure 10. Eye Pattern and Time Interval Error Histogram: 3.0 Gbps for MHL Switch

TYPICAL CHARACTERISTICS (continued)

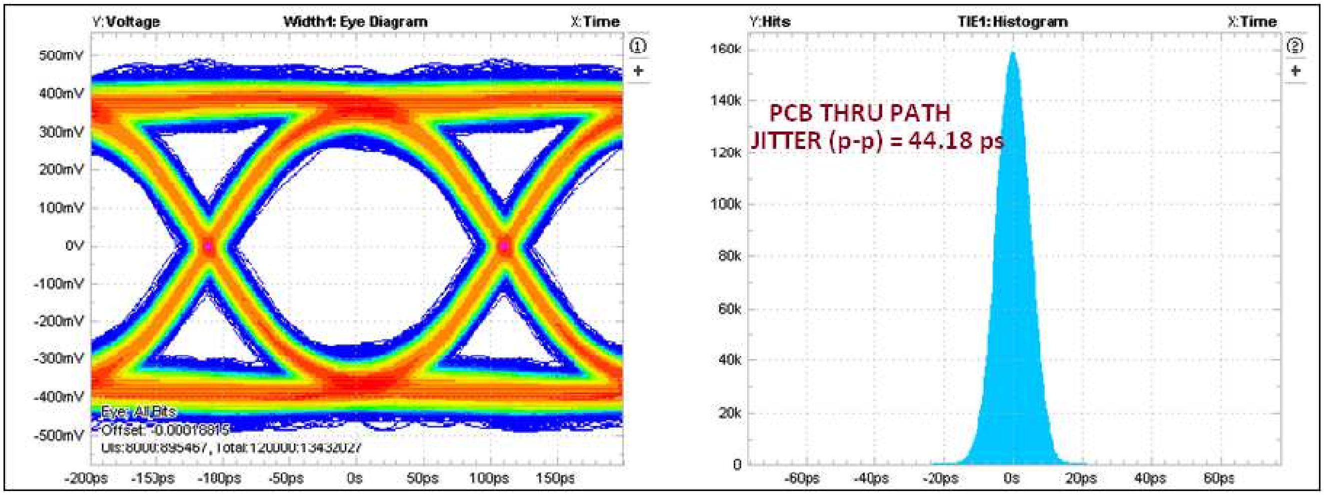
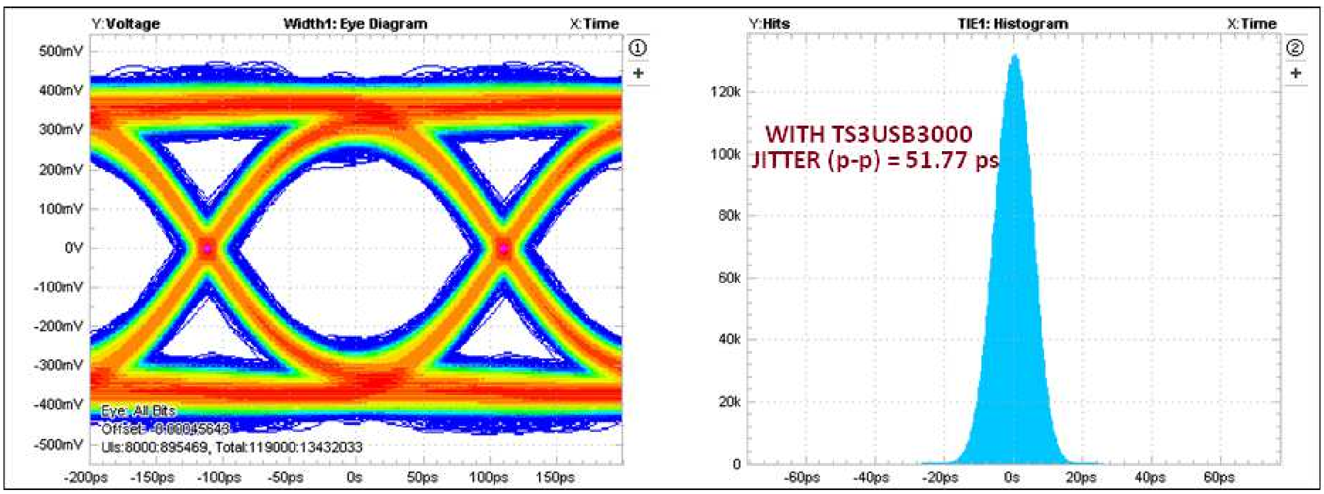


Figure 11. Eye Pattern and Time Interval Error Histogram: 4.5 Gbps With No Device



The TS3USB3000 contributes only 7.6ps of peak-to-peak jitter for 4.5 Gbps data rate.

Figure 12. Eye Pattern and Time Interval Error Histogram: 4.5 Gbps for MHL Switch

TYPICAL CHARACTERISTICS (continued)

USB 2.0 EYE PATTERN

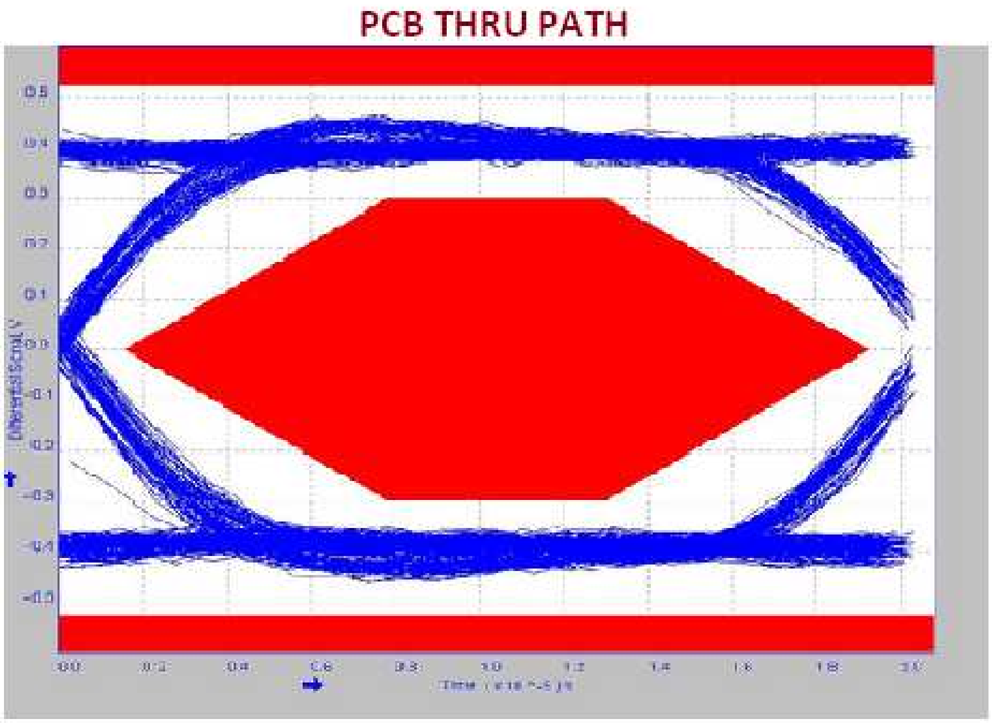


Figure 13. 480-Mbps USB 2.0 Eye Pattern with No Device

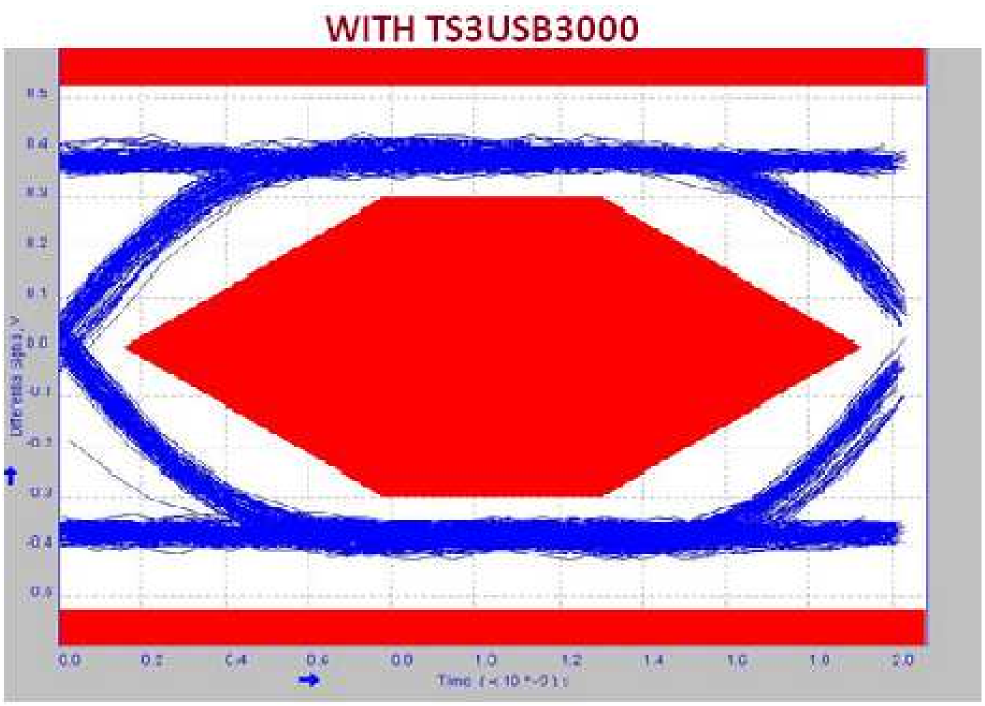


Figure 14. 480-Mbps USB 2.0 Eye Pattern for USB Switch

TYPICAL CHARACTERISTICS (continued)

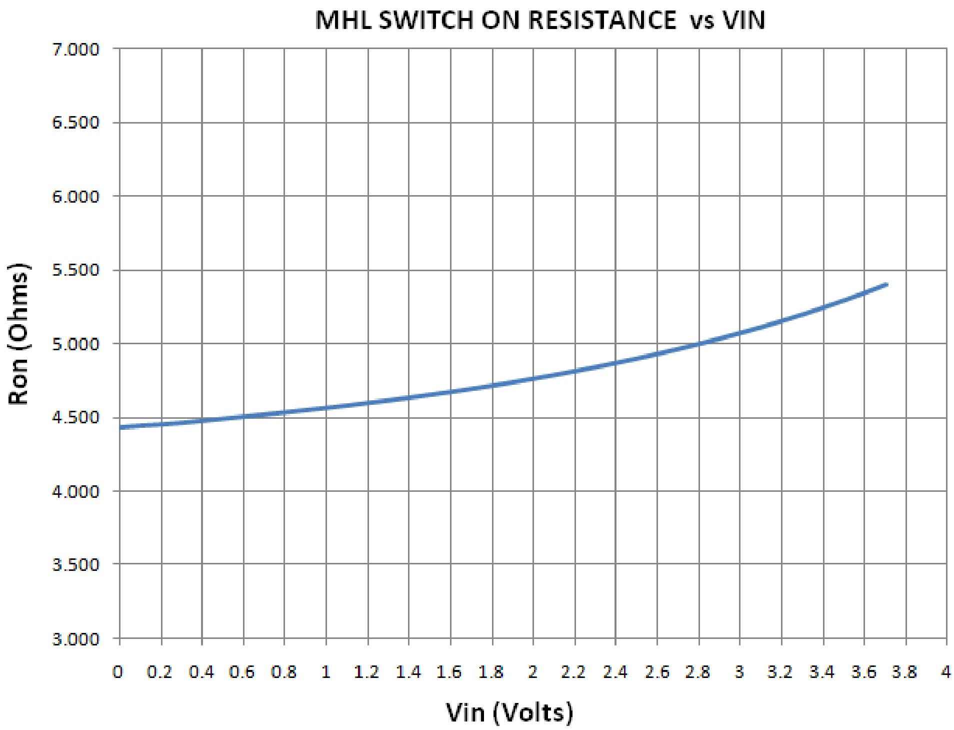


Figure 15. ON-Resistance vs. VI for MHL Switch

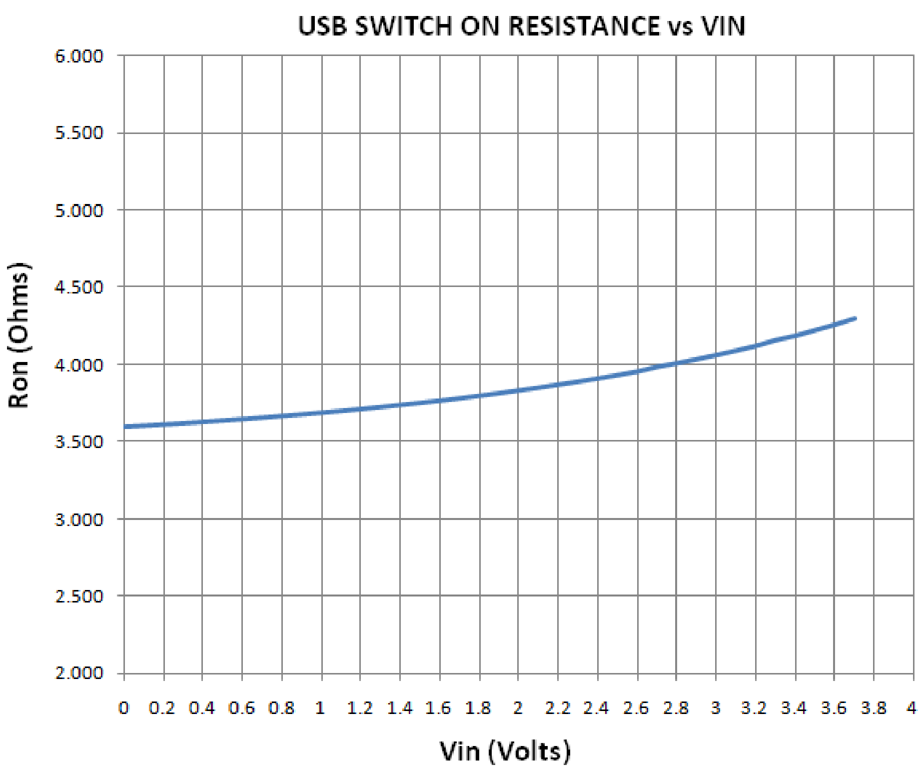


Figure 16. ON-Resistance vs. VI for USB Switch

TYPICAL CHARACTERISTICS (continued)

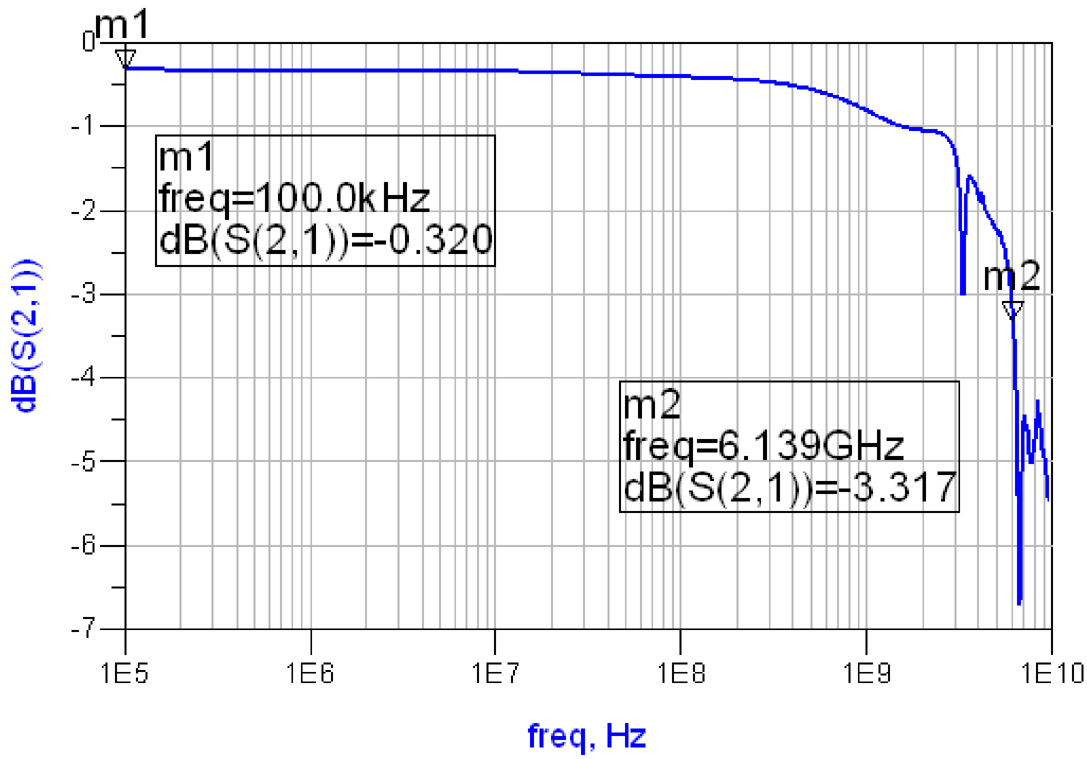


Figure 17. Differential S21 vs. Frequency for MHL Switch

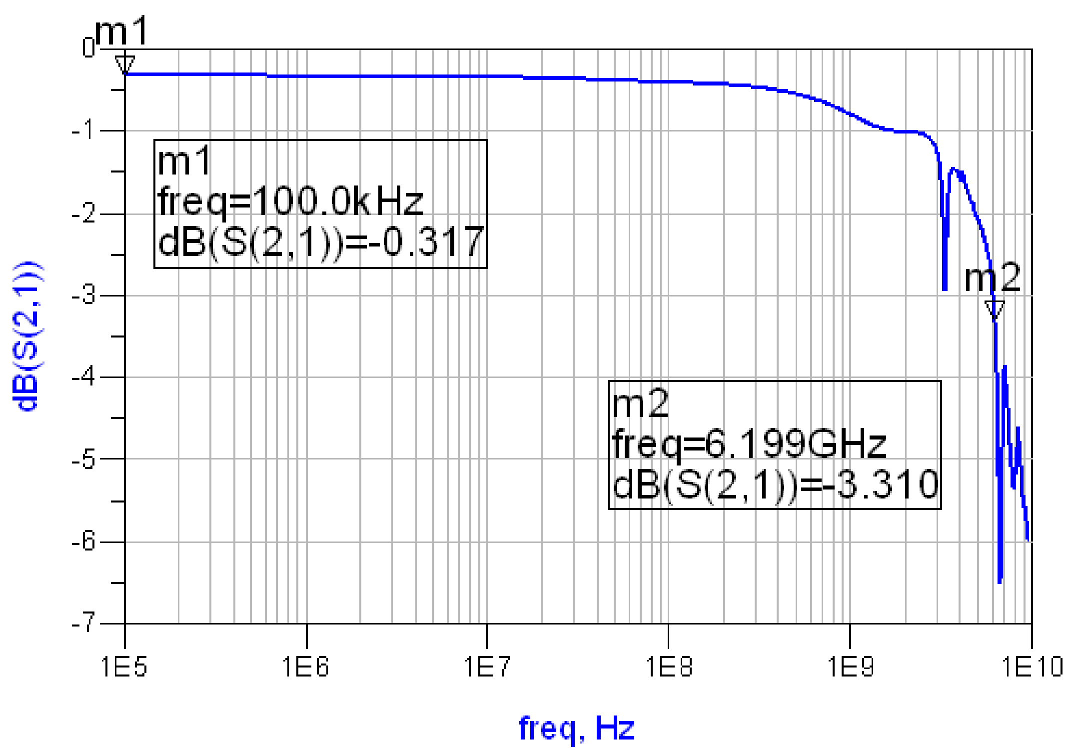


Figure 18. Differential S21 vs. Frequency for USB Switch

TYPICAL CHARACTERISTICS (continued)

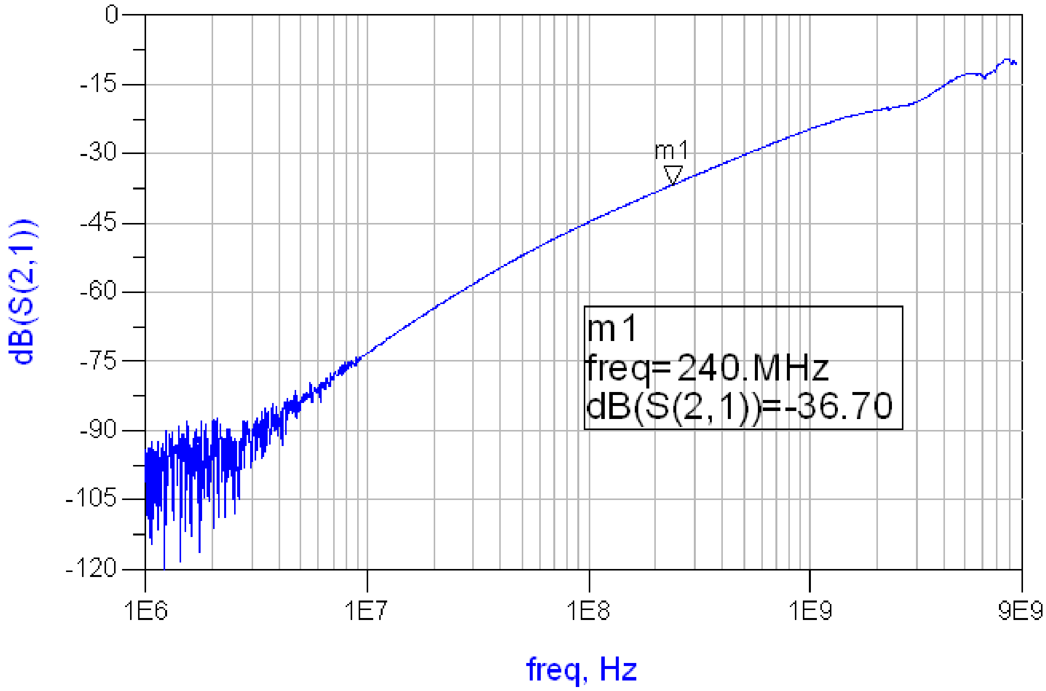


Figure 19. Off Isolation vs. Frequency for MHL Path

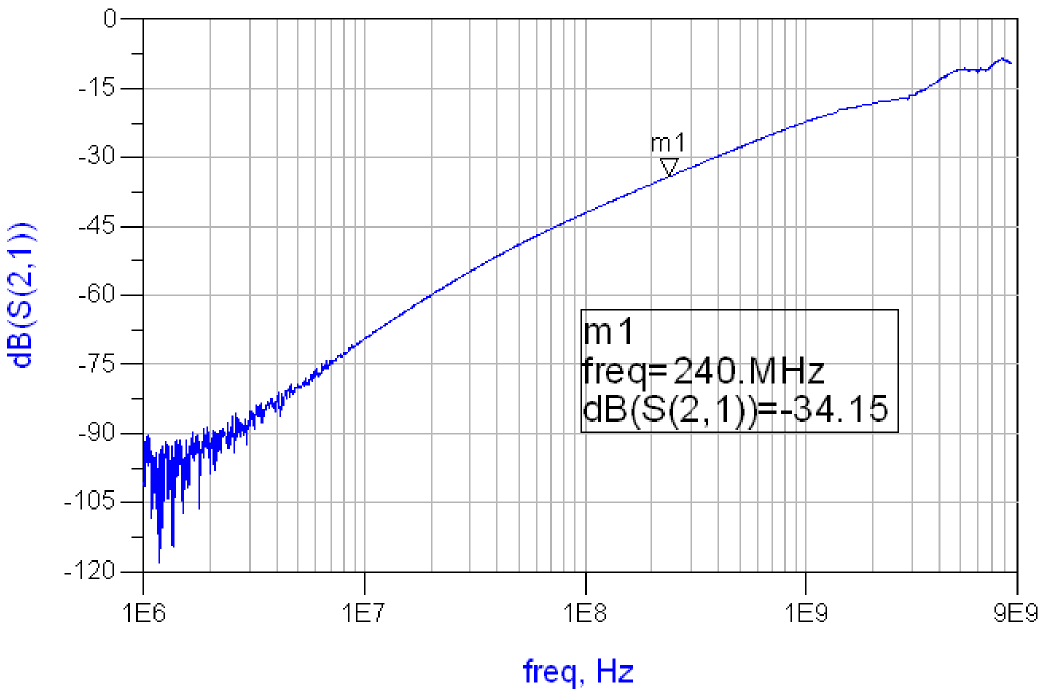


Figure 20. Off Isolation vs. Frequency for USB Path

TYPICAL CHARACTERISTICS (continued)

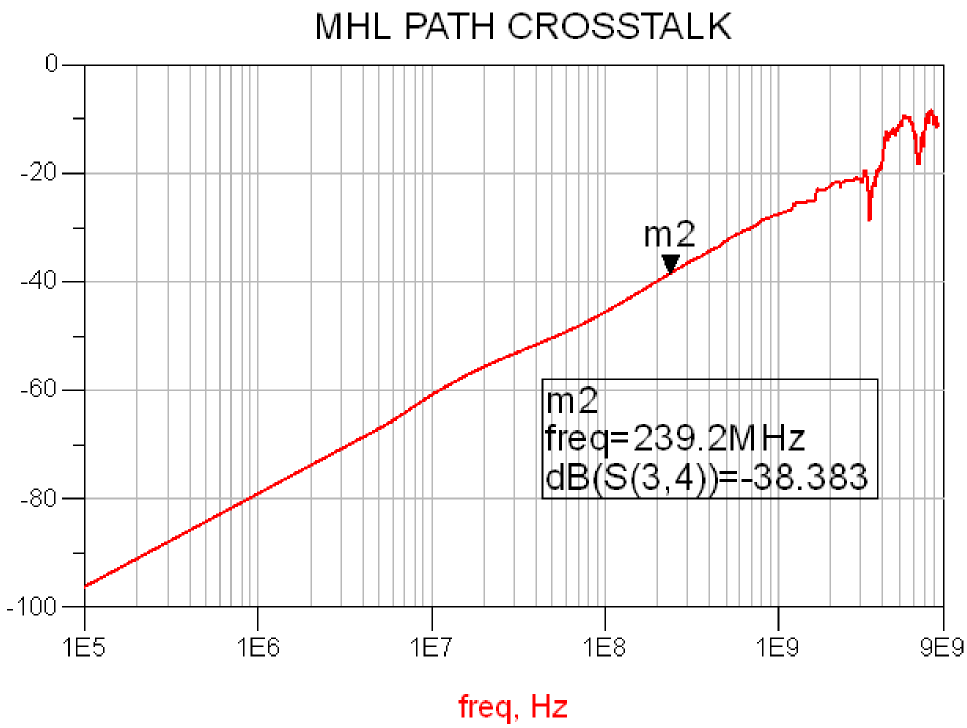


Figure 21. Cross talk vs. Frequency for MHL Path

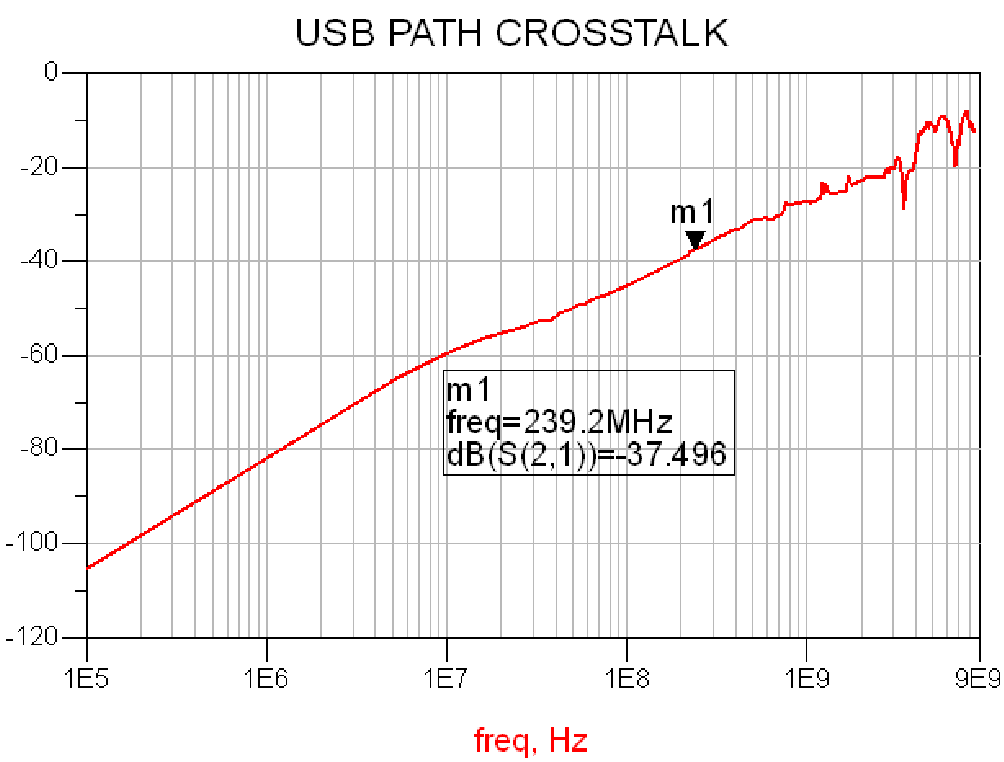


Figure 22. Cross talk vs. Frequency for USB Path

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)
TS3USB3000RLSR	PREVIEW	UQFN	RLS	10	3000	TBD	Call TI	Call TI	
TS3USB3000RSER	PREVIEW	UQFN	RSE	10	3000	Green (RoHS & no Sb/Br)	CU 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.

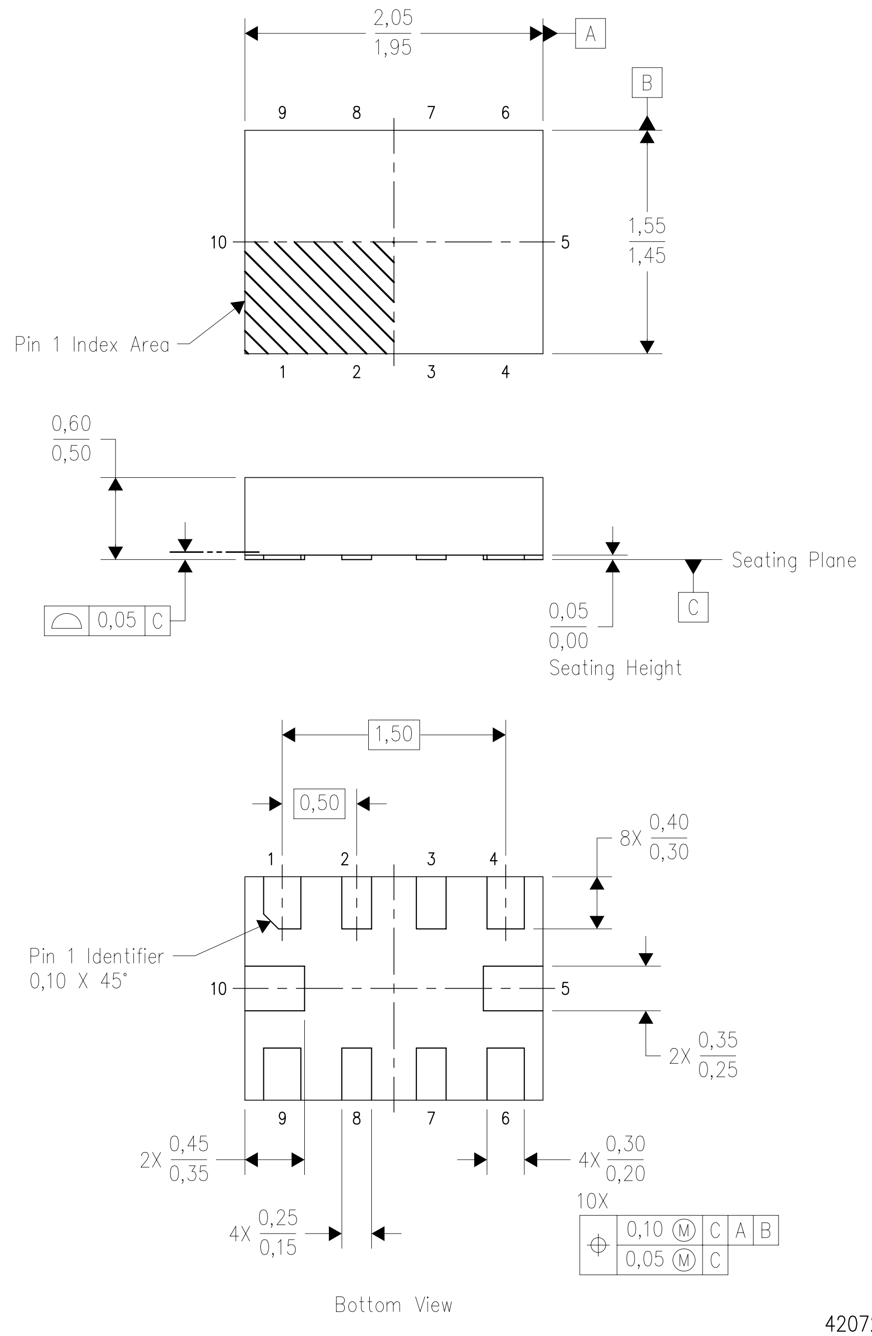
(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been 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.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

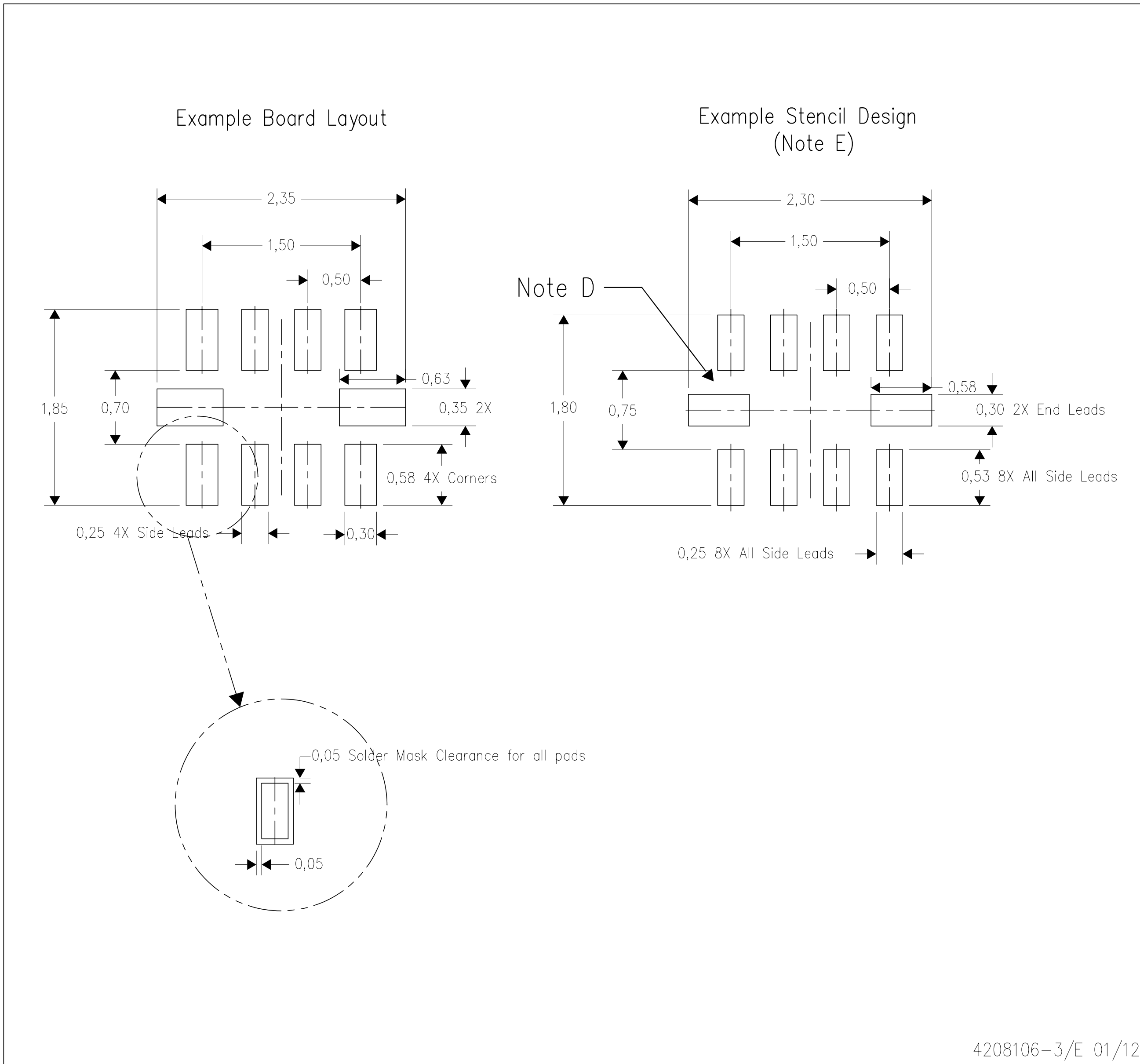
RSE (R-PUQFN-N10) PLASTIC QUAD FLATPACK NO-LEAD



4207268-3/D 01/11

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 UEFD.

RSE (R–PUQFN–N10) 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 0,127 mm (5 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. Side aperture dimensions over–print land for acceptable area ratio > 0.66. Customer may reduce side aperture dimensions if stencil manufacturing process allows for sufficient release at smaller opening.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license 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 significant portions 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. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

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