



# USB 2.0 Hi-Speed Differential 8:1 Multiplexer

**MAX4999**

## General Description

The MAX4999 differential Hi-Speed USB analog multiplexer features low on-capacitance ( $C_{ON}$ ) switching, making it an ideal solution for the USB server/mass storage market. The MAX4999 is designed for USB 2.0 low-/full-/Hi-Speed applications with capability of supporting data rates up to 480Mbps.

The MAX4999 is a differential 8:1 multiplexer. The MAX4999 features three digital inputs to control the signal path. Typical applications include switching a USB connector between eight USB hosts and a USB device.

An enable input (EN) is provided to disable all channels and place the device into a high-impedance state (standby mode), shutting off the charge pump for minimum power consumption.

The MAX4999 operates from a +3.0V to +3.6V power-supply voltage and is specified over the -40°C to +85°C extended temperature range. The MAX4999 is available in a 5mm x 5mm, 32-pin TQFN package.

## Applications

Keyboard, Video, Mouse (KVM)  
Servers/RAID  
Mass Storage  
Workstations

## Features

- ◆ Single +3.0V to +3.6V Power-Supply Voltage
- ◆ Low 6.5Ω (typ) On-Resistance ( $R_{ON}$ )
- ◆ -3dB Bandwidth: 1200MHz (typ)
- ◆ Enable Input Puts All Channels in High-Impedance State (Standby Mode)
- ◆ Low Operating Current (1μA) and Ultra-Low Quiescent Current (30nA) in Standby Mode
- ◆ Low Threshold Eliminates the Need for Translators in 1.8V Low-Voltage Systems
- ◆ Small 32-Pin, 5mm x 5mm, TQFN Package

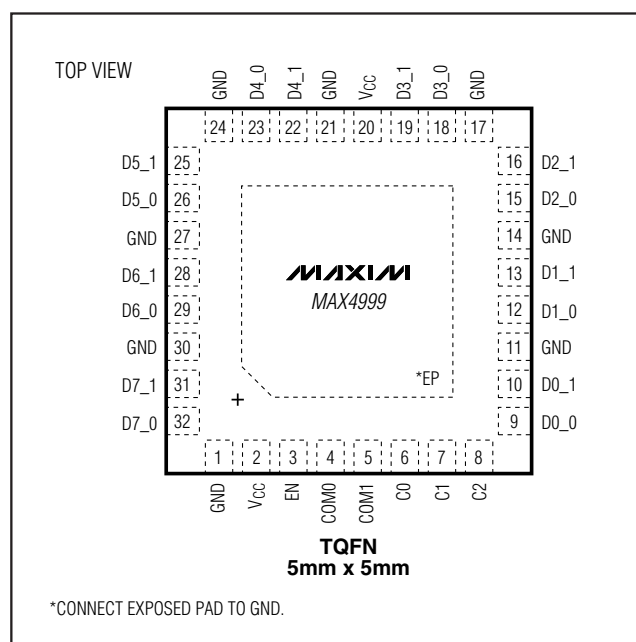
## Ordering Information

| PART        | TEMP RANGE     | PIN-PACKAGE |
|-------------|----------------|-------------|
| MAX4999ETJ+ | -40°C to +85°C | 32 TQFN-EP* |

+Denotes a lead-free package.

\*EP = Exposed pad.

## Pin Configuration



# USB 2.0 Hi-Speed Differential 8:1 Multiplexer

## ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND.)

|                                                                                        |              |
|----------------------------------------------------------------------------------------|--------------|
| V <sub>CC</sub> .....                                                                  | -0.3V to +4V |
| All Other Pins (Note 1) .....                                                          | -0.3V to +4V |
| Continuous Current (COM <sub>-</sub> to any switch) .....                              | ±60mA        |
| Peak Current (COM <sub>-</sub> to any switch) (pulsed at 1ms,<br>10% duty cycle) ..... | ±120mA       |

Continuous Power Dissipation (T<sub>A</sub> = +70°C)

|                                                  |                 |
|--------------------------------------------------|-----------------|
| 32-Lead TQFN (derate 34.5mW/°C above +70°C) .... | 2759mW          |
| Operating Temperature Range .....                | -40°C to +85°C  |
| Storage Temperature Range .....                  | -65°C to +150°C |
| Lead Temperature (soldering, 10s) .....          | +300°C          |
| Soldering Temperature (reflow) .....             | +260°C          |

**Note 1:** Signals exceeding GND 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.

## PACKAGE THERMAL CHARACTERISTICS (Note 2)

TQFN

|                                                                 |         |
|-----------------------------------------------------------------|---------|
| Junction-to-Ambient Thermal Resistance (θ <sub>JA</sub> ) ..... | 29°C/W  |
| Junction-to-Case Thermal Resistance (θ <sub>JC</sub> ) .....    | 2.0°C/W |

**Note 2:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to [www.maxim-ic.com/thermal-tutorial](http://www.maxim-ic.com/thermal-tutorial).

## ELECTRICAL CHARACTERISTICS

(V<sub>CC</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> = +3.3V and T<sub>A</sub> = +25°C.) (Note 3)

| PARAMETER                                                               | SYMBOL             | CONDITIONS                                                                                                                                                      | MIN | TYP  | MAX | UNITS |
|-------------------------------------------------------------------------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------|-----|-------|
| POWER SUPPLY                                                            |                    |                                                                                                                                                                 |     |      |     |       |
| Supply Voltage                                                          | V <sub>CC</sub>    |                                                                                                                                                                 | 3.0 |      | 3.6 | V     |
| Quiescent Supply Current                                                | I <sub>O</sub>     | Charge pump on                                                                                                                                                  |     |      | 5   | μA    |
|                                                                         |                    | Charge pump off                                                                                                                                                 |     |      | 1   |       |
| ANALOG SWITCH                                                           |                    |                                                                                                                                                                 |     |      |     |       |
| On-Resistance                                                           | R <sub>ON</sub>    | I <sub>COM_</sub> = ±10mA                                                                                                                                       |     | 6.5  | 12  | Ω     |
| On-Resistance Match                                                     | ΔR <sub>ONSC</sub> | V <sub>COM_</sub> = 1V, T <sub>A</sub> = +25°C                                                                                                                  |     |      | 0.8 | Ω     |
| On-Resistance Match Between Channels                                    | ΔR <sub>ONBC</sub> | V <sub>COM_</sub> = 1V, T <sub>A</sub> = +25°C                                                                                                                  |     |      | 1   | Ω     |
| Leakage Current COM <sub>-</sub> , D <sub>-</sub> _0, D <sub>-</sub> _1 | I <sub>L</sub>     | V <sub>CC</sub> = +3.6V                                                                                                                                         | -1  |      | +1  | μA    |
| SWITCH AC PERFORMANCE (Note 4)                                          |                    |                                                                                                                                                                 |     |      |     |       |
| Crosstalk                                                               | V <sub>DCT1</sub>  | Any switch to non-paired switch at 500MHz (Figure 3)                                                                                                            |     | -30  |     | dB    |
| Off-Isolation                                                           | V <sub>OFF</sub>   | Any switch to non-paired switch at 240MHz (Figure 3)                                                                                                            |     | -27  |     | dB    |
| Bandwidth -3dB                                                          | BW                 | R <sub>L</sub> = 45Ω unbalanced (Figure 3)                                                                                                                      |     | 1200 |     | MHz   |
| On-Capacitance                                                          | C <sub>ON</sub>    | f = 1MHz                                                                                                                                                        |     | 6    |     | pF    |
|                                                                         |                    | Taken from S11 parameters at f = 240MHz                                                                                                                         |     | 3.0  |     |       |
| Off-Capacitance                                                         | C <sub>OFF</sub>   | f = 1MHz, COM <sub>-</sub>                                                                                                                                      |     | 5    |     | pF    |
|                                                                         |                    | Taken from S11 parameters at f = 240MHz                                                                                                                         |     | 3.0  |     |       |
| Propagation Delay                                                       | t <sub>PD</sub>    | R <sub>L</sub> = R <sub>S</sub> = 50Ω (Figure 2)                                                                                                                |     | 300  |     | ps    |
| Turn-On Time                                                            | t <sub>ON</sub>    | V <sub>D_0</sub> or V <sub>D_1</sub> = +1.5V, R <sub>L</sub> = 300Ω, C <sub>L</sub> = 35pF, V <sub>IH</sub> = V <sub>CC</sub> , V <sub>IL</sub> = 0V (Figure 1) |     | 10   |     | μs    |

# USB 2.0 Hi-Speed Differential 8:1 Multiplexer

## ELECTRICAL CHARACTERISTICS

( $V_{CC} = +3.0V$  to  $+3.6V$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , unless otherwise noted. Typical values are at  $V_{CC} = +3.3V$  and  $T_A = +25^{\circ}C$ .) (Note 3)

| PARAMETER              | SYMBOL     | CONDITIONS                                                                                                         | MIN | TYP     | MAX | UNITS   |
|------------------------|------------|--------------------------------------------------------------------------------------------------------------------|-----|---------|-----|---------|
| Turn-Off Time          | $t_{OFF}$  | $V_{D\_0}$ or $V_{D\_1} = +1.5V$ , $R_L = 300\Omega$ , $C_L = 35pF$ , $V_{IH} = V_{CC}$ , $V_{IL} = 0V$ (Figure 1) |     | 10      |     | $\mu s$ |
| Output Skew Same Port  | $t_{PD}$   | Skew between any $D\_0$ , $D\_1$ line, same port $45\Omega$ unbalanced I/O, $f = 240MHz$ (Figure 2)                |     | 30      |     | ps      |
| <b>SWITCH LOGIC</b>    |            |                                                                                                                    |     |         |     |         |
| Input Logic Low        | $V_{IL}$   | $V_{CC} = +3.0V$                                                                                                   |     |         | 0.6 | V       |
| Input Logic High       | $V_{IH}$   | $V_{CC} = +3.6V$                                                                                                   | 1.7 |         |     | V       |
| Input Logic Hysteresis | $V_{HYST}$ |                                                                                                                    |     | 200     |     | mV      |
| Input Leakage Current  | $I_{LEAK}$ | $V_{CC} = +3.6V$ , $V_{COM\_} = 0V$ or $V_{CC}$                                                                    | -1  |         | +1  | $\mu A$ |
| <b>ESD PROTECTION</b>  |            |                                                                                                                    |     |         |     |         |
| All Pins               |            | Human Body Model                                                                                                   |     | $\pm 2$ |     | kV      |

**Note 3:** All units are 100% production tested at  $T_A = +85^{\circ}C$ . Limits over the operating temperature range are guaranteed by design and not production tested.

**Note 4:** Guaranteed by design.

## Test Circuits/Timing Diagrams

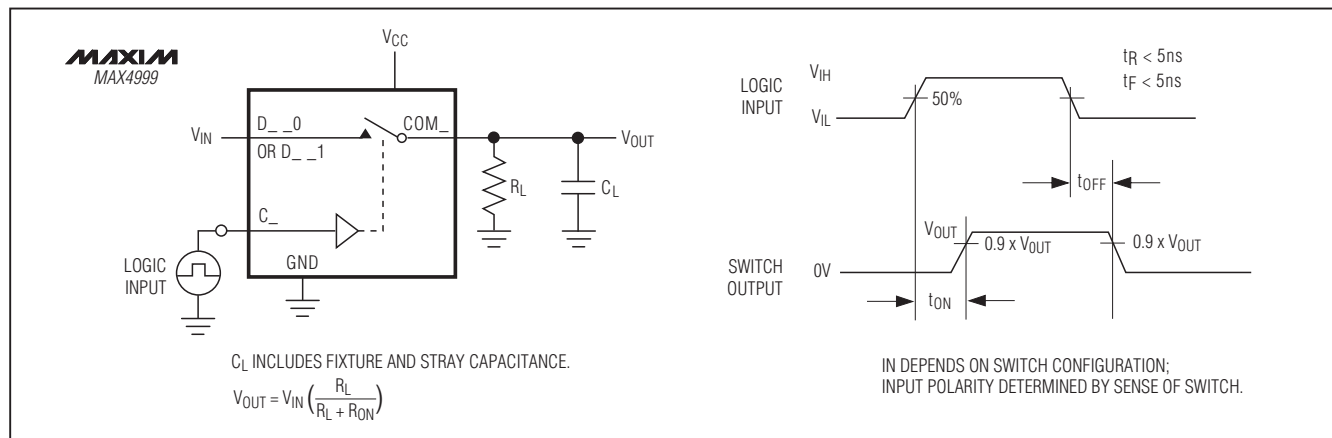


Figure 1. Switching Time

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## Test Circuits/Timing Diagrams (continued)

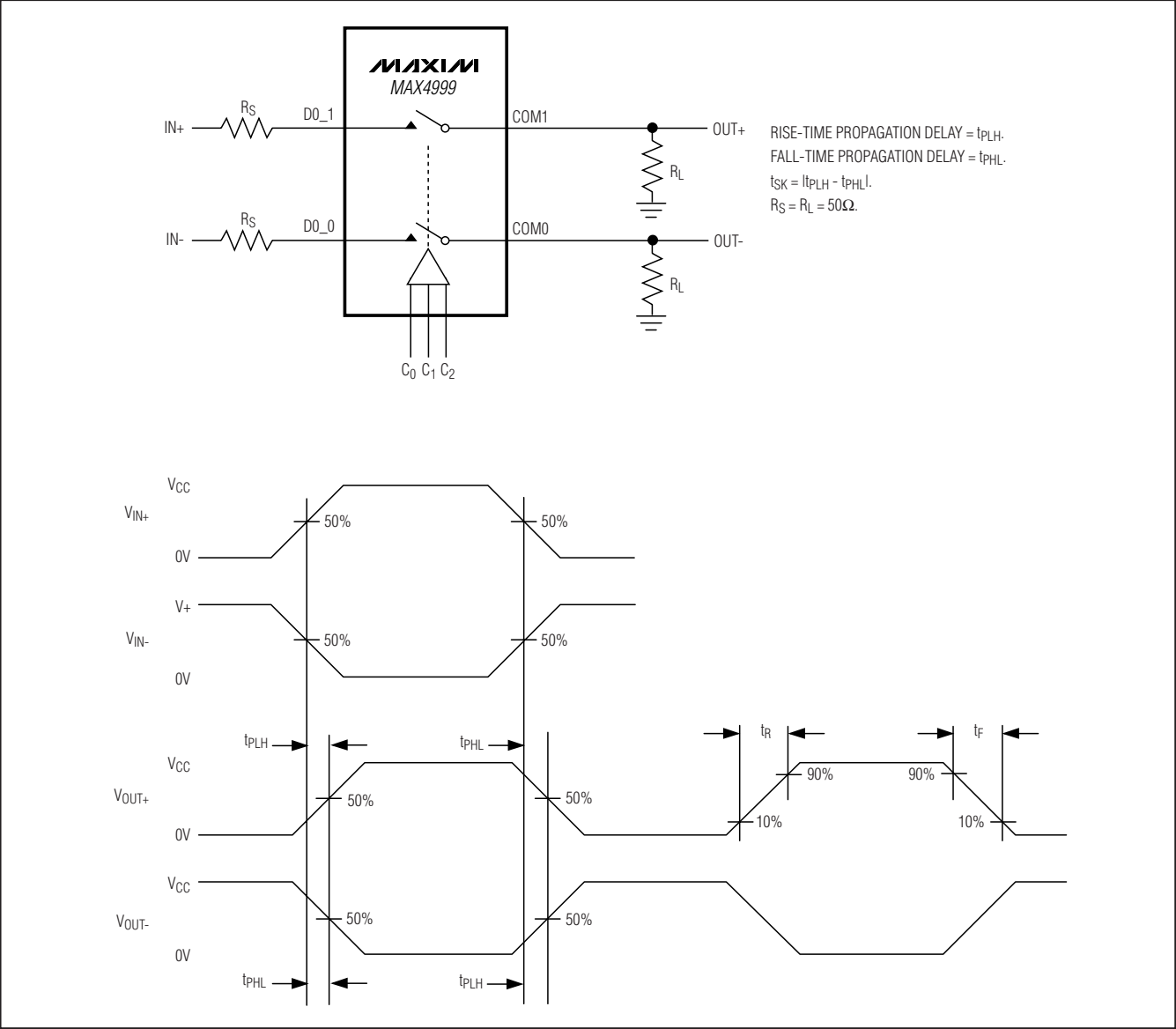


Figure 2. Propagation Delay and Skew

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## Test Circuits/Timing Diagrams (continued)

MAX4999

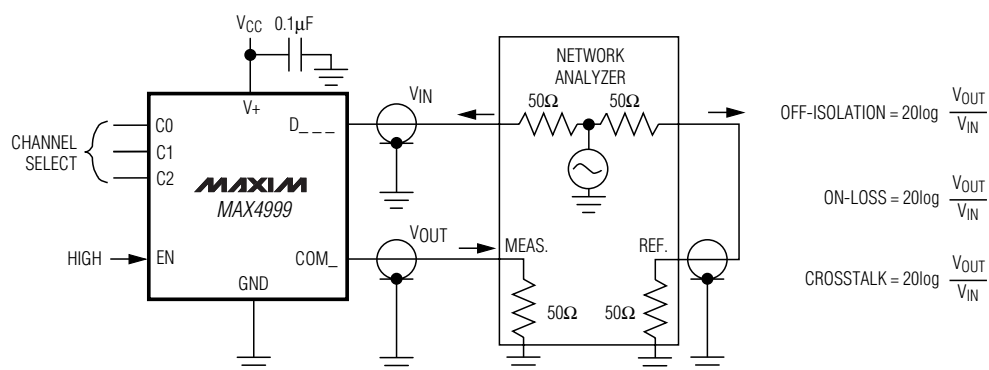
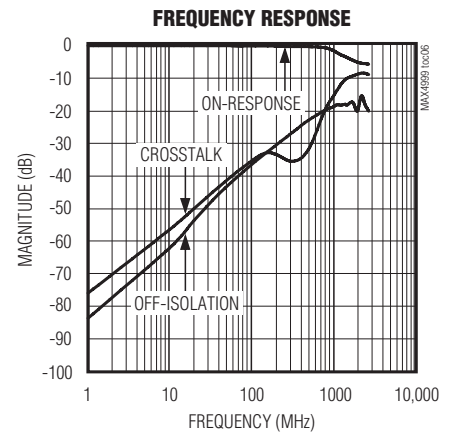
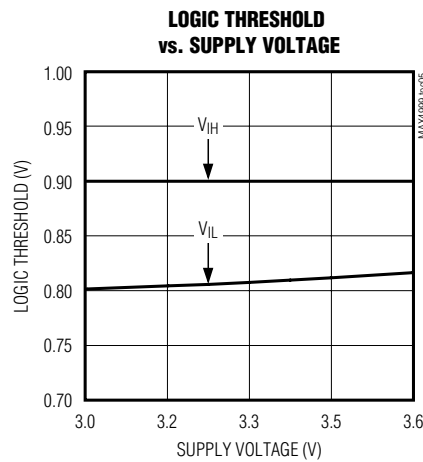
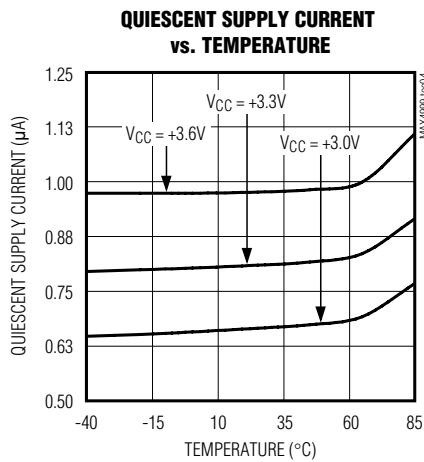
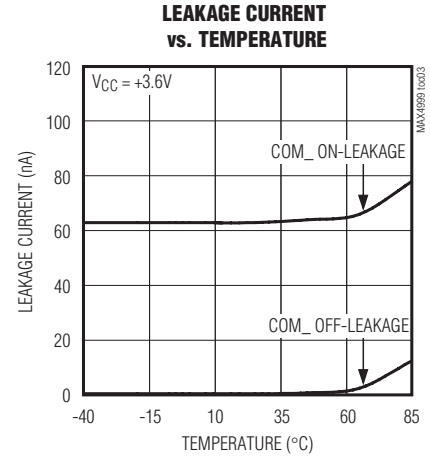
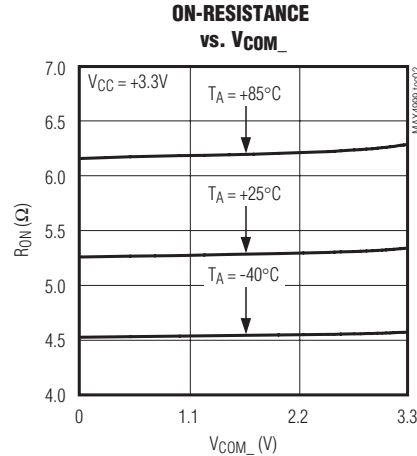
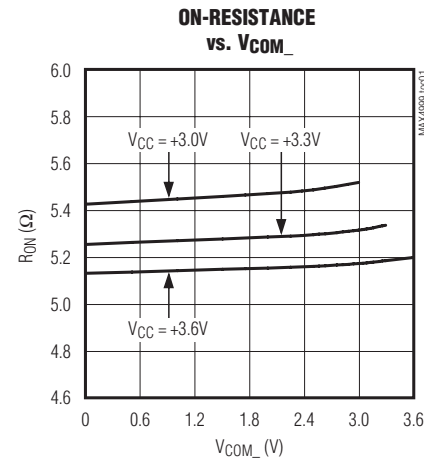


Figure 3. Off-Isolation, On-Loss, and Crosstalk

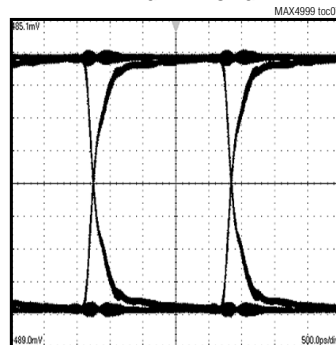
# USB 2.0 Hi-Speed Differential 8:1 Multiplexer

## Typical Operating Characteristics

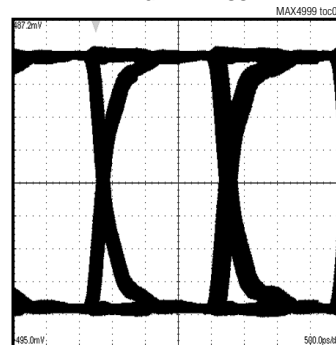
( $V_{CC} = +3.3V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



**EYE DIAGRAM - SINGLE**



**EYE DIAGRAM - DOUBLE**



# USB 2.0 Hi-Speed Differential 8:1 Multiplexer

## Pin Description

| PIN                              | NAME            | FUNCTION                                                                                                                 |
|----------------------------------|-----------------|--------------------------------------------------------------------------------------------------------------------------|
| 1, 11, 14, 17,<br>21, 24, 27, 30 | GND             | Ground                                                                                                                   |
| 2, 20                            | V <sub>CC</sub> | Power-Supply Input. Bypass V <sub>CC</sub> to GND with a 0.1μF capacitor placed as close to V <sub>CC</sub> as possible. |
| 3                                | EN              | Enable Input                                                                                                             |
| 4                                | COM0            | Analog Switch Common D- Terminal                                                                                         |
| 5                                | COM1            | Analog Switch Common D+ Terminal                                                                                         |
| 6                                | C0              | Control Input 0                                                                                                          |
| 7                                | C1              | Control Input 1                                                                                                          |
| 8                                | C2              | Control Input 2                                                                                                          |
| 9                                | D0_0            | Analog Switch 0 D- Terminal                                                                                              |
| 10                               | D0_1            | Analog Switch 0 D+ Terminal                                                                                              |
| 12                               | D1_0            | Analog Switch 1 D- Terminal                                                                                              |
| 13                               | D1_1            | Analog Switch 1 D+ Terminal                                                                                              |
| 15                               | D2_0            | Analog Switch 2 D- Terminal                                                                                              |
| 16                               | D2_1            | Analog Switch 2 D+ Terminal                                                                                              |
| 18                               | D3_0            | Analog Switch 3 D- Terminal                                                                                              |
| 19                               | D3_1            | Analog Switch 3 D+ Terminal                                                                                              |
| 22                               | D4_1            | Analog Switch 4 D+ Terminal                                                                                              |
| 23                               | D4_0            | Analog Switch 4 D- Terminal                                                                                              |
| 25                               | D5_1            | Analog Switch 5 D+ Terminal                                                                                              |
| 26                               | D5_0            | Analog Switch 5 D- Terminal                                                                                              |
| 28                               | D6_1            | Analog Switch 6 D+ Terminal                                                                                              |
| 29                               | D6_0            | Analog Switch 6 D- Terminal                                                                                              |
| 31                               | D7_1            | Analog Switch 7 D+ Terminal                                                                                              |
| 32                               | D7_0            | Analog Switch 7 D- Terminal                                                                                              |
| —                                | EP              | Exposed Pad. Connect EP to GND or leave unconnected.                                                                     |

## Detailed Description

The MAX4999 differential Hi-Speed USB analog multiplexer features low on-capacitance (C<sub>ON</sub>) and low on-resistance (R<sub>ON</sub>) necessary for high-performance switching applications. The low C<sub>ON</sub> is designed for USB server/mass storage devices. This device is ideal for USB 2.0 Hi-Speed applications at 480Mbps, while also meeting the requirements for USB low-/full-speed applications.

### Digital Control Inputs (C0, C1, C2)

The MAX4999 provides three digital control inputs (C0, C1, C2) to select the analog signal path between the COM\_ and D-/D+ channels. The truth table for the MAX4999 is shown in the *Functional Diagram/Truth Table*. Driving the control inputs rail-to-rail minimizes power consumption.

### Enable Input (EN)

The MAX4999 features an enable input that when driven low, places the device in standby mode. In standby mode, all channels are high impedance and the internal charge pump is disabled, thus minimizing the quiescent supply current. For normal operation, drive EN high.

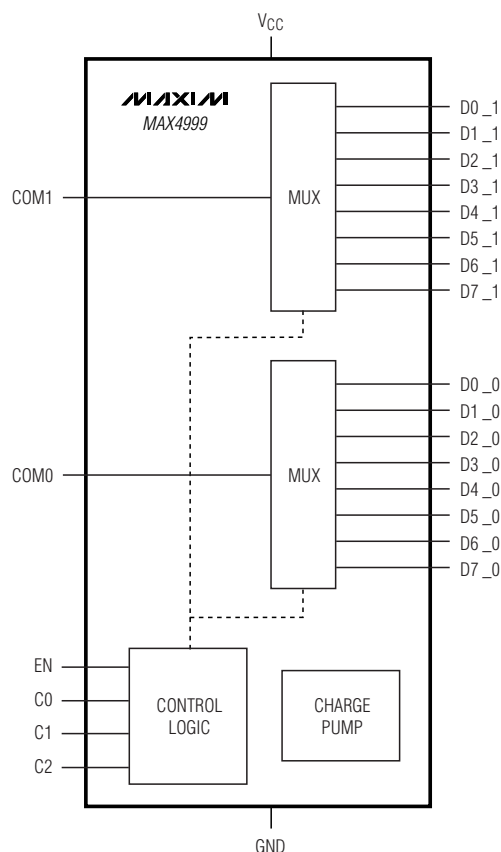
### Analog Signal Levels

Signals applied to COM1 are routed to D+\_1 terminals. Signals applied to COM0 are routed to D+\_0 terminals. This multiplexer is bidirectional, allowing COM\_ and D-/D+ terminals to be configured as either inputs or outputs. Additionally, the MAX4999 can be used for non-USB signals if the signals fall within the normal operating range.

The MAX4999 features an internal charge pump that allows signal levels greater than the supply voltage. Limit the analog input/output signal level to no more than the *Absolute Maximum Ratings*.

# USB 2.0 Hi-Speed Differential 8:1 Multiplexer

## Functional Diagram/Truth Table



| MAX4999 |    |    |    |                                                                               |
|---------|----|----|----|-------------------------------------------------------------------------------|
| EN      | C2 | C1 | C0 | FUNCTION                                                                      |
| 1       | 0  | 0  | 0  | COM_ <sub>__</sub> →D0_ <sub>__</sub>                                         |
| 1       | 0  | 0  | 1  | COM_ <sub>__</sub> →D1_ <sub>__</sub>                                         |
| 1       | 0  | 1  | 0  | COM_ <sub>__</sub> →D2_ <sub>__</sub>                                         |
| 1       | 0  | 1  | 1  | COM_ <sub>__</sub> →D3_ <sub>__</sub>                                         |
| 1       | 1  | 0  | 0  | COM_ <sub>__</sub> →D4_ <sub>__</sub>                                         |
| 1       | 1  | 0  | 1  | COM_ <sub>__</sub> →D5_ <sub>__</sub>                                         |
| 1       | 1  | 1  | 0  | COM_ <sub>__</sub> →D6_ <sub>__</sub>                                         |
| 1       | 1  | 1  | 1  | COM_ <sub>__</sub> →D7_ <sub>__</sub>                                         |
| 0       | X  | X  | X  | STANDBY MODE.<br>ALL SWITCHES IN HIGH-IMPEDANCE STATE.<br>CHARGE PUMP IS OFF. |

X = DON'T CARE

## Applications Information

### Increasing USB Channels

The MAX4999 features an enable input that allows two MAX4999s to be connected, allowing multiplexing between 16 USB channels. Figure 4 shows the typical application with a single USB common terminal multiplexed to eight channels (8:1). See the Eye Diagram - Single graph in the *Typical Operating Characteristics*. Figure 5 shows two MAX4999 devices configured with the USB common terminal multiplexed to 16 USB channels (16:1). See the Eye Diagram - Double graph in the *Typical Operating Characteristics*. The MAX4999 was designed to be symmetrical so that the two common ports may be wired in parallel with very short wiring to create a 16:1 configuration. When operating in 16:1 configuration, interchange COM0 and COM1 on the second device to reverse the D+ and D- pins. This minimizes vias and crossovers (Figure 5).

### USB Switching

The MAX4999 analog multiplexers are fully compliant with the USB 2.0 specification. The low on-resistance and low on-capacitance of the MAX4999 make it ideal for high-performance switching applications.

### Board Layout

Hi-Speed switches require proper layout and design procedures for optimum performance. Keep design-controlled impedance PCB traces as short as possible. Ensure that high-quality bypass ceramic capacitors (X7R, X5R or better) are placed as close to the device as possible and use large ground planes where possible.

# USB 2.0 Hi-Speed Differential 8:1 Multiplexer

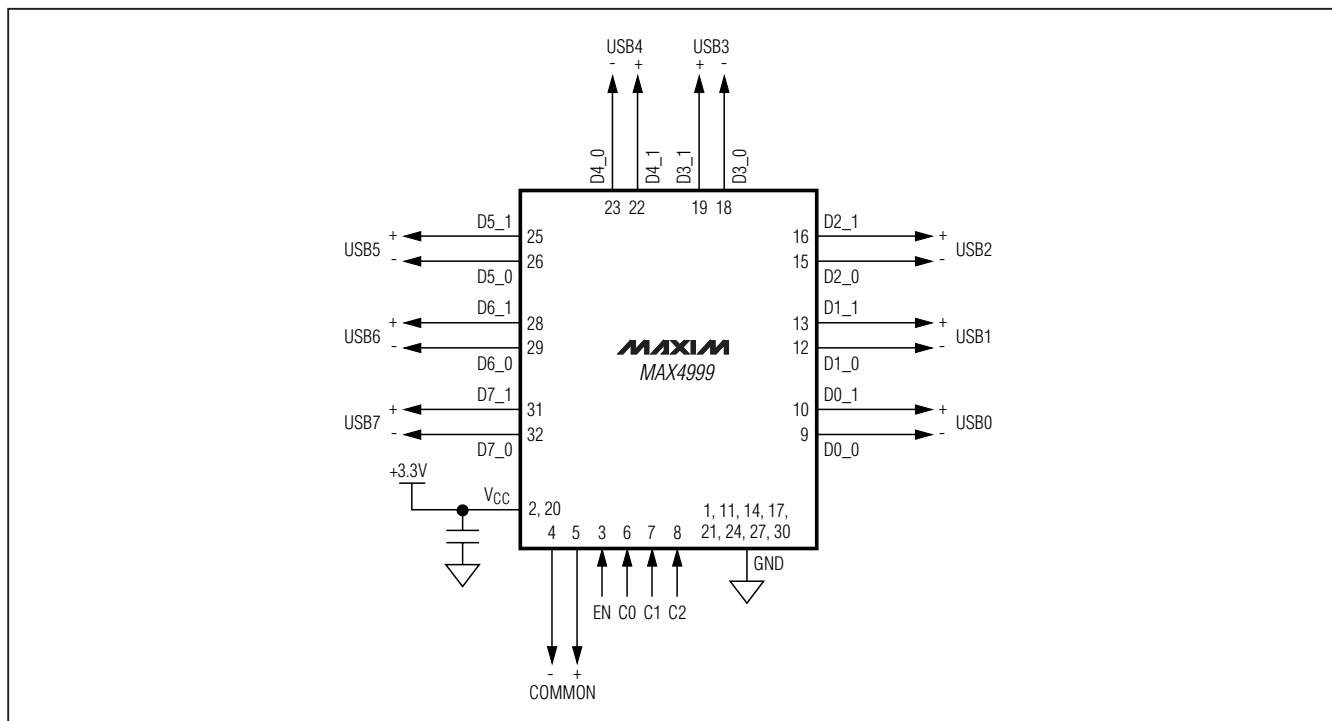


Figure 4. The MAX4999 Multiplexes Between Eight Differential Channels (8:1)

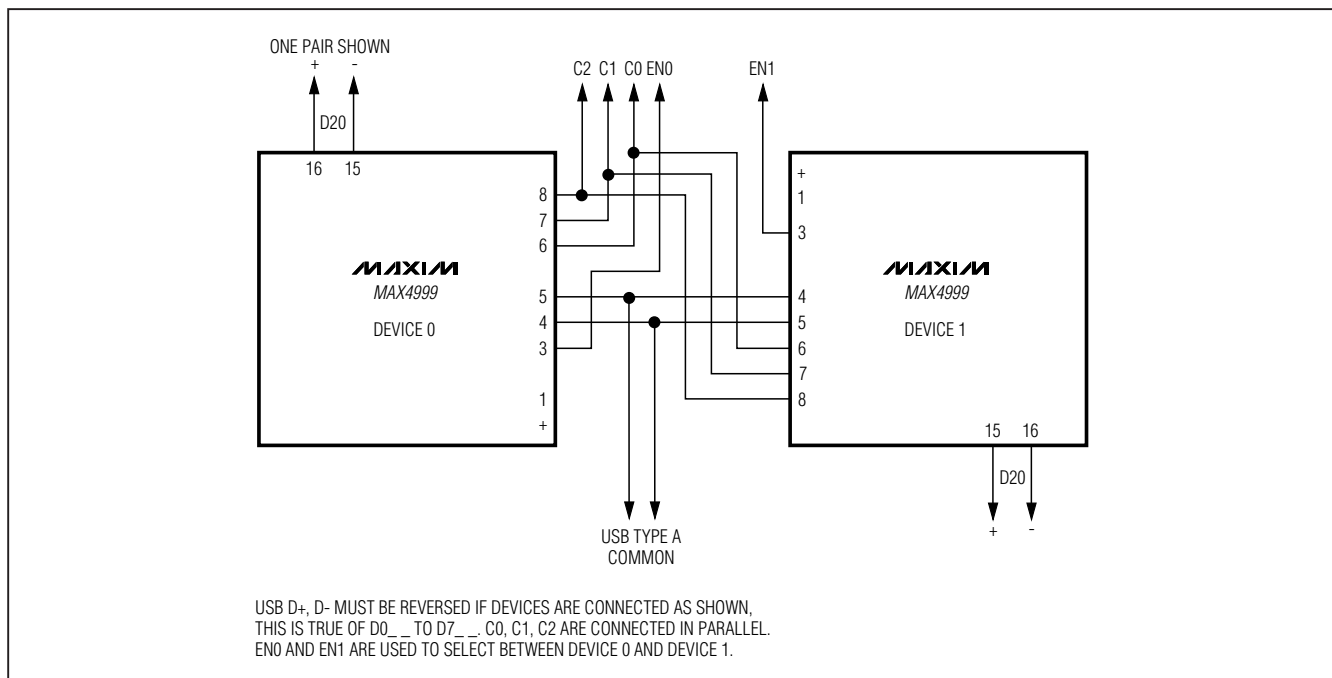


Figure 5. Combining Two MAX4999 Devices for 16:1 USB Connections

# USB 2.0 Hi-Speed Differential 8:1 Multiplexer

## Chip Information

PROCESS: CMOS

## 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.        |
|--------------|--------------|-------------------------|-------------------------|
| 32 TQFN      | T3255+4      | <a href="#">21-0140</a> | <a href="#">90-0012</a> |

# USB 2.0 Hi-Speed Differential 8:1 Multiplexer

## Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION                                                                                                                                                                                   | PAGES<br>CHANGED |
|--------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| 0                  | 5/08             | Initial release                                                                                                                                                                               | —                |
| 1                  | 6/11             | Added <i>Package Thermal Characteristics</i> ; renamed pins in Figure 4; changed pin references in <i>Electrical Characteristics</i> , Figures 3 and 5, TOCs, and <i>Functional Diagram</i> . | 2, 5, 6, 8, 9    |

MAX4999

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