

NS5S1153

USB 2.0 High Speed and Audio Switch with Negative Swing Capability

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

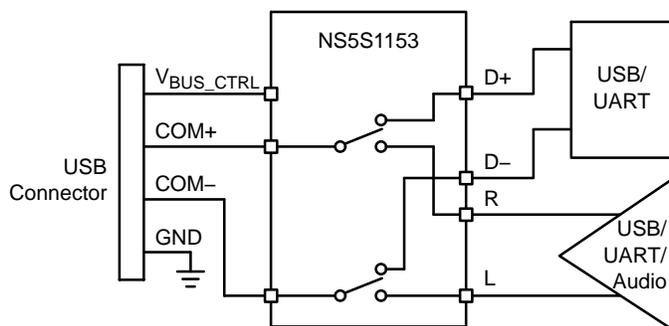


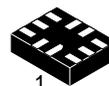
Figure 1. Application Diagram



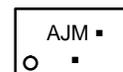
ON Semiconductor®

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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.

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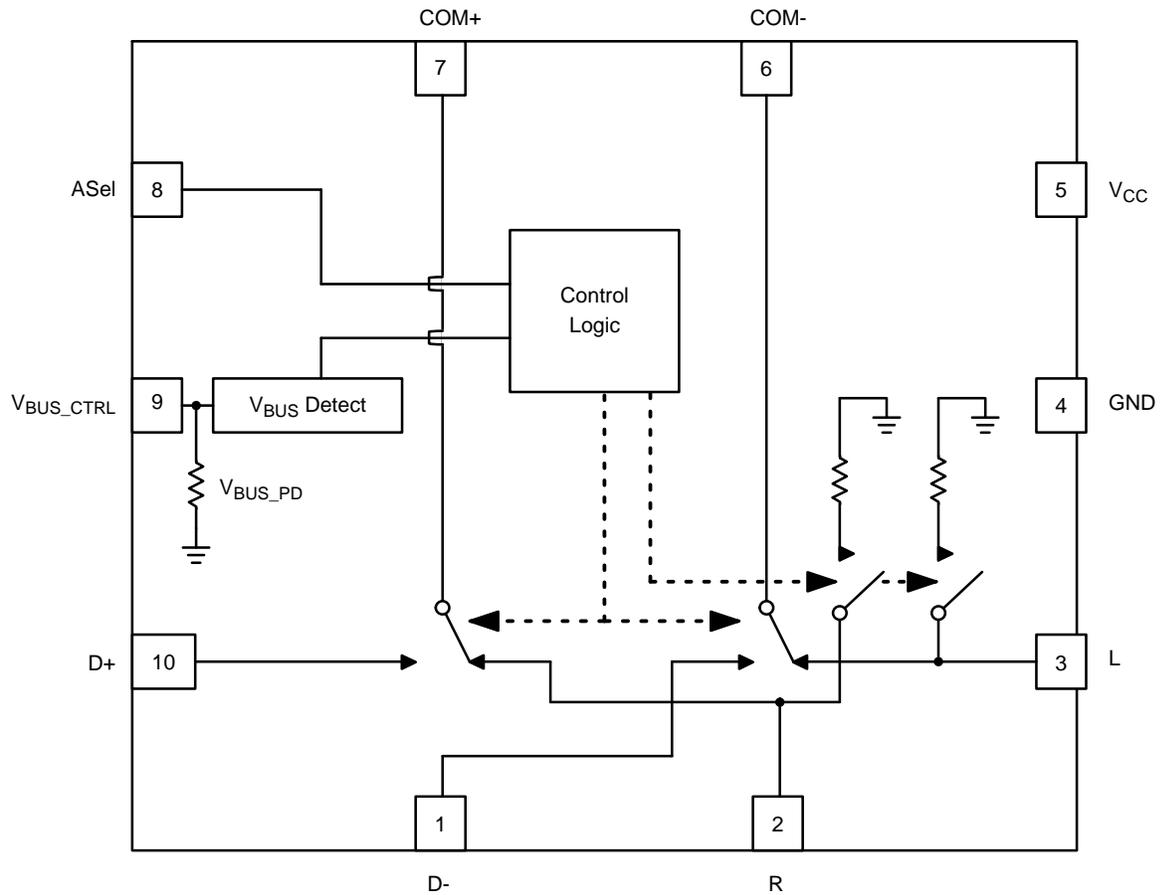


Figure 2. Functional Block Diagram
(Top View)

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 |

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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

CONTROL INPUT (Typical: T = 25°C, V_{CC} = 3.3 V)

| Symbol | Pins | Parameter | Test Conditions | V _{CC} (V) | -40°C to +85°C | | | Unit |
|-----------------|-----------------------|--|---------------------------------------|---------------------|----------------|-----|-----|------|
| | | | | | Min | Typ | Max | |
| V _{IH} | ASEL | Control Input HIGH Voltage | | 2.7 | 1.3 | - | - | V |
| | | | | 3.3 | 1.4 | | | |
| | | | | 4.2 | 1.5 | | | |
| V _{IL} | ASEL | Control Input LOW Voltage | | 2.7 | - | - | 0.4 | V |
| | | | | 3.3 | | | 0.4 | |
| | | | | 4.2 | | | 0.4 | |
| I _{IN} | ASEL | 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 | 1.9 | - | - | V |
| | | | | 3.3 | 2.2 | | | |
| | | | | 4.2 | 2.7 | | | |
| V _{IL} | V _{BUS_CTRL} | V _{BUS} Control Input LOW Voltage | | 2.7 | - | - | 0.8 | V |
| | | | | 3.3 | | | 1.1 | |
| | | | | 4.2 | | | 1.6 | |
| 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)

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

| Symbol | Pins | Parameter | Test Conditions | V _{CC} (V) | -40°C to +85°C | | | Unit |
|-------------------|--------------------------|------------------------|---|---------------------|----------------|------|-----|------|
| | | | | | Min | Typ | Max | |
| R _{ON} | D+ to COM+ D- to COM- | On-Resistance | I _{ON} = 10 mA V _{IS} = 0 V to V _{CC} | 2.7 | | 3.0 | 5.5 | Ω |
| | | | | 3.3 | | 3.0 | 4.6 | |
| | | | | 4.2 | | 3.0 | 4.6 | |
| R _{FLAT} | D+ to COM+ D- to COM- | On-Resistance Flatness | I _{ON} = 10 mA V _{IS} = 0 V to V _{CC} | 2.7 | | 0.08 | | Ω |
| | | | | 3.3 | | 0.08 | | |
| | | | | 4.2 | | 0.08 | | |
| ΔR _{ON} | D+ to COM+ D- to COM- | On-Resistance Matching | I _{ON} = 10 mA V _{IS} = 0 V to V _{CC} | 2.7 | | 0.03 | | Ω |
| | | | | 3.3 | | 0.03 | | |
| | | | | 4.2 | | 0.03 | | |

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

| Symbol | Pins | Parameter | Test Conditions | V _{CC} (V) | -40°C to +85°C | | | Unit |
|---------------------|------------------------|--|--|---------------------|----------------|------|-----|------|
| | | | | | Min | Typ | Max | |
| R _{ON} | R to COM+ L to COM- | On-Resistance | I _{ON} = 10 mA V _{IS} = -1.5 to 1.5 | 2.7 | | 3.0 | 4.6 | Ω |
| | | | | 3.3 | | 3.0 | 4.6 | |
| | | | | 4.2 | | 3.0 | 4.6 | |
| R _{FLAT} | R to COM+ L to COM- | On-Resistance Flatness | I _{ON} = 10 mA V _{IS} = -1.5 to 1.5 | 2.7 | | 0.11 | | Ω |
| | | | | 3.3 | | 0.11 | | |
| | | | | 4.2 | | 0.11 | | |
| ΔR _{ON} | R to COM+ L to COM- | On-Resistance Matching | I _{ON} = 10 mA V _{IS} = -0.85 to 0.85 | 2.7 | | 0.03 | | Ω |
| | | | | 3.3 | | 0.03 | | |
| | | | | 4.2 | | 0.03 | | |
| 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 |

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AC ELECTRICAL CHARACTERISTICS

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

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

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

| Symbol | Pins | Parameter | Test Conditions | -40°C to +85°C | | | Unit |
|------------------|--------------------------|-------------------------------|-----------------------------|----------------|-----|-----|------|
| | | | | Min | Typ | Max | |
| 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 |

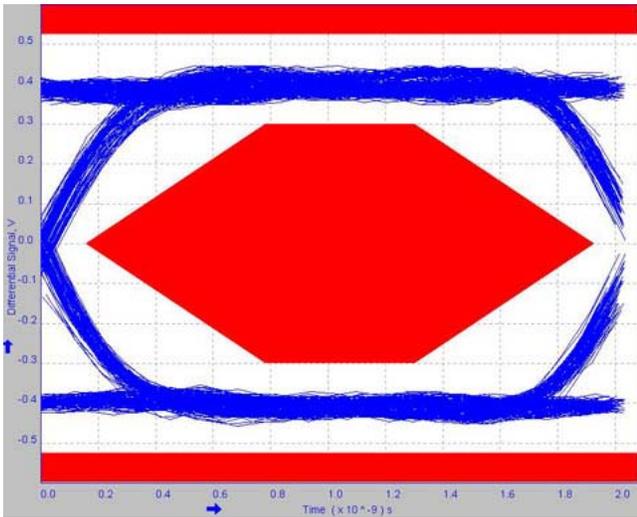


Figure 3. High Speed USB Eye Diagram of Signal Path without Switch

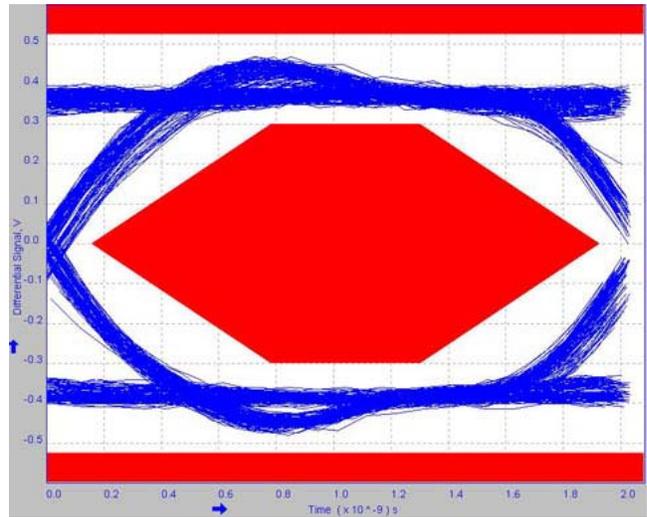


Figure 4. High Speed USB Eye Diagram of Signal Path with NS5S1153 ($V_{CC} = 3.6\text{ V}$)

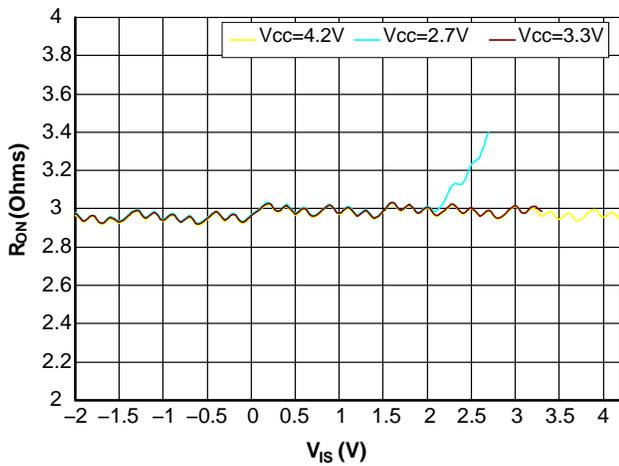


Figure 5. Audio ON Resistance vs. Signal Voltage @ $T = 25^{\circ}\text{C}$, $2.7\text{ V} \leq V_{CC} \leq 4.2\text{ V}$

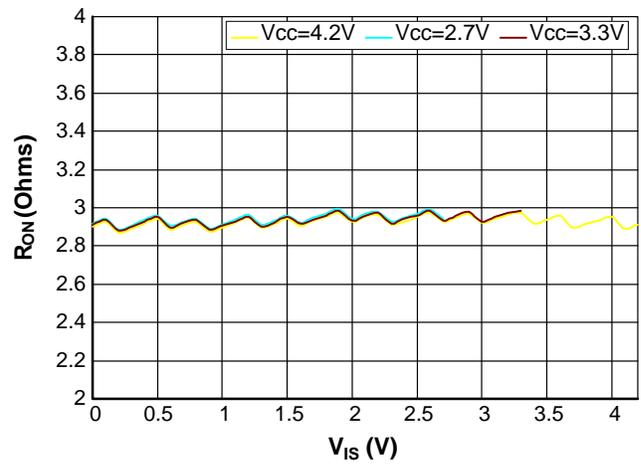


Figure 6. USB ON Resistance vs. Signal Voltage @ $T = 25^{\circ}\text{C}$, $2.7\text{ V} \leq V_{CC} \leq 4.2\text{ V}$

NS5S1153

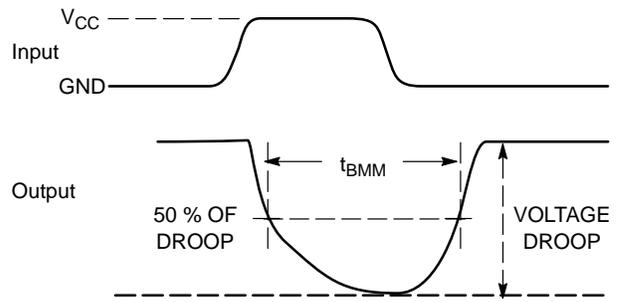
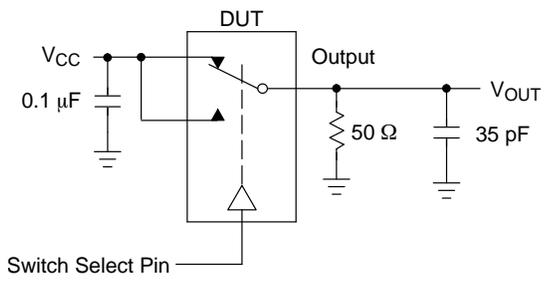


Figure 7. t_{BMM} (Time Break-Before-Make)

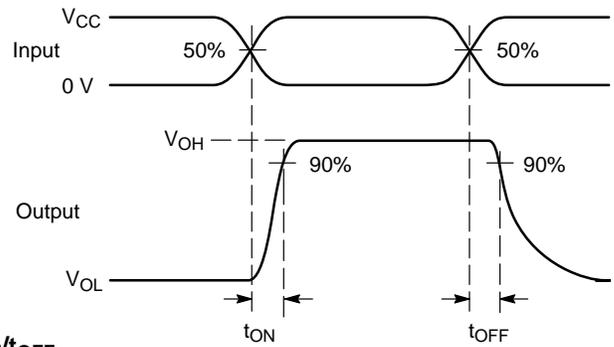
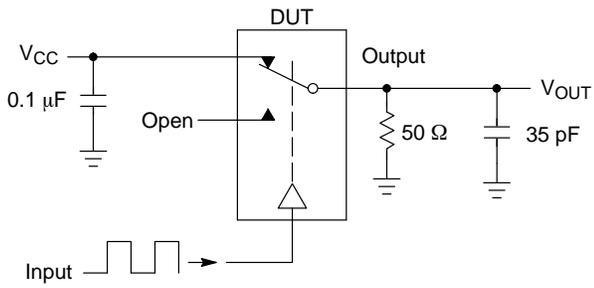


Figure 8. $t_{\text{ON}}/t_{\text{OFF}}$

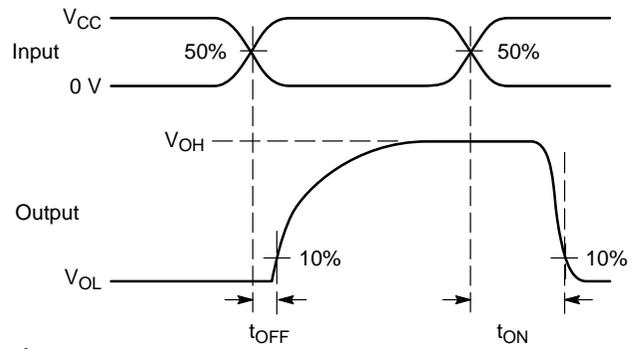
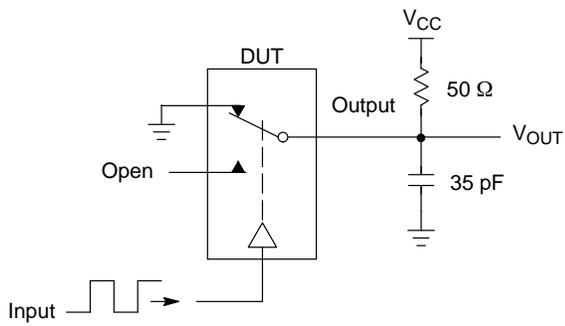
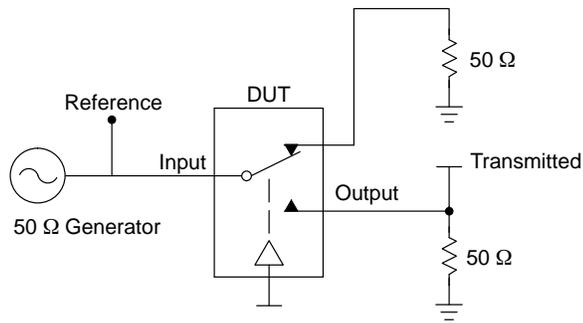


Figure 9. $t_{\text{ON}}/t_{\text{OFF}}$

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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.

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

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

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

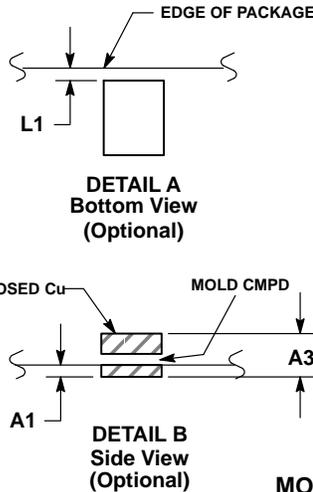
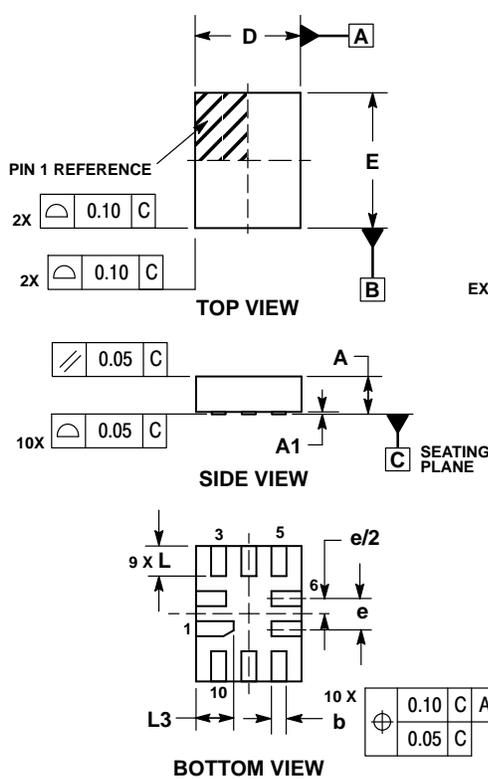
V_{CT} = Use V_{ISO} setup and test to all other switch analog input/outputs terminated with 50 Ω

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

NS5S1153

PACKAGE DIMENSIONS

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

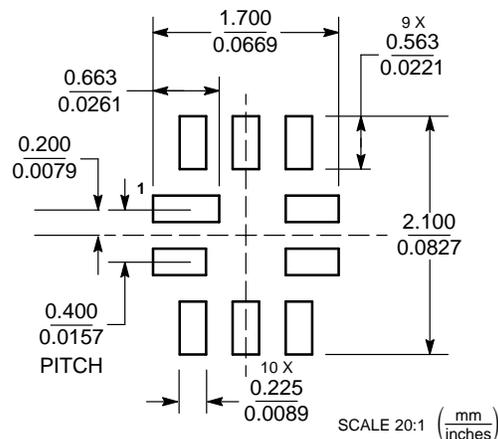


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
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 |

MOUNTING FOOTPRINT



*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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