DUAL USB 2.0 HIGH-SPEED (480Mbps) AND MOBILE HIGH-DEFINITION LINK (MHL) or Mobility Display Port (MyDP) SWITCH

Check for Samples: TS3USB3031

FEATURES

- **V_{CC} Range 2.5V to 4.3V**
- **Mobile High-definition Link (MHL) or Mobility Display Port (MyDP) Switch**
  - **Bandwidth (-3dB) 6.5 GHz**
  - **Ron (Typ) 5.5Ω**
  - **Con (Typ) 1.3pF**
- **USB Switches (2 sets)**
  - **Bandwidth (-3dB) 6.5 GHz**
  - **Ron (Typ) 4.5Ω**
  - **Con (Typ) 1.0pF**
- **Current Consumption 28µA 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**
  - **2kV Human Body Model (A114B, Class II)**
  - **1kV Charged Device Model (C101)**
- **Package**
  - **12-pin QFN Package (1.8 x 1.8mm, 0.5mm Pitch)**

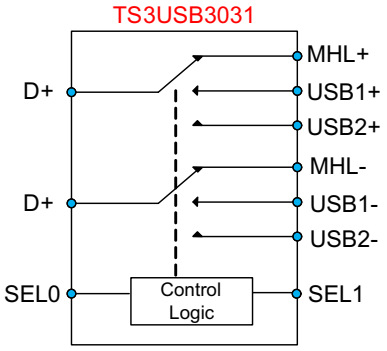
DESCRIPTION

The TS3USB3031 is a double-pole, triple throw (DP3T) multiplexer that includes a high speed Mobile High-Definition Link (MHL) or Mobility Display Port (MyDP) switch and dual 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 MHL/MyDP signals and two sets of USB data. The MHL/MyDP path supports the latest MHL Rev. 3.0 specification.

The TS3USB3031 has a V_{CC} range of 2.5V 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 TS3USB3031 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 TS3USB3031 comes with a small 12-pin QFN package with only 1.8mm x 1.8mm in size, which makes it a perfect candidate to be used in mobile applications.

SWITCH DIAGRAM



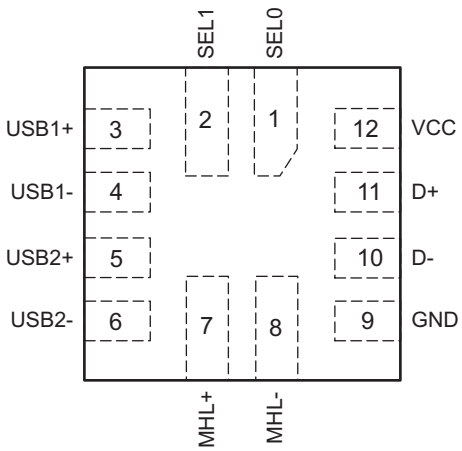
This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

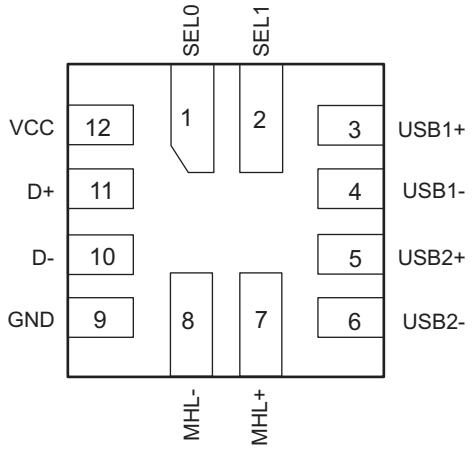
ORDERING INFORMATION

For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com

PIN DESCRIPTION



Top View



Bottom View

PIN DESCRIPTION TABLE

PIN #	PIN NAME	PIN TYPE	DESCRIPTION
1	SEL0	Input	Output Select 1
2	SEL1	Input	Output Select 2
3	USB1+	I/O	USB Data 1 (Differential +)
4	USB1-	I/O	USB Data 1 (Differential -)
5	USB2+	I/O	USB Data 2 (Differential +)
6	USB2-	I/O	USB Data 2 (Differential -)
7	MHL+	I/O	MHL Data (Differential +)
8	MHL-	I/O	MHL Data (Differential -)
9	GND	Ground	Ground
10	D-	I/O	Data Switch Output (Differential -)
11	D+	I/O	Data Switch Output (Differential +)
12	VCC	Power	Supply

FUNCTION TABLE

SEL1	SEL0	SWITCH STATUS
Low	Low	D+/D- to USB1+/USB1-
Low	High	D+/D- to USB2+/USB2-
High	Low	D+/D- to MHL+/MHL-
High	High	USB and MHL switches in High-Z

SUMMARY OF TYPICAL CHARACTERISTICS

	MHL PATH	USB PATH 1	USB PATH 2
Number of switches	2	2	2
ON-state resistance (r_{on})	5.5 Ω	4.5 Ω	4.5 Ω
ON-state resistance match (Δr_{on})	<0.1 Ω	<0.1 Ω	<0.1 Ω
ON-state capacitance ($C_{I/O}$,on)	1.3 pF	1.0 pF	1.0 pF
Bandwidth (BW)	6.5 GHz	6.5 GHz	6.5 GHz

TYPICAL APPLICATION

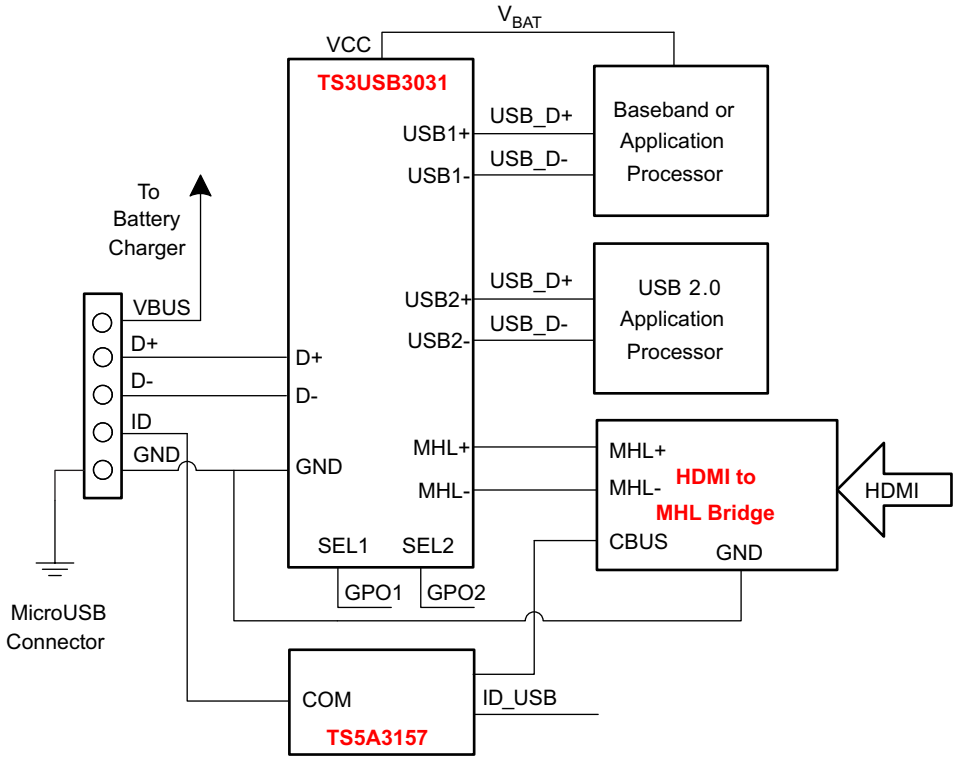


Figure 1. Typical TS3USB3031 Application

The diagram above represents a typical application of the TS3USB3031 MHL switch. The TS3USB3031 is used to switch signals between the 2 sets of USB paths, which go to either the baseband or application processor, and the MHL path, which goes to the HDMI to MHL bridge. The TS3USB3031 has internal 6MΩ pull-down resistors on SEL0 and SEL1. The pull-down on SEL0 and SEL1 ensure the USB1 channel is selected by default. 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.

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 (SEL0, SEL1)		-0.3	5.5	
I_{IK}	Digital logic input clamp current(3)	VI < 0	-50		mA
I_{OUT}	Continuous switch DC output current (USB and MHL)			60	mA
$I_{OUT, PEAK}$	Peak switch DC output current (1ms duration pulse at <10% duty cycle)			150	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

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

		TYP	UNIT
θ_{JA}	Package thermal impedance	TBD	°C/W

RECOMMENDED OPERATING CONDITIONS

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

		MIN	MAX	UNIT
V_{CC}	Supply voltage range	2.5	4.3	V
$V_{I/O\ (USB)}$	Analog voltage Range	0	3.6	V
$V_{I/O\ (MHL)}$				
V_I	Digital input voltage range (SEL0, SEL1)	0	VCC	V
$T_{RAMP\ (VCC)}$	Power Supply Ramp Time Requirement (VCC)	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} = 2.5V	$V_{I/O}$ = 1.5V, I_{ON} = -8mA (See Figure 2)		5.5	7.0	Ω
ΔR_{ON}	ON-state resistance match between + and - paths	V_{CC} = 2.5V	$V_{I/O}$ = 1.5V, I_{ON} = -8mA		0.1		Ω
$R_{ON\ (FLAT)}$	ON-state resistance flatness	V_{CC} = 2.5V	$V_{I/O}$ = 1.5V to 3.3V, I_{ON} = -8mA		1		Ω
I_{OZ}	OFF leakage current	V_{CC} = 4.3V	Switch OFF, $V_{MHL+/MHL-}$ = 1.5V to 3.3V, $V_{D+/D-}$= 0V (See Figure 3)	-2		2	µA
I_{OFF}	Power-off leakage current	V_{CC} = 0V	Switch ON or OFF, $V_{MHL+/MHL-}$ = 1.5V to 3.3V, $V_{D+/D-}$= NC	-10		10	µA
I_{ON}	ON leakage current	V_{CC} = 4.3V	Switch ON, $V_{MHL+/MHL-}$ = 1.5V to 3.3V, $V_{D+/D-}$= NC	-2		2	µA
USB Switch (USB1 and USB2)							
R_{ON}	ON-state resistance	V_{CC} = 2.5V	$V_{I/O}$ = 0.4V, I_{ON} = -8mA (See Figure 2)		4.5	6.0	Ω
ΔR_{ON}	ON-state resistance match between + and - paths	V_{CC} = 2.5V	$V_{I/O}$ = 0.4V, I_{ON} = -8mA		0.1		Ω
$R_{ON\ (FLAT)}$	ON-state resistance flatness	V_{CC} = 2.5V	$V_{I/O}$ = 0V to 0.4V, I_{ON} = -8mA		1		Ω

ELECTRICAL CHARACTERISTICS (continued)

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
I_{OZ}	OFF leakage current	V_{CC} = 4.3V	Switch OFF, $V_{USB+/USB-}$ = 0V to 0.4V, $V_{D+/D-}$= 0V (See Figure 3)	-2		2	µA
I_{OFF}	Power-off leakage current	V_{CC} = 0V	Switch ON or OFF, $V_{USB+/USB-}$ = 0V to 0.4V, $V_{D+/D-}$= NC	-10		10	µA
I_{ON}	ON leakage current	V_{CC} = 4.3V	Switch ON, $V_{USB+/USB-}$ = 0V to 0.4V, $V_{D+/D-}$= NC	-2		2	µA
Digital Control Inputs (SEL, $\overline{OE}$)							
V_{IH}	Input logic high	V_{CC} = 2.5V to 4.3V		1.3			V
V_{IL}	Input logic low	V_{CC} = 2.5V to 4.3V				0.6	V
I_{IN}	Input leakage current	V_{CC} = 4.3V, $V_{I/O}$ = 0V to 3.6V, V_{IN} = 0 to 4.3V		-10		10	µA

DYNAMIC 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
t_{pd}	Propagation Delay	R_L = 50Ω, CL = 5pF, V_{CC} = 2.5V to 4.3V, $V_{I/O(USB)}$= 0.4V, $V_{I/O(MHL)}$=3.3V			50		ps
t_{switch}	Switching time between USB/MHL channels in Active Modes					400	ns
t_{ON}	Switch Turn-on time (From Disabled to Active Mode)					100	µs
t_{OFF}	Switch Turn-off time (From Active to Disabled Mode)					100	µs
$C_{ON(MHL)}$	MHL path ON capacitance	V_{CC} = 3.3V, $V_{I/O}$ =0 or 3.3V, f = 240MHz	Switch ON		1.3		pF
$C_{ON(USB)}$	USB1 and USB2 paths ON Capacitance	V_{CC} = 3.3V, $V_{I/O}$ =0 or 3.3V, f = 240MHz	Switch ON		1.0		pF
$C_{OFF(MHL)}$	MHL path OFF capacitance	V_{CC} = 3.3V, $V_{I/O}$ =0 or 3.3V, f = 240MHz	Switch OFF		1.0		pF
$C_{OFF(USB)}$	USB1 and USB2 paths OFF Capacitance	V_{CC} = 3.3V, $V_{I/O}$ =0 or 3.3V, f = 240MHz	Switch OFF		0.8		pF
C_I	Digital input capacitance	V_{CC} = 3.3V, V_I =0 or 2V			2.2		pF
$O_{ISO\ (MHL)}$	MHL path OFF Isolation	V_S = -10dBm, V_{DC_BIAS} = 2.4V, RT = 50Ω, f = 240MHz (See Figure 4)	Switch OFF		-38		dB
$O_{ISO\ (USB)}$	USB path OFF Isolation	V_S = -10dBm, V_{DC_BIAS} = 0.2V RT = 50Ω, f = 240MHz (See Figure 4)	Switch OFF		-38		dB
$X_{TALK\ (MHL)}$	MHL Channel Crosstalk	V_S = -10dBm, V_{DC_BIAS} = 2.4V, RT = 50Ω, f = 240MHz (See Figure 5)	Switch ON		-41		dB
$X_{TALK\ (USB)}$	USB Channel Crosstalk	V_S = -10dBm, V_{DC_BIAS} = 0.2V, RT = 50Ω, f = 240MHz (See Figure 5)	Switch ON		-38		dB
$BW_{(MHL)}$	MHL path -3dB bandwidth	V_{CC} = 2.5V to 4.3V, R_L = 50Ω (See Figure 6)	Switch ON		6.5		GHz
$BW_{(USB)}$	USB path -3dB bandwidth	V_{CC} = 2.5V to 4.3V, R_L = 50Ω (See Figure 6)	Switch ON		6.5		GHz
Supply							
V_{CC}	Power supply voltage			2.5		4.3	V
I_{CC}	Positive supply current	V_{CC} = 4.3V, V_{IN} = V_{CC} or GND, $V_{I/O}$ = 0V, Switch ON or OFF			28	40	µA

PARAMETER MEASUREMENT INFORMATION

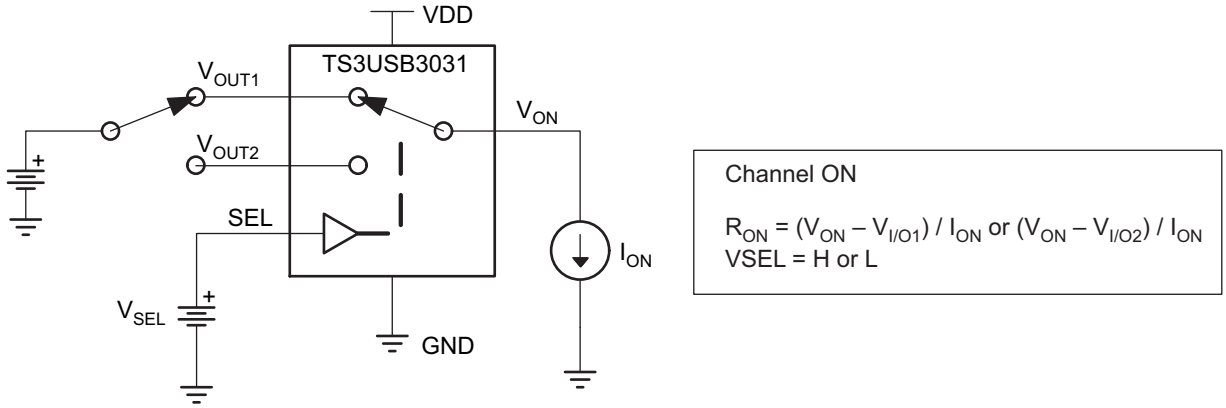


Figure 2. ON State Resistance (R_{ON})

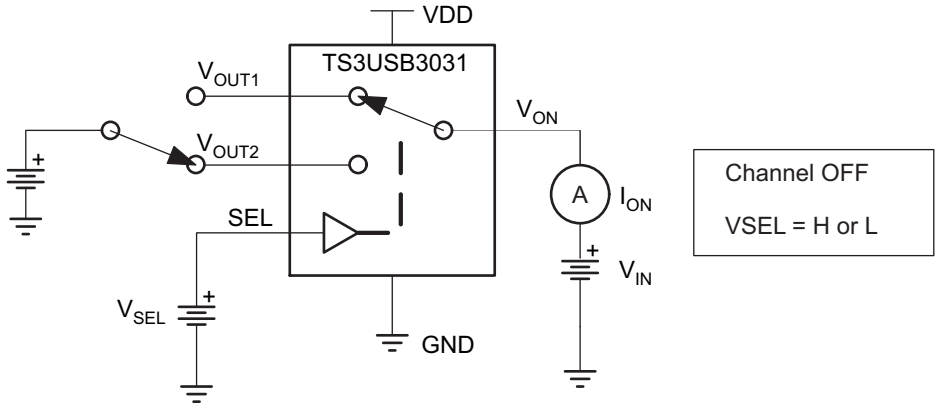


Figure 3. OFF Leakage Current (I_{OZ})

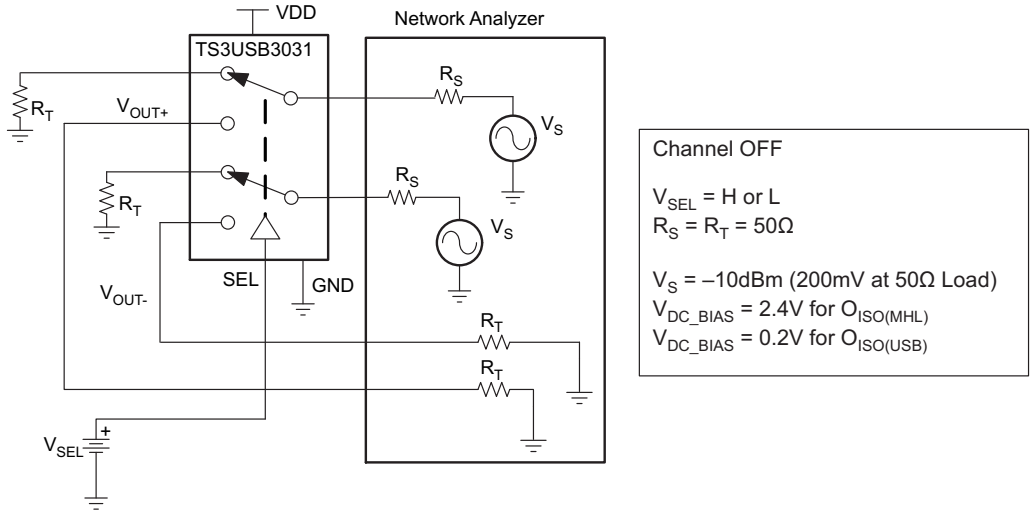


Figure 4. Differential Off-Isolation (O_{ISO})

PARAMETER MEASUREMENT INFORMATION (continued)

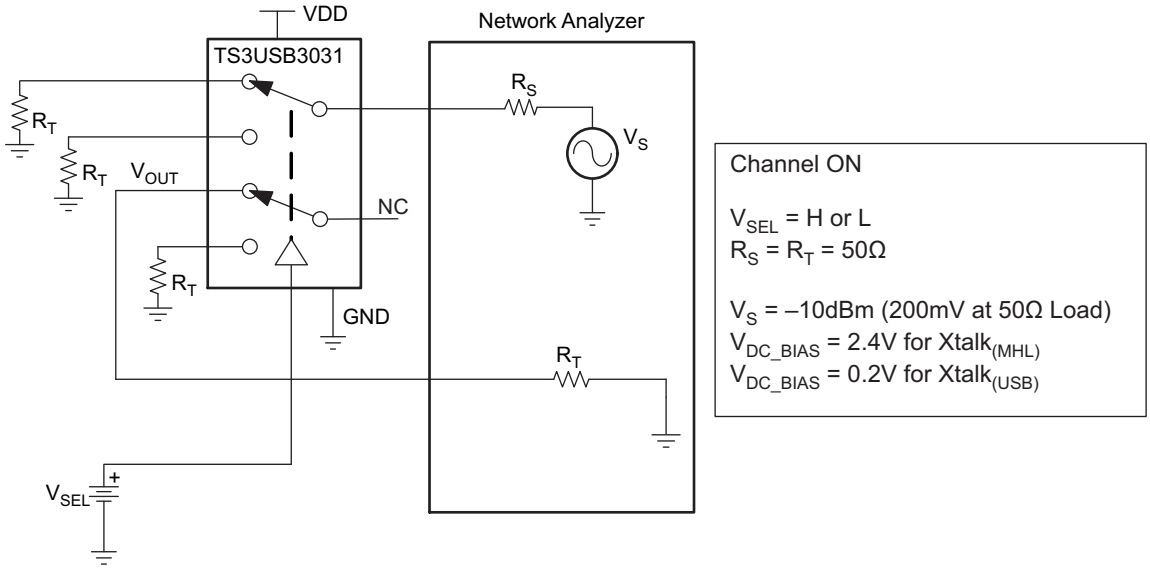


Figure 5. Crosstalk (Xtalk)

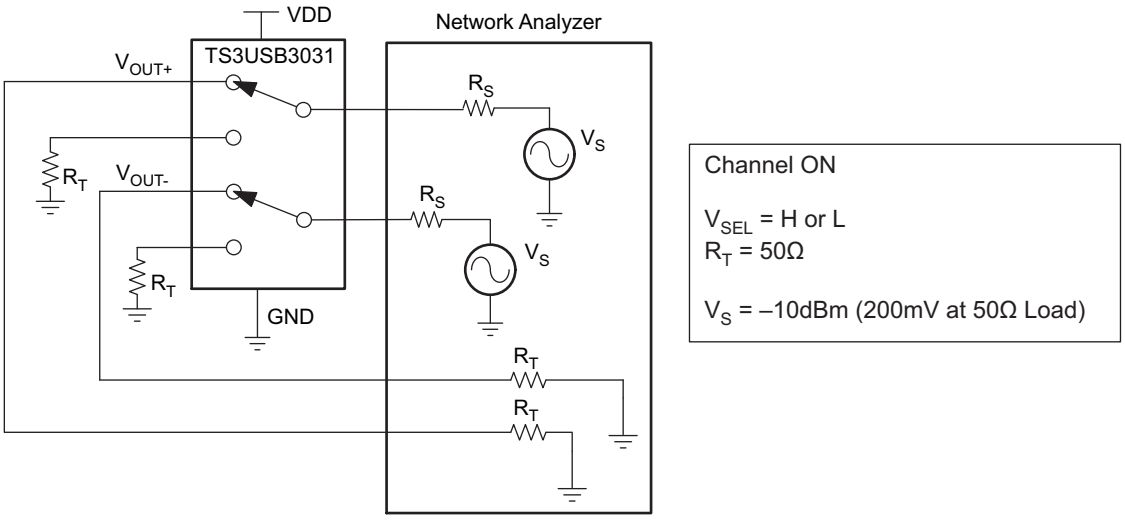


Figure 6. Differential Bandwidth (BW)

TYPICAL CHARACTERISTICS

MHL Eye Pattern

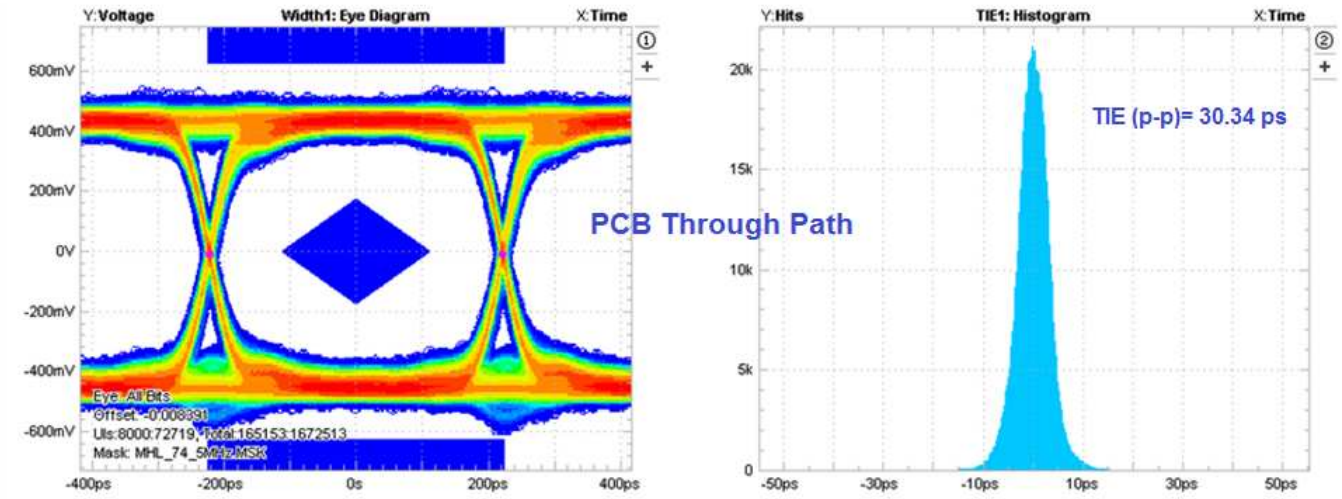


Figure 7. Eye Pattern and Time Interval Error Histogram: 2.25Gbps With No Device

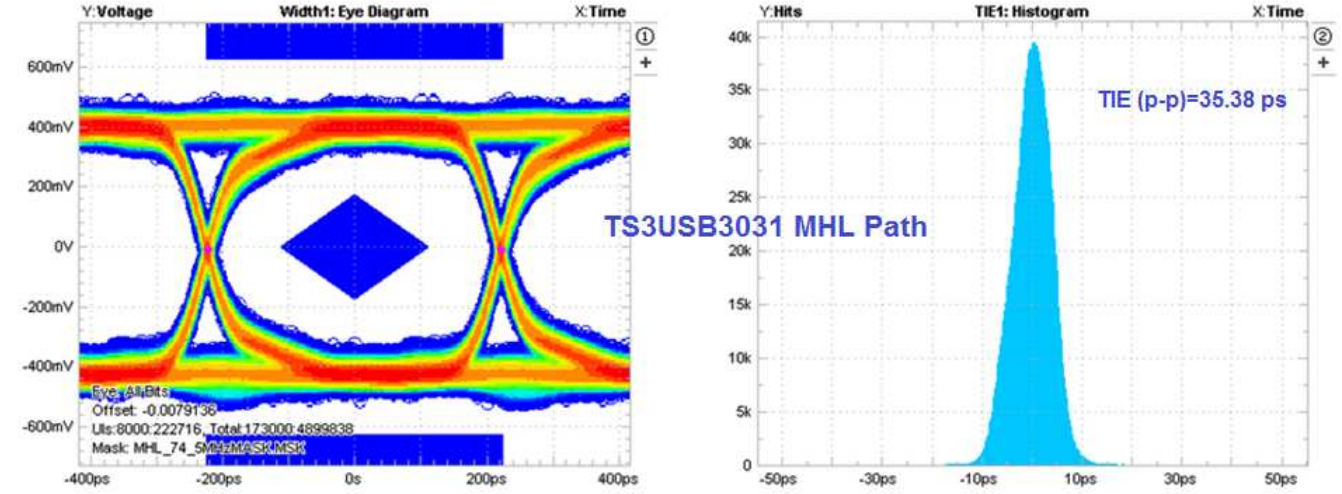


Figure 8. Eye Pattern and Time Interval Error Histogram: 2.25Gbps With TS3USB3031
TS3USB3031 Added Jitter = 5.04 ps

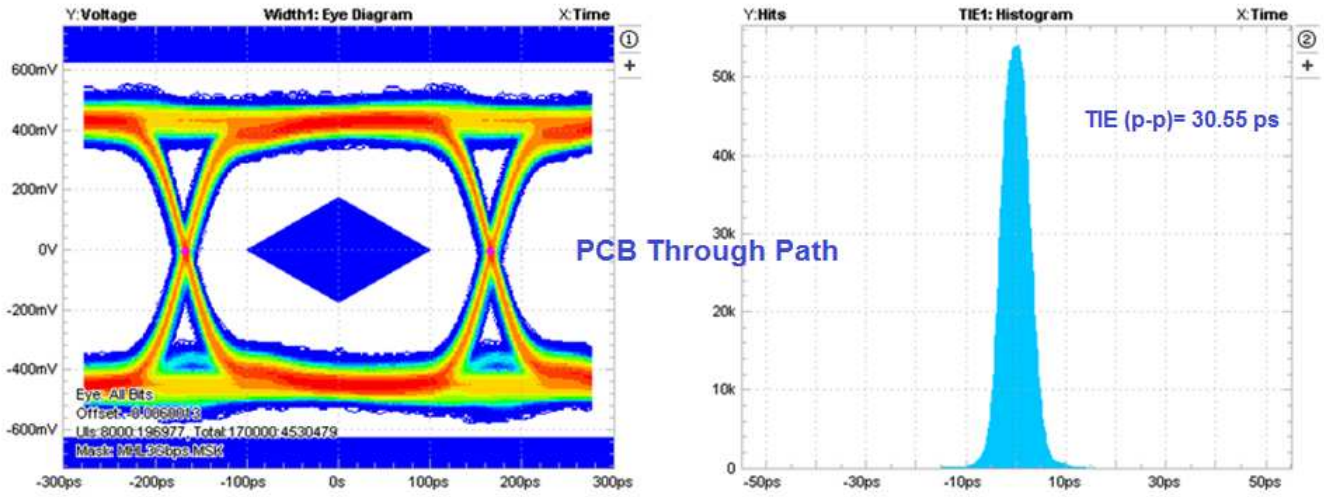


Figure 9. Eye Pattern and Time Interval Error Histogram: 3.0 Gbps With No Device

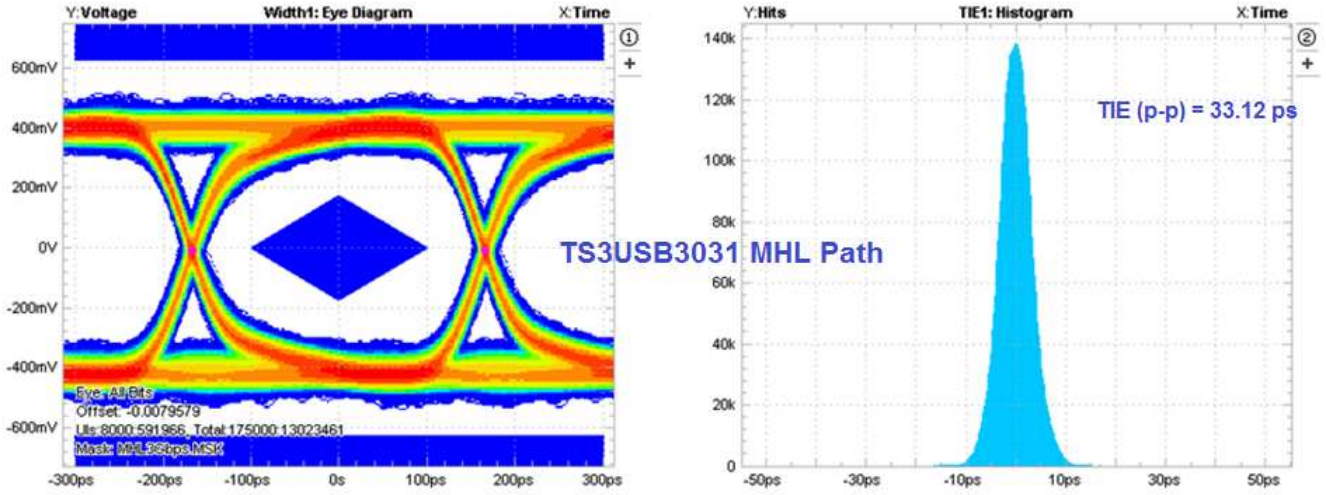


Figure 10. Eye Pattern and Time Interval Error Histogram: 3.0 Gbps With TS3USB3031 TS3USB3031 Added Jitter = 2.57 ps

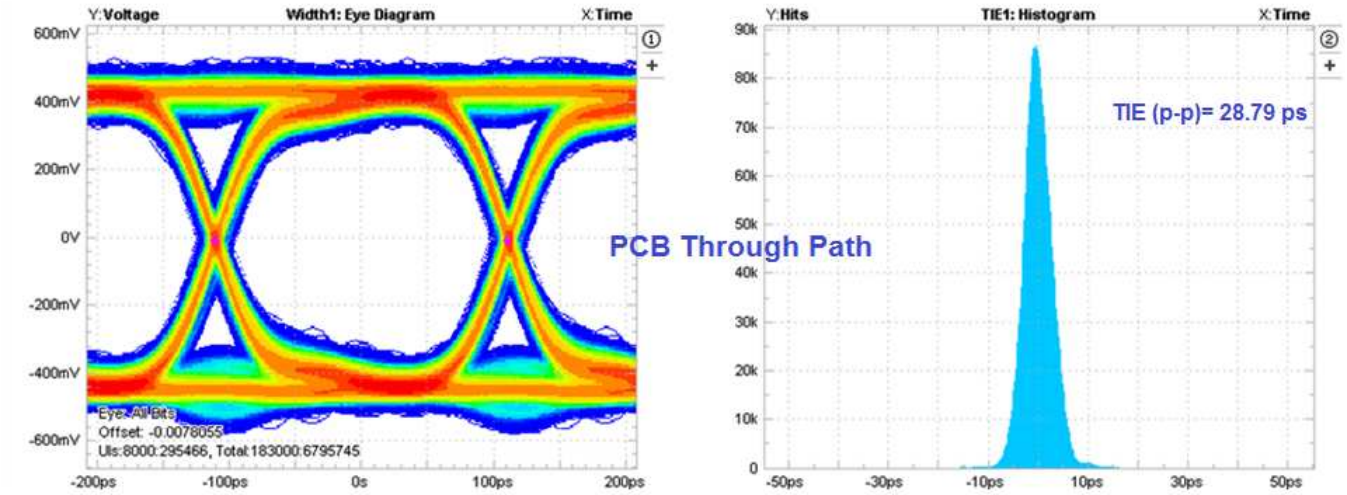


Figure 11. Eye Pattern and Time Interval Error Histogram: 4.5 Gbps With No Device

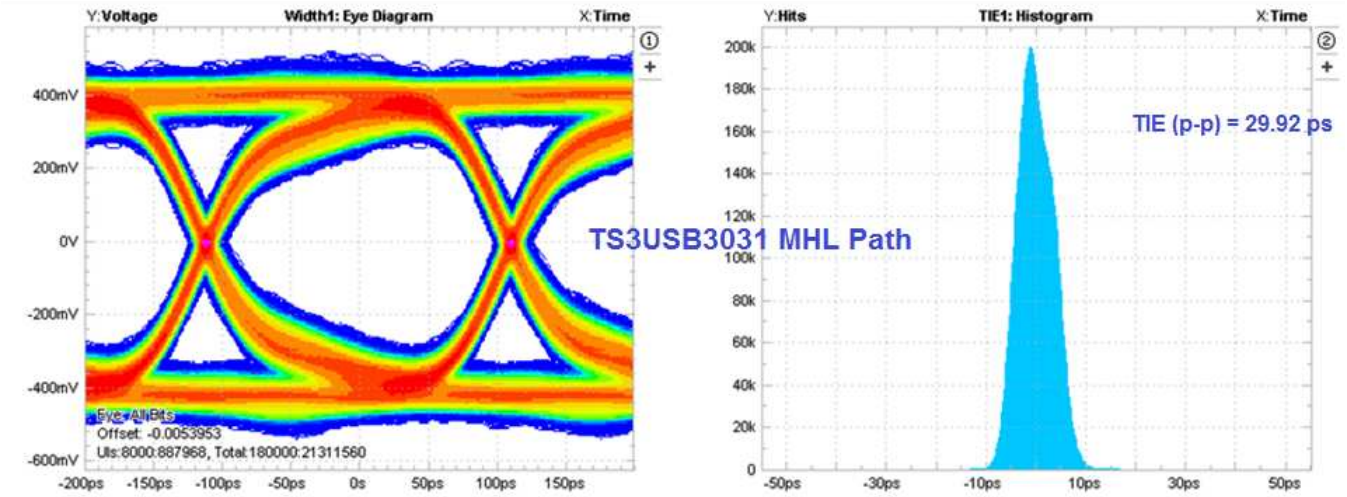


Figure 12. Eye Pattern and Time Interval Error Histogram: 4.5 Gbps With TS3USB3031
TS3USB3031 Added Jitter = 1.13 ps

USB EYE Pattern

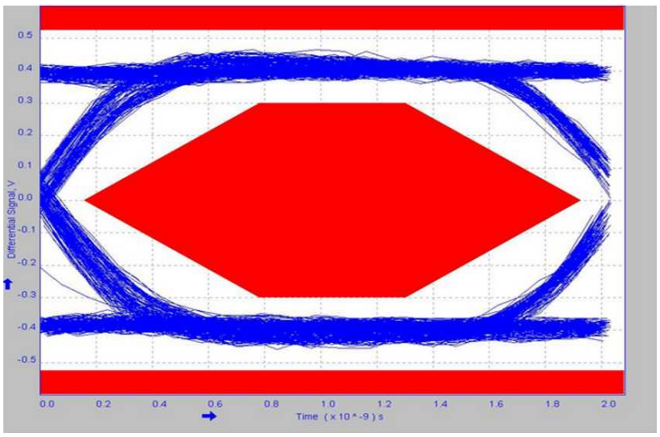


Figure 13. 480-Mbps USB 2.0 Eye Pattern with No Device

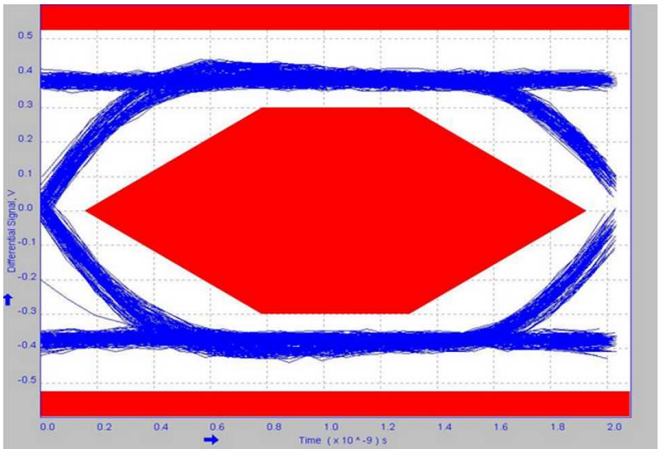


Figure 14. 480-Mbps USB 2.0 Eye Pattern for USB Switch

ON-Resistence

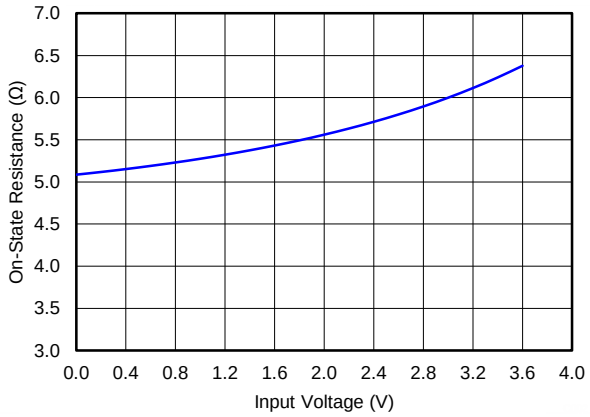


Figure 15. ON-Resistance vs. VI for MHL Switch

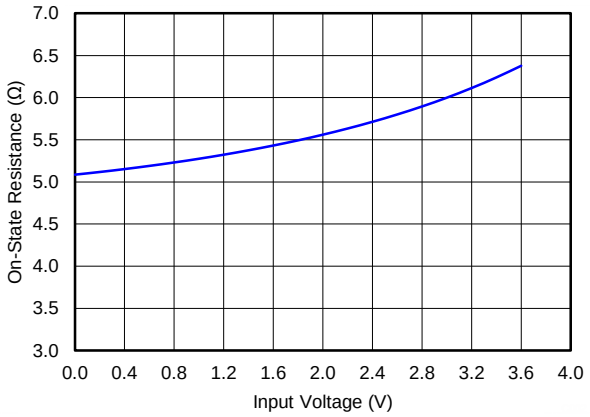


Figure 16. ON-Resistance vs. VI for USB Switch

Differential S21 vs. Frequency

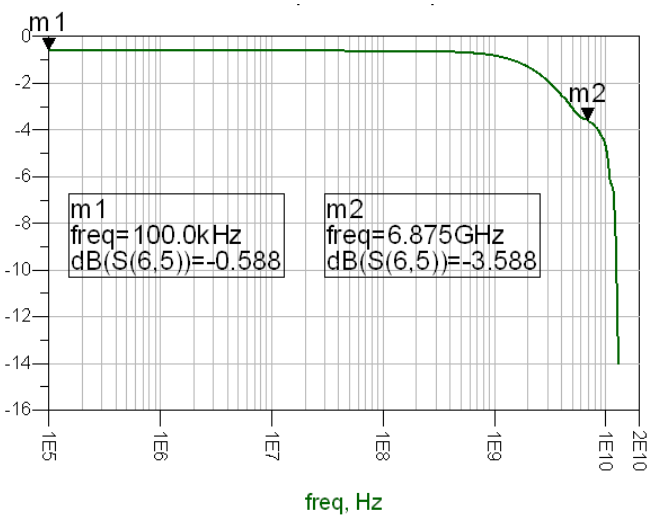


Figure 17. Differential S21 vs. Frequency for MHL Switch

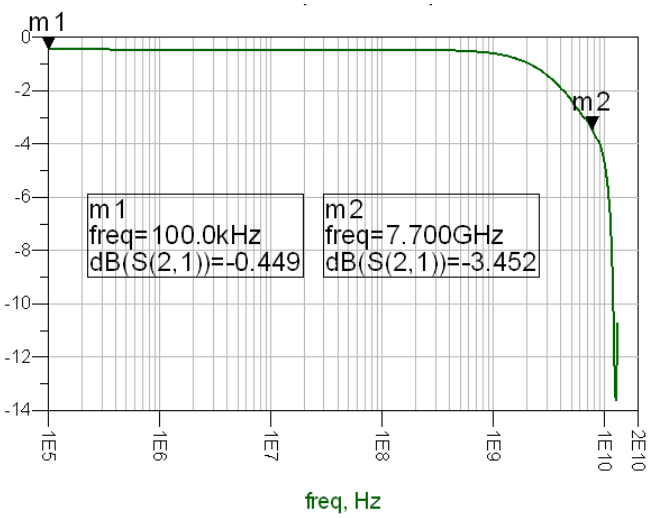


Figure 18. Differential S21 vs. Frequency for USB Switch

Differential OFF-Isolation

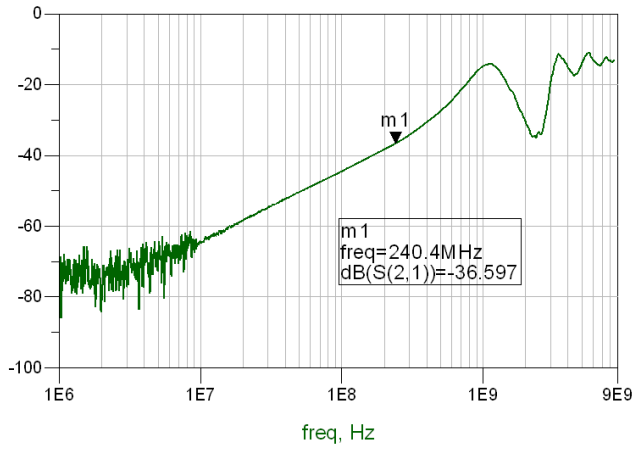


Figure 19. Off Isolation vs. Frequency for MHL Path

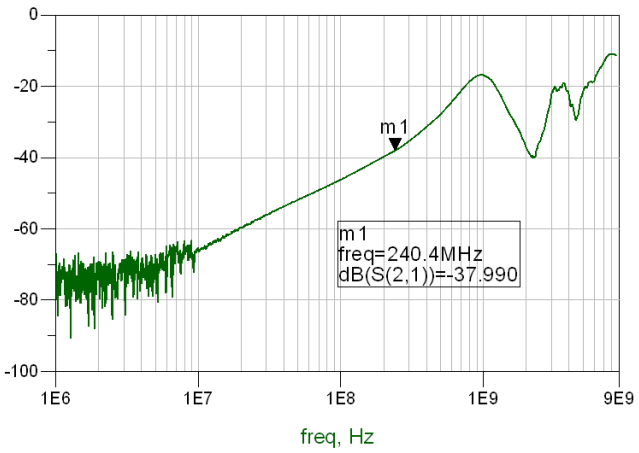


Figure 20. Off Isolation vs. Frequency for USB Path

Cross talk vs. Frequency

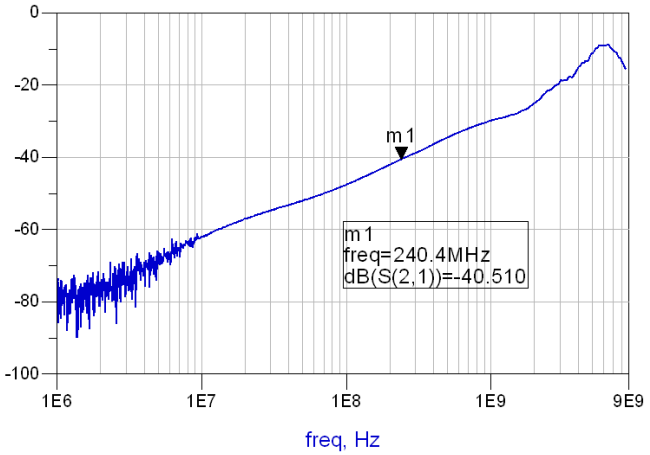


Figure 21. Cross talk vs. Frequency for MHL Path

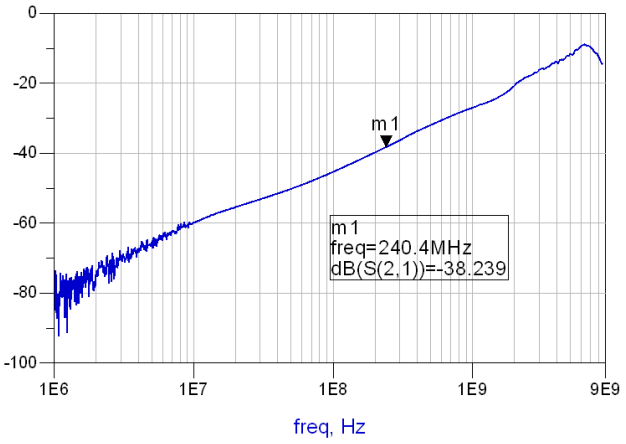


Figure 22. Cross talk vs. Frequency for USB Path

REVISION HISTORY

Changes from Original (June 2013) to Revision A	Page
• Added TYPICAL CHARACTERISTICS section.	9

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TS3USB3031RMGR	ACTIVE	WQFN	RMG	12	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	DY	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)

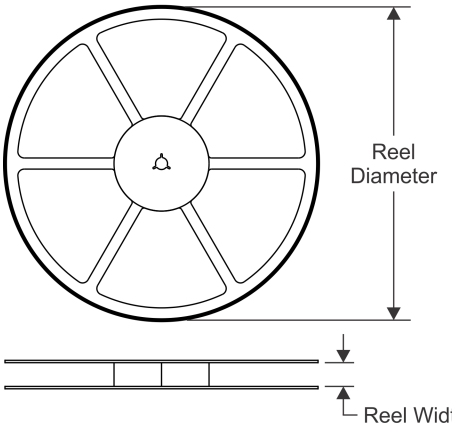
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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

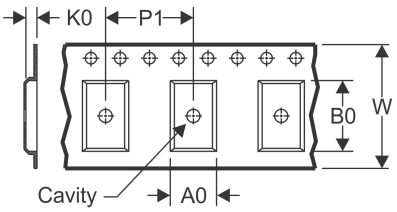
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

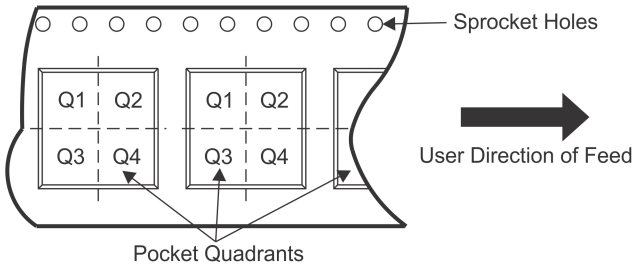


TAPE DIMENSIONS



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

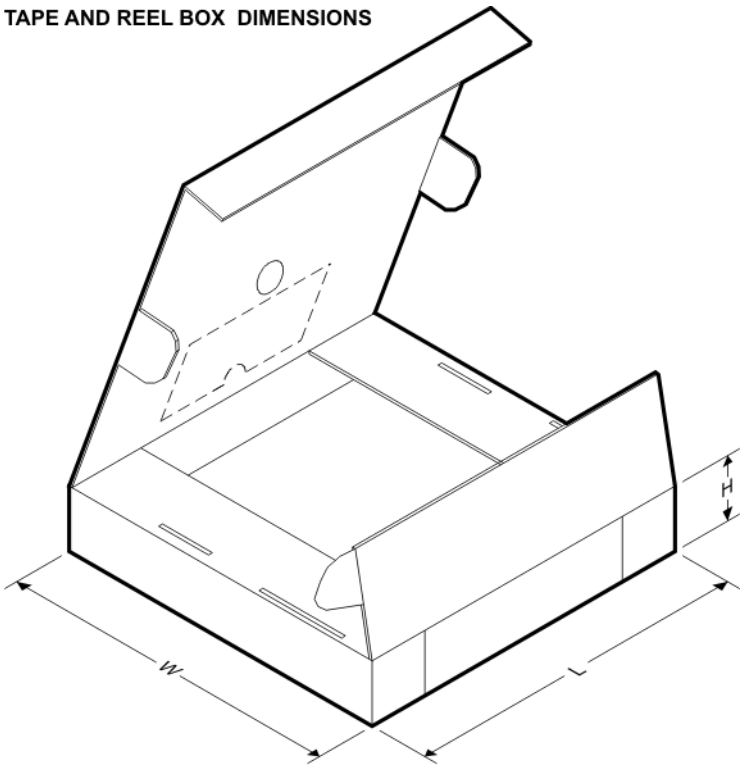
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TS3USB3031RMGR	WQFN	RMG	12	3000	180.0	8.4	2.05	2.05	1.0	4.0	8.0	Q1

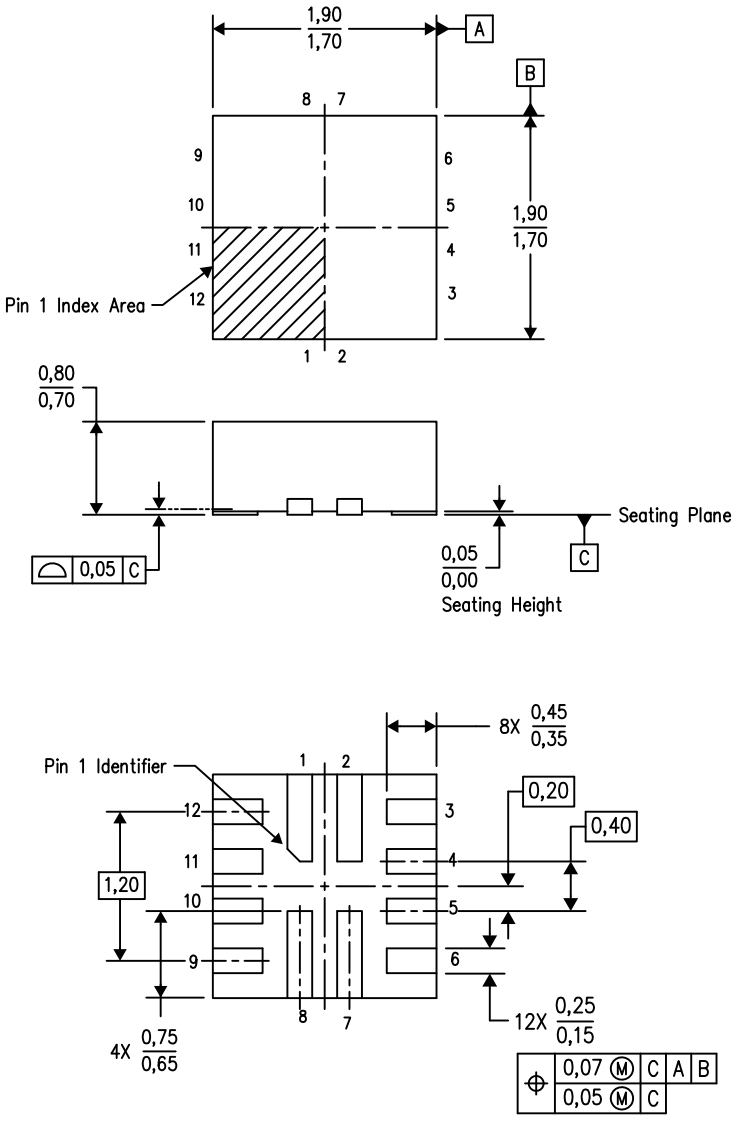
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TS3USB3031RMGR	WQFN	RMG	12	3000	210.0	185.0	35.0

RMG (S–PWQFN–N12) PLASTIC QUAD FLATPACK NO–LEAD

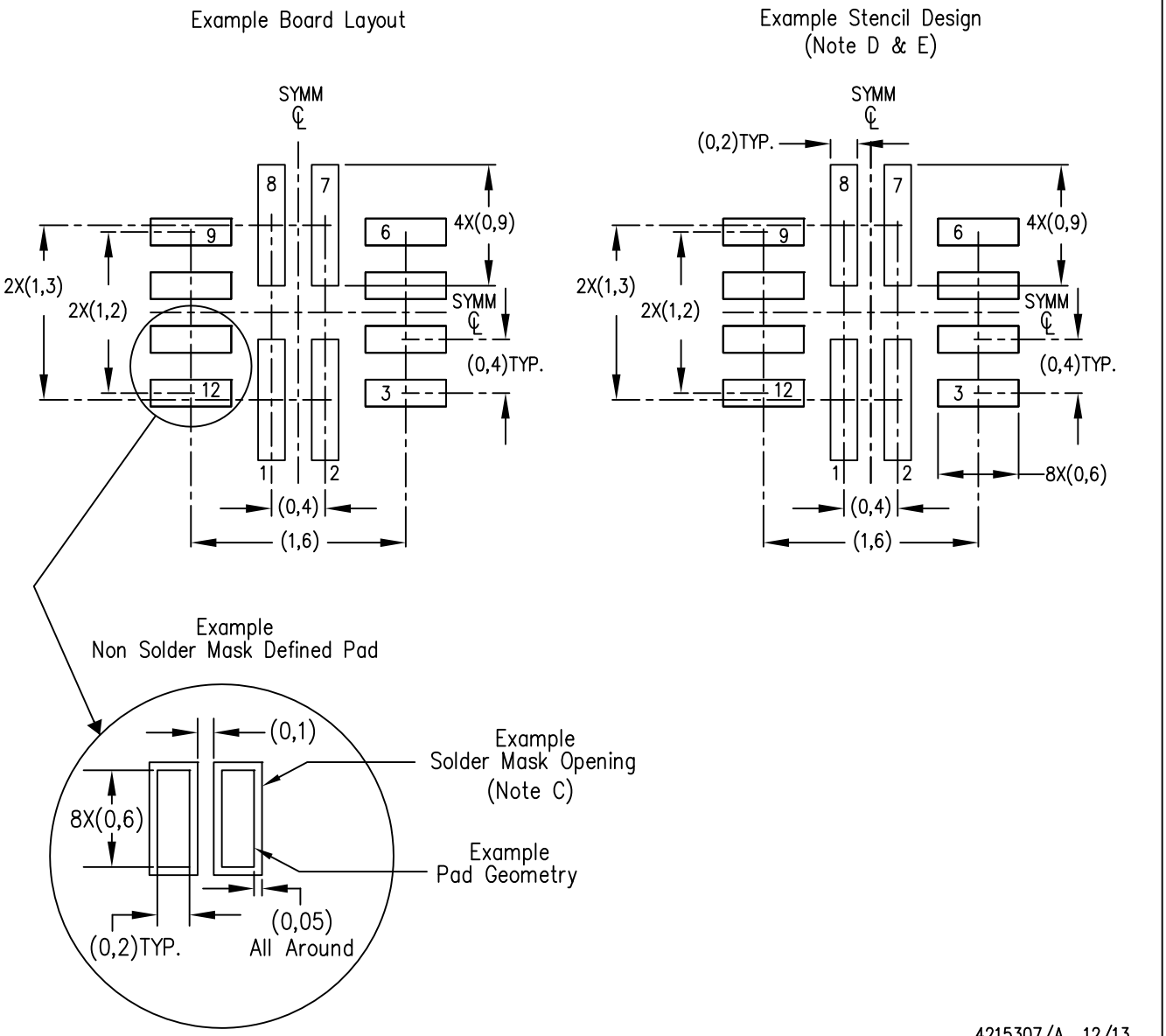


Bottom View

4218646/B 05/13

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.

RMG (S–PWQFN–N12) PLASTIC QUAD FLATPACK NO–LEAD



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.
D. Maximum stencil thickness 0,1 mm (4 mils).
E. 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.

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