

USB 2.0 High Speed and Audio Switch with Negative Swing Capability NS5S1153

The NS5S1153 is a DPDT switch for combined true-ground audio and USB 2.0 high speed data applications. It allows portable systems to use a single port to pass either USB data or audio signals from an external headset; headset; the 2 channels being compliant to USB 2.0, USB 1.1 and USB 1.0.

The switch is capable of passing signals with negative voltages as low as 2 V below ground. The device features shunt resistors on the audio ports. These resistors are switched in when the audio channel is off and provide a safe path to ground for any charge that may build up on the audio lines. This reduces Pop & Click noise in the audio system. The NS5S1153 is also equipped with VBUS detection circuitry to immediately switch to USB mode in the event that a voltage is detected on VBUS.

The NS5S1153 is housed in a space saving, ultra low profile 1.4 x 1.8 x 0.5 mm 10 pin UQFN package.

Features

- 2:1 High Speed Switch
- USB 2.0, USB 1.1 & USB 1.0 Capable on all channels
- High Bandwidth of 820 MHz on D+/D-
- Capable of Passing Negative Swing Signals Down to -2 V on R/L Channel
- 1.8 V Compatible Control Pin & VBUS Detection Circuitry for Automatic Switching
- Audio Channel Shunt Resistors for Pop & Click Noise Reduction
- Ultra-Low THD in Audio Mode: 0.01% into 16 Ω Load
- 5.25 V Tolerant Common Pins
- This is a Pb-Free Device

Typical Applications

- Micro or Mini USB Applications
- Shared High Speed Data or Audio on a Single Connector
- Mobile Phones
- Tablets
- Bar Code Scanners
- Portable Devices

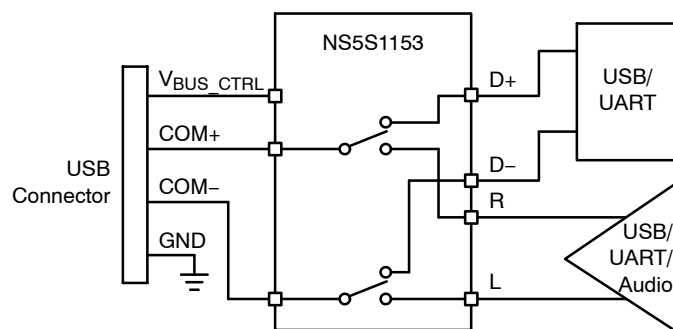
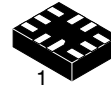
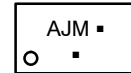


Figure 1. Application Diagram

MARKING DIAGRAMS



UQFN10
CASE 488AT



AJ = Specific Device Code
M = Date Code
▪ = Pb-Free Package

(Note: Microdot may be in either location)

ORDERING INFORMATION

Device	Package	Shipping†
NS5S1153MUTAG	UQFN10 (Pb-Free)	3000 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

The diagram illustrates the internal circuitry of a USB Type-C connector. Key components include:

- Control Logic:** A central block that manages the connection, receiving signals from the ASEL pin and the V_{BUS} Detect circuit. It controls the COM+ and COM- pins and the internal switches.
- V_{BUS} Detect:** A circuit that monitors the voltage on the V_{BUS} pin (pin 9) through a pull-down resistor (V_{BUS_PD}) to determine if a valid USB bus is connected.
- Internal Switches:** Two sets of switches controlled by the Control Logic. One set connects the COM+ and COM- pins to the D+ and D- pins. The other set connects the COM+ and COM- pins to the V_{CC} and GND pins, respectively, when the connector is configured as a power source.
- Pin Connections:**
 - COM+ (Pin 7):** Connected to the D+ pin (Pin 10) and the V_{CC} pin (Pin 5) via internal switches.
 - COM- (Pin 6):** Connected to the D- pin (Pin 10) and the GND pin (Pin 4) via internal switches.
 - ASEL (Pin 8):** A select pin that controls the internal switches.
 - V_{BUS}_CTRL (Pin 9):** A control pin connected to the V_{BUS} Detect circuit.
 - D+ (Pin 10):** The positive data line.
 - D- (Pin 1):** The negative data line.
 - V_{CC} (Pin 5):** The positive power supply pin.
 - GND (Pin 4):** The ground pin.
 - L (Pin 3):** A pin used for USB Type-C to USB Type-A or USB Type-C to USB Type-C connections.
 - R (Pin 2):** A pin used for USB Type-C to USB Type-A or USB Type-C to USB Type-C connections.

**Figure 2. Functional Block Diagram
(Top View)**

PIN DESCRIPTIONS

Pin #	Name	Direction	Description
1	D-	I/O	Negative Data Line for USB Signals
2	R	I/O	Right Line for Audio Signals
3	L	I/O	Left Line for Audio Signals
4	GND	Power	Ground
5	V _{CC}	Power	Power Supply
6	COM-	I/O	Left Audio / Negative Data Common Line
7	COM+	I/O	Right Audio / Positive Data Common Line
8	A _{SEL}	Input	Control Input Override Select Line
9	V _{BUS_CTRL}	Input	Control Input Select Line from V _{BUS} . If this pin is driven by an open drain I/O, we suggest maximum 100 kΩ pull up.
10	D+	I/O	Positive Data Line for USB Signals

TRUTH TABLE

A_{SEL}	V_{BUS}	L, R	D+, D–	L, R SHUNT
Low	Low	ON	OFF	OFF
Low	High	OFF	ON	ON
High	X	ON	OFF	OFF

NS5S1153

OPERATING CONDITIONS

MAXIMUM RATINGS

Symbol	Pins	Parameter	Value	Unit
V _{CC}	V _{CC}	Positive DC Supply Voltage	−0.5 to +6.0	V
V _{BUS}	V _{BUS_CTRL}	V _{BUS} Control Input Voltage	−0.5 to +6.0	V
V _{IS}	D+ to COM+ D− to COM−	Analog Signal Voltage	−0.5 to +6.0	V
	R to COM+ L to COM−		−2.5 to V _{CC} + 0.5	
V _{IS}	COM+, COM−	DC Signal Voltage Tolerance (<24 hours)	5.25	V
V _{IN}	ASel	Control Input Override Voltage	−0.5 to +6.0	V
I _{CC}	V _{CC}	Positive DC Supply Current	50	mA
T _S		Storage Temperature	−65 to +150	°C
I _{IS_CON}	COM+, COM− R, L, D+, D−	Analog Signal Continuous Current–Closed Switch	± 100	mA
I _{IS_PK}	COM+, COM− R, L, D+, D−	Analog Signal Continuous Current 10% Duty Cycle	± 500	mA
I _{IN}	ASel	Control Input Override Current	1	mA
	V _{BUS_CTRL}	V _{BUS} Control Input Current	1	

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

RECOMMENDED OPERATING CONDITIONS

Symbol	Pins	Parameter	Min	Max	Unit
V _{CC}	V _{CC}	Positive DC Supply Voltage	2.7	5.0	V
V _{BUS}	V _{BUS_CTRL}	V _{BUS} Control Input Voltage	GND	5.25	V
V _{IS}	D+ to COM+ D− to COM−	Analog Signal Voltage (Note 1)	GND	V _{CC}	V
	R to COM+ L to COM−		−2.0	V _{CC}	
V _{IN}	ASel	Control Input Override Voltage	GND	V _{CC}	V
T _A		Operating Temperature	−40	+85	°C

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

1. In USB mode, any signal applied to the off-state audio inputs R, L may not swing below ground or above 1.5 V.

DC ELECTRICAL CHARACTERISTICS

Symbol	Pins	Parameter	Test Conditions	V _{CC} (V)	-40°C to +85°C			Unit
					Min	Typ	Max	
CONTROL INPUT (Typical: T = 25°C, V _{CC} = 3.3 V)								
V _{IH}	A _{SEL}	Control Input HIGH Voltage		2.7 3.3 4.2	1.3 1.4 1.5	–	–	V
V _{IL}	A _{SEL}	Control Input LOW Voltage		2.7 3.3 4.2	–	–	0.4 0.4 0.4	V
I _{IN}	A _{SEL}	Current Input Leakage Current	0 ≤ V _{IS} ≤ V _{CC}	4.2	–	–	±50	nA
V _{IH}	V _{BUS_CTRL}	V _{BUS} Control Input HIGH Voltage		2.7 3.3 4.2	1.9 2.2 2.7	–	–	V
V _{IL}	V _{BUS_CTRL}	V _{BUS} Control Input LOW Voltage		2.7 3.3 4.2	–	–	0.8 1.1 1.6	V
I _{IN}	V _{BUS_CTRL}	V _{BUS} Current Input Leakage Current	0 ≤ V _{IS} ≤ V _{CC}	4.2	–	–	±25	μA

SUPPLY CURRENT AND LEAKAGE (Typical: T = 25°C, V_{CC} = 3.3 V)

I _{NC,NO(OFF)}	D+, D–	OFF State Leakage	V _{BUS_CTRL} = 0 V, 4.2 V; V _{COM–} , V _{COM+} = 0 V, 4.2 V V _{D+} , V _{D–} = 4.2 V, 0 V or float V _L , V _R = float or 4.2 V, 0 V	4.2			±80	nA
I _{COM(ON)}	COM–, COM+	ON State Leakage	V _{BUS_CTRL} = 0 V, 4.2 V; V _{COM–} , V _{COM+} = 0 V, 4.2 V V _{D+} , V _{D–} = 4.2 V, 0 V or float V _L , V _R = float or 4.2 V, 0 V	4.2			±100	nA
I _{CC}	V _{CC}	Quiescent Supply	V _{IS} = GND to V _{CC} ; I _D = 0 A	4.2		21	35	μA
I _{OFF}	COM–, COM+	Power OFF Leakage	0 ≤ V _{IS} ≤ 4.2 V	0			50	μA

USB ON RESISTANCE (Typical: T = 25°C, V_{CC} = 3.3 V)

R _{ON}	D+ to COM+ D– to COM–	On-Resistance	I _{ON} = 10 mA V _{IS} = 0 V to V _{CC}	2.7 3.3 4.2		3.0 3.0 3.0	5.5 4.6 4.6	Ω
R _{FLAT}	D+ to COM+ D– to COM–	On-Resistance Flatness	I _{ON} = 10 mA V _{IS} = 0 V to V _{CC}	2.7 3.3 4.2		0.08 0.08 0.08		Ω
ΔR _{ON}	D+ to COM+ D– to COM–	On-Resistance Matching	I _{ON} = 10 mA V _{IS} = 0 V to V _{CC}	2.7 3.3 4.2		0.03 0.03 0.03		Ω

AUDIO ON RESISTANCE (Typical: T = 25°C, V_{CC} = 3.3 V)

R _{ON}	R to COM+ L to COM–	On-Resistance	I _{ON} = 10 mA V _{IS} = –1.5 to 1.5	2.7 3.3 4.2		3.0 3.0 3.0	4.6 4.6 4.6	Ω
R _{FLAT}	R to COM+ L to COM–	On-Resistance Flatness	I _{ON} = 10 mA V _{IS} = –1.5 to 1.5	2.7 3.3 4.2		0.11 0.11 0.11		Ω
ΔR _{ON}	R to COM+ L to COM–	On-Resistance Matching	I _{ON} = 10 mA V _{IS} = –0.85 to 0.85	2.7 3.3 4.2		0.03 0.03 0.03		Ω
R _{SH}	L, R	Shunt Resistance (Resistor + Switch)	I _{ON} = 10 mA	2.7		118	160	Ω
V _{BUS_PD}	V _{BUS_CTRL}	V _{BUS_CTRL} Pull-down Resistor	I _{ON} = 10 mA			530		kΩ

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

AC ELECTRICAL CHARACTERISTICS

Symbol	Pins	Parameter	Test Conditions	V _{CC} (V)	-40°C to +85°C			Unit
					Min	Typ	Max	

TIMING/FREQUENCY (Typical: T = 25°C, V_{CC} = 3.3 V, R_L = 50 Ω, C_L = 35 pF, f = 1 MHz)

t _{ON}		Turn-ON Time (Closed to Open) (Figures 8 and 9)		2.7 – 4.2	–	14	–	μs
t _{OFF}		Turn-OFF Time (Closed to Open) (Figures 8 and 9)		2.7 – 4.2	–	75	–	ns
T _{BBM}		Break-Before-Make Time (Figure 7)			–	7.0	–	μs
BW	D+ to COM+ D- to COM-	-3 dB Bandwidth (Figure 10)	C _L = 5 pF R _S = 50 Ω		–	900	–	MHz

ISOLATION (Typical: T = 25°C, V_{CC} = 3.3 V, R_L = 50 Ω, C_L = 5 pF)

O _{IRR}	Open	OFF-Isolation (Figure 10)	f = 100 kHz, R _S = 50 Ω		–	-81	–	dB
X _{TALK}	COM+ to COM-	Non-Adjacent Channel Crosstalk (Figure 10)	f = 100 kHz, R _S = 50 Ω		–	-93	–	dB
THD+N		Total Harmonic Distortion + Noise	V _{BUS_CTRL} = 0 V A _{SEL} = 3.0 V f = 20 Hz to 20 kHz V _{COM} = 0.5 V _{pp} R _L = 600 Ω	3.0	–	0.001	–	%
THD		Total Harmonic Distortion	V _{BUS_CTRL} = 0 V A _{SEL} = 0 V, 3.6 V f = 1 kHz V _{COM} = ±2.0 V _{pp} R _L = 16 Ω	3.6	–	0.01	–	%
PSRR		Power Supply Rejection Ratio	f = 10 kHz R _{COM} = 50 Ω	3.0	–	60	–	dB

CAPACITANCE (Typical: T = 25°C, V_{CC} = 3.3 V, R_L = 50 Ω, C_L = 5 pF, f = 1 MHz, A_{SEL} = 0 V)

C _{IN}	A _{SEL}	Control Pin Input Capacitance	V _{CC} = 0 V		–	2.6	–	pF
C _{ON}	D+ to COM+ D- to COM-	USB ON Capacitance	V _{BUS_CTRL} = 5 V		–	6.9	–	pF
C _{ON}	R to COM+ L to COM-	Audio ON Capacitance	V _{BUS_CTRL} = 0 V		–	9.3	–	pF
C _{OFF}	D+, D-	USB OFF Capacitance	V _{BUS_CTRL} = 0 V		–	4.8	–	pF
C _{OFF}	R, L	Audio OFF Capacitance	V _{BUS_CTRL} = 5 V		–	4.8	–	pF

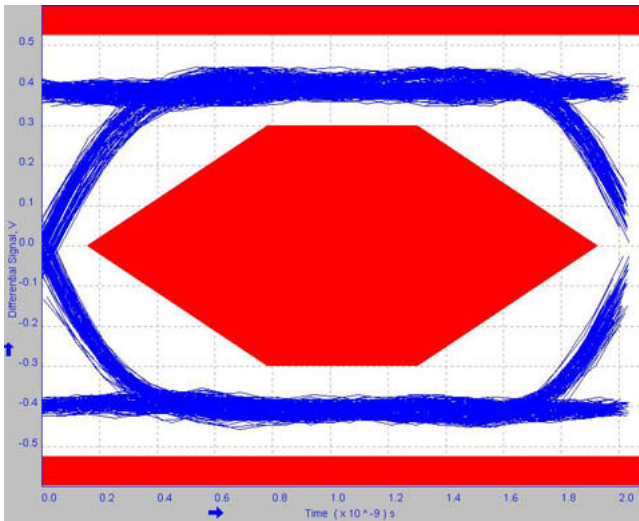


Figure 3. High Speed USB Eye Diagram of Signal Path without Switch

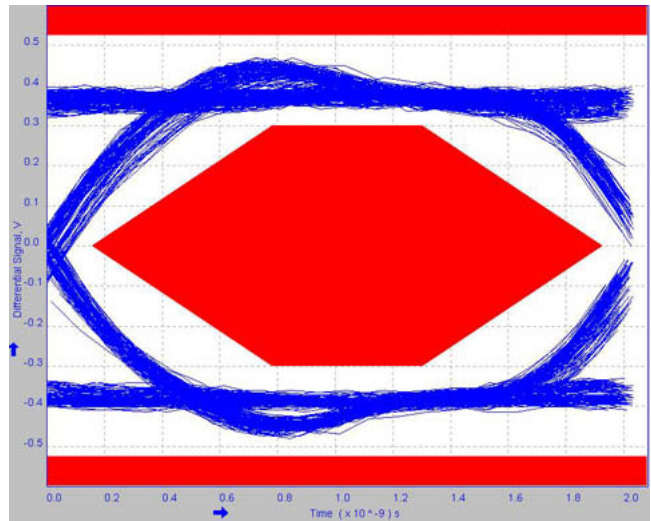


Figure 4. High Speed USB Eye Diagram of Signal Path with NS5S1153 ($V_{CC} = 3.6\text{ V}$)

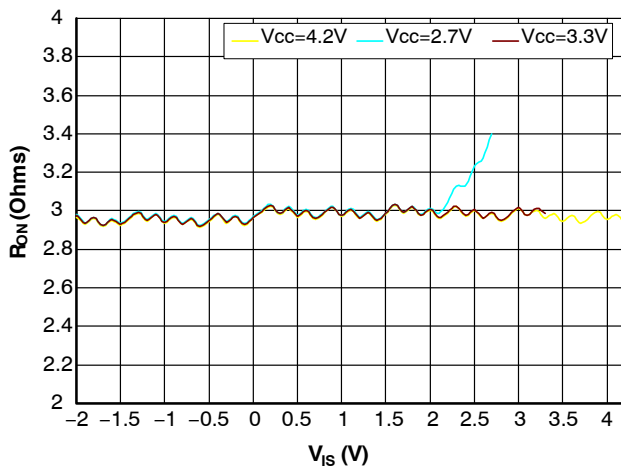


Figure 5. Audio ON Resistance vs. Signal Voltage @ $T = 25^{\circ}\text{C}$, $2.7\text{ V} \leq V_{CC} \leq 4.2\text{ V}$

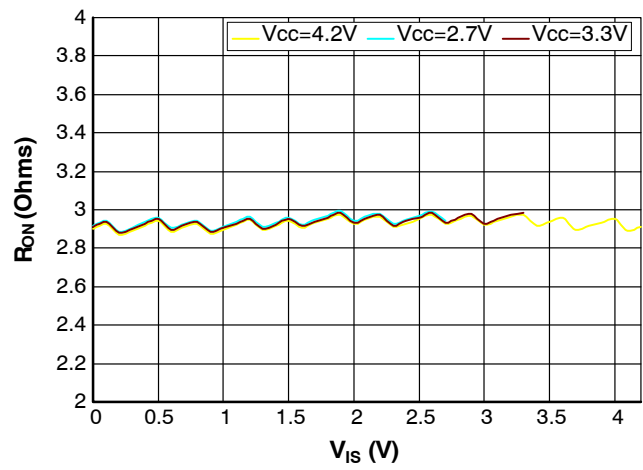


Figure 6. USB ON Resistance vs. Signal Voltage @ $T = 25^{\circ}\text{C}$, $2.7\text{ V} \leq V_{CC} \leq 4.2\text{ V}$

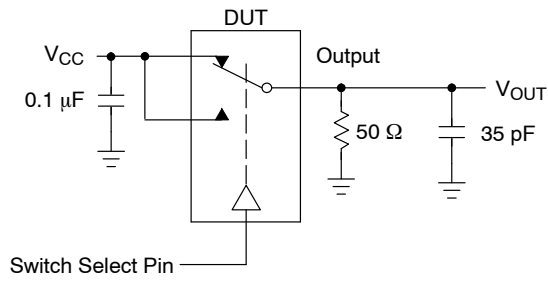


Figure 7. t_{BMM} (Time Break-Before-Make)

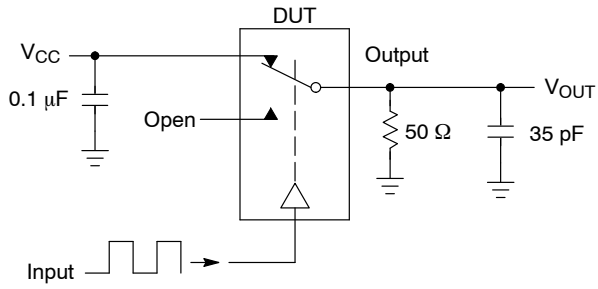
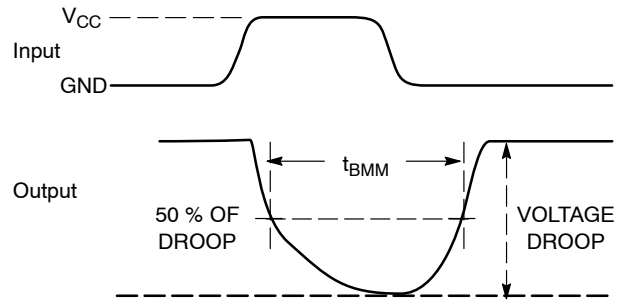


Figure 8. t_{ON}/t_{OFF}

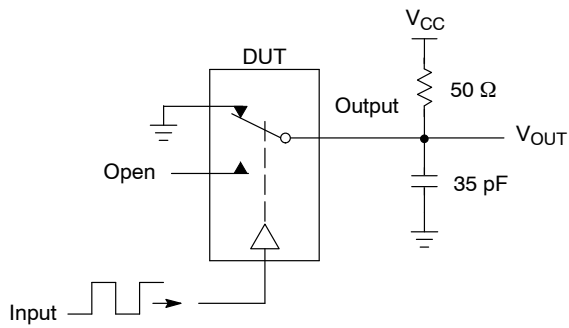
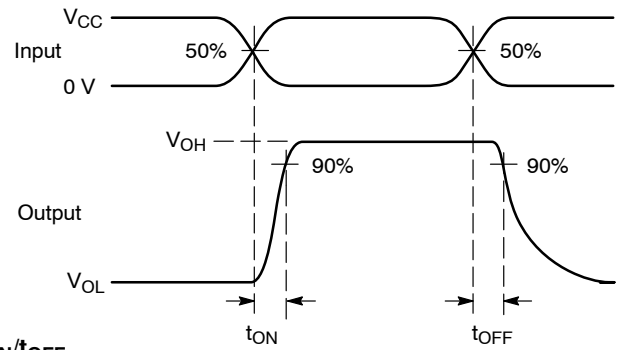
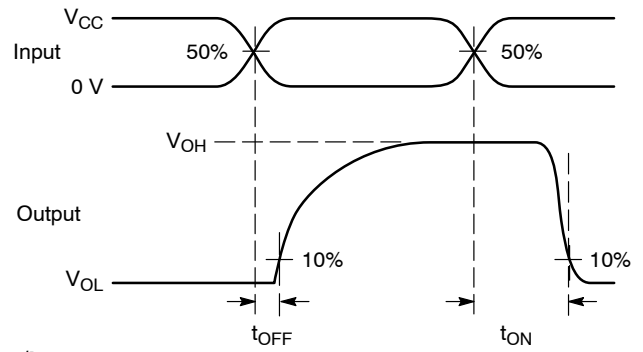
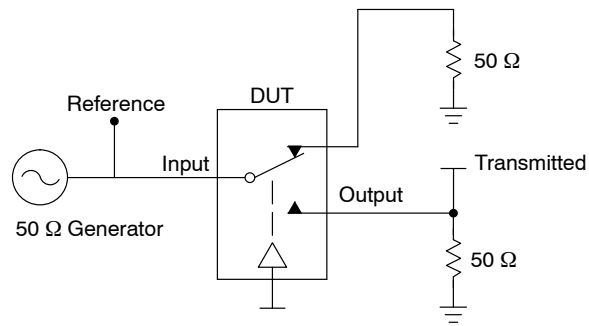


Figure 9. t_{ON}/t_{OFF}





Channel switch control/s test socket is normalized. Off isolation is measured across an off channel. On loss is the bandwidth of an On switch. V_{ISO} , Bandwidth and V_{ONL} are independent of the input signal direction.

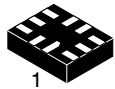
$$V_{ISO} = \text{Off Channel Isolation} = 20 \log \left(\frac{V_{OUT}}{V_{IN}} \right) \text{ for } V_{IN} \text{ at } 100 \text{ kHz}$$

$$V_{ONL} = \text{On Channel Loss} = 20 \log \left(\frac{V_{OUT}}{V_{IN}} \right) \text{ for } V_{IN} \text{ at } 100 \text{ kHz to } 50 \text{ MHz}$$

Bandwidth (BW) = the frequency 3 dB below V_{ONL}

V_{CT} = Use V_{ISO} setup and test to all other switch analog input/outputs terminated with 50 Ω

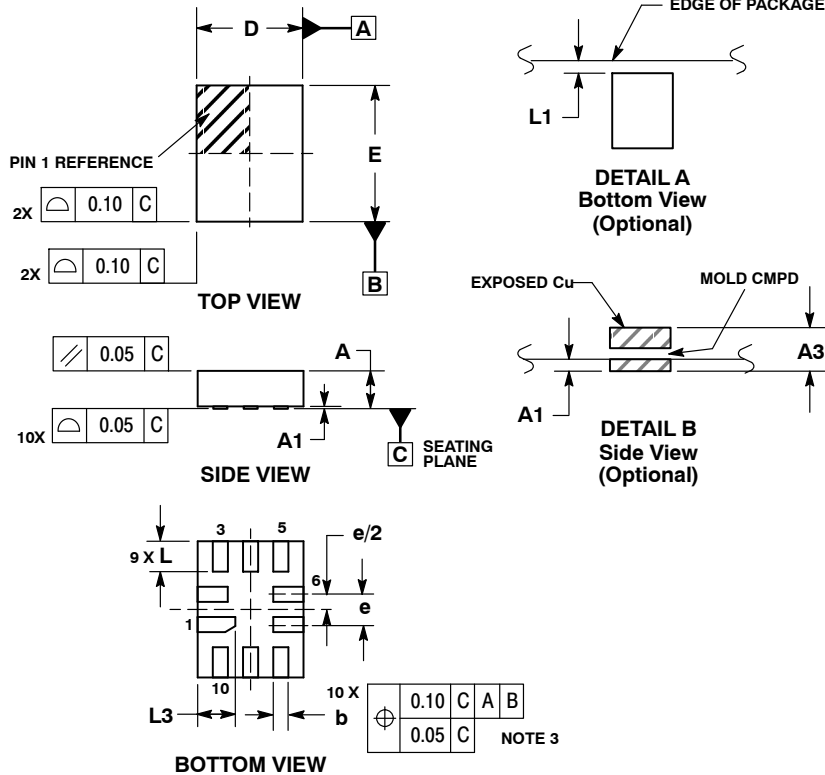
**Figure 10. Off Channel Isolation/On Channel Loss (BW)/Crosstalk
(On Channel to Off Channel)/ V_{ONL}**



SCALE 5:1

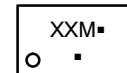
UQFN10 1.4x1.8, 0.4P
CASE 488AT
ISSUE A

DATE 01 AUG 2007


NOTES:

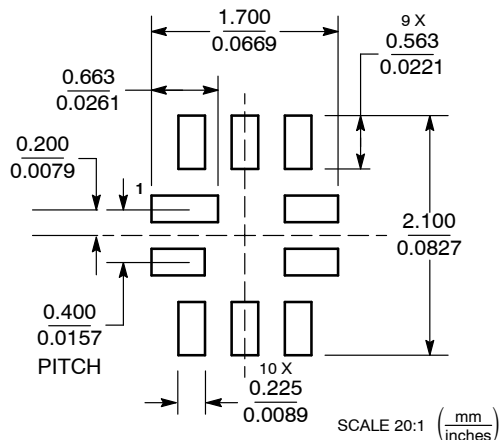
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2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.25 AND 0.30 MM FROM TERMINAL.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

DIM	MILLIMETERS	
	MIN	MAX
A	0.45	0.60
A1	0.00	0.05
A3	0.127 REF	
b	0.15	0.25
D	1.40	BSC
E	1.80	BSC
e	0.40	BSC
L	0.30	0.50
L1	0.00	0.15
L3	0.40	0.60

GENERIC MARKING DIAGRAM*


- XX = Specific Device Code
M = Date Code
▪ = Pb-Free Package
(Note: Microdot may be in either location)

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present.

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DESCRIPTION:	10 PIN UQFN, 1.4 X 1.8, 0.4P	PAGE 1 OF 1

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