# USB 2.0 High-Speed and Audio Switches with Negative Signal Capability

## Features

- Single +2.7V to +4.4V Supply Voltage
- Low 50µA Supply Current
- -3dB Bandwidth: 1500MHz (typ)
- Low 2.5Ω(typ)On-Resistance
- THD+N: 0.02%
- Shorting D+/R and D-/L to Vbus will not cause leakage when $V_{DD} = 0$
- Internal Shunt Resistors for Click-and-Pop Reduction
- VBUS Detection for Automatic Switch Path Selection
- Packaging (Pb-free & Green available):
   = 10-pin contact UQFN, 1.4 x 1.8, (ZM10)

## Description

The PI3USB223 combines AC coupled audio signals and USB2.0 HS (480Mbps) on the same pins. This enables users to use a single connector to drive either a USB end point or an audio end point.

PI3USB223 incorporates gate pump technology required to maintain low Ron for ideal audio THD while reducing the capacitance affect of high speed USB signals. The device also incorporates a substrate pump technology which allows -2V signals to pass through the switch without causing any leakage.

The PI3USB223 features protection on D+/R and D-/L to ensure no damage will happen to the IC if these pins are shorted accidentally to Vbus as well as ensuring there is no leakage when $V_{DD}$ is on or off. Also, it includes VBUS detection (VB) to automatically switch to the USB signal path upon detection of a valid VBUS signal. It also features internal shunt resistors on the audio path to reduce clicks and pops heard during output. The device is available in a space-saving 10-pin, 1.4mm x 1.8mm UQFN package, and operate over the -40°C to +85°C temperature range.

## Truth Table

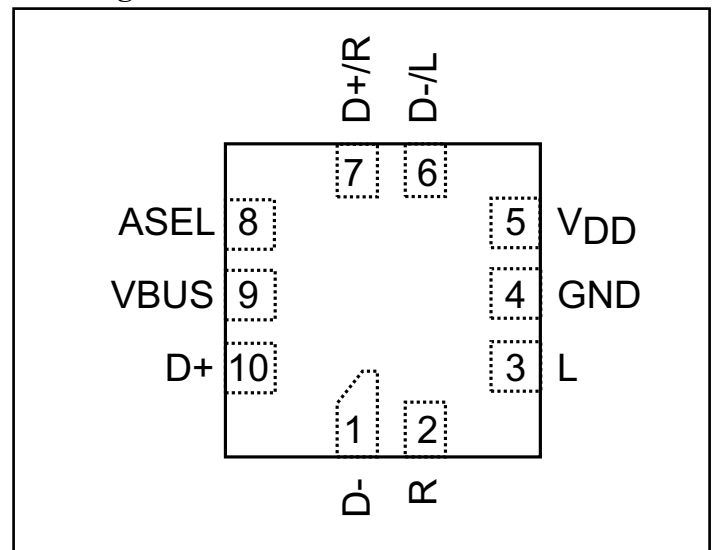| ASEL | $V_{DD}$ | VBUS | L/R | D+/D- | L/R Shunt |
|------|----------|------|-----|-------|-----------|
| X | L | L | OFF | OFF | OFF |
| X | H | L | OFF | OFF | ON |
| X | L | H | OFF | OFF | OFF |
| L | H | H | OFF | ON | ON |
| H | H | H | ON | OFF | OFF |

## Block Diagram
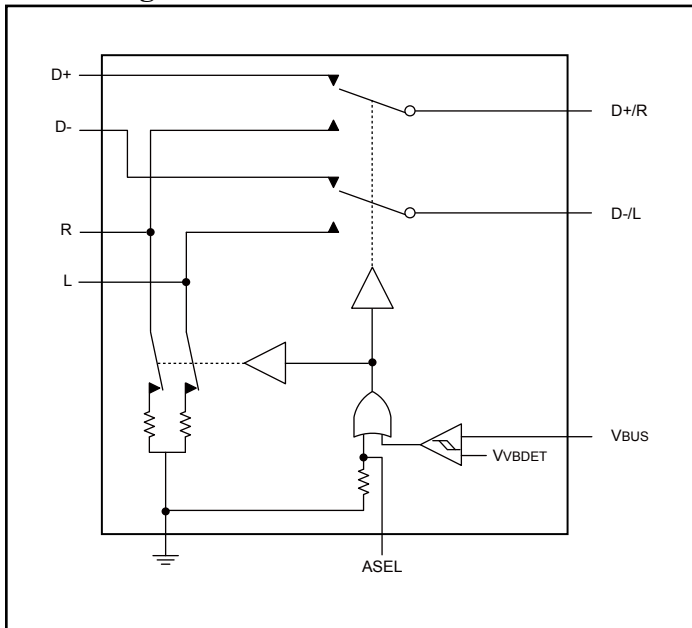


## Pin Diagram

## Pin Description

| Pin# | Name | Function |
|------|------|----------|
| 1 | D- | USB D- from system side |
| 2 | R | Audio Input (Right) |
| 3 | L | Audio Input (Left) |
| 4 | GND | Ground |
| 5 | $V_{DD}$ | Positive Supply Voltage Input. Bypass $V_{DD}$ to GND with a 0.1μF capacitor as close to the device as possible. |
| 6 | D-/L | Common Terminal for D- or Left Audio |
| 7 | D+/R | Common Terminal for D+ or Right Audio |
| 8 | ASEL | Switch SEL to override VBUS detection when VBUS and $V_{DD}$ are both high. If ASEL is HIGH, then audio path will be on If ASEL is LOW then USB path will be on ASEL has an internal 3M-ohm pull-down |
| 9 | VBUS | If ASEL is tied LOW, then VBUS detection can be used for auto switching. If ASEL is LOW VBUS = HIGH means USB path is active |
| 10 | D+ | USB D+ from system side |

## Maximum Ratings

(Above which useful life may be impaired.  For user guidelines, not tested.)

| (Voltages referenced to GND.) | |
| --- | --- |
| $V_{DD}$, ASEL ................................................................ | -0.3V to +5.0V |
| $V_{BUS}$ ........................................................................ | -0.3V to +5.5V |
| $V_{(R/D+)}$ and $V_{(L/D-)}$[1] ....................................... | -2.0V to +5.0V |
| $V_{(R/D+)}$ and $V_{(L/D-)}$[2] ....................................... | -0.3V to +5.0V |
| $V_R$ and $V_L$................................................. | -2.0Vto ($V_{DD}$+ 0.3V) |
| $V_{D+}$ and $V_D$ ......................................... | -0.3V to ($V_{DD}$+ 0.3V) |
| Continuous Current into Any Terminal................................... | ±100mA |
| Operating Temperature Range ..................................... | -40°C to +85°C |
| Storage Temperature Range ........................................ | -65°C to +150°C |

**Notes:**
1.  If Audio path is enabled
2.  If USB path is enabled

Stresses greater than those listed under MAXIMUM RAT-INGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.
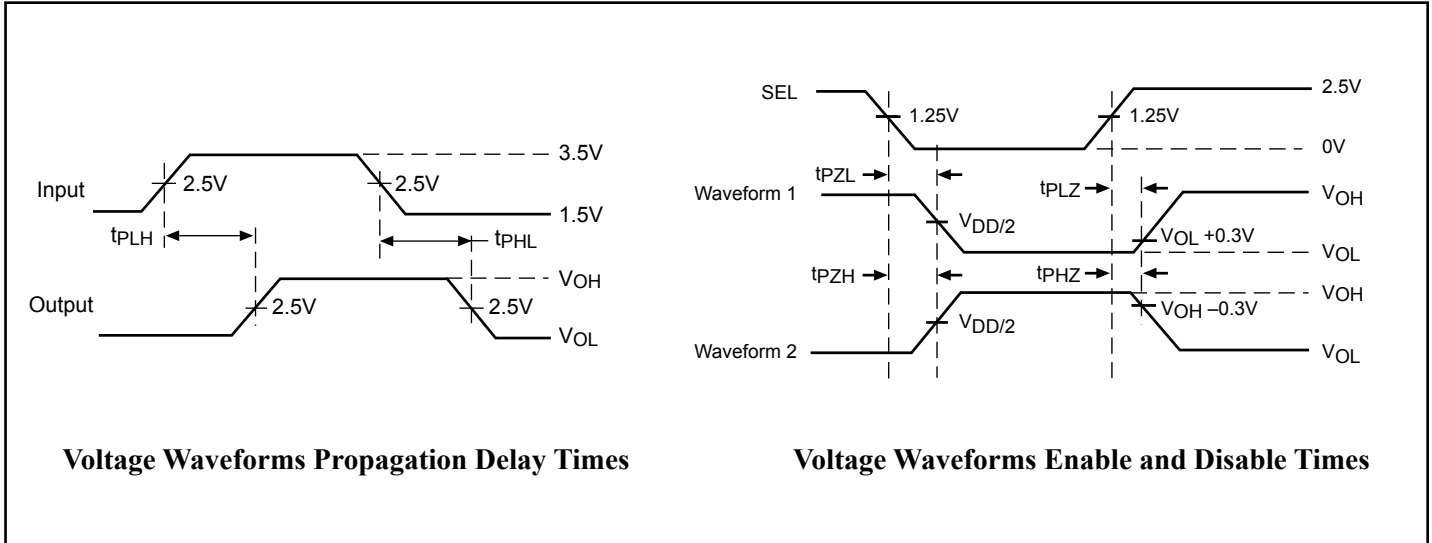
## DC Electrical Characteristics

($V_{DD}$ = 2.7V to 4.4V, $T_A$ = –40°C  to +85°C, unless otherwise noted. Typical values are at $V_{DD}$ = 3.0V to 3.6V, $T_A$ = 25°C)

| Parameter | Symbol | Test Conditions | | Min. | Typ. | Max. | Units |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Operating Power-supply range | $V_{DD}$ | | | 2.7 | – | 4.4 | V |
| Supply Current | $I_{CC}$ | $V_{DD}$ = 3.3V | ASEL = VBUS = 0V | – | – | 50 | μA |
| Power-supply Rejection Ratio | PSRR | | f = 10kHz,  $V_{DD}$ = 3.0 ±0.3V, $R_{D+/R}$ =50Ω | – | 60 | – | dB |
| Analog Signal Range | $V_{D+/-}$ | | | 0 | | $V_{DD}$ | V |
| | $V_{R/L}$ | | | -2 | | $V_{DD}$ | |
| R/L On-Resistance | $R_{ON(R/L)}$ | | $V_{DD}$ = 3.0V, $V_{R/L}$ = -1.5V, +1.5V, $I_{D+/R \text{ and } D-/L}$ = 10mA | | 2 | 5 | |
| D+/D- On-Resistance | $R_{ON(D+/-)}$ | | $V_{DD}$ = 3.0V, $V_{D+/-}$ = -0.4V to 0.6V, $I_{D+/R \text{ and } D-/L}$ = 10mA | | 3.5 | 6 | |
| | | | $V_{DD}$ = 3.0V, $V_{D+/R \text{ and } D-/L}$ = 1.0V to 3.0V, $I_{D+/R \text{ and } D-/L}$ = 10mA | | | 12 | |
| R/L On-Resistance Match between Channels | $\Delta R_{ON(R/L)}$ | | $V_{DD}$ = 3.0V, $V_{R/L}$ = 0V, $I_{D+/R \text{ and } D-/L}$ = 10mA | | | 0.2 | Ω |
| D+/- On-Resistance Match between Channels | $\Delta R_{ON(D+/D-)}$ | | $V_{DD}$ = 3.0V, $V_{D+/-}$ = 0V, $I_{D+/R \text{ and } D-/L}$ = 10mA | | | 0.2 | |
| R/L On-Resistance Flatness | $R_{FLAT(R/L)}$ | | $V_{DD}$ = 3.0V, $I_{D+/R \text{ and } D-/L}$ = 10mA, $V_{R/L}$ = -1.5V to+1.5V | | 0.3 | 0.5 | |
| D+/D- On-Resistance Flatness | $R_{FLAT(D+/-)}$ | | $V_{DD}$ = 3.0V, $I_{D+/R \text{ and } D-/L}$ =  10mA, $V_{D+/-}$ =  -0.4V to 0.6V | | 0.25 | 0.5 | |
| Shunt Switch Resistance | $R_{SH}$ | | Voltage on R or L = $V_{DD}$ | | 25 | | kΩ |
| D+/- Off-Leakage Current | $I_{D+/-(OFF)}$ | | $V_{DD}$ = 3.0V, $V_{D+/-}$ = 5V, $V_{D+/R \text{ and } D-/L}$ = -1.5V, +2.5V | -1 | | 1 | μA |
| R/L Off-Leakage Current | $I_{R/L(OFF)}$ | | $V_{DD}$ = 3.0V, $V_{R/L}$ = 0V, $V_{D+/R \text{ and } D-/L}$ = 0V, +2.5V | -1 | | 1 | |

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| Parameter | Symbol | Test Conditions | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|
| D+/R and D-/L Off-Leakage Current | $I_{D+/R\ and\ D-/L(OFF)}$ | | $V_{DD}$ = 3.0V, $V_{D+/R\ and\ D-/L}$ = 3.6V, $V_{D+/-}$ = $V_{R/L}$ = 0V | | | 5 | μA |
| | | | $V_{DD}$ = 3.3V, $V_{D+/R\ and\ D-/L}$ = 0V, $V_{D+/-}$ = $V_{R/L}$ = 0V | | | 5 | |
| | | | $V_{DD}$ = 0V, $V_{D+/R\ or\ D-/L}$ = 5.0V, $V_{D+/-}$ = $V_{R/L}$ = 0V | | | 5 | |
| System Bus Input Voltage | $V_{BUS}$ | | | 0 | | 5.5 | V |
| D+/R and D-/L On-Leakage Current | $I_{D+/R\ and\ D-/L(ON)}$ | USB Mode | $V_{DD}$ = 3.0V, $V_{R/L}$ = 0V, 2.5V, unconnected, $V_{D+/R\ and\ D-/L}$ = 0V, 2.5V | -200 | | 200 | nA |
| | | Audio Mode | $V_{DD}$ = 3.0V, $V_{D+/-}$ = 0V, 2.5V, unconnected, $V_{D+/R\ and\ D-/L}$ = -1.5V, +2.5V | -200 | | 200 | |
| Turn-On Time | $t_{ON}$ | R/L to D-/L or D+/R, $V_{DD}$ = 3.0V, Fig. 2 | $V_{R/L}$ = 1.5V, $Z_L$ = 50-ohm//35pF, ASEL = $V_{DD}$, $V_{BUS}$ = 5.0V to 0V | | 12 | 60 | μs |
| | | D+/- to D-/L or D+/R, $V_{DD}$ = 3.0V, Fig. 2 | $V_{R/L}$ = 1.5V, $Z_L$ = 50-ohm//35pF, $V_{VBUS}$ = 5.0V, ASEL = 0V to $V_{DD}$ | | 12 | 60 | |
| Turn-Off Time | $t_{OFF}$ | R/L to D-/L or D+/R, $V_{DD}$ = 3.0V, Fig. 2 | $V_{R/L}$ = 1.5V, $Z_L$ = 50-ohm//35pF, ASEL = $V_{DD}$, $V_{BUS}$ = 5.0V to 0V | | 1.4 | 5 | |
| | | D+/- to D-/L or D+/R, $V_{DD}$ = 3.0V, Fig. 2 | $V_{R/L}$ = 1.5V, $Z_L$ = 50-ohm//35pF, $V_{VBUS}$ = 5.0V, ASEL = 0V to $V_{DD}$ | | 0.7 | 5 | |
| Break-Before-Make Time Delay | $t_D$ | $Z_L$ = 50Ω // 35pF | | | 13.5 | | |
| Output Skew Same Switch | $t_{SK(P)}$ | Figure 3 | | | 10 | | ps |
| Output Skew Between Switches | $t_{SK(O)}$ | Figure 3 | | | 10 | | |
| R/L Off-Capacitance | $C_{R/L(OFF)}$ | $V_{D+/R\ and\ D-/L}$ = 0.5V$_{PP}$, DC Bias = 0V, f = 1MHz, | | | 3 | | pF |
| D+/- Off-Capacitance | $C_{D+/-(OFF)}$ | $V_{D+/R\ and\ D-/L}$ = 1.5V$_{PP}$, DC Bias = 0V, f = 240MHz, | | | 2.5 | | |
| On-Capacitance | $C_{D+/R\ and\ D-/L(ON)}$ | USB Path, F = 240MHz, DC bias = 0V | | | 9 | | |
| | | Audio path, f = 100kHz, DC bias = 0V | | | 8 | | |
| **AC PERFORMANCE** | | | | | | | |
| R/L -3dB Bandwidth | $BW_{R/L}$ | $R_S$ = $R_L$ = 50Ω, $V_{R/L}$ = 0dBm, Figure 4 | | | 1100 | | MHz |
| D+/- -3dB Bandwidth | $BW_{D+/-}$ | $R_S$ = $R_L$ = 50Ω, $V_{D+/-}$ = 0dBm, Figure 4 | | | 1500 | | |

| Parameter | Symbol | Test Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Insertion Loss | $I_{N(USB\ Path)}$ | Frequency = 240MHz | | -0.5 | | dB |
| Off Isolation | $I_{SO}$ | Figure 4, f = 240MHz | | -35 | | |
| Crosstalk | $X_{TALK}$ | f = 100kHz, $V_{COM}$ = $1V_{RMS}$, $R_S$ = $R_L$ = 50Ω, Figure 4 | | -80 | | |
| Total Harmonic Distortion + Noise | THD + N (for audio path) | R/L to D+/R and D-/L, f = 20Hz to 20kHz, $V_{D+/R\ and\ D-/L}$ = $0.5V_{PP}$, DC Bias = 0V, $R_L$ =600Ω | | 0.02 | | % |
| **LOGIC INPUT** | | | | | | |
| Input Logic High | $V_{IH}$ for ASEL | | 1.6 | | | V |
| Input Logic Low | $V_{IL}$ for ASEL | | | | 0.4 | |
| | $V_{IH}$ for Vbus | | 2.2 | | 5.5 | |
| | $V_{IL}$ for Vbus | | 0 | | 0.6 | |
| Input Leakage Current | $I_{IN}$ | VASEL and VVbus = 0V or $V_{DD}$ | -10 | | 10 | µA |
| **ESD PROTECTION** | | | | | | |
| All Pins | | Human Body Model | | ±2 | | kV |
| D+/R, D-/L, and VBUS | | Human Body Model | | ±12 | | |
| D+/R, D-/L, and VBUS | | Contact, IEC61000-4-2 | | ±8 | | |

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## Switching Waveforms



**Voltage Waveforms Propagation Delay Times**

**Voltage Waveforms Enable and Disable Times**

## Test Circuits and Timing Diagrams



**Figure 1. AC Test Circuit**
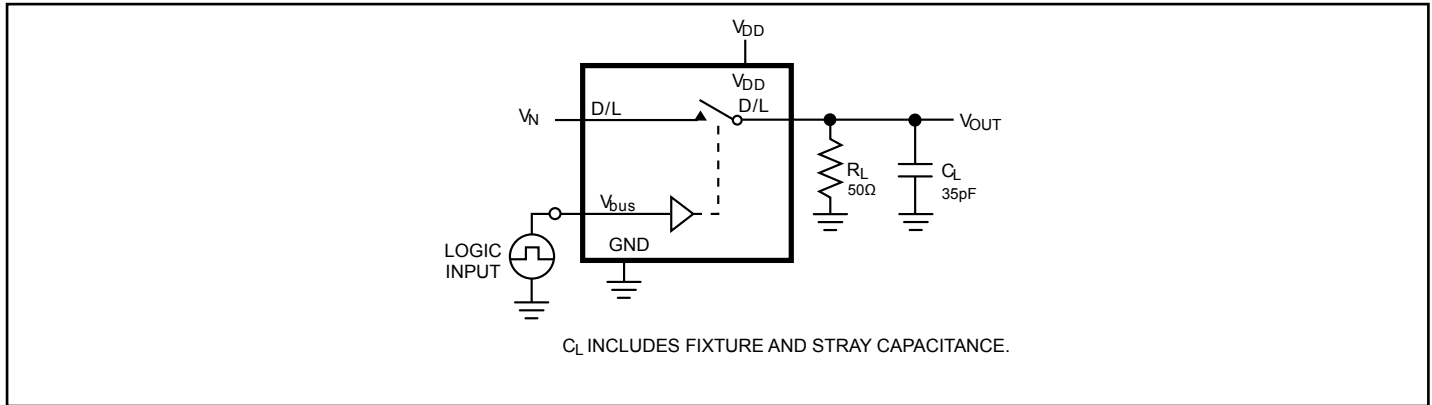
**Note:**
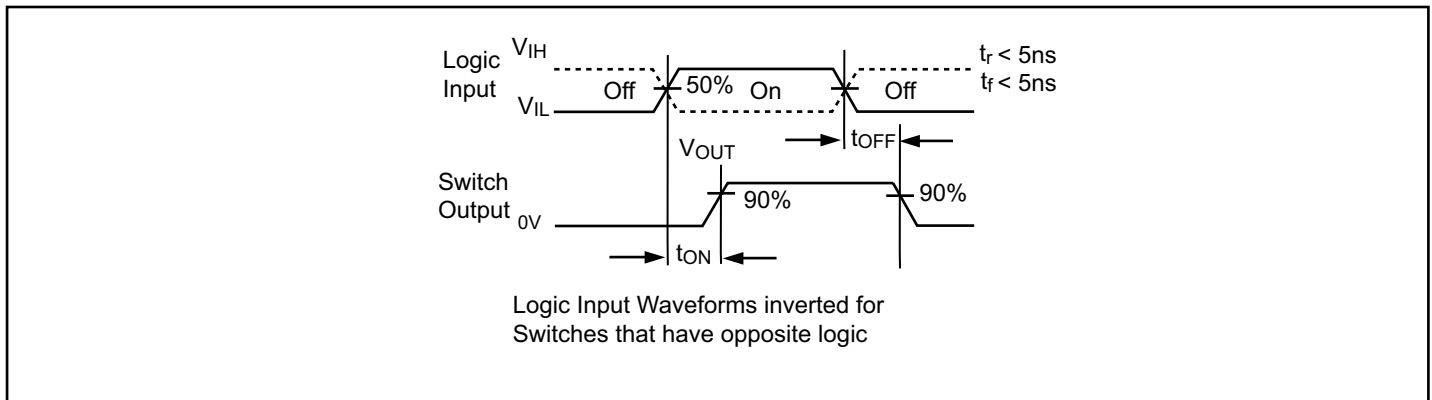1.  Unused input (NC or NO) must be grounded.
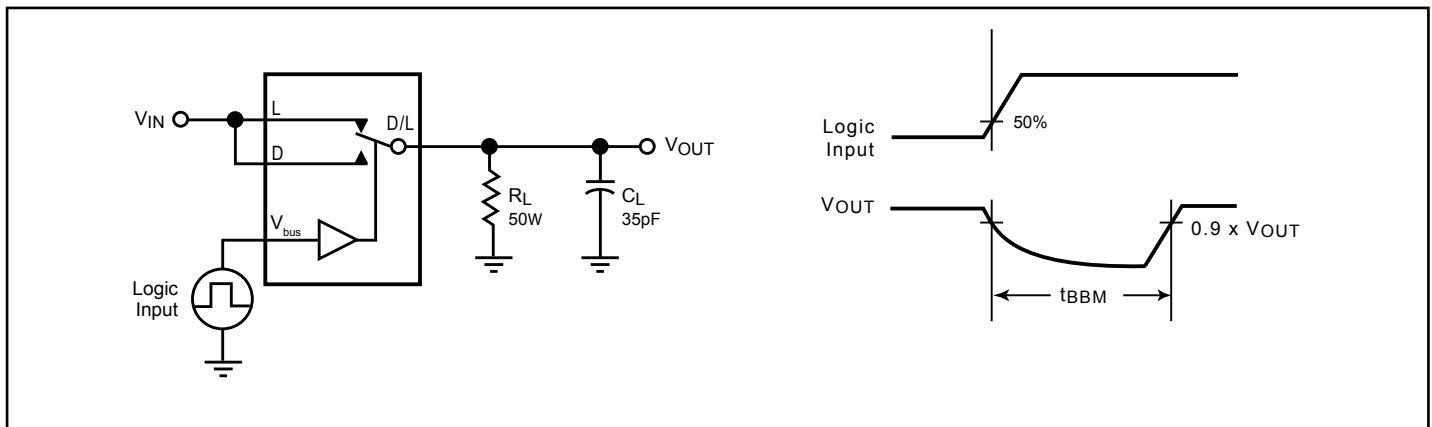


**Figure 2. AC Waveforms**



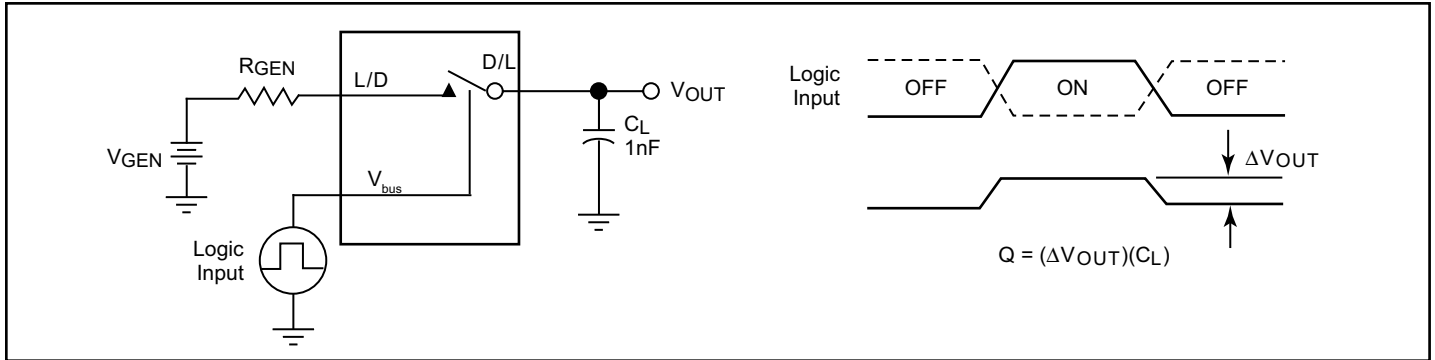**Figure 3. Break Before Make Interval Timing**
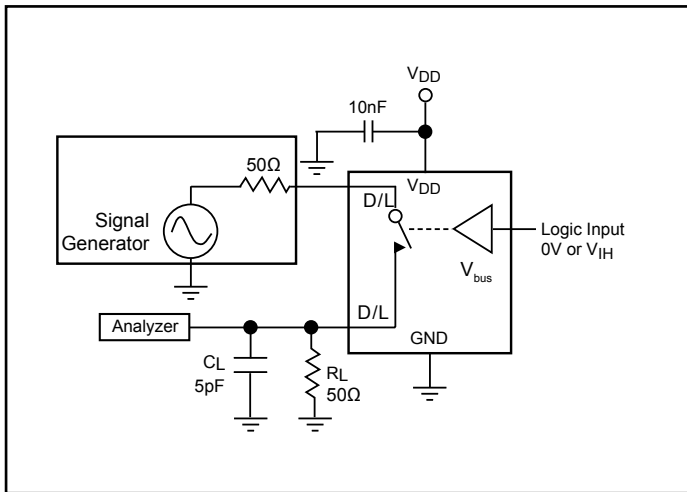
**Figure 4. Charge Injection Test**

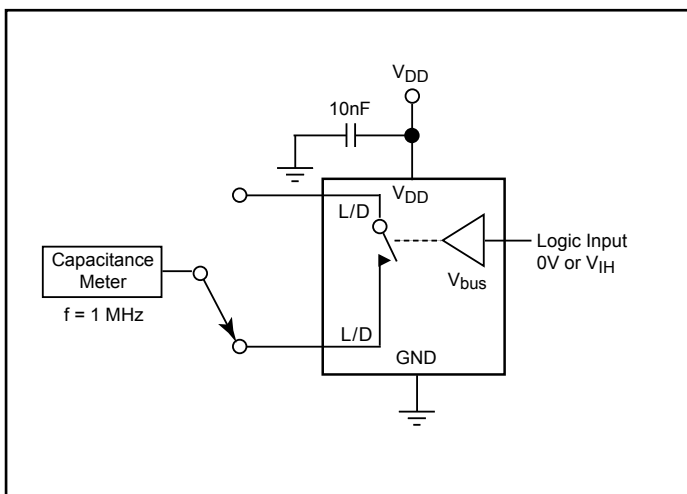

**Figure 5. Off Isolation**
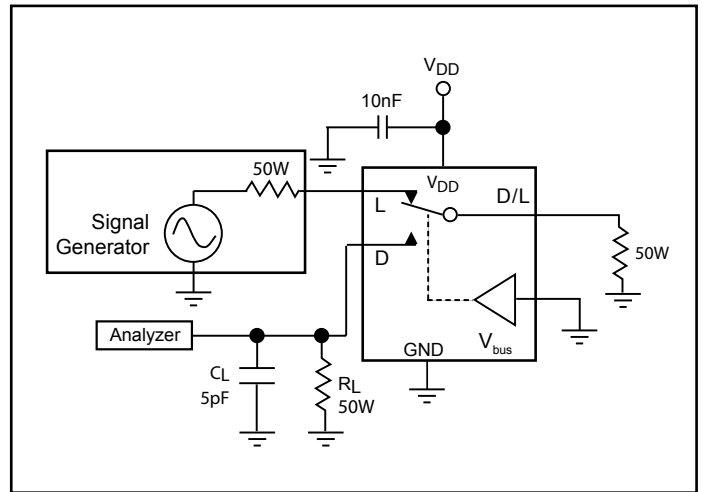


**Figure 6. Crosstalk**



**Figure 7. Channel Off Capacitance**
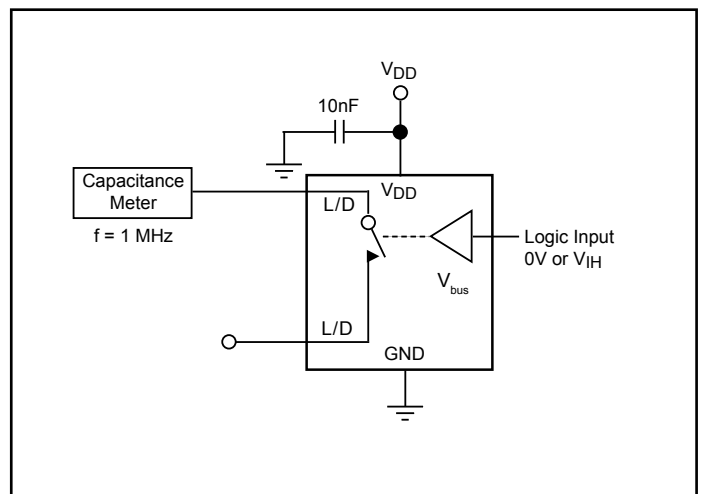


**Figure 8. Channel On Capacitance**
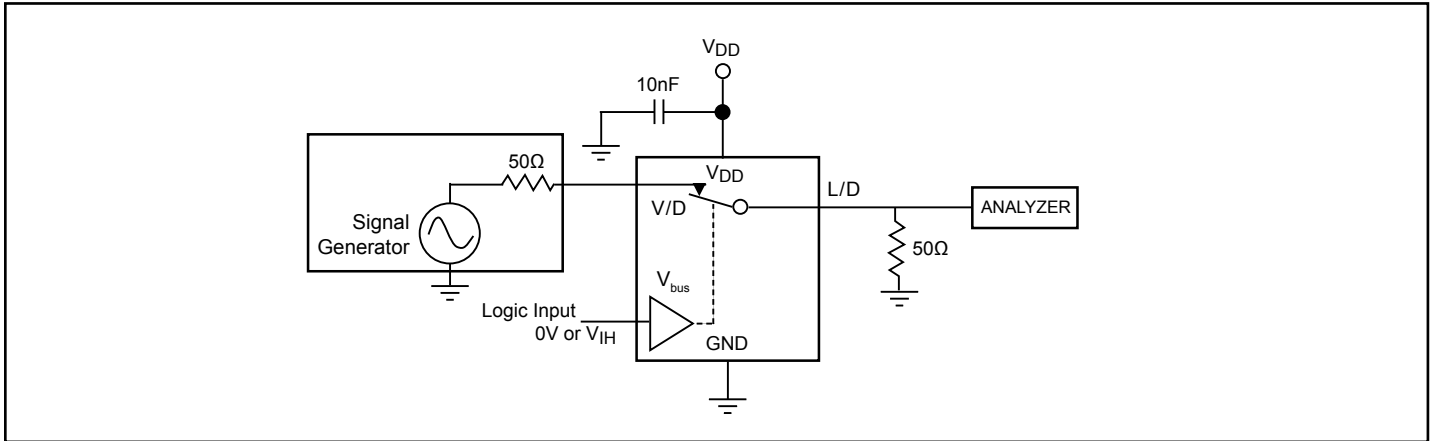
**Figure 9. Bandwidth**

## Packaging Mechanical: 10-Contact UQFN (ZM)



NOTE :

1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
3. REFER JEDEC MO-236/MO-248
4. RECOMMENDED LAND PATTERN IS FOR REFERENCE ONLY.

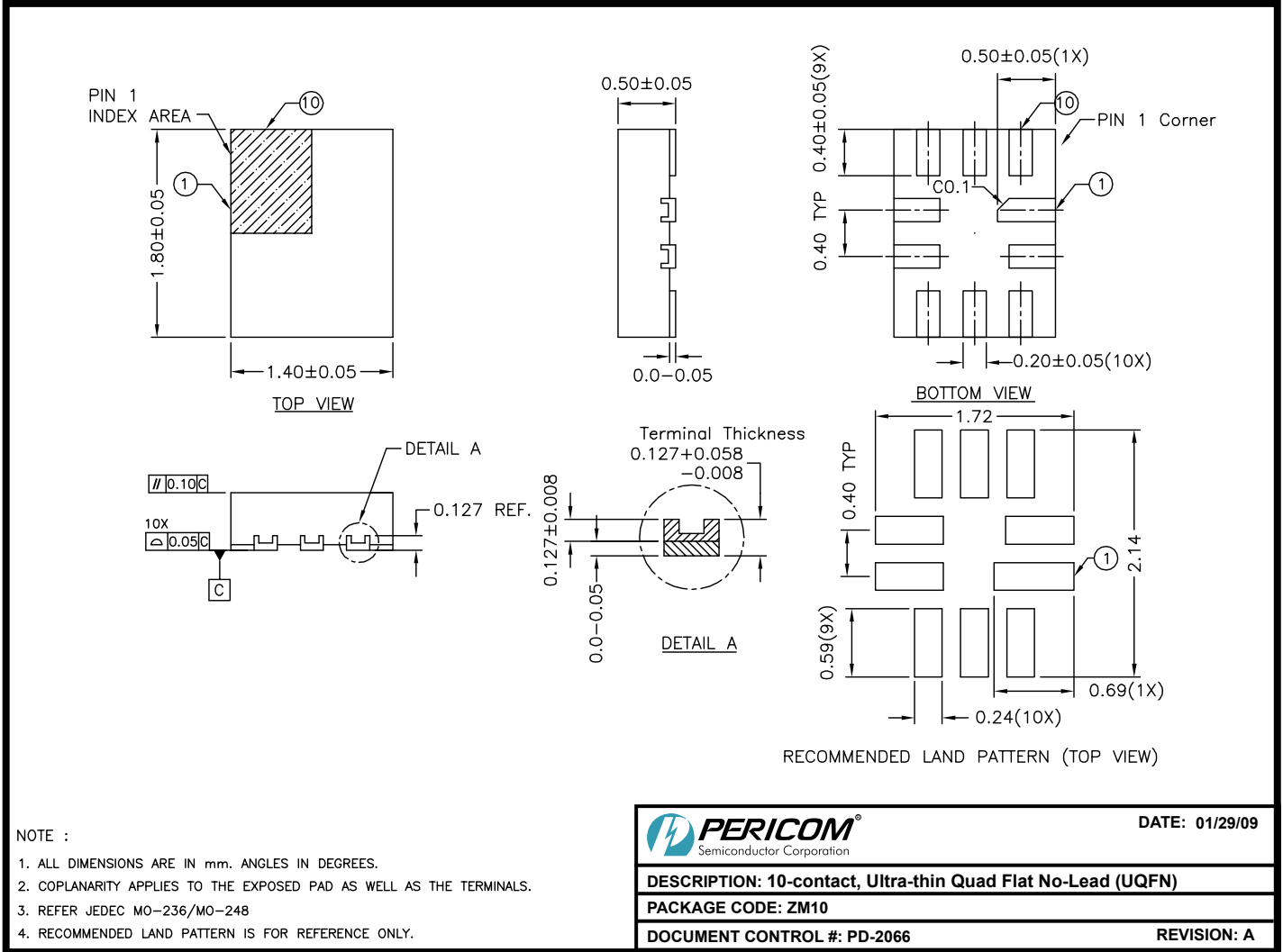| | |
|---|---|
| **DESCRIPTION: 10-contact, Ultra-thin Quad Flat No-Lead (UQFN)** | **DATE: 01/29/09** |
| **PACKAGE CODE: ZM10** | |
| **DOCUMENT CONTROL #: PD-2066** | **REVISION: A** |

09-0072

Note: For latest package info, please check: http://www.pericom.com/support/packaging/packaging-mechanicals-and-thermal-characteristics/

## Ordering Information

| Ordering Code | Package Code | Package Description | Top Mark |
|---|---|---|---|
| PI3USB223ZMEX | ZM | 10-contact, Ultra-thin Quad Flat No-Lead (UQFN), Tape & Reel | RP |

**Notes:**
• Thermal characteristics can be found on the company web site at www.pericom.com/packaging/
• E = Pb-free and Green
• X suffix = Tape/Reel

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