



# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

**MAX14978**

## General Description

The MAX14978 high-performance, passive analog switch is ideal for switching Hi-Speed USB and SuperSpeed USB data between one source and two loads, or vice versa. The device can be used in desktop and notebook applications where SuperSpeed USB ports are in limited supply. The device consists of two sets of analog switches with one set used for USB low-speed, full-speed, and Hi-Speed signals and the second set used for USB SuperSpeed. The device operates from a single +3.3V supply.

The device features low insertion loss for all speeds. It has  $\pm 6\text{kV}$  Human Body Model (HBM) ESD protection on all I/O pins. In addition, the low/full/Hi-Speed COM\_ ports have ESD protection to  $\pm 15\text{kV}$  HBM and  $\pm 8\text{kV}$  IEC 61000-4-2 contact.

The device is available in a small, 3.5mm x 9.0mm, 42-pin TQFN package and is specified over the extended -40°C to +85°C temperature range.

## Applications

Desktop PCs  
Laptop PCs  
Industrial USB Switching

## Features

- ◆ Designed for SuperSpeed USB Applications:
  - Low/Full/Hi-Speed (1.5/12/480Mbps)
  - SuperSpeed (5.0Gbps)
- ◆ Superior Return Loss and Insertion Loss for SuperSpeed Analog Switches
- ◆ Low Quiescent Current: 36 $\mu\text{A}$  (typ)
- ◆ All Link Training is Preserved (SuperSpeed)
- ◆ LVCMOS Control ( $1.4\text{V} \leq V_{IH} \leq 3.6\text{V}$ )
- ◆ Operation from a Single +3.3V Power Supply
- ◆ Small, 3.5mm x 9.0mm, 42-Pin TQFN Package

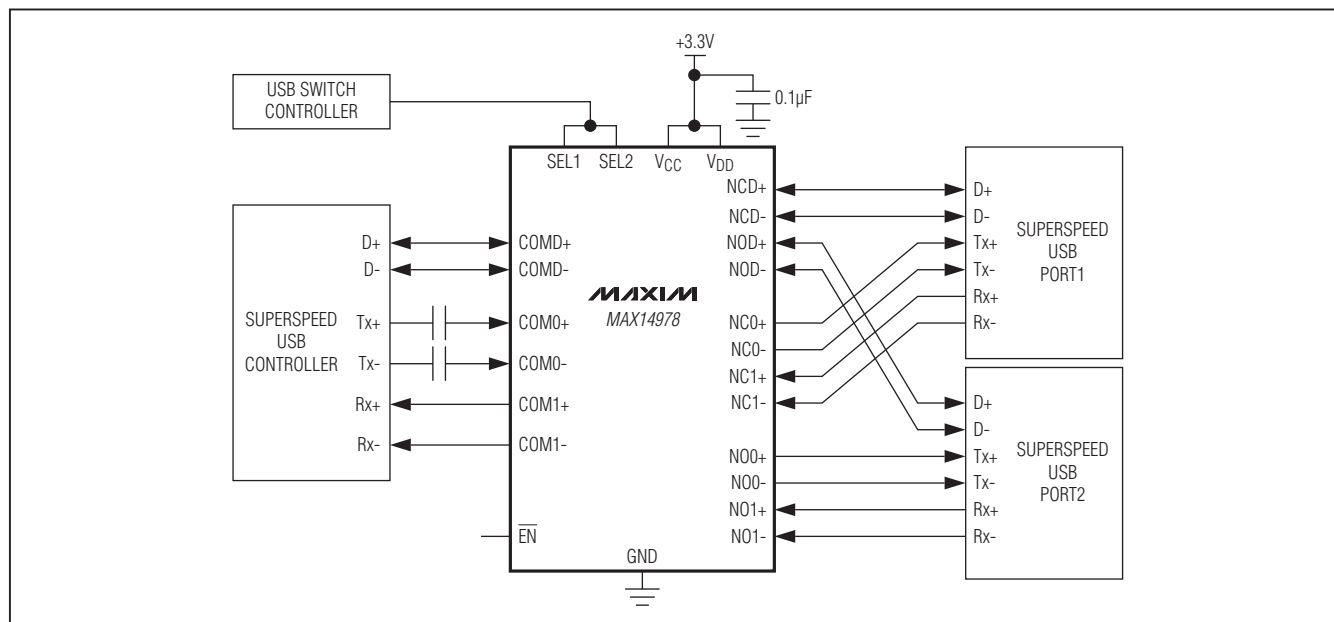
## Ordering Information

| PART         | TEMP RANGE     | PIN-PACKAGE |
|--------------|----------------|-------------|
| MAX14978ETO+ | -40°C to +85°C | 42 TQFN-EP* |

+ Denotes a lead(Pb)-free/RoHS-compliant package.

\*EP = Exposed pad.

## Typical Operating Circuit



# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

## ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND, unless otherwise noted.)

|                                         |                       |
|-----------------------------------------|-----------------------|
| VCC                                     | -0.3V to +6.0V        |
| VDD                                     | -0.3V to +4.0V        |
| SEL1, EN, COMD_, NOD_                   |                       |
| NCD_ (Note 1)                           | -0.3V to (VCC + 0.3V) |
| SEL2, COM0_, COM1_, NC0_                |                       |
| NC1_, NO0_, NO1_ (Note 1)               | -0.3V to (VDD + 0.3V) |
| ICOM0_ - NO0_I, ICOM0_ - NC0_I          |                       |
| ICOM0_ - NO1_I, ICOM0_ - NC1_I (Note 1) | 0 to +2.0V            |
| Continuous Current (COM0_               |                       |
| COM1_ to NO0_, NO1_, NC0_, NC1_)        | ±70mA                 |

|                                                       |                 |
|-------------------------------------------------------|-----------------|
| Peak Current (COM0_, COM1_ to NO0_, NO1_, NC0_, NC1_) |                 |
| (pulsed at 1ms, 10% duty cycle)                       | ±70mA           |
| Continuous Current into Any Terminal                  | ±30mA           |
| Continuous Power Dissipation (TA = +70°C)             |                 |
| TQFN (derate 35.7mW/°C above +70°C)                   | 2857mW          |
| Operating Temperature Range                           | -40°C to +85°C  |
| Storage Temperature Range                             | -65°C to +150°C |
| Junction Temperature                                  | +150°C          |
| Lead Temperature (soldering, 10s)                     | +300°C          |
| Soldering Temperature (reflow)                        | +260°C          |

**Note 1:** Signals on SEL\_, NO\_, NC\_, or COM\_ exceeding VCC, VDD, or VGND are clamped by internal diodes. Limit forward-diode current to maximum current rating.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

(VCC = +3.0V to +5.5V, VDD = +3.0V to +3.6V, TA = -40°C to +85°C, unless otherwise noted. Typical values are at VCC = VDD = +3.3V, TA = +25°C.) (Note 2)

| PARAMETER                                                | SYMBOL            | CONDITIONS                                                                                        | MIN       | TYP       | MAX       | UNITS |
|----------------------------------------------------------|-------------------|---------------------------------------------------------------------------------------------------|-----------|-----------|-----------|-------|
| Power-Supply Range                                       | VCC               |                                                                                                   | 3.0       |           | 5.5       | V     |
|                                                          | VDD               |                                                                                                   | 3.0       |           | 3.6       |       |
| Supply Current                                           | ICC               | VSEL1 = 0V or VCC, VEN = 0V VCC = 3.0V                                                            |           | 0.6       | 1.5       | μA    |
|                                                          | IDD               | VSEL2 = 0V or VDD VDD = 3.3V                                                                      |           |           | 60        |       |
| Shutdown Supply Current, ICC                             | ISHDN             | Hi-Speed USB switches, switch disabled (VEN = VCC)                                                |           | 0.1       |           | μA    |
| Increase in Supply Current, ICC, with VSEL1, VEN Voltage |                   | Hi-Speed USB switches, 0V ≤ VSEL1 ≤ VIL or VIH ≤ VSEL1 ≤ VCC or 0V ≤ VEN ≤ VIL or VIH ≤ VEN ≤ VCC |           |           | 1         | μA    |
| Analog Signal Range                                      | VCOM_, VNO_, VNC_ | Hi-Speed USB switches, VEN = 0V (Note 3)                                                          | 0         |           | VCC       | V     |
|                                                          |                   | SuperSpeed USB switches                                                                           | -0.3      |           | VDD - 1.2 |       |
| Fault-Protection Trip Threshold                          | VFP               | Hi-Speed USB switches, COMD_ only, TA = +25°C                                                     | VCC + 0.6 | VCC + 0.8 | VCC + 1   | V     |
| On-Resistance                                            | RON               | Hi-Speed USB switches, VCOMD_ = 0V to VCC                                                         |           | 5         | 10        | Ω     |
|                                                          |                   | Hi-Speed USB switches, VCC = 3.0V, VCOMD_ = 3.6V                                                  |           | 5.5       |           |       |
|                                                          |                   | SuperSpeed USB switches, VDD = 3.0V, ICOM_ = 15mA, VNO_ = VNC_ = 0V, 1.8V                         |           | 7         |           |       |

# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

MAX14978

## ELECTRICAL CHARACTERISTICS (continued)

(V<sub>CC</sub> = +3.0V to +5.5V, V<sub>DD</sub> = +3.0V to +3.6V, T<sub>A</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V<sub>CC</sub> = V<sub>DD</sub> = +3.3V, T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                                          | SYMBOL          | CONDITIONS                                                                                                                 |                      | MIN  | TYP  | MAX  | UNITS    |
|----------------------------------------------------|-----------------|----------------------------------------------------------------------------------------------------------------------------|----------------------|------|------|------|----------|
| On-Resistance Match Between Channels               | $\Delta R_{ON}$ | Hi-Speed USB switches, $V_{CC} = 3.0V$ , $V_{COMD\_} = 2.0V$ (Notes 4, 5)                                                  |                      |      | 0.1  | 1    | $\Omega$ |
|                                                    |                 | SuperSpeed USB switches, $V_{DD} = 3.0V$ , $I_{COM\_} = 15mA$ , $V_{NO\_}$ or $V_{NC\_} = 0V$ (Notes 4, 5)                 |                      |      | 0.6  | 2    |          |
| On-Resistance Match Between Pairs of Same Channels | $\Delta R_{ON}$ | SuperSpeed USB switches, $V_{DD} = 3.0V$ , $I_{COM\_} = 15mA$ , $V_{NO\_}$ or $V_{NC\_} = 0V$ (Notes 4, 5)                 |                      |      | 0.1  | 1    | $\Omega$ |
| On-Resistance Flatness                             | $R_{FLAT}$      | Hi-Speed USB switches, $V_{CC} = 3.0V$ , $V_{COMD\_} = 0V$ to $V_{CC}$ (Note 6)                                            |                      |      | 0.1  |      | $\Omega$ |
|                                                    |                 | SuperSpeed USB switches, $V_{DD} = 3.0V$ , $I_{COM\_} = 15mA$ , $V_{NO\_}$ or $V_{NC\_} = 0V$ (Notes 5, 6)                 |                      |      | 0.06 | 2    |          |
| Off-Leakage Current                                | $I_{COM(OFF)}$  | Hi-Speed USB switches, $V_{CC} = 5.5V$ , $V_{COMD\_} = 0V$ or $5.5V$ , $V_{NOD\_}$ , $V_{NCD\_} = 5.5V$ or $0V$            |                      | -250 |      | +250 | nA       |
|                                                    |                 | SuperSpeed USB switches, $V_{DD} = 3.6V$ , $V_{COM\_} = 0V$ , $1.8V$ ; $V_{NO\_}$ or $V_{NC\_} = 1.8V$ , $0V$              |                      | -1   |      | +1   | $\mu A$  |
| On-Leakage Current                                 | $I_{COM(ON)}$   | Hi-Speed USB switches, $V_{CC} = 5.5V$ , $V_{COMD\_} = 0V$ or $5.5V$ , $V_{NOD\_}$ , $V_{NCD\_} =$ unconnected             |                      | -250 |      | +250 | nA       |
|                                                    |                 | SuperSpeed USB switches, $V_{DD} = 3.6V$ , $V_{COM\_} = 0V$ , $1.8V$ ; $V_{NO\_}$ or $V_{NC\_} = V_{COM\_}$ or unconnected |                      | -1   |      | +1   | $\mu A$  |
| AC PERFORMANCE                                     |                 |                                                                                                                            |                      |      |      |      |          |
| On-Channel -3dB Bandwidth                          | BW              | Hi-Speed USB switches, $R_L = R_S = 50\Omega$ , signal = 0dBm                                                              |                      | 950  |      |      | MHz      |
| On-Loss                                            | GLOSS           | SuperSpeed USB switches, $R_L = R_S = 50\Omega$ , unbalanced                                                               | 1MHz < f < 100MHz    | -0.5 |      |      | dB       |
|                                                    |                 |                                                                                                                            | 500MHz < f < 1.25GHz | -1.4 |      |      |          |
| Off-Isolation                                      | VISO            | Hi-Speed USB switches, $V_{NOD\_}$ , $V_{NCD\_} = 0dBm$ , $R_L = R_S = 50\Omega$ , Figure 1                                | f = 10MHz            | -48  |      |      | dB       |
|                                                    |                 |                                                                                                                            | f = 250MHz           | -20  |      |      |          |
|                                                    |                 |                                                                                                                            | f = 500MHz           | -17  |      |      |          |
|                                                    |                 | SuperSpeed USB switches, signal = 0dBm, $R_S = R_L = 50\Omega$                                                             | f = 10MHz            | -56  |      |      |          |
|                                                    |                 |                                                                                                                            | f = 1.25GHz          | -26  |      |      |          |

# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

## ELECTRICAL CHARACTERISTICS (continued)

(VCC = +3.0V to +5.5V, VDD = +3.0V to +3.6V, TA = -40°C to +85°C, unless otherwise noted. Typical values are at VCC = VDD = +3.3V, TA = +25°C.) (Note 2)

| PARAMETER                      | SYMBOL                              | CONDITIONS                                                                                                                                                            | MIN         | TYP | MAX  | UNITS |
|--------------------------------|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----|------|-------|
| Crosstalk (Note 7)             | VCT                                 | Hi-Speed USB switches, V <sub>NOD_</sub> , V <sub>NCD_</sub> = 0dBm, R <sub>L</sub> = R <sub>S</sub> = 50Ω, Figure 1                                                  | f = 10MHz   | -73 |      | dB    |
|                                |                                     |                                                                                                                                                                       | f = 250MHz  | -54 |      |       |
|                                |                                     |                                                                                                                                                                       | f = 500MHz  | -33 |      |       |
|                                |                                     | SuperSpeed USB switches, crosstalk between any two pairs, R <sub>S</sub> = R <sub>L</sub> = 50Ω, unbalanced, Figure 1                                                 | f = 50MHz   | -53 |      |       |
|                                |                                     |                                                                                                                                                                       | f = 1.25GHz | -32 |      |       |
| Signaling Data Rate            | BR                                  | SuperSpeed USB switches, R <sub>S</sub> = R <sub>L</sub> = 50Ω                                                                                                        |             | 5.0 |      | Gbps  |
| <b>LOGIC INPUT</b>             |                                     |                                                                                                                                                                       |             |     |      |       |
| Input Logic-High               | V <sub>IH</sub>                     |                                                                                                                                                                       | 1.4         |     |      | V     |
| Input Logic-Low                | V <sub>IL</sub>                     |                                                                                                                                                                       |             |     | 0.5  | V     |
| Input Leakage Current          | I <sub>IN</sub>                     | Hi-Speed USB switches                                                                                                                                                 | -250        |     | +250 | nA    |
|                                |                                     | SuperSpeed USB switches, V <sub>SEL2</sub> = 0V or V <sub>DD</sub>                                                                                                    | -1          |     | +1   | μA    |
| Input Logic Hysteresis         | V <sub>HYST</sub>                   | SuperSpeed USB switches                                                                                                                                               |             | 100 |      | mV    |
| <b>DYNAMIC PERFORMANCE</b>     |                                     |                                                                                                                                                                       |             |     |      |       |
| Turn-On Time                   | t <sub>ON</sub>                     | Hi-Speed USB switches, V <sub>NOD_</sub> or V <sub>NCD_</sub> = 1.5V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, V <sub>EN</sub> = V <sub>CC</sub> to 0V, Figure 2 |             | 20  | 100  | μs    |
|                                |                                     | SuperSpeed USB switches, V <sub>NO_</sub> or V <sub>NC_</sub> = 1.0V, R <sub>L</sub> = 50Ω, Figure 2                                                                  |             | 90  | 250  | ns    |
| Turn-Off Time                  | t <sub>OFF</sub>                    | V <sub>NOD_</sub> or V <sub>NCD_</sub> = 1.5V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, V <sub>EN</sub> = 0V to V <sub>CC</sub> , Figure 2                       |             | 1   | 5    | μs    |
|                                |                                     | SuperSpeed USB switches, V <sub>NO_</sub> or V <sub>NC_</sub> = 1.0V, R <sub>L</sub> = 50Ω, Figure 2                                                                  |             | 10  | 50   | ns    |
| Propagation Delay              | t <sub>PLH</sub> , t <sub>PHL</sub> | Hi-Speed USB switches, R <sub>L</sub> = R <sub>S</sub> = 50Ω, Figure 3                                                                                                |             | 100 |      | ps    |
|                                |                                     | SuperSpeed USB switches, R <sub>L</sub> = R <sub>S</sub> = 50Ω                                                                                                        |             | 50  |      |       |
| Output Skew Between Switches   | t <sub>SK</sub>                     | Hi-Speed USB switches, skew between switch 1 and 2, R <sub>L</sub> = R <sub>S</sub> = 50Ω, Figure 3                                                                   |             | 40  |      | ps    |
| Output Skew Between Pairs      | t <sub>SK1</sub>                    | SuperSpeed USB switches, R <sub>S</sub> = R <sub>L</sub> = 50Ω, unbalanced; skew between any two pairs, Figure 3                                                      |             | 50  |      | ps    |
| Output Skew Between Same Pair  | t <sub>SK2</sub>                    | SuperSpeed USB switches, R <sub>S</sub> = R <sub>L</sub> = 50Ω, unbalanced; skew between two lines on same pair, Figure 3                                             |             | 10  |      | ps    |
| Fault-Protection Response Time | t <sub>FP</sub>                     | Hi-Speed USB switches, V <sub>COMD_</sub> = 0V to 5V step, R <sub>L</sub> = R <sub>S</sub> = 50Ω, V <sub>CC</sub> = 3.3V, Figure 4                                    | 0.5         |     | 5.0  | μs    |

# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

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## ELECTRICAL CHARACTERISTICS (continued)

(V<sub>CC</sub> = +3.0V to +5.5V, V<sub>DD</sub> = +3.0V to +3.6V, T<sub>A</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V<sub>CC</sub> = V<sub>DD</sub> = +3.3V, T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                            | SYMBOL                                       | CONDITIONS                                                                                                                                       | MIN | TYP  | MAX | UNITS |
|--------------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-----|------|-----|-------|
| Fault-Protection Recovery Time       | t <sub>FPR</sub>                             | Hi-Speed USB switches, V <sub>COMD_</sub> = 5V to 0V step, R <sub>L</sub> = R <sub>S</sub> = 50Ω, V <sub>CC</sub> = 3.3V, Figure 4               |     |      | 100 | μs    |
| NO_ or NC_ Off-Capacitance           | C <sub>NO(OFF)</sub> or C <sub>NC(OFF)</sub> | Hi-Speed USB switches, f = 1MHz, Figure 5                                                                                                        |     | 2    |     | pF    |
|                                      |                                              | SuperSpeed USB switches, Figure 5                                                                                                                |     | 1    |     |       |
| COM_ Off-Capacitance                 | C <sub>COM(OFF)</sub>                        | Hi-Speed USB switches, f = 1MHz, Figure 5                                                                                                        |     | 5.5  |     | pF    |
|                                      |                                              | Hi-Speed USB switches, f = 240MHz, Figure 5                                                                                                      |     | 4.8  |     |       |
| COM_ On-Capacitance                  | C <sub>COM(ON)</sub>                         | Hi-Speed USB switches, f = 1MHz, Figure 5                                                                                                        |     | 6.5  |     | pF    |
|                                      |                                              | Hi-Speed USB switches, f = 240MHz, Figure 5                                                                                                      |     | 5.5  |     |       |
|                                      |                                              | SuperSpeed USB switches, Figure 5                                                                                                                |     | 2    |     |       |
| Total Harmonic Distortion Plus Noise | THD+N                                        | Hi-Speed USB switches, V <sub>COMD_</sub> = 1V <sub>P-P</sub> , V <sub>BIAS</sub> = 1V, R <sub>L</sub> = R <sub>S</sub> = 50Ω, f = 20Hz to 20kHz |     | 0.03 |     | %     |
| <b>ESD PROTECTION</b>                |                                              |                                                                                                                                                  |     |      |     |       |
| COMD+, COMD-                         |                                              | Human Body Model                                                                                                                                 |     | ±15  |     | kV    |
|                                      |                                              | IEC 61000-4-2 Air Gap Discharge                                                                                                                  |     | ±15  |     |       |
|                                      |                                              | IEC 61000-4-2 Contact Discharge                                                                                                                  |     | ±8   |     |       |
| COM0_, COM1_                         |                                              | Human Body Model                                                                                                                                 |     | ±6   |     | kV    |
| All Pins                             |                                              | Human Body Model                                                                                                                                 |     | ±2   |     | kV    |

**Note 2:** All devices are 100% production tested at T<sub>A</sub> = +25°C. All temperature limits are guaranteed by design.

**Note 3:** The switch turns off for voltages above V<sub>FP</sub>, protecting downstream circuits in case of a fault condition.

**Note 4:** ΔRON(MAX) = |RON(CH1) - RON(CH2)|.

**Note 5:** Guaranteed by design. Not production tested.

**Note 6:** Flatness is defined as the difference between the maximum and minimum value of on-resistance, as measured over specified analog-signal ranges.

**Note 7:** Between any two switches.

# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

## Test Circuits/Timing Diagrams

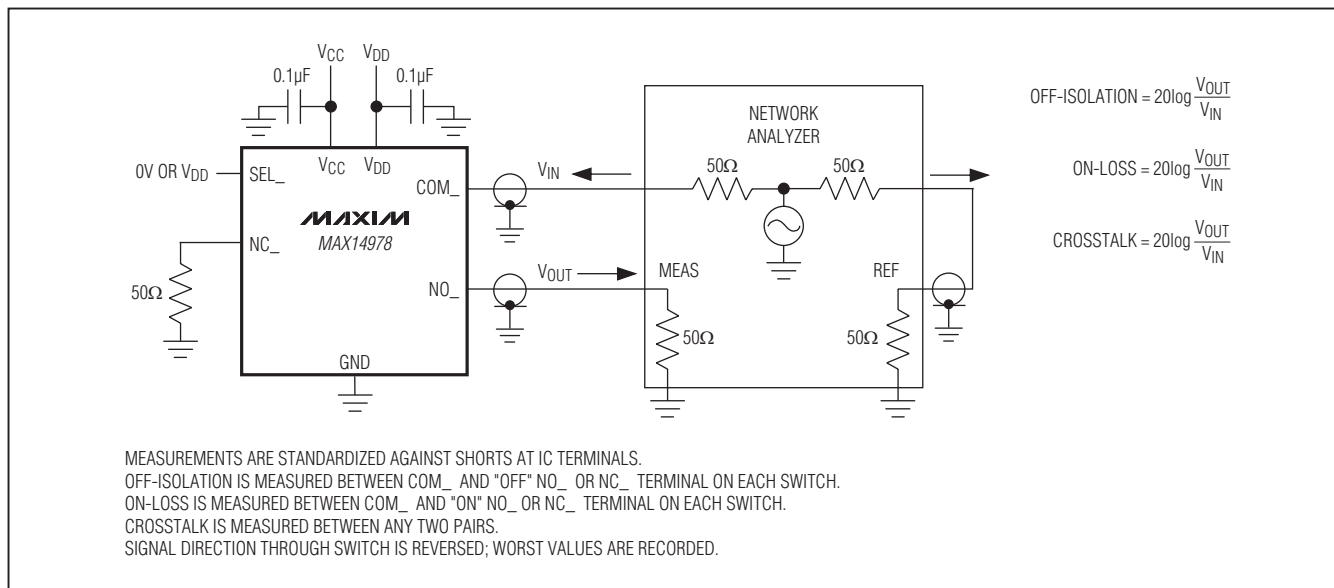


Figure 1. Off-Isolation, On-Loss, and Crosstalk

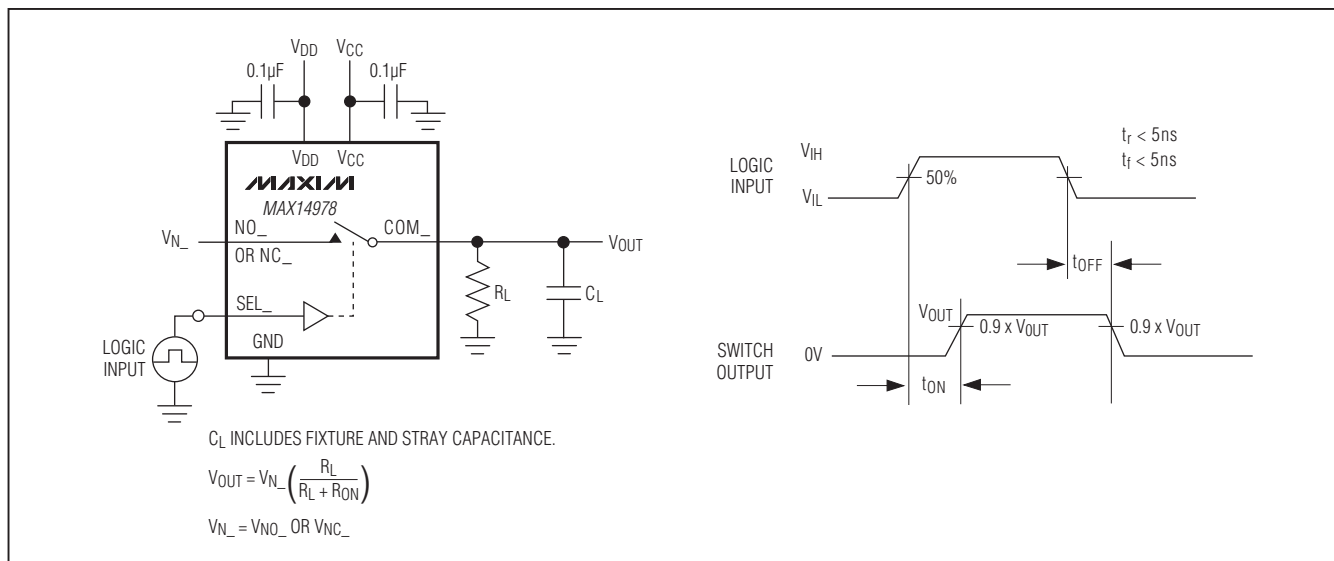


Figure 2. Switching Time

# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

## Test Circuits/Timing Diagrams (continued)

MAX14978

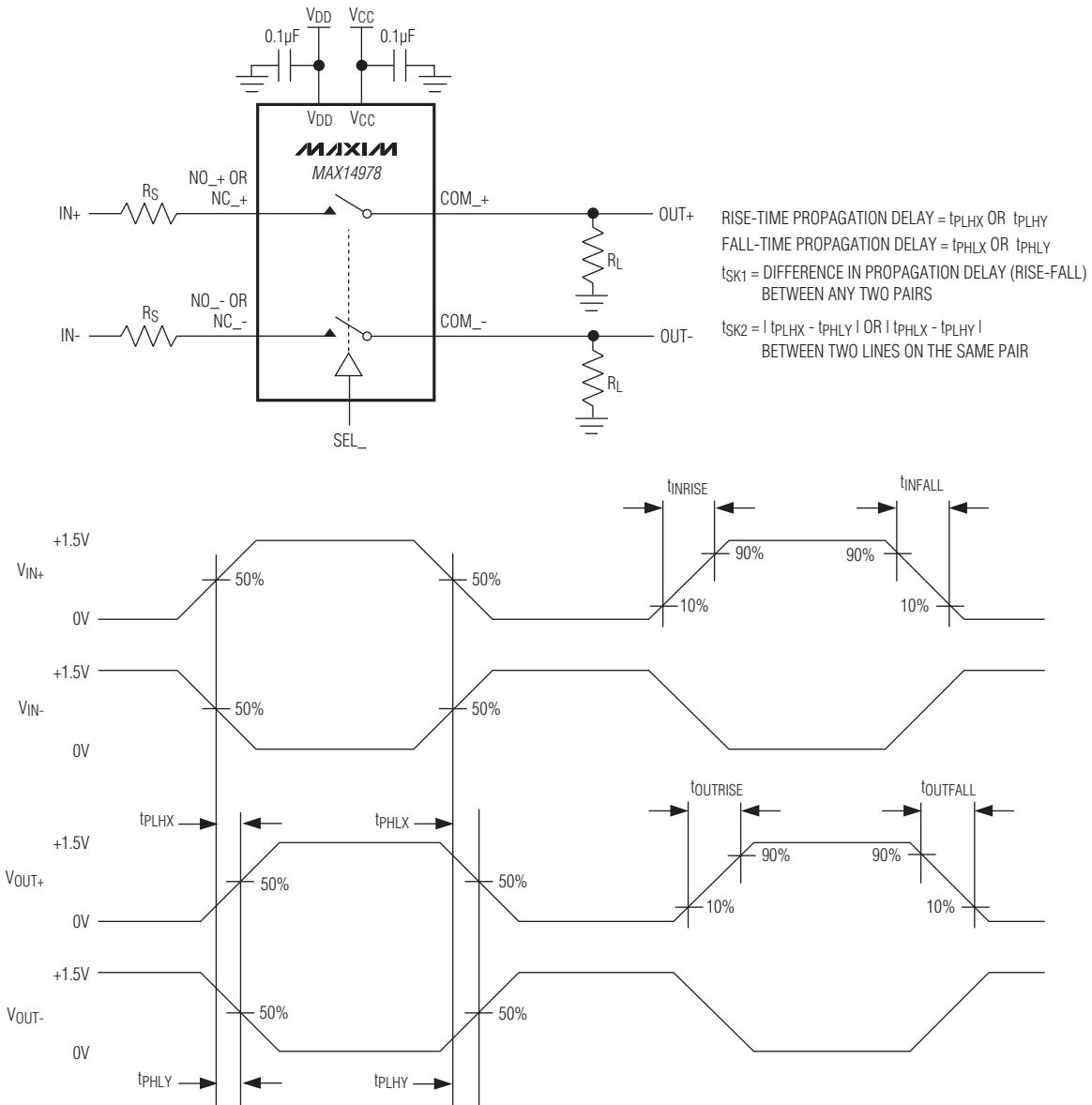


Figure 3. Propagation Delay, Output Skew

# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

## Test Circuits/Timing Diagrams (continued)

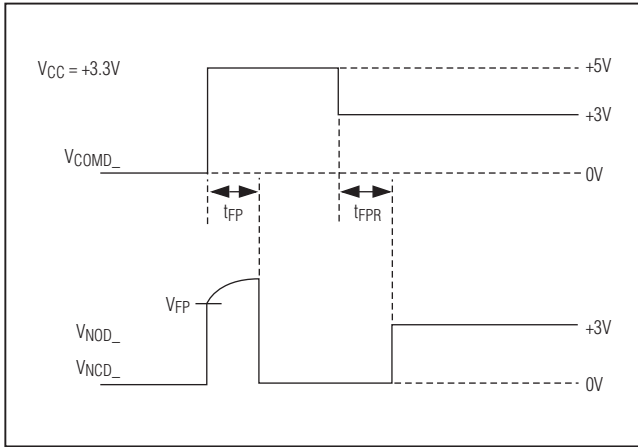


Figure 4. Fault Protection Response/Recovery Time

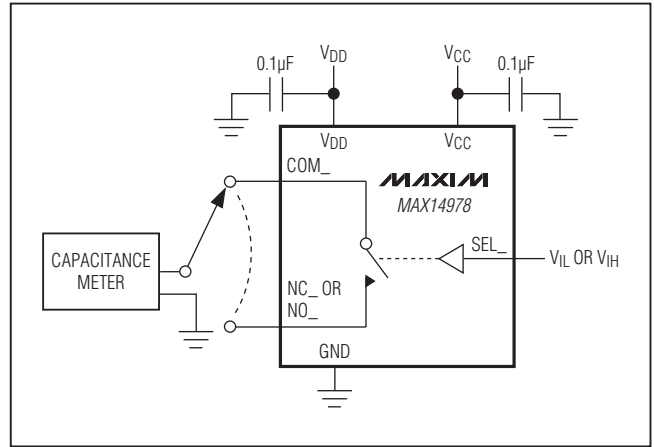
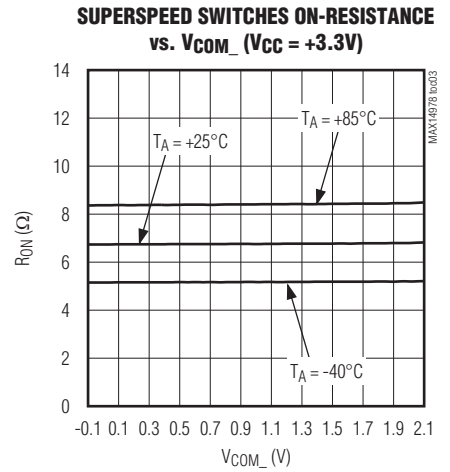
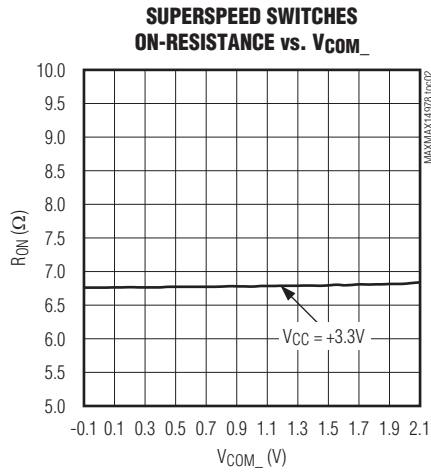
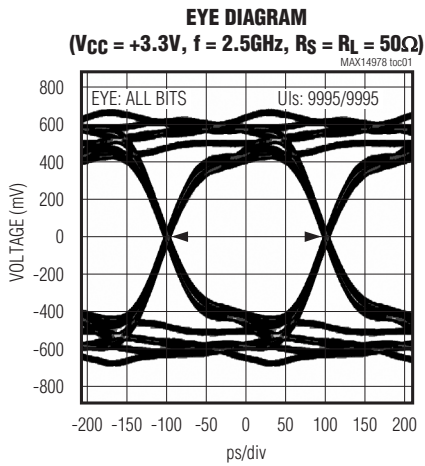


Figure 5. Channel Off-/On-Capacitance

## Typical Operating Characteristics

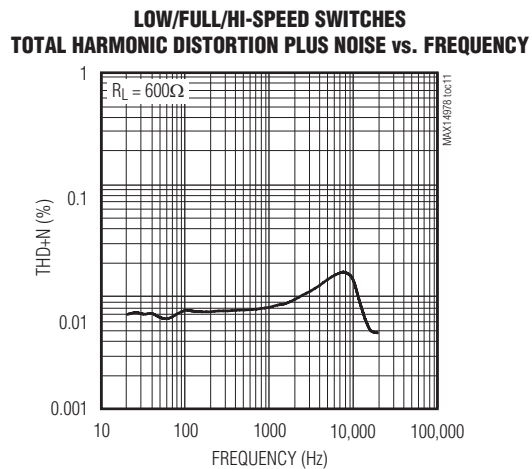
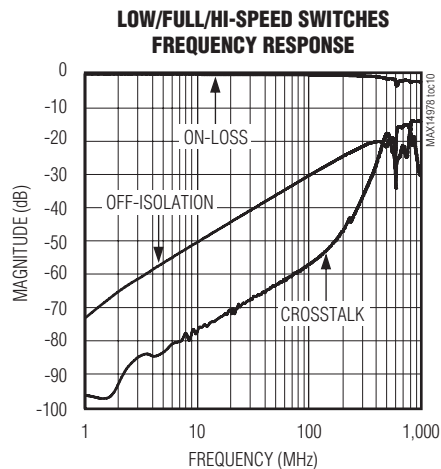
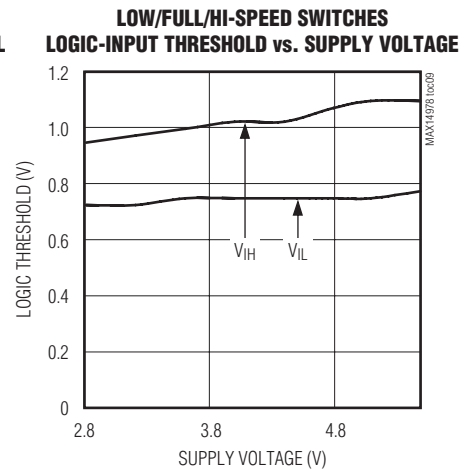
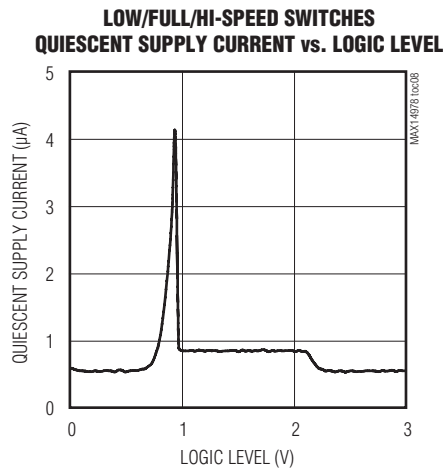
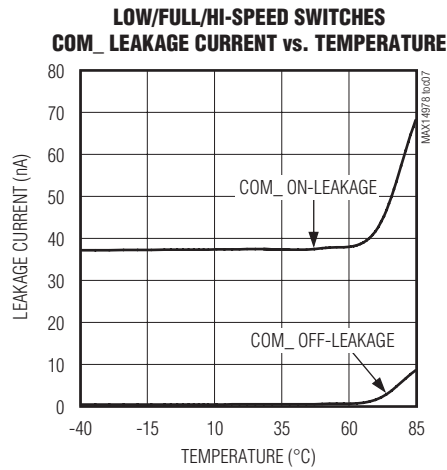
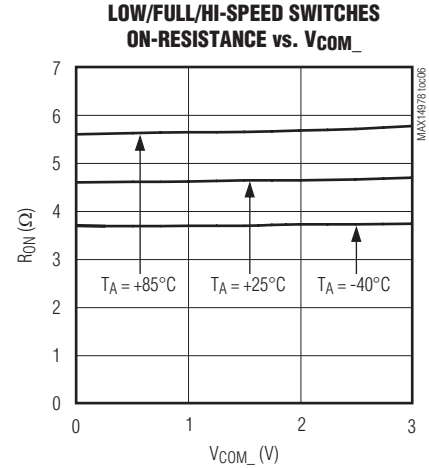
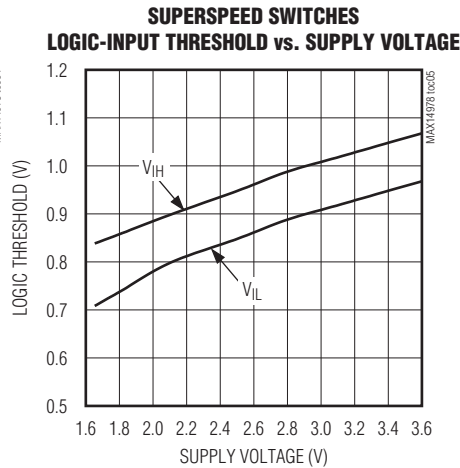
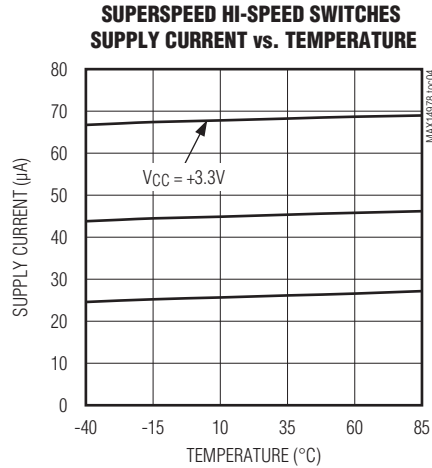
( $V_{CC} = V_{DD} = 3.3V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

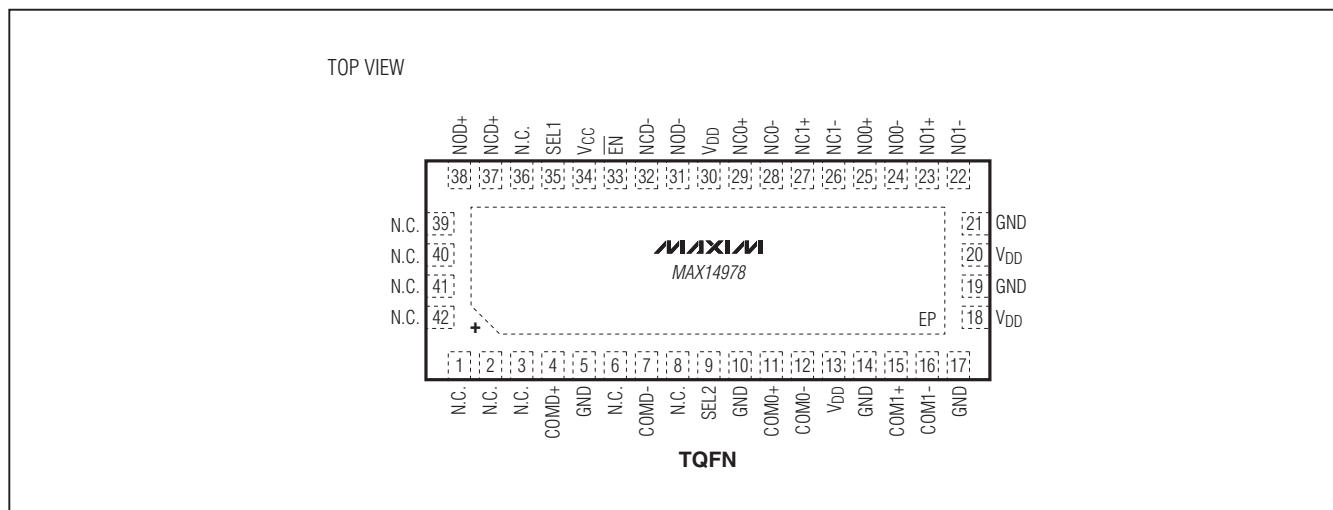
## Typical Operating Characteristics (continued)

( $V_{CC} = V_{DD} = 3.3V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

## Pin Configuration



## Pin Description

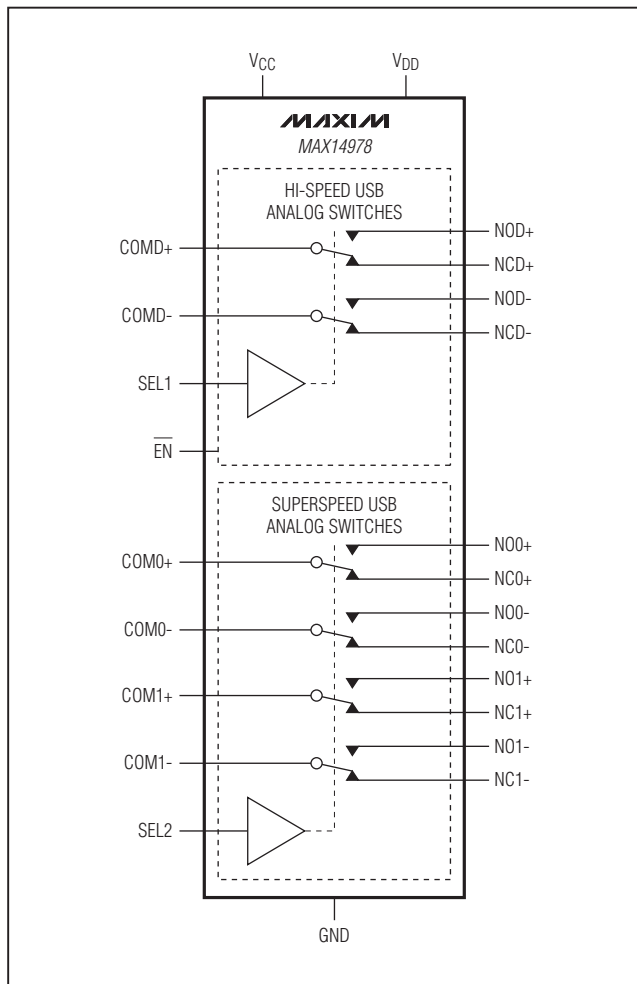
| PIN                            | NAME            | FUNCTION                                                                                                                                                    |
|--------------------------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1, 2, 3, 6,<br>8, 36,<br>39–42 | N.C.            | No Connection. Not internally connected.                                                                                                                    |
| 4                              | COMD+           | Hi-Speed USB Analog Switch, Common D+ Terminal                                                                                                              |
| 5, 10, 14,<br>17, 19, 21       | GND             | Ground                                                                                                                                                      |
| 7                              | COMD-           | Hi-Speed USB Analog Switch, Common D- Terminal                                                                                                              |
| 9                              | SEL2            | Digital Control Input for SuperSpeed USB Analog Switches                                                                                                    |
| 11                             | COM0+           | SuperSpeed USB Analog Switch 0, Common Positive Terminal                                                                                                    |
| 12                             | COM0-           | SuperSpeed USB Analog Switch 0, Common Negative Terminal                                                                                                    |
| 13, 18,<br>20, 30              | V <sub>DD</sub> | Positive Supply Voltage Input for SuperSpeed USB Switches. Bypass V <sub>DD</sub> to GND with a 0.1μF ceramic capacitor as close as possible to the device. |
| 15                             | COM1+           | SuperSpeed USB Analog Switch 1, Common Positive Terminal                                                                                                    |
| 16                             | COM1-           | SuperSpeed USB Analog Switch 1, Common Negative Terminal                                                                                                    |
| 22                             | NO1-            | SuperSpeed USB Analog Switch 1, Normally Open Negative Terminal                                                                                             |
| 23                             | NO1+            | SuperSpeed USB Analog Switch 1, Normally Open Positive Terminal                                                                                             |
| 24                             | NO0-            | SuperSpeed USB Analog Switch 0, Normally Open Negative Terminal                                                                                             |
| 25                             | NO0+            | SuperSpeed USB Analog Switch 0, Normally Open Positive Terminal                                                                                             |
| 26                             | NC1-            | SuperSpeed USB Analog Switch 1, Normally Closed Negative Terminal                                                                                           |
| 27                             | NC1+            | SuperSpeed USB Analog Switch 1, Normally Closed Positive Terminal                                                                                           |
| 28                             | NC0-            | SuperSpeed USB Analog Switch 0, Normally Closed Negative Terminal                                                                                           |
| 29                             | NC0+            | SuperSpeed USB Analog Switch 0, Normally Closed Positive Terminal                                                                                           |
| 31                             | NOD-            | Hi-Speed USB Analog Switch, Normally Open D- Terminal                                                                                                       |
| 32                             | NCD-            | Hi-Speed USB Analog Switch, Normally Closed D- Terminal                                                                                                     |

# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

## Pin Description (continued)

| PIN | NAME                   | FUNCTION                                                                                                                                                                                    |
|-----|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 33  | $\overline{\text{EN}}$ | Active-Low Enable Input for Hi-Speed USB Switches. Drive $\overline{\text{EN}}$ high to put Hi-Speed USB switches in high impedance. Drive $\overline{\text{EN}}$ low for normal operation. |
| 34  | VCC                    | Positive-Supply Voltage Input for Hi-Speed USB Switches. Bypass VCC to GND with a 0.1 $\mu$ F ceramic capacitor as close as possible to the device.                                         |
| 35  | SEL1                   | Digital Control Input for Hi-Speed USB Analog Switches                                                                                                                                      |
| 37  | NCD+                   | Hi-Speed USB Analog Switch, Normally Closed D+ Terminal                                                                                                                                     |
| 38  | NOD+                   | Hi-Speed USB Analog Switch, Normally Open D+ Terminal                                                                                                                                       |
| —   | EP                     | Exposed Pad. EP is internally connected to GND. Connect EP to a large ground plane to maximize thermal performance. EP is not intended as an electrical connection point.                   |

## Functional Diagram/Truth Table



| HI-SPEED USB SWITCHES  |      |                  |                  |                   |
|------------------------|------|------------------|------------------|-------------------|
| $\overline{\text{EN}}$ | SEL1 | NOD <sub>-</sub> | NCD <sub>-</sub> | COMD <sub>-</sub> |
| 0                      | 0    | OFF              | ON               | —                 |
| 0                      | 1    | ON               | OFF              | —                 |
| 1                      | X    | OFF              | OFF              | HIGH-Z            |

| SUPERSPEED USB SWITCHES |                 |                 |
|-------------------------|-----------------|-----------------|
| SEL2                    | NO <sub>-</sub> | NC <sub>-</sub> |
| 0                       | OFF             | ON              |
| 1                       | ON              | OFF             |

# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

## Detailed Description

The MAX14978 is ideal for SuperSpeed USB and low/full/Hi-Speed (1.5/12/480Mbps) USB switching applications. The low  $V_{IH}$  threshold of the device permits it to be used with logic levels as low as 1.4V. The device's Hi-Speed USB analog switches are based on a charge-pump-assisted n-channel architecture and operate with 36 $\mu$ A (typ) quiescent current. The device features dual digital control inputs (SEL\_) to switch Hi-Speed USB and SuperSpeed USB signal paths separately.

### Digital Control Inputs (SEL1, SEL2)

The device's provides dual digital control inputs (SEL1, SEL2) to select the signal path between the COM\_ and NO\_ or NC\_ channels. Drive SEL1 and SEL2 rail-to-rail to minimize power consumption. See the *Functional Diagram/Truth Table*.

### Analog-Signal Levels

The device's switches are bidirectional, allowing NO\_, NC\_, and COM\_ to be configured as either inputs or outputs.

The Hi-Speed USB switches are equipped with a charge-pump-assisted n-channel architecture that allows the switch to pass analog signals that exceed  $V_{CC}$  up to the overvoltage fault-protection threshold. This allows USB signals that exceed  $V_{CC}$  to pass, allowing compliance with USB requirements for voltage levels.

The SuperSpeed USB switches accept signals on the COM\_, NO\_, and NC\_ channels within a range of -0.1V to ( $V_{DD} - 1.2V$ ). Signals on the COM\_+ channels are routed to either the NO\_+ or NC\_+ channels, and signals on the COM\_- channels are routed to either the NO\_- or NC\_- channels.

### Overvoltage Fault Protection

The device features overvoltage fault protection on COMD\_. Fault protection prevents these switches from being damaged due to shorts to the USB VBUS voltage rail. Fault protection protects the switch and USB transceiver from damaging voltage levels. When voltages on COMD\_ exceed the fault-protection threshold ( $V_{FP}$ ), COMD\_, NCD\_ and NOD\_ are high impedance.

## Enable Input

The device features a shutdown mode for the Hi-Speed USB analog switches that reduces the  $V_{CC}$  quiescent current to 0.1 $\mu$ A (typ) and places COMD+ and COMD- in high impedance. Drive  $\overline{EN}$  high to place the Hi-Speed USB analog switches in shutdown mode, and drive  $\overline{EN}$  low for normal operation.

## Applications Information

### USB Switching

The device's analog switches are fully compliant with the USB 2.0 and USB 3.0 specifications. The low on-resistance and low on-capacitance of these switches make them ideal for high-performance switching applications. The device is ideal for routing USB data lines and for applications that require switching between multiple USB hosts or devices. The device's Hi-Speed USB analog switches also feature overvoltage fault protection to guard systems against shorts to the USB VBUS voltage rail that is required for all Hi-Speed USB applications.

### Extended ESD Protection

As with all Maxim devices, ESD protection structures are incorporated on all pins to protect against electrostatic discharges encountered during handling and assembly. COMD+ and COMD- are further protected against static electricity. Maxim's engineers have developed state-of-the-art structures to protect these pins against ESD up to  $\pm 15kV$  without damage. The ESD structures withstand high ESD in normal operation and when the device is powered down. After an ESD event, the device continues to function without latchup.

The device is characterized for protection to the following limits:

- $\pm 15kV$  using Human Body Model
- $\pm 15kV$  using IEC 61000-4-2 Air Gap Discharge method
- $\pm 8kV$  using IEC 61000-4-2 Contact Discharge method

**Note:** High ESD performance is only applicable to the Hi-Speed USB section of the switch. The SuperSpeed USB section is rated to  $\pm 6kV$  HBM.

# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

## ESD Test Conditions

ESD performance depends on a variety of conditions. Contact Maxim for a reliability report that documents test setup, test methodology, and test results.

## Human Body Model

Figure 6a shows the Human Body Model, and Figure 6b shows the current waveform it generates when discharged into a low-impedance state. This model consists of a 100pF capacitor charged to the ESD voltage of interest, which is then discharged into the test device through a 1.5k $\Omega$  resistor.

## IEC 61000-4-2

The main difference between tests done using the Human Body Model and IEC 61000-4-2 is higher peak current in IEC 61000-4-2. Because series resistance is lower in the IEC 61000-4-2 ESD test model (Figure 7a) the ESD-withstand voltage measured to this standard is generally

lower than that measured using the Human Body Model. Figure 7b shows the current waveform for the  $\pm 8$ kV IEC 61000-4-2 Level 4 ESD Contact Discharge test.

The Air Gap Discharge test involves approaching the device with a charged probe. The Contact Discharge method connects the probe to the device before the probe is energized.

## Layout

High-speed switches require proper layout and design procedures for optimum performance. Keep design-controlled impedance PCB traces as short as possible or follow impedance layouts per the SuperSpeed USB specification. Ensure that power-supply bypass capacitors are placed as close as possible to the device. Multiple bypass capacitors are recommended. Connect all grounds and the exposed pad to large ground planes where possible.

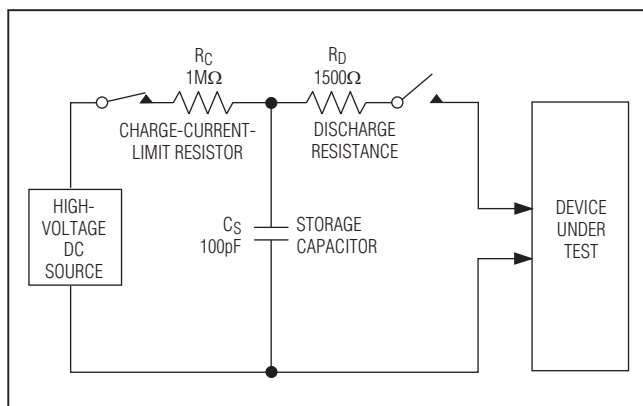


Figure 6a. Human Body ESD Test Model

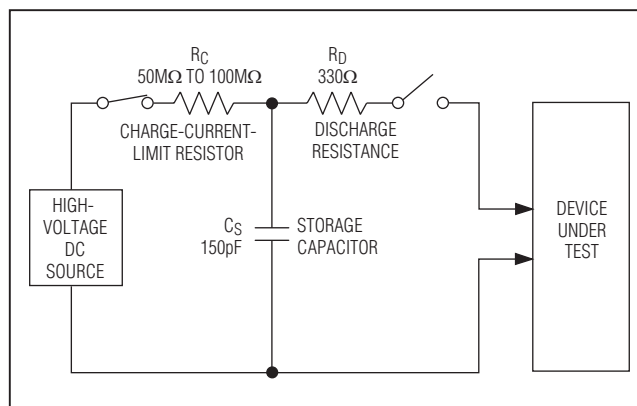


Figure 7a. IEC 61000-4-2 ESD Test Model

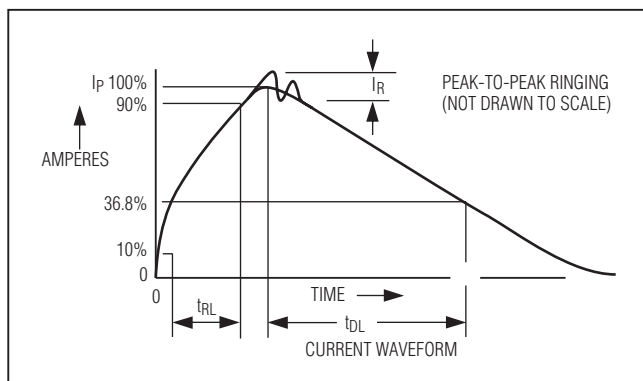


Figure 6b. Human Body Current Waveform

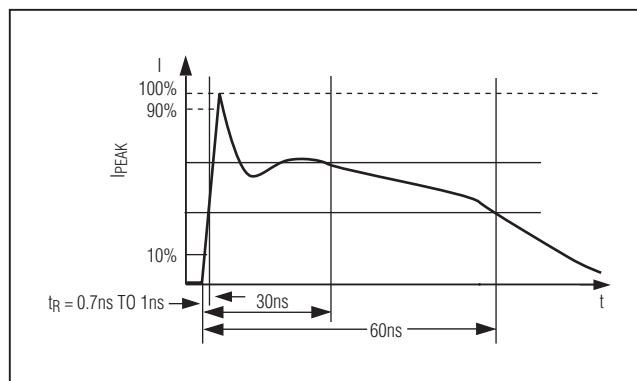


Figure 7b. IEC 61000-4-2 ESD Generator Current Waveform

## SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

### Power-Supply Sequencing

**Caution:** Do not exceed the absolute maximum ratings because stresses beyond the listed ratings may cause permanent damage to the device.

Proper power-supply sequencing is recommended for all CMOS devices. Always apply VCC and VDD before applying analog signals, especially if the analog signals are not current limited.

### Package Information

For the latest package outline information and land patterns (footprints), go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages). Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO.             | LAND PATTERN NO.        |
|--------------|--------------|-------------------------|-------------------------|
| 42 TQFN-EP   | T423590M+1   | <a href="#">21-0181</a> | <a href="#">90-0079</a> |

# SuperSpeed USB Passive Switch (Low/Full/Hi/SuperSpeed)

## Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION                                                                    | PAGES<br>CHANGED |
|--------------------|------------------|--------------------------------------------------------------------------------|------------------|
| 0                  | 9/10             | Initial release                                                                | —                |
| 1                  | 4/11             | Updated analog signal range specification in <i>Electrical Characteristics</i> | 2                |

MAX14978

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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