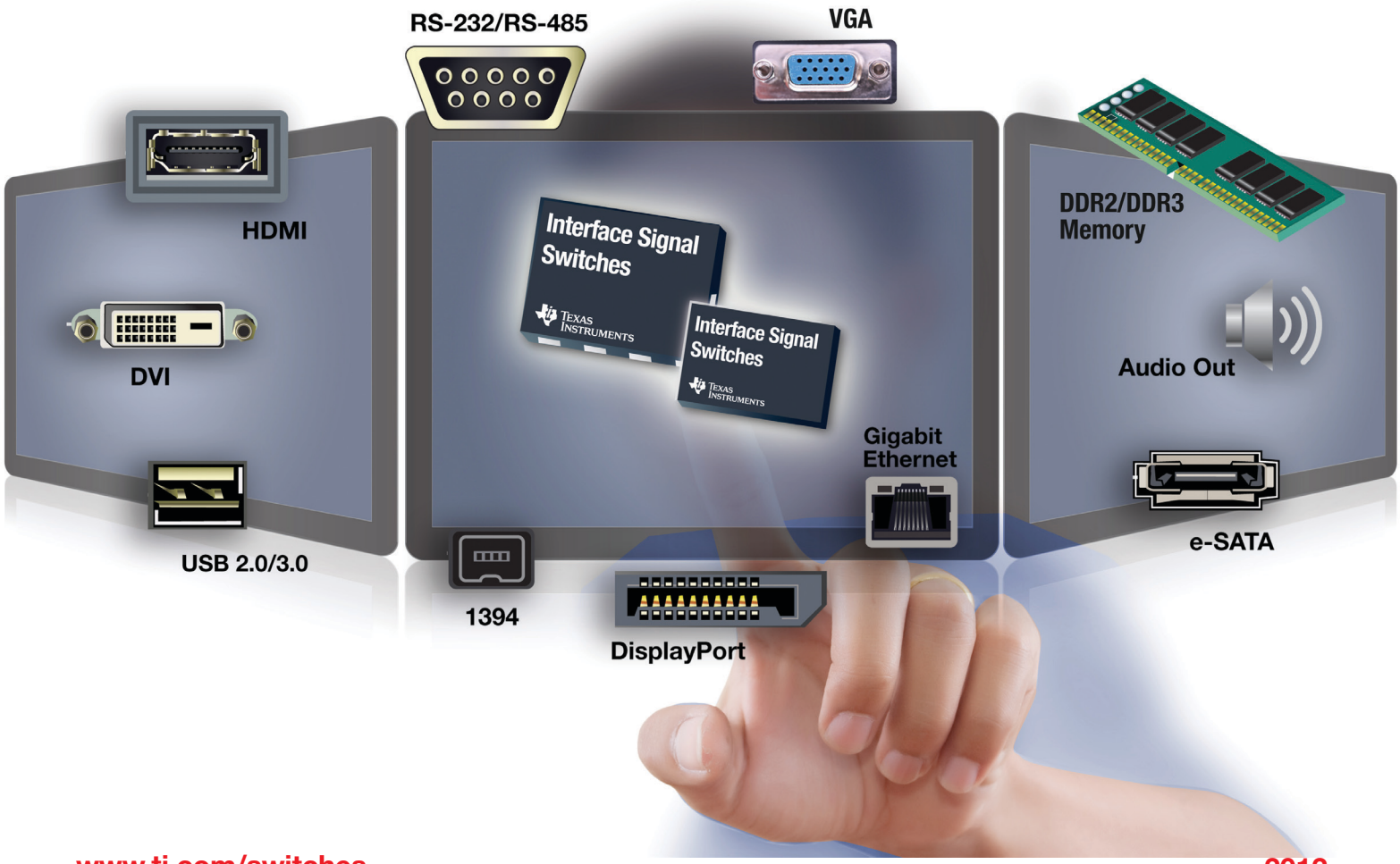
# Analog Switch Guide

The TI signal switch product portfolio consists of high-performance, low-power digital, analog and specialty switches.



## Table of Contents / Introduction

Today's competitive environment creates a constant need for higher performance. One common method to optimize system performance involves the use of FET switches (also referred to as signal switches) to provide a high-speed bidirectional bus interface between DSPs, CPUs, industry standard buses, memory and peripherals. The Texas Instruments (TI) signal switch product portfolio consists of digital switches, analog switches and specialty switches that provide high-performance, low-power replacements for standard bus-interface devices when signal buffering (current drive) is not required. Availability in advanced packaging (BGA, QFN and WCSP) also allows TI signal switches to occupy reduced board area in space-constrained applications. TI signal switches optimize next-generation datacom, networking, computing, portable communications and consumer electronic designs by supporting both digital and analog applications.



### Analog Switches

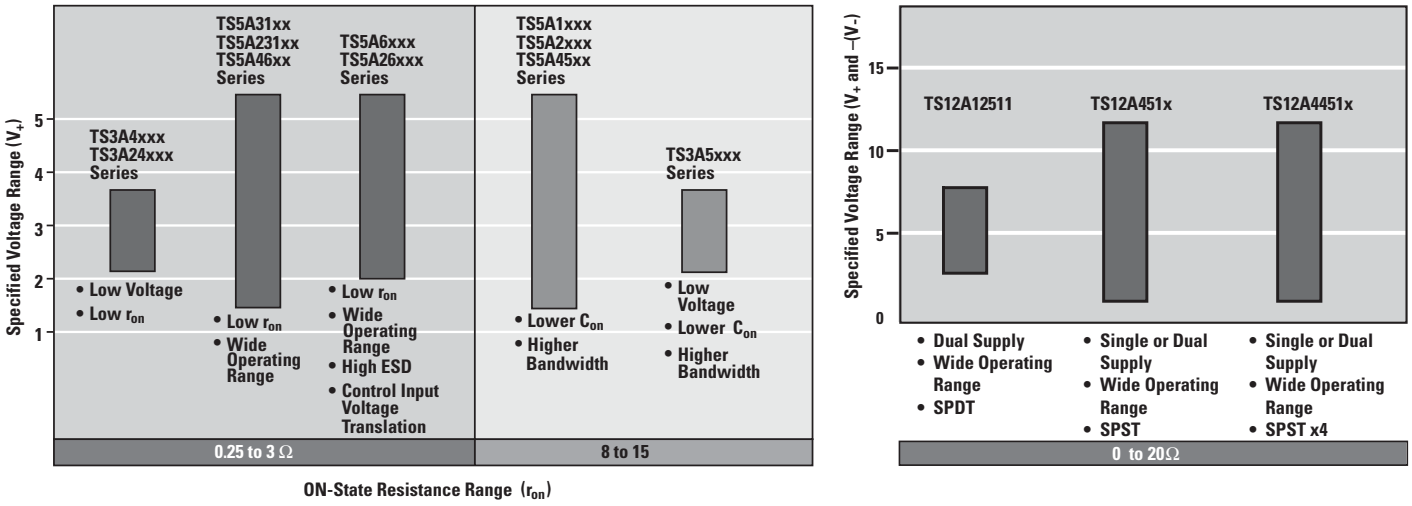
TI's analog switches are designed to pass (or isolate) analog signals (both voltage and current) and support analog applications such as audio and video data transmission. TI analog switches are available in a wide range of voltages (from 0.8 to 12 V), support fast data throughput (up to 2-GHz bandwidth) and offer low on-resistance and input capacitance for decreased signal distortion and insertion loss. TI analog switches are available in the TI Switch (TS) technology family. The TS product family encompasses a variety of analog switches with different ON resistances, bandwidth, charge injection, and total harmonic distortion to target any application.

## Switch Nomenclature

| TS-Series Analog and Speciality Switch Part Numbers | TS | 3 | V | 330 | R G Y | R |
|---|---|---|---|---|---|---|
| **Prefix:** TS = TI Signal switch, TSU = TI Smart switch | | | | | | |
| **Max V+ (VCC) Voltage:** 3 = 3.3 V, 5 = 5 V | | | | | | |
| **Type:** A = Analog switch, AP = Analog switch with over/undershoot protection, DV = Digital video switch V = Video switch, L = LAN switch, N = Network switch, PCIE = PCI Express® switch | | | | | | |
| **Typical Device Number** | | | | | | |
| **Typical Package Designator** | | | | | | |
| **Tape and Reel:** R or none = standard reel, T = small reel | | | | | | |

## Selecting the Right TI Analog Switch

### Analog Switch Family




When switches are first considered, a schematic of the ideal switch (similar to the one below) might come to mind. In figure 1, an input signal applied to the left I/O pin (or port) results in an identical output signal at the right I/O pin, and vice versa. However, in the real world, switches are not ideal; and there is always some loss. In the case of clean, properly working mechanical switches, the loss is so miniscule that it hardly bears noting.

### Ideal Switch

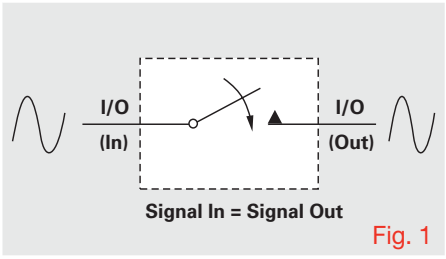



Fig. 1

Like mechanical switches, solid-state switches are not ideal either. In fact, losses associated with solid-state switches can be significant. Why use a switch like this if it is so far from ideal? The answer is convenience and reliability. Mechanical switches are subject to wear out and mechanical reliability issues. Solid-state switches are small, fast, easy-to-use and easy-to-control and consume relatively little power compared to traditional electrically controlled switches such as relays. The switches referred to here are Complementary Metal-Oxide Semiconductor (CMOS) Field-Effect Transistor (FET) switches.

### Digital vs. Analog Signal Switches

Digital switches are designed to pass (or isolate) digital signal levels and may exhibit the capability to satisfactorily pass analog signals. Examples are CBT and CBTLV switch families.

Analog switches are designed to pass (or isolate) analog signals and often exhibit good digital signal performance as well. One example is TI's TS technology.

TI offers a wide variety of signal switches, and sometimes the nomenclature can be confused to imply limited functionality for a device or family. However, it should be apparent the most important switch characteristic depends on how it is used:

- What V+ levels are present?
- What amplitude signals are required to be passed?
- What is the maximum signal distortion limit for the system?

The following are some things to consider when selecting the right analog switch.

### Analog Signal Considerations

V+ — For noncharge-pump switches, V+ determines the analog signal amplitude that can be passed without clipping. The gate(s) of the pass transistors must be biased relative to the minimum and maximum values of the expected input voltage range. Some switches allow for biasing from two supplies, making it easy to pass both positive and negative signals. Switches with integrated charge pumps can elevate the gate voltage above $V_+$ (at the expense of larger $I_+$) and thus pass signals of a magnitude greater than $V_+$.

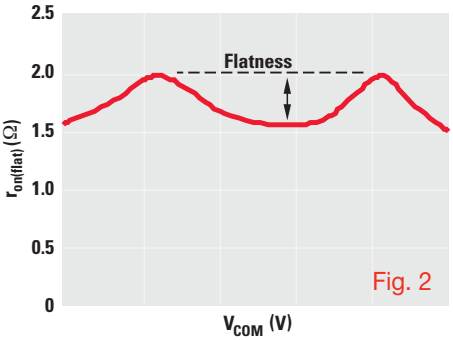
VIH/VIL — Why are these important analog switch considerations? In most applications, the signal switch is controlled by the output of a digital source; therefore, the control signal levels, $V_{IH}$ and $V_{IL}$, must be compatible with that source to ensure proper operation of the switch.

## Selecting the Right TI Analog Switch (Continued)

ON-State Resistance ($r_{ON}$) — Because $r_{ON}$ contributes to signal loss and degradation, low-$r_{ON}$ tradeoffs must be considered. Non-charge pump switches achieve low $r_{ON}$ with large pass transistors. These larger transistors lead to larger die sizes and increased $C_{I/O}$. This additional channel capacitance can be very significant, as it limits the frequency response of the switch. Switches using charge-pump technology can achieve low $r_{ON}$ and $C_{I/O}$ but require significantly higher $I_+$.

ON-State Resistance Flatness ($r_{ON(flat)}$) — Specifies the minimum and maximum value of $r_{ON}$ over the specified range of conditions. These conditions are typically changes in temperature or supply voltage. Figure 2 is an example of $r_{ON(flat)}$.

**Typical $r_{ON(flat)}$ Measurement**




On/Off Capacitance ($C_{ON}/C_{OFF}$) — Total switch and load capacitance must be considered because it can affect response time, settling time and fanout limits.

Frequency Response — All CMOS switches have an upper limit to the frequency that can be passed. No matter how low $r_{ON}$ and $C_{I/O}$ can be maintained in the chip manufacturing process, they still form an undesired low-pass filter that attenuates the switch output signal.

Sine-Wave Distortion or Total Harmonic Distortion (THD) — These are measurements of the linearity of the device. Nonlinearity can be introduced in a number of ways (design, device physics, etc.); but typically the largest contributor is $r_{ON}$, which varies with $V_{I/O}$ for all types of CMOS switches. Having a low $r_{ON}$ is important, but a flat $r_{ON}$ over the signal range is as equally important. For signal ranges of $0 < V_{I/O} < (V_+ - 2\ V)$, n-channel switches exhibit very flat $r_{ON}$ characteristics; but $r_{ON}$ increases very rapidly as $V_{I/O}$ approaches $V_+$ and VGS decreases. Parallel n-/p-channel switches offer good $r_{ON}$ flatness for signal ranges of $0 < V_{I/O} < V_+$, with the best flatness characteristic at the highest recommended switch $V_+$.

Crosstalk — There are two types of crosstalk to consider:

- Control (enable) to output — The level of crosstalk is a measure of how well decoupled the switch control signal is from the switch output. Due to the parasitic capacitance of CMOS processes, changing the state on the control signal causes noise to appear on the output. In audio applications, this can be a source of the annoying pop that is sometimes heard when switching the unit on or off.

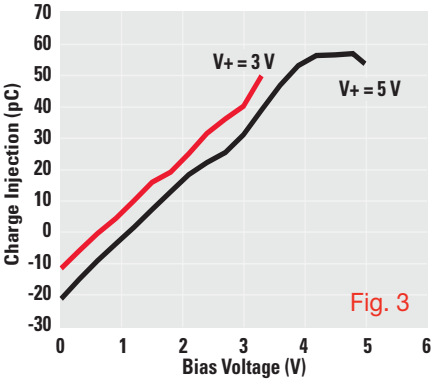
- Between switches — The level of crosstalk also is a measure of adjacent-channel rejection. As with control-to-output crosstalk, parasitic capacitance can couple the signal on one switch with that on another switch.

OFF Isolation — A measurement of OFF-state switch impedance. It is measured in dB at a specific frequency with the corresponding channel (NC to COM or NO to COM) in the OFF state.

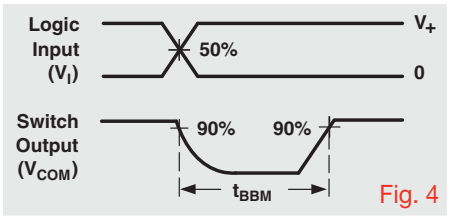
Feedthrough — This characteristic is related to the ability of the switch to block signals when off. As with crosstalk, parasitic capacitance allows high frequencies to couple through the switch, making it appear to be on.

Charge Injection (Q) — TI specifies enable-to-output crosstalk, and some competitors use this parameter. As with enable-to-output crosstalk, changing the state on the control pin causes a charge to be coupled to the channel of the transistor, introducing signal noise. It is presented in this report for a relative comparison with the competition. A graph of bias voltage vs. charge injection is displayed in figure 3 above.

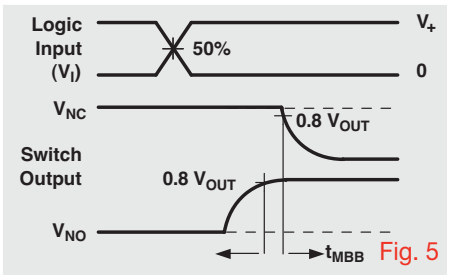
**Typical Charge Injection Plot**




**Typical BBM Timing**




**Typical MMB Timing**




Break-Before-Make (BBM) Time — Guarantees that two multiplexer paths are never electrically connected when the signal path is changed by the select input. This parameter is measured under a specified range of conditions and by the propagation delay between the output of two adjacent analog channels (NC and NO), when the control signal changes state (as shown in figure 4 above).

Make-Before-Break (MBB) Time — Guarantees that two multiplexer paths are never open when the signal path is changed by the select input. This parameter is measured under a specified range of conditions and by the propagation delay between the output of two adjacent analog channels (NC and NO), when the control signal changes state (as shown in figure 5 above).

# Selection Tables

## Analog Switch Configurations

| Device | $r_{ON}$ (typ) | $r_{ON}$ Flatness (typ) | $r_{ON}$ Mismatch (typ) | v + (v) min | v + (v) max | ESD | ON Time (ns) (typ) | OFF Time (ns) (typ) | Pins/Packages | Features |
|---|---|---|---|---|---|---|---|---|---|---|
| **SPST** | | | | | | | | | | |
| TS5A3166 | 0.9 | 0.15 | — | 1.65 | 5.5 | 2 kV HBM | 4.5 | 9 | 5/SC70,SOT-23, WCSP | |
| TS5A3167 | 0.9 | 0.15 | — | 1.65 | 5.5 | 2 kV HBM | 4.5 | 9 | 5/SC70,SOT-23, WCSP | |
| TS5A4594 | 8 | 1.5 | — | 2.7 | 5.5 | 2 kV HBM | 12 | 9 | 5/SC70,SOT-23 | |
| TS5A4595 | 8 | 1.5 | — | 2.7 | 5.5 | 2 kV HBM | 12 | 9 | 5/SC70,SOT-23 | |
| TS5A4596 | 8 | 1.5 | — | 2.7 | 5.5 | 2 kV HBM | 12 | 9 | 5/SC70,SOT-23 | |
| TS5A4597 | 8 | 1.5 | — | 2.7 | 5.5 | 2 kV HBM | 12 | 9 | 5/SC70,SOT-23 | |
| TS12A4514 | 6.5 | 1 | — | 3 | 12 | — | 22 | 20 | 8/SOIC, 8DIP, 5SOT-23 | |
| TS12A4515 | 6.5 | 1 | — | 3 | 12 | — | 22 | 20 | 8/SOIC, 8DIP, 5SOT-23 | |
| TS12A4516 | 12 | 1.2 | — | ±1.65 | ±6 | — | 58 | 28 | 8/SOIC, 8DIP, 5SOT-23 | Dual Supply |
| TS12A4517 | 12 | 1.2 | — | ±1.65 | ±6 | — | 58 | 28 | 8/SOIC, 8DIP, 5SOT-23 | Dual Supply |
| TS5A1066 | 7.5 | 2.5 | — | 1.65 | 5.5 | 2 kV HBM | 4.8 | 3 | 5/SC70,SOT-23, WCSP | |
| **SPST x 2** | | | | | | | | | | |
| TS5A23166 | 0.9 | 0.25 | 0.1 | 1.65 | 5.5 | 2 kV HBM | 4.5 | 8 | 8/US8,WCSP | |
| TS5A23167 | 0.9 | 0.25 | 0.1 | 1.65 | 5.5 | 2 kV HBM | 4.5 | 8 | 8/US8,WCSP | |
| TS5A2066 | 7.5 | 3.5 | 0.4 | 1.65 | 5.5 | 2 kV HBM | 5.2 | 2.6 | 8/USB, 8/SM8, 8/WCSP | |
| TS3A4741 | 0.7 | 0.23 | 0.03 | 1.65 | 3.6 | — | 5 | 4 | 8/SSOP/MSOP | |
| TS3A4742 | 0.7 | 0.23 | 0.03 | 1.65 | 3.6 | — | 5 | 4 | 8/SSOP/MSOP | |
| **SPST x 4** | | | | | | | | | | |
| TS3A4751 | 0.7 | 0.23 | 0.03 | 1.65 | 3.6 | 4 kV HBM | 5 | 4 | 14/TSSOP, SON, µQFN | |
| TS12A44513 | 6.5 | 1 | 2.5 | 2 | 12 | 2 kV HBM | 25 | 20 | 14/TSSOP, 14/SOIC | |
| TS12A44514 | 6.5 | 1 | 2.5 | 2 | 12 | 2 kV HBM | 25 | 20 | 14/TSSOP, 14/SOIC | |
| TS12A44515 | 6.5 | 1 | 2.5 | 2 | 12 | 2 kV HBM | 25 | 20 | 14/TSSOP, 14/SOIC | |
| **SPDT** | | | | | | | | | | |
| TS5A2053 | 7.5 | 1.7 | 0.8 | 1.65 | 5.5 | 2 kV HBM | 5.3 | 1.9 | 8/SM8/US8 | |
| TS5A3157 | 10 | 4 | 0.15 | 1.65 | 5.5 | 2 kV HBM | 6 | 3.5 | 6/SC70,SOT-23,WCSP | |
| TS5A63157 | 4 | 1.5 | 0.05 | 1.65 | 5.5 | 2 kV HBM | 3.4 | 2.8 | 6/SC70, SOT-23 | Undershoot/Overshoot Protection |
| TS12A12511 | 5 | 1.3 | 1 | ±2.7 | ±6, +12 | 2 kV HBM | 56 | 25 | 8/SON, 8/SOT-23, 8/MSOP | Single or Dual Supply |
| TS5A3153 | 0.8 | 0.09 | 0.05 | 1.65 | 5.5 | 2 kV HBM | 12.5 | 8.5 | 8/US8/WCSP | |
| TS5A3154 | 0.8 | 0.09 | 0.05 | 1.65 | 5.5 | 2 kV HBM | 5.2 | 9.5 | 8/US8/WCSP | |
| TS5A9411 | 5.3 | 0.03 | 2 | 2.25 | 5.5 | 2 kV HBM | 9 | 7 | 6/SC70 | |
| TS5A3159 | 0.75 | 0.15 | 0.1 | 1.65 | 5.5 | 2 kV HBM | 20 | 15 | 6/SC70, SOT-23 | |
| TS5A3159A | 0.7 | 0.1 | 0.05 | 1.65 | 5.5 | 2 kV HBM | 12 | 5 | 6/SC70,SOT-23,WCSP | |

## Selection Tables

### Analog Switch Configurations (Continued)

| Device | $r_{ON}$ (typ) | $r_{ON}$ Flatness (typ) | $r_{ON}$ Mismatch (typ) | v + (v) min | v + (v) max | ESD | ON Time (ns) (typ) | OFF Time (ns) (typ) | Pins/Packages | Features |
|---|---|---|---|---|---|---|---|---|---|---|
| **SPDT (continued)** | | | | | | | | | | |
| TS5A3160 | 0.7 | 0.1 | 0.05 | 1.65 | 5.5 | 2 kV HBM | 3.5 | 3.5 | 6/SC70, SOT-23 | |
| TS5A4624 | 0.7 | 0.1 | 0.05 | 1.65 | 5.5 | 2 kV HBM | 12 | 5 | 6/SC70 | |
| TS5A6542 | 0.5 | 0.1 | 0.05 | 2.25 | 5.5 | ±15 kV Contact (IEC L-4) | 12.5 | 9.5 | 8/WCSP, µQFN | |
| TS5A12301E | 0.5 | 0.1 | 0.05 | 2.25 | 5.5 | ±15 kV Air-Gap | 72 | 80 | 6/WCSP (0.4mm pitch) | 1.8-V Logic Compatible Logic Threshold Independently of V+ |
| **SPDT x 2** | | | | | | | | | | |
| TS5A23157 | 10 | 4 | 0.15 | 1.65 | 5.5 | 2 kV HBM | 5.7 | 3.8 | 10/MSOP, µQFN | |
| TS5A623157 | 4 | 4 | 0.15 | 1.65 | 5.5 | 2 kV HBM | 3.5 | 2.8 | 10/MSOP, µQFN | Overshoot/Undershoot Protection |
| TS5A23159 | 0.7 | 0.1 | 0.05 | 1.65 | 5.5 | 2 kV HBM | 8 | 5 | 10/MSOP/QFN | |
| TS3A24157 | 0.5 | 0.01 | 0.05 | 1.65 | 3.6 | 2 kV HBM | 20 | 12 | 10/ µQFN, VSSOP | Ultra-Low |
| TS3A24159 | 0.26 | 0.01 | 0.01 | 1.65 | 3.6 | 2 kV HBM | 20 | 12 | 10/WCSP, SON, VSSOP | $R_{ON}$ |
| TS5A26542 | 0.5 | 0.1 | 0.05 | 2.25 | 5.5 | ±15 kV Contact (IEC L-4) | 12.5 | 9 | 12/WCSP | |
| **TS3A225E** | 0.1 | — | — | 2.7 | 4.5 | ±8kV Contact Discharge (IEC L-4) | 21 | 21 | 16/WCSP, QFN | Autonomous Audio Headset Switch |
| **TS3A26746E** | 0.08 | — | — | 3 | 3.6 | ±8kV Contact Discharge (IEC L-4) | 150 | 5 | 6/WCSP | 2 X 2 Crosspoint Switch for Audio Applications |
| TS5A22362 | 0.52 | 0.076 | 0.04 | 2.3 | 5.5 | 2.5 kV HBM | 27 | 13 | 10/WCSP, 10/SON, VSSOP | Negative Rail Capability |
| TS5A22364 | 0.52 | 0.076 | 0.04 | 2.3 | 5.5 | 2.5 kV HBM | 27 | 13 | 10/WCSP, 10/SON, VSSOP | Negative Rail Capability, Click Pop Suppression |
| TS5A22366 | 0.7 | 0.135 | 0.05 | 2.25 | 5.5 | 2.5 kV HBM | 193 | 182 | 12/WCSP (0.4mm pitch), 10/µQFN | Negative Rail Capability |
| **SPDT x 4** | | | | | | | | | | |
| TS3A5018 | 7 | 5 | 0.3 | 1.65 | 3.6 | 2 kV HBM | 3.5 | 2 | 16/SOIC, SSOP, (QSOP), TSSOP, TVSOP, SON | |
| TS3A44159 | 0.3 | 0.07 | 0.045 | 1.65 | 4.3 | 2 kV HBM | 17 | 12 | 16/TSSOP, SON, µQFN | |
| **SPDT x 6** | | | | | | | | | | |
| TS3A27518E | 4.4 | 0.91 | 0.3 | 1.65 | 3.6 | ±6 kV Contact (IEC L-3) | 14.1 | 16.1 | 24BGA, SON | |
| **SP3T** | | | | | | | | | | |
| TS5A3359 | 0.7 | 0.1 | 0.1 | 1.65 | 5.5 | 2 kV HBM | 2.5 | 6 | 8/US8, 8/WCSP | |
| **SP4T x 2** | | | | | | | | | | |
| TS3A5017 | 11 | 7 | 1 | 2.3 | 3.6 | 2 kV HBM | 5 | 1.5 | 16/SOIC, SSOP, (QSOP), TSSOP, TVSOP, SON, µQFN | |

*New products are listed in bold red.*

## Selection Tables

### Analog Switch Configurations (Continued)

| Device | $r_{ON}$ (typ) | Normally Closed (NC) | Normally Open (NO) | Enable Pin | Break Before Make (BBM) | Make Before Break (MBB) | Over-/Undershoot Protectiom | $I_{OFF}$ |
|---|---|---|---|---|---|---|---|---|
| **SPST** | | | | | | | | |
| TS5A3166 | 0.9 | | X | | | | | X |
| TS5A3167 | 0.9 | X | | | | | | X |
| TS5A4594 | 8 | | X | | | | | |
| TS5A4595 | 8 | X | | | | | | |
| TS5A4596 | 8 | | X | | | | | |
| TS5A4597 | 8 | X | | | | | | |
| TS12A4514 | 6.5 | | X | | | | | |
| TS12A4515 | 6.5 | X | | | | | | |
| TS12A4516 | 12 | | X | | | | | |
| TS12A4517 | 12 | X | | | | | | |
| TS5A1066 | 7.5 | | X | | | | | |
| **SPST x 2** | | | | | | | | |
| TS5A23166 | 0.9 | | X(2) | | | | | X |
| TS5A23167 | 0.9 | X(2) | | | | | | X |
| TS5A2066 | 7.5 | | X(2) | | | | | |
| TS3A4741 | 0.7 | | X(2) | | | | | |
| TS3A4742 | 0.7 | X(2) | | | | | | |
| **SPST x 4** | | | | | | | | |
| TS3A4751 | 0.7 | | X(4) | | | | | |
| TS12A44513 | 6.5 | X(2) | X(2) | | | | | |
| TS12A44514 | 6.5 | | X(4) | | | | | |
| TS12A44515 | 6.5 | X(4) | | | | | | |
| **SPDT** | | | | | | | | |
| TS5A2053 | 7.5 | | | X | | | | |
| TS5A3157 | 10 | | | | | | | |
| TS5A63157 | 4 | | | | X | | X | X |
| TS12A12511 | 5 | | | | X | | | |
| TS5A3153 | 0.08 | | | X | X | | | X |
| TS5A3154 | 0.08 | | | X | | X | | X |
| TS5A9411 | 5.3 | | | | X | | | |
| TS5A3159 | 0.75 | | | | X | | | |
| TS5A3159A | 0.7 | | | | X | | | X |
| TS5A3160 | 0.7 | | | | X | | | X |

## Selection Tables

### Analog Switch Configurations (Continued)

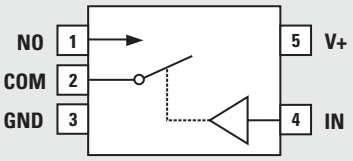
| Device | $r_{ON}$ (typ) | Normally Closed (NC) | Normally Open (NO) | Enable Pin | Break Before Make (BBM) | Make Before Break (MBB) | Over-/Undershoot Protectiom | $I_{OFF}$ |
|---|---|---|---|---|---|---|---|---|
| **SPDT (continued)** | | | | | | | | |
| TS5A4624 | 0.7 | | | | X | | | X |
| TS5A6542 | 0.5 | | | | X | | | |
| TS5A12301E | 0.5 | | | | X | | | X |
| **SPDT x 2** | | | | | | | | |
| TS5A23157 | 10 | | | | X | | X | X |
| TS5A623157 | 4 | | | | X | | X | |
| TS5A23159 | 0.7 | | | | X | | | X |
| TS3A24157 | 0.5 | | | | X | | | |
| TS3A24159 | 0.26 | | | | X | | | |
| TS5A26542 | 0.5 | | | | X | | | |
| **TS3A225E** | 0.1 | | | | X | | | X |
| **TS3A26746E** | 0.08 | | | | X | | | X |
| TS5A22362 | 0.52 | | | | X | | | |
| TS5A22364 | 0.52 | | | | X | | | |
| TS5A22366 | 0.7 | | | | X | | | |
| **SPDT x 4** | | | | | | | | |
| TS3A5018 | 7 | | | X | | | | |
| TS3A44159 | 0.3 | | | | X | | | |
| **SPDT x 6** | | | | | | | | |
| TS3A27518E | 4.4 | | | X | | | | X |
| **SP3T** | | | | | | | | |
| TS5A3359 | 0.7 | | | | X | | | X |
| **SP4T x 2** | | | | | | | | |
| TS3A5017 | 11 | | | X | | | | |

*New products are listed in bold red.*

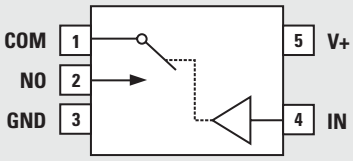
## Pinouts

### SPST

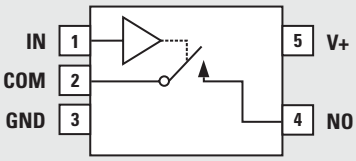
TS5A1066, TS5A3166



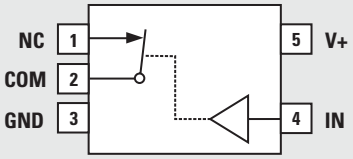

TS5A4594, TS12A4514, TS12A4516



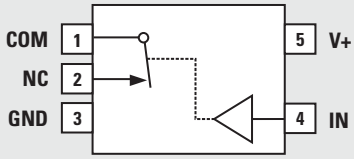

TS5A4596



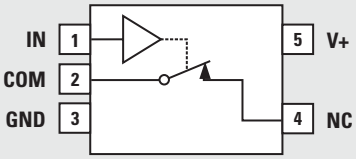

TS5A3167



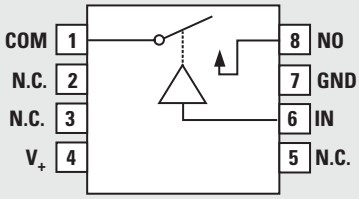

TS5A4595, TS12A4515, TS12A4517



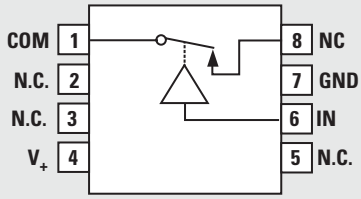

TS5A4597




TS12A4514, TS12A4516

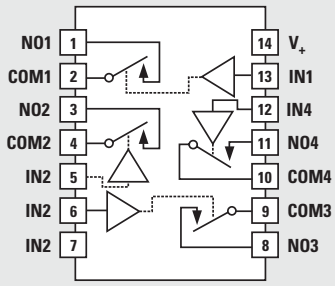



TS12A4515, TS12A4517

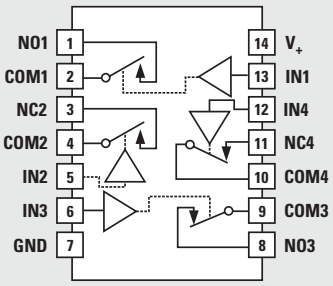



### SPST x 4

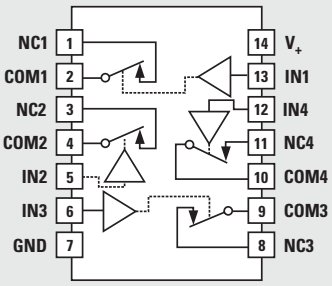
TS3A4751, TS12A44514




TS12A44513



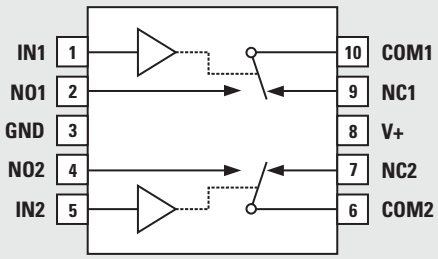

TS12A44515



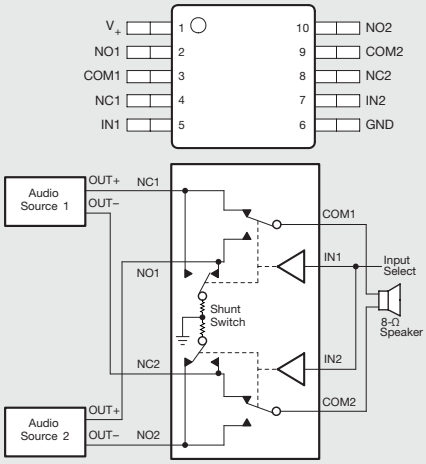
## Pinouts

### SPDT x 2

TS5A23157, TS5A23159, TS5A23160

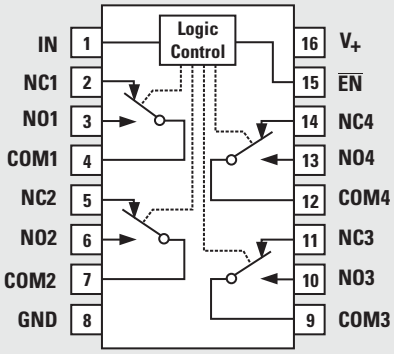



TS5A22364



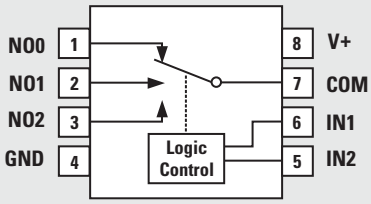

### SPDT x 4

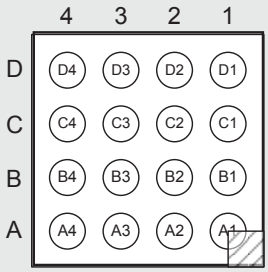
TS3A5018




### SP3T

TS5A3357, TS5A3359

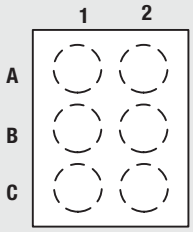



TSA225E

| | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| D | /MIC_PRESENT | TIP_SENSE | MICp | MICn |
| C | RING2 | GND(1) | VDD(1) | RING2_SENSE |
| B | SLEEVE | GND(1) | VDD(1) | SLEEVE_SENSE |
| A | DET_TRIGGER | ADDR_SEL | SDA | SCL |

YZP Package
(Top View)

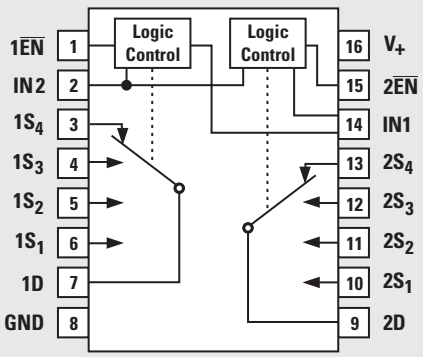



TS3A26746E

| | 1 | 2 |
|---|---|---|
| A | SEL | V+ |
| B | MIC | SLEEVE |
| C | GND | RING2 |

### SP4T x 2

TS3A5017



## Applications

### 2x2 Crosspoint Switch for Audio Applications

**TS3A26746E**

NEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts3a26746e**

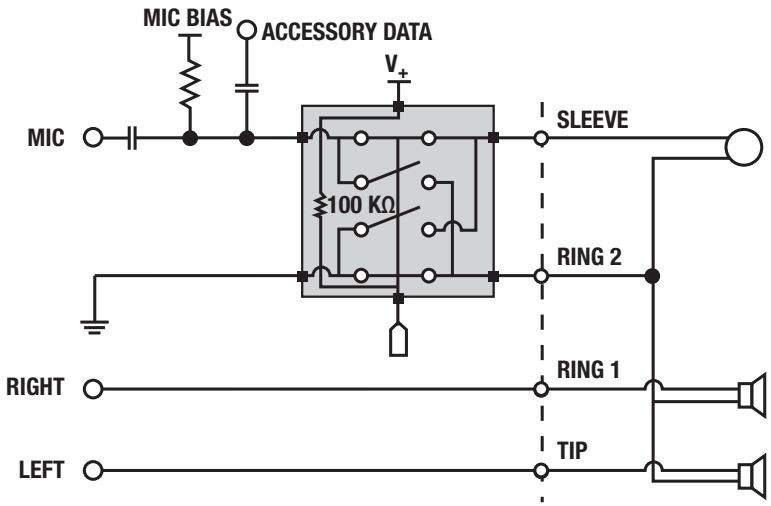
**Key Features**

- Superior PSRR performance (-75 dB)
- Control input is 1.8 V logic compatible
- ESD performance (SLEEVE, RING2)
  - o ±8-kV contact discharge (IEC 61000-4-2)
- 6-bump, 0.5 mm pitch CSP package (1.45 x 0.95 x 0.5 mm)

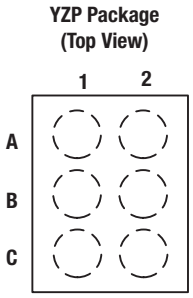
**Applications**

- Cellular phones
- Digital still cameras
- PDAs
- Portable instrumentation
- Portable navigation devices

The TS3A26746E is a 2 × 2 cross-point switch that is used to interchange the ground and MIC connections on a headphone connector. The ground switch has an ultra low $r_{ON}$ of <0.1 Ω to minimize voltage drop across it, preventing undesired increases in headphone ground reference voltage. The switch state is controlled via the SEL input. When SEL=High, GND is connected to RING2 and MIC is connected to SLEEVE. When SEL=Low, GND is connected to SLEEVE and MIC is connected to RING2. An internal 100k pull-up resistor on the SEL input sets the default state of the switch. This device effectively switches the GND and MIC lines to the appropriate coordinates with minimal signal distortion and power loss.




*Typical application block diagram.*




| | 1 | 2 |
|---|---|---|
| A | SEL | V+ |
| B | MIC | SLEEVE |
| C | GND | RING2 |

# Applications

## Audio Headset Switch Device
## TS3A225E

NEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts3a225e**

### Key Features

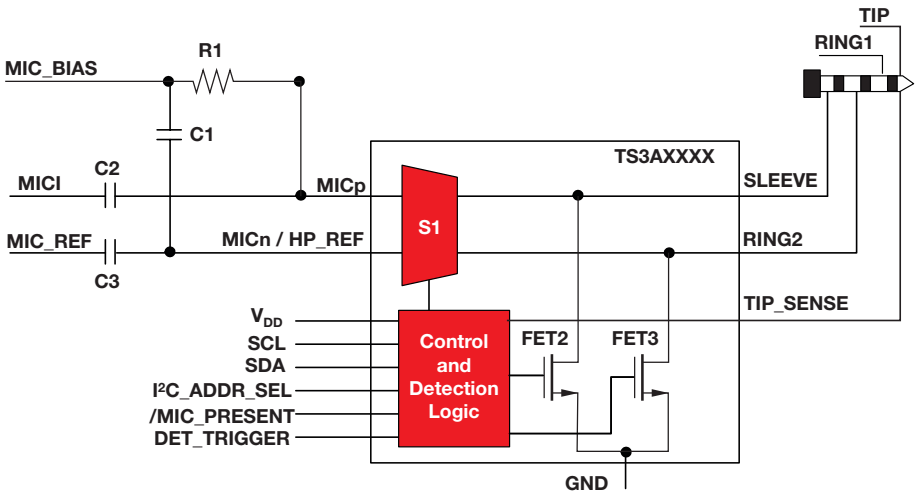
- $V_{DD}$ range = 2.7 V to 4.5 V
- Break-before-make stereo jack switches
- Ultra-low resistance ground FET switches (< 100 mΩ)
- HDA compatible MIC present indicator
- Optional $I^2C$ switch control
- 95 dB audio isolation
- IEC ESD protection on stereo jack pins
- ±8-kV contact discharge (IEC 61000-4-2)
- ESD performance tested per JESD 22 (all pins)
- 2-kV Human Body Model (HBM) (A114-B, Class II)

### Applications

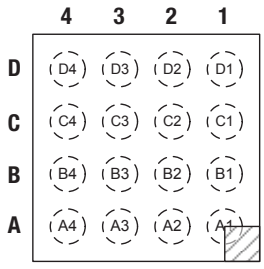
- Mobile phones
- Mobile music players
- Notebook computers
- Mobile audio applications

The TS3A225E is an audio headset switch device. The device detects the presence of an analog microphone and switches a system analog microphone pin between different connectors in an audio stereo jack. The microphone connection in a stereo connector can be swapped with the ground connection depending on manufacturer. When the device detects a certain configuration, it automatically connects the microphone line to the appropriate pin. The device also reports the presence of an analog microphone on an audio stereo jack.

In some systems, it is desirable to connect the stereo jack pin to ground. The TS3A225E provides two internal low resistance (<100 m) FET switches for ground shorting.




YFF Package
(Top View)



## Applications

### ±6 V, +12 V 5-Ω SPDT Analog Switch
### TS12A12511

Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts12a12511**

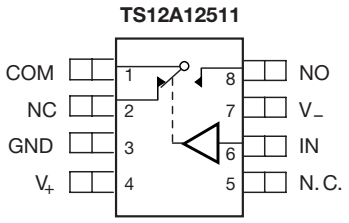
**Key Features**

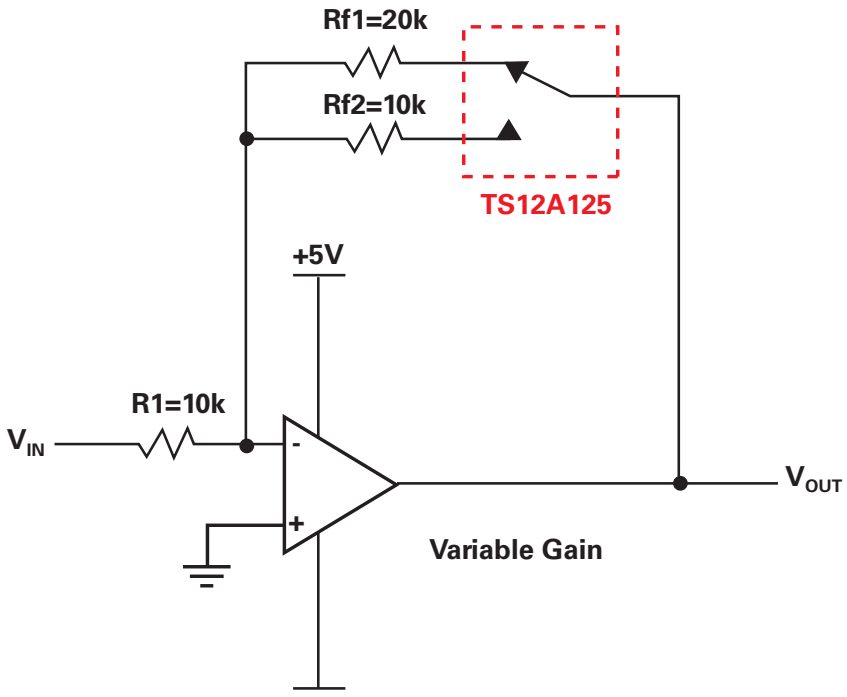
- ±2.7 V to ±6 V dual-supply operation
- +2.7 V to +12 V single-supply operation
- ON-state resistance: 8 Ω max with ±5 V supply
- Low ON and OFF-leakage currents: ±1 nA at 25°C, ±50 nA at 85°C
- Fast switching speed: $t_{ON}$=115 ns, $t_{OFF}$=56 ns (±5 V supply)
- Break-before-make operation
- +3.3 V, +5 V compatible digital control inputs
- Available in 8-pin MSOP, SOT, QFN packages

**Applications**

- Automatic test equipment
- Power routing
- Communication systems
- Data acquisition systems
- Sample-and-hold systems
- Relay replacement
- Battery-powered systems

The TS12A12511 is a single-pole double-throw (SPDT) analog switch capable of passing signals with swings of 0 to 12 V or –6 to 6 V. This switch conducts equally well in both directions when it is on. It also offers a low ON-state resistance of 5 (typical), which is matched to within one between channels. The max current consumption is <1 µA and –3 dB bandwidth is >93 MHz. The TS12A12511 exhibits break-before-make switching action, preventing momentary shorting when switching channels. This device is available packaged in an 8-lead MSOP, 8-lead SOT-23, and 8-pin QFN.




*TS12A12511 variable gain.*

## Applications

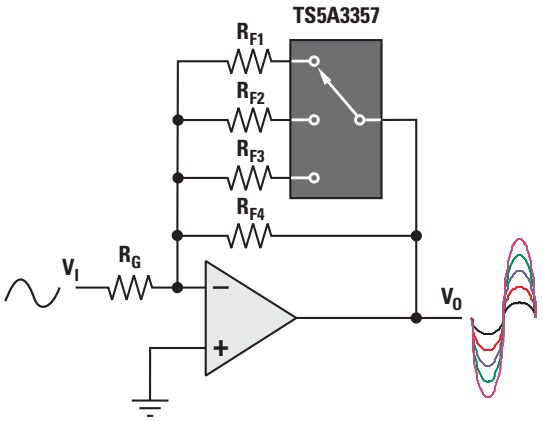
### Single 5-Ω SP3T Analog Switch—5-V/3.3-V 3:1 Analog Multiplexer/Demultiplexer
### TS5A3357

Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts5a3357**

**Key Features**
- Specified break-before-make switching
- Low ON-state resistance
- High bandwidth
- Control inputs are 5.5-V tolerant
- Low charge injection
- Excellent ON-state resistance matching
- Low total harmonic distortion
- 1.65- to 5.5-V single-supply operation

**Applications**
- High-performance analog audio switching
- Audio signal routing/MUXing from three sources
- Simplified large PCB routing, especially on space-constrained PCBs

The TS5A3357 is a high-performance, single-pole, triple-throw (SP3T) analog switch designed to operate from 1.65 V to 5.5 V. It offers low ON-state resistance and low I/O capacitance for very low signal distortion. The break-before-make feature allows transfer of a signal from one port to another with minimal signal distortion. This device also offers a low charge injection, which makes it suitable for high-performance audio and data acquisition systems.




*Amplifier gain adjustment.*

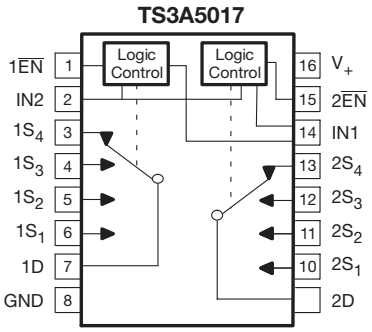
### Dual SP4T Analog Switch
### TS3A5017

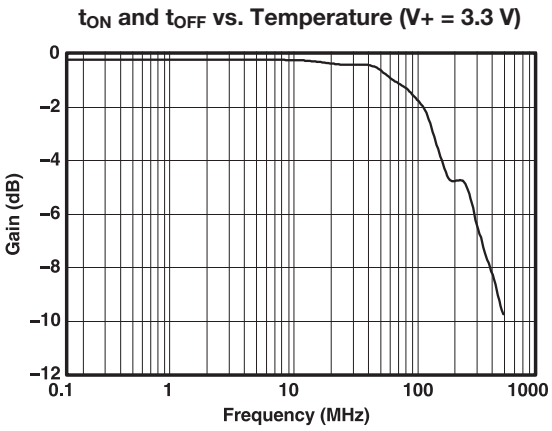
Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts3a5017**

**Key Features**
- Isolation in the powered-down mode, V+ = 0
- Low ON-state resistance
- Low charge injection
- Excellent ON-state resistance matching
- Low total harmonic distortion (THD)
- 2.3-V to 3.6-V single-supply operation
- Latch-up performance exceeds 100 mA per JESD 78, class II
- ESD performance tested per JESD 22

**Applications**
- Sample and hold circuits
- Battery-powered equipment
- Audio and video signal routing
- Communication circuits

The TS3A5017 is a dual single-pole quadruple-throw (4:1) analog switch that is designed to operate from 2.3 V to 3.6 V. This device can handle both digital and analog signals, and signals up to V+ can be transmitted in either direction.



## Applications

### Dual/Single SPDT Analog Switches with Input Logic Translation and IEC ESD

### TS5A26542, TS5A6542, TS5A12301E

Get samples, data sheets and app reports at: **www.ti.com/sc/device/PARTnumber**

#### Key Features

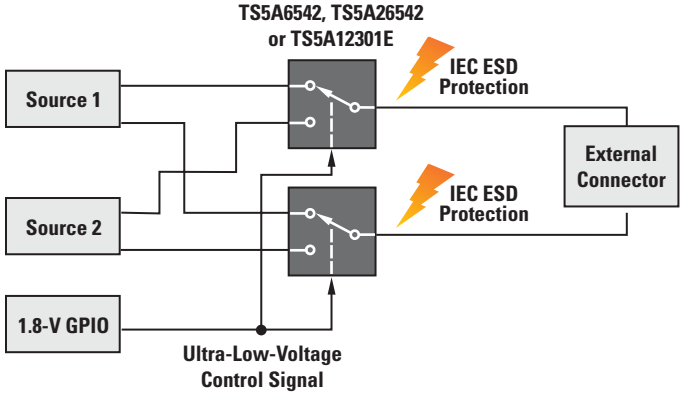
- Specified break-before-make switching
- Low ON-state resistance (0.75 Ω typ)
- Low charge injection
- Excellent ON-state resistance matching
- Low total harmonic distortion
- 2.25- to 5.5-V power supply ($V_+$)
- 1.8 V logic compatible thresholds
  - TS5A6542 and TS5A26542: $V_{IO}$ bias used to allow low threshold control voltage
  - TS5A12301E: Low threshold voltage independent of $V_+$ and no use of additional bias ($V_{IO}$)
  - No need for separate translation devices
- ESD performance tested per JESD 22
  - 2000-V Human Body Model (HBM) (A114-B, Class II)
  - 1000-V charged-device model (C101)
- Common inputs
  - ±15-kV IEC61000-4-2, contact discharge for TS5A26542 and TS5A6542
  - Comm inputs can be interfaced to the external world due to IEC ESD compliance
  - No need for separate ESD devices

#### Applications

- Cell phones
- PDAs
- Portable instrumentation

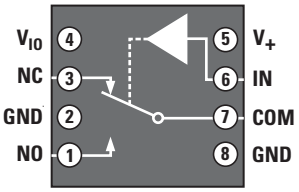
The TS5A26542, TS5A6542, and TS5A12301E are single-pole double-throw (SPDT) analog switches that are designed to operate from 2.25 V to 5.5 V. The TS5A26524 is a dual SPDT, whereas the TS5A6542 and TS5A12301E are single SPDT switches. The devices offer a low ON-state resistance with an excellent channel-to-channel ON-state resistance matching, and the break-before-make feature to prevent signal distortion during the transferring of a signal from one path to another.

These devices have excellent total harmonic distortion (THD) performance and consume very low power. These features make them suitable for portable audio applications. All of the switches can be controlled by 1.8-V signals.

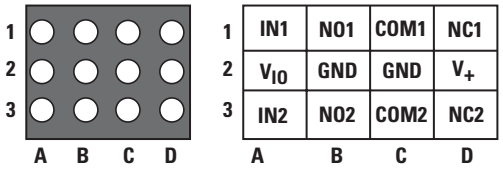



*IEC ESD protection on analog switch outputs.*

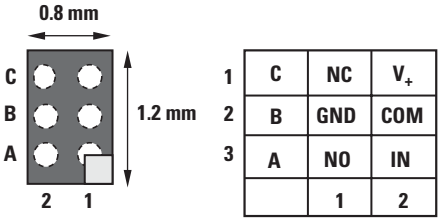
#### Package Pinouts




*TS5A6542 WCSP (YZP) package (bottom view).*




*TS5A26542 WCSP (YZP) package (bottom view).*




*TS5A12301E WCSP (YFP) package (top view).*

## Applications

### 0.6-Ω Dual Analog Switches

### TS5A22362/4/6

Get samples, data sheets and app reports at: **www.ti.com/sc/device/PARTnumber**

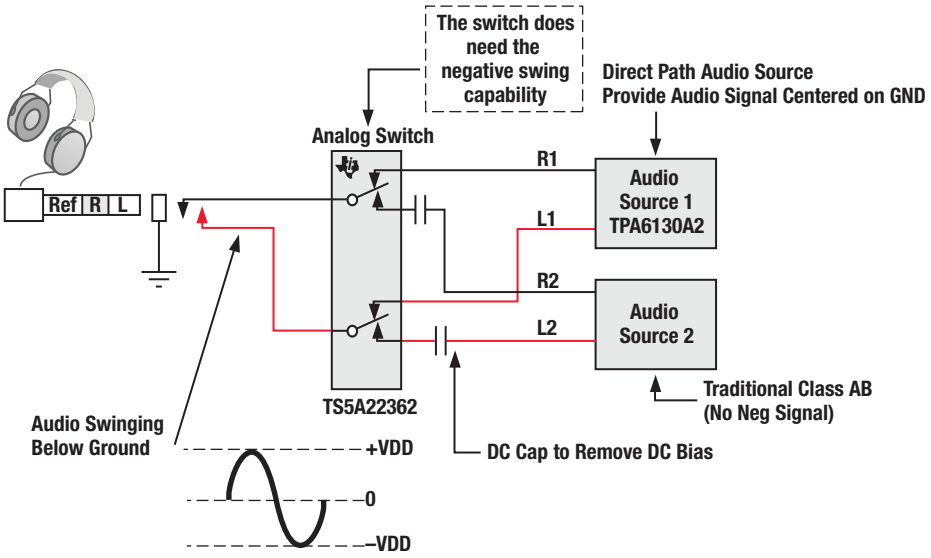
**Key Features**

- Negative signaling capability: Analog I/O range = $V_+$ –5.5 V to $V_+$
- Internal shunt switch prevents audible click-and-pop when switching between two sources (TS5A22364 only)
- Low ON-state resistance (0.65-Ω typ)
- Low charge injection
- Excellent ON-State resistance matching
- 2.3-V to 5.5-V power supply ($V_+$)
- TS5A22362/TS5A22364 packaging options:
  - 10-WCSP (0.5 mm pitch – YZP) 1.9 x 1.4
  - SON-10 (DRL) 3 x 3
  - VSSOP-10 (DGS) 4.9 x 3

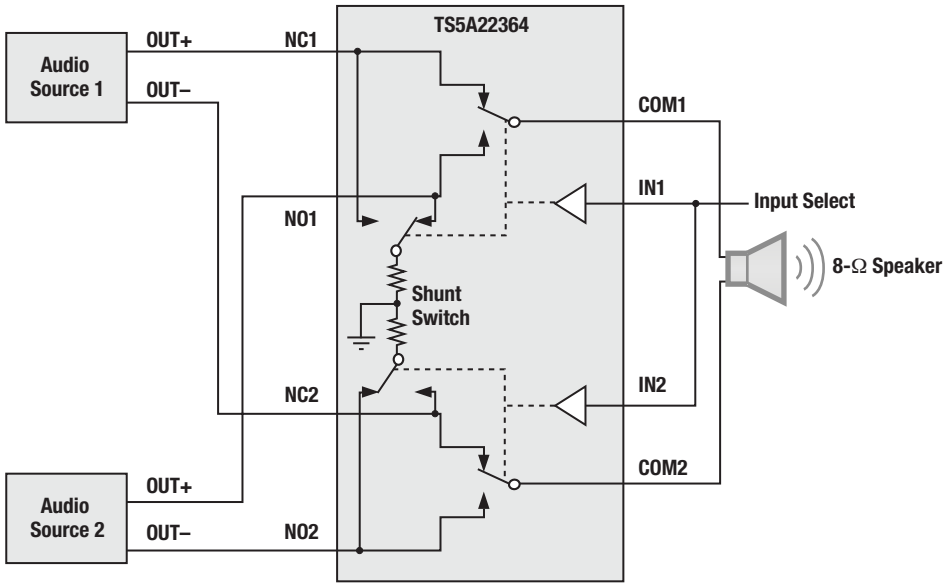
**Applications**

- Cell phones
- PDAs
- Portable instrumentation
- Audio routing

The TS5A22362, TS5A22364, and TS5A22366 are dual single-pole double-throw (SPDT) analog switches that are designed to operate from 2.25 to 5.5 V. The devices feature negative signal capability that allow signals below ground to pass through the switch without distortion. The break-before-make feature prevents signal distortion during the transferring of a signal from one path to another. Low ON-state resistance, excellent channel-to-channel ON-state resistance matching, and minimal total harmonic distortion (THD) performance make these switches ideal for audio applications.




*Direct path amplifier – negative rail capability.*




*TS5A22364 – negative rail capability and click-pop suppression*

## Selection Tables

| Device | Configuration | $V_{CC}$ ($V_{DD}$) (min) (V) | $V_{CC}$ ($V_{DD}$) (max) (V) | $r_{ON}$ (typ) (Ω) | Bandwidth (MHz) | Crosstalk (dB) | Off Isolation (dB) | $I_{CC}$ ($I_{DD}$) (typ)(µA) | Pins/ Packages | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| **Video Switch** | | | | | | | | | | |
| TS3DV20812 | 8-channel SPDT | 2.25 | 3.6 | 4 | 1100 | –35 | –20 | 250 | 36/QFN | 2 Gbps Differential Switch, 8-Ch with 3-Side Band Signals |
| TS3DV421 | 8-channel SPDT | 1.5 | 2.1 | 12.5 | 1900 | –50 | –50 | 230 | 42/QFN, 48/TVSOP | 4-Ch Differential 8:16 Mux Switch for DVI/ HDMI |
| TS3DV520E | 10-channel SPDT | 3 | 3.6 | 4 | 950 | –37 | –37 | 250 | 42/QFN, 56/QFN | 5-Ch Differential 10:20 Mux Switch for DVI/HDMI |
| **TS3DV621** | 12-channel SPDT | 3 | 3.6 | 8 | 2200 | –43 | –42 | 300 | 42/QFN, | 12-Channel 1:2 MUX/DEMUX Switch with Integrated 4-Channel Sideband Signal Switching |
| TS3V712E | 7-channel SPDT | 3 | 3.6 | 3 | 1360 | –50 | –38 | 200 | 32/QFN | 7-Ch Video Switch |
| **TS3V712EL** | 7-channel SPDT | 3 | 3.6 | 4 | 1300 | –47 | –38 | 200 | 32/WQFN | 7-Ch, 1:2 Video Switch With Integrated Level Shifters |
| **TS3V713EL** | 7-channel SPDT | 3 | 3.6 | 4 | 1300 | –50 | –40 | 200 | 32/WQFN | 7-Ch, 1:2 Video Switch With Integrated Level Shifters |
| **SLAN Switch** | | | | | | | | | | |
| TS3L500 | 8-channel SPDT | 3 | 3.6 | 4 | 1100 | –37 | –37 | 250 | 56/QFN | 16-Bit to 8-Bit SPDT Bigabit LAN Switch with Low Flat $r_{ON}$ |
| TS3L500AE | 8-channel SPDT | 3 | 3.6 | 4 | 950 | –37 | –37 | 250 | 56/QFN | 16-Bit to 8-Bit SPDT Gigabit LAN Switch with LED Switch and Enhanced ESD Protection |
| **TS3L501E** | 16-channel SPDT | 3 | 3.6 | 4 | 600 | –37 | –37 | 250 | 42/WQFN | 16-Bit To 8-Bit Multiplexer/Demultiplexer Gigabit Ethernet LAN Switch with Power Down Mode |
| **PCI Express Signal Switch** | | | | | | | | | | |
| TS2PCIE2212 | 4-channel SPDT | 1.7 | 1.9 | 10 | 1250 | –39 | –38 | 160 | 48/PBGA | PCIe Gen-I Signal Switch |
| TS2PCIE412 | 16-channel SPDT | 1.5 | 2.1 | 12 | 2100 | –81 | –74 | — | 42/QFN | x2 4-Ch PCIe 2:1 Multiplexer/Demultiplexer PCIe Gen-I Switch |
| **Network Signal Switch** | | | | | | | | | | |
| TS5N118 | Cross-Point | 4.75 | 5.25 | 3 | 25 | –50 | –50 | 10000 | 16/SSOP, TSSOP | 1-Bit 1-of-8 FET Multiplexer/Demultiplexer for DS1 and DS3 Signal Levels |
| TS5N214 | Cross-Point | 4.75 | 5.25 | 3 | 25 | –50 | –50 | 10000 | 16/SSOP, TSSOP | 2-Bit 1-of-4 FET Multiplexer/Demultiplexer for DS1 and DS3 Signal Levels |
| TS5N412 | Cross-Point | 4.75 | 5.25 | 3 | 25 | –50 | –50 | 10000 | 16/SSOP, TSSOP | 4-Bit 1-of-2 FET Multiplexer/Demultiplexer for DS1 and DS3 Signal Levels |
| **USB 2.0 Signal Switch** | | | | | | | | | | |
| TS3USB221 | 2-channel SPDT | 2.3 | 3.6 | 6 | 1100 | –40 | –41 | 30 | 10/SON, 10/QFN | High-Speed USB 2.0 (480 Mbps) 1:2 Mux/ Demux Switch with Single Enable |
| TS3USB221A | 2-channel SPDT | 2.3 | 3.6 | 3 | 900 | –39 | –40 | 30 | 10/QFN | High-Speed USB 2.0 (480 Mbps) 1:2 Mux/ Demux Switch with Single Enable with 12kV HBM ESD Protection |
| TS3USB31 | 2-channel SPST | 3 | 4.3 | 6 | 1220 | –53 | –30 | 1 | 8/µQFN | High-Speed USB 2.0 (480 Mbps) 1:1 Switch |
| TS3USB31E | 2-channel SPST | 2.25 | 4.3 | 6.4 | 1100 | –53 | –30 | 1 | 8/µQFN | High-Speed USB 2.0 (480 Mbps) 1:1 Switch with 15kV HBM ESD Protection |
| **TS5USBA224** | 2-channel SPDT | 2.7 | 5.5 | 4 | 650 | –31 | –22 | 6 | 10/µQFN | USB 2.0 High-Speed (480 Mbps) and Audio Switches with Negative Signal Capability and 1.8-V Logic Compatibility |
| TS3USB30 | 2-channel SPDT | 3 | 4.3 | 6 | 955 | –56 | –39 | 1 | 10/UQFN | High-Speed USB 2.0 (480 Mbps) 1:2 Mux/Demux Switch with Single Enable |
| TS3USB30E | 2-channel SPDT | 3 | 4.3 | 6 | 900 | –54 | –40 | 1 | 10/VSSOP, 10/TQFN | High-Speed USB 2.0 (480 Mbps) 1:2 Mux/Demux Switch with Single Enable with 15kV HBM ESD Protection |

*New products are listed in bold red.*

## Selection Tables

| Device | Configuration | $V_{CC}$ ($V_{DD}$) (min) (V) | $V_{CC}$ ($V_{DD}$) (max) (V) | $r_{ON}$ (typ) (Ω) | Bandwidth (MHz) | Crosstalk (dB) | Off Isolation (dB) | $I_{CC}$ ($I_{DD}$) (typ) (µA) | Pins/Packages | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| **USB 2.0 Signal Switch continued** | | | | | | | | | | |
| TS3DS10224 | 2-channel 2:4 MUX | 3 | 3.6 | 10 | 1200 | –30 | –30 | 50 | 20/QFN | High-Speed 2:4 Differential Multiplexer / Demultiplexer |
| TS3USBA225 | 2-channel SP3T | 2.7 | 4.3 | 6.5 | 1900 | –45 | –35 | 25 | 12/UQFN | USB 2.0 High-Speed (480 Mbps) and Audio Switches with Negative Signal Capability and 1.8-V Logic Compatibility and Power-Down Mode |
| TS3USB3200 | 3-channel SPDT | 2.7 | 4.3 | 5.7 | 6000 | –83 | –83 | 30 | 16/QFN | DPDT USB 2.0 Hligh-Speed (480Mbps) and Mobile High-Definition Link (MHL) Switch with ID Select and Flexible Power Control |
| **DDR Memory Module Switches** | | | | | | | | | | |
| TS2DDR2811 | 8-channel SPST | 3 | 3.6 | 4 | 1100 | –37 | –37 | 250 | 20/BGA | 1-GHz Bandwidth, 8-Channel SPST Switch for DDR2 |
| TS3DDR3812 | 16-chanel SPDT | 3 | 3.6 | 8 | 1675 | –43 | –42 | 300 | 42/WQFN | 12-Channel, 1:2 MUX/DEMUX Switch for DDR3 Applications |

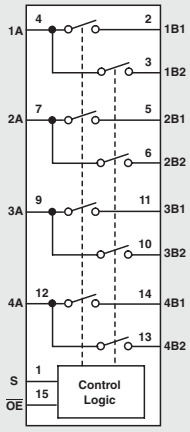
| Device | Configuration | | nCH | $V_{cc}$ ($V_{dd}$) (min) (V) | $V_{cc}$ ($V_{dd}$) (max) (V) | $r_{ON}$ (max) (Ω) | Bandwidth (MHz) | Crosstalk (dB) | Off Isolation (dB) | $I_{CC}$ ($I_{DD}$) Max (µA) | Pins/ Packages | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Smart Switch** | | | | | | | | | | | | |
| TSU5511 | Dual SP3T + SPST | Audio | 2 | –1.3 | 1.3 | 6 | 788 | –120 | –100 | 70 | 20 WCSP | Micro-USB Connector to UART and Audio Switches with ID Detection and Charger Detection |
| | | Mic | 1 | 0 | 2.3 | 12 | 573 | –125 | –37 | | | |
| | | USB | 2 | 0 | 3.6 | 10 | 830 | –42 | –20 | | | |
| | | UART | 2 | 0 | 4.4 | 61 | 295 | –98 | –100 | | | |
| TSU6111/A | Dual SP2T | USB | 2 | 0 | 4.4 | 18 | 950 | –32 | –26 | | 16/QFN | Micro-USB Connector to UART and USB Switches with ID Detection and Charger Detection |
| | | UART | 2 | 0 | 4.4 | 18 | 950 | –32 | –26 | | | |
| TSU6712/A | Dual SP3T + Dual SPST | Audio | 2 | –0.8 | 0.8 | 5.5 | 100 | –100 | –100 | 150 | 25/WCSP | Micro-USB connector to UART, USB, Audio and Video Switches with ID Detection and Charger Detection |
| | | Mic | 1 | 0 | 2.3 | 70 | 40 | –100 | –95 | | | |
| | | USB | 2 | –0.5 | 2 | 18 | 400 | –78 | –58 | | | |
| | | UART | 2 | 0 | 4.4 | 15 | 480 | –40 | –24 | | | |
| TSU5611 | Dual SP3T + SPST | Audio | 2 | –1.3 | 1.3 | 3.8 | 900 | –100 | –100 | 60 | 20/WLBGA | DP3T Switch with Impedence Detection Micro-USB Switch To Support USB, UART, Audio, and Charger Detection |
| | | Mic | 1 | 0 | 2.3 | 9 | 573 | –100 | –55 | | | |
| | | USB | 2 | 0 | 3.6 | 4.5 | 920 | –40 | –29 | | | |
| | | UART | 2 | 0 | 3.6 | 4.5 | 920 | –40 | –29 | | | |
| TSU8111 | Dual SPDT + charger | USB | 2 | 0 | 3.6 | 8 | 920 | –32 | –26 | 100 | 20/BGA | Single-Cell Charger and USB SP2T Switch Supports USB & UART |
| | | UART | 2 | 0 | 3.6 | 8 | 920 | –32 | –26 | | | |
| BQ24392 | Dual SPST + charger detection | USB | 2 | 0 | 3.6 | 8 | 920 | –32 | –26 | 250 | 10/QFN | Charger Detection Device with High Speed USB Switch Battery Charger Specification v1.2 |
| TSU6721 | Dual SP3T + SPDT +SPST | USB | 2 | 0 | 3.6 | 8 | 920 | –32 | –26 | TBD | 25/BGA | MCPC Compatible USB Port Multimedia Switch Supports USB, UART, Audio, ID, MIC, and Load Switch |
| | | UART | 2 | 0 | 3.6 | 8 | 920 | –32 | –26 | | | |
| | | Audio | 2 | –1.5 | +1.5 | 2 | 450 | –85 | –100 | | | |
| | | Mic | 1 | 0 | 2.3 | 40 | 40 | –85 | –95 | | | |
| | | Load Switch | 1 | 4.0 | 6.5 | 0.15 | — | — | — | | | |

*Preview products are listed in bold blue. New products are listed in bold red.*

## Pinouts

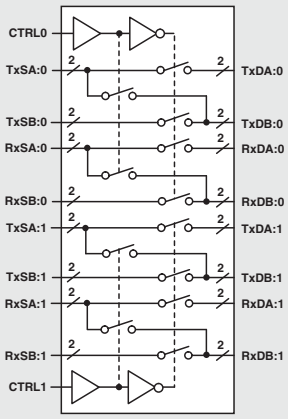
### Network

TS5N412

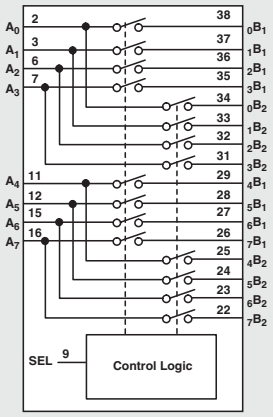



### PCI Express®

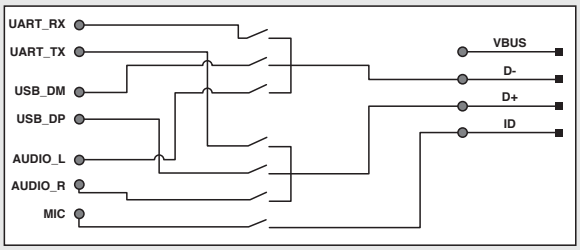
TS2PCIE2212



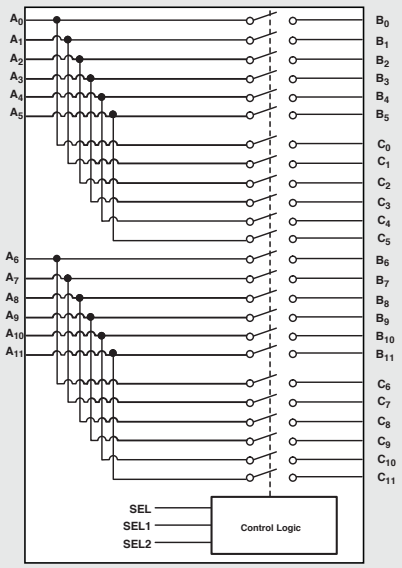

TS2PCIE412




TSU5511




TS3DDR3812



## Applications

### 12-Ch 1:2 Mux/DeMux for DVI/HDMI and DP Applications w/4-Ch Sideband Switching

### TS3DV621

NEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts3dv621**

**Key Features**

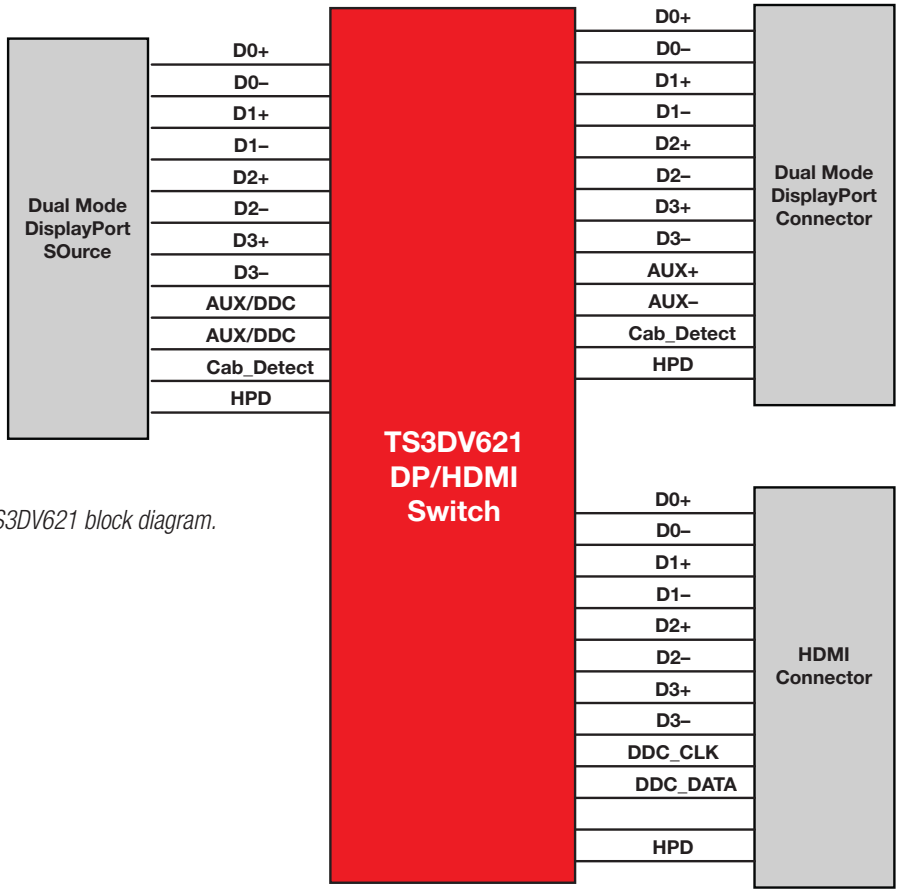
- Compatible with HDMI v1.4, DVI 1.0 and display port 1.1a high-speed digital interface
  - Wide bandwidth of 2.2 GHz
  - Four integrated side band signals switching
  - Support all video formats up to 1080 P and SXGA (1280 x 1024 at 75 Hz)
  - HDCP compatible
- Low and flat ON-state resistance ($r_{ON}$ = 8 Ω typ)
- Low input/output capacitance ($C_{ON}$ = 4 pF typ)
- $V_{CC}$ operating range from 3 V to 3.6 V
- Rail-to-rail switching on data I/O ports (0 to $V_{cc}$)
- Dedicated enable logic supports Hi-Z mode
- $I_{OFF}$ protection prevents current leakage in powered down state
- ESD performance tested per JESD22
  - 2-kV human body model (A114B, Class II)
  - 1-kV charged device model (C101)
- 42-pin RUA package (9 x 3.5 mm, 0.5 mm pitch)

**Applications**

- HDMI/DVI and DP signal switching
- Laptop, desktop and tablet computers and docking stations
- LCD TVs, A/V receivers, multimedia hubs/consoles

The TS3DV621 is a multiple SP4T switch with impedance detection. The switch features impedance detection, which supports the detection of various accessories that are attached through DP and DM. This device is fully controlled using $I^2C$ and enables USB data, stereo and mono audio, video, microphone, and UART data to use a common connector port.

Power for this device is supplied through $V_{BAT}$ of the system or through $V_{BUS}$ when attached. The switch can be controlled through $I^2C$. JIG and BOOT pins are used when a USB, UART JIG cable is used to test during development and manufacturing.




*TS3DV621 block diagram.*

## Applications

### 7-Channel VGA Mux/DeMux with Level Shifting

### TS3V712EL

NEW

Get samples, data sheets, EVMs and app reports at: **www.ti.com/sc/device/ts3v712el**

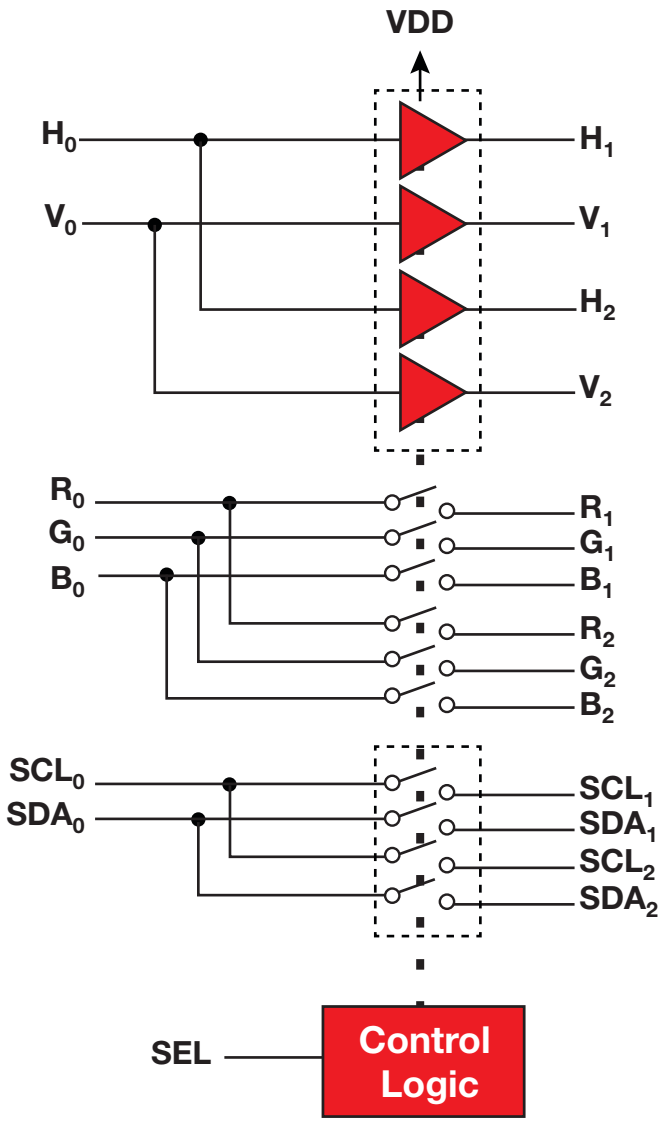
**Key Features**

- Supports 7-channel VGA signals (R,G,B, HSYNC, VSYNC, DDC CLK, and DDC DAT) integrated level shifting buffers for HSYNC and VSYNC
- Operating voltage range
  - $V_{DD}$ = 3.3 V ± 10%
  - $V_{DD\_}5$ = 5 V ± 10%
- High bandwidth of 1.3 GHz (–3 dB)
- R,G,B switches
  - $r_{ON}$ = 4 Ω (typ)
  - $_{CON}$ = 8 pF (typ)
- Voltage clamping NMOS switches for SCL and SDA channels
- ESD performance (14 pins on port 1 and port 2)
  - ±2-kV IEC61000-4-2, contact discharge
  - 7-kV human body model per JESD22-A114E
- ESD performance (all pins)
  - 3-kV human body model per JESD22-A114E
- 32-pin QFN package (RTG) (6 mm x 3 mm)

**Applications**

- Notebook computers
- Docking stations
- KVM switches

The TS3V712EL is a high bandwidth, 7-channel video demultiplexer for switching between a single VGA source and one of two end points. The device is designed for ensuring video signal integrity and minimizing video signal attenuation by providing high bandwidth of 1.3 GHz. The TS3V712EL has integrated level shifting buffers for the HSYNC and VSYNC signals which provide voltage level translation between 3.3 V and 5 V logic. The SCL and SDA lines use NMOS switches which clamp the output voltage to 1 V below $V_{DD}$. The video signals are protected against ESD with integrated diodes to $V_{DD}$ and GND that support levels up to ±2-kV contact discharge (IEC61000-4-2) and 7-kV human body model (JESD22-A114E).




*TS3V712EL block diagram.*

## Applications

### 7-Channel 7:14 SPDT VGA Signal Switch with Level Shifter

### TS3V713EL

NEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts3v713el**

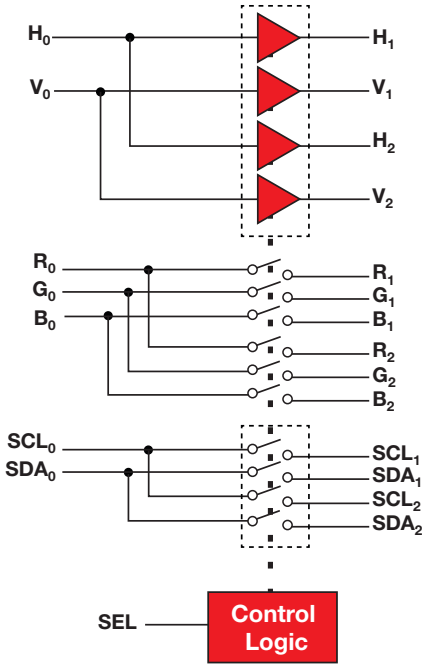
**Key Features**

- High bandwidth of 1.3 GHz (typ)
- Seven channels for VGA signal (R,G,B, VSYNC, HSYNC, DDC1, DDC2
- Integrated level shifting for HSYNC, VSYNC
- I/O capacitance of 4 pF
- P2P with pericom PI3V713

**Applications**

- Notebook computer
- Analog VGA peripheral ports
- Panel LVDS bus MUX
- Video/audio switching
- High speed logic data I/O MUX

The TS3V713EL is a high bandwidth, 7-channel video multiplexer/demultiplexer for switching between a single VGA source and one of two end points. The device is designed for ensuring video signal integrity and minimizing video signal attenuation by providing high bandwidth of 1.3 GHz. The TS3V713EL has integrated level shifting buffers for the HSYNC and VSYNC signals which provide voltage level translation between 3.3 V and 5 V logic. The SCL and SDA lines use NMOS switches which clamp the output voltage to 1 V below $V_{DD}$. The video signals are protected against ESD with integrated diodes to $V_{DD}$ and GND that support levels up to ±2-kV contact discharge (IEC61000-4-2) and 8-kV human body model (JESD22-A114E).




### 8:16 Mux/DeMux for Gigabit Ethernet LAN

### TS3L501E

Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts3l501e**

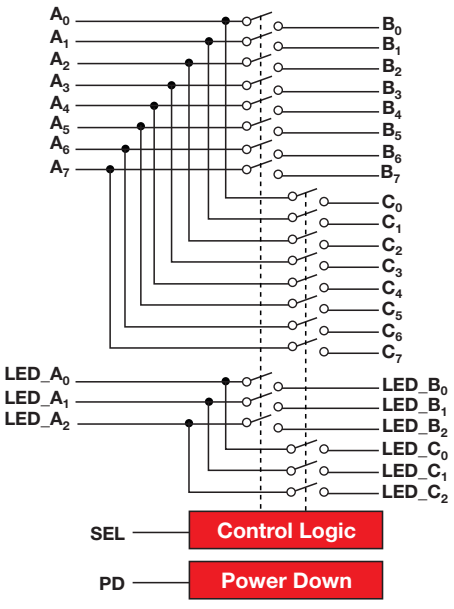
**Key Features**

- Low bit-to-bit skew ($t_{SK(o)}$ = 100 ps max)
- Low and flat ON-state resistance
  - $r_{ON}$ = 4 Ω typ, $r_{ON(FLAT)}$ = 0.5 Ω typ
- Low input/output capacitance
  - $C_{ON}$ = 8 pF typ
- ESD performance (A, B, C, LED pins)
  - ±4-kV IEC61000-4-2, contact discharge
  - 6-kV human body model (HBM)
- 42-pin QFN package (RUA) – 9 mm x 3.5 mm
- Half that of direct competition
- Allows for low power loss and THD
- Low capacitance ensure great signal BW
- Eliminates need for external ESD
- 37% size decrease from TS3L500AE

**Applications**

- 10/100/1000 Base-T signal switching
- Differential (LVDS, LVPECL) signal switching
- Audio/video switching
- Hub and router signal switching

The TS3L501E is a 16-bit to 8-bit multiplexer/demultiplexer LAN switch with a single select (SEL) input and Power down Mode input. The device provides additional I/Os for switching status indicating LED signals and includes high ESD protection. SEL input controls the data path of the multiplexer/demultiplexer. Power down input can put the device into the standby mode for minimizing current consumption per mode selection. The device provides a low and flat ON-state resistance ($r_{ON}$) and an excellent ON-state resistance match. Low input/output capacitance, high bandwidth, low skew, and low crosstalk among channels make this device suitable for various LAN applications, such as 10/100/1000 Base-T. This device can be used to replace mechanical relays in LAN applications. It also can be used to route signals from a 10/100 Base-T Ethernet transceiver to the RJ-45 LAN connectors in laptops or in docking stations. It is characterized for operation over the free-air temperature range of –40°C to 85°C.



## Applications

### High-Speed USB/Audio Switch
### TS5USBA224

NEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts5usba224**

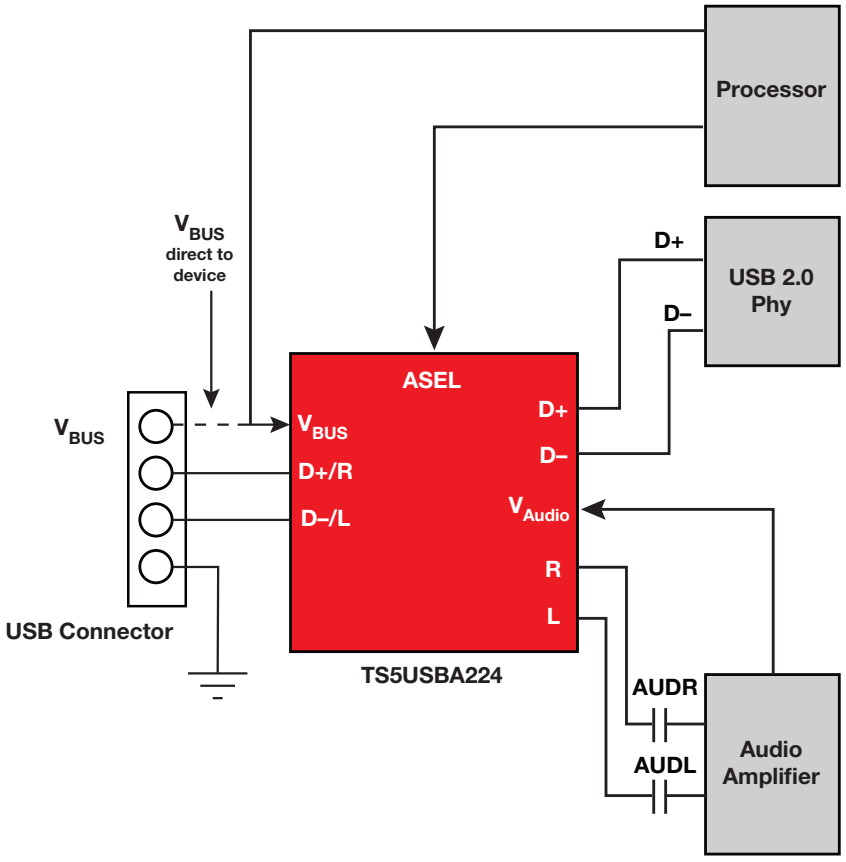
**Key Features**

- Powered from $V_{AUDIO}$ (3.3 V typ)
- $V_{BUS}$ input detects data cable connection and automatically switches to USB path (if $A_{SEL}$ = L)
- Manual switching to audio path (if $A_{SEL}$ = H)
- 1.8-V logic threshold compatibility for digital inputs
- USB channels: 4-Ω $R_{ON}$
- Audio channels: 3-Ω $R_{ON}$
- High bandwidth (650 MHz) for USB path
- Negative rail signaling support for audio path
- Total harmonic distortion <0.05%
- 10-µQFN (1.8mm × 1.4mm)

**Applications**

- Notebook computers
- Analog VGA peripheral ports

The TS5USBA224 is a double-pole, double throw (DPDT) multiplexer that includes a low-distortion audio switch and a USB 2.0 High-Speed (480 Mbps) switch in the same package. This configuration allows the system designer to use a common connector for audio and USB data. The audio switch is designed to allow audio signals to swing below ground which makes this common connector configuration possible. The TS5USBA224 is powered up using $V_{AUDIO}$. When $A_{SEL}$=High, the audio path is selected regardless of the logic level at $V_{BUS}$. If $A_{SEL}$=Low and $V_{BUS}$=High, the USB path is selected. Otherwise if $A_{SEL}$=Low and $V_{BUS}$=Low, the audio path is selected. The TS5USBA224 also features shunt resistors on the audio path to reduce clicks and pops that may be heard when the audio switches are selected.




*TS5USBA224 block diagram.*

## Applications

### High-Speed 2:4 Differential Multiplexer / De-multiplexer

### TS3DS10224

PREVIEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts3ds10224**

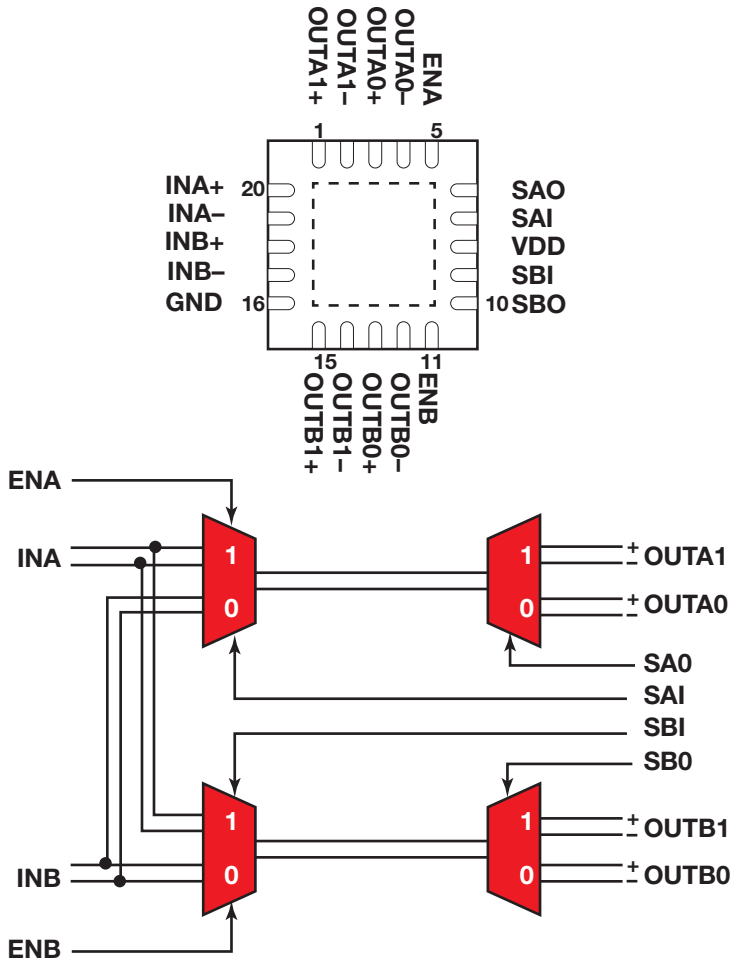
**Key Features**

- Flexible configurations:
  - Single 1 to 4
  - Dual 1 to 2
  - Fan-out 1 to 2
- High BW (1.2 GHz typ)
- Low $r_{ON}$ and $C_{ON}$:
  - 10 Ω $r_{ON}$ typ
  - 8 pF $C_{ON}$ typ
- ESD performance (I/O pins)
  - ±8-kV contact discharge (IEC61000-4-2)
  - 2-kV human body model per JESD22-A114E (to GND)
- ESD performance (all pins)
  - 2-kV human body model per JESD22-A114E
- Small QFN package (3 x 3, 0.4-mm pitch)

**Applications**

- Notebook computers
- PDA/ebook/tablet
- Display port auxiliary channel multiplexing
- USB 2.0 multiplexing

The TS3DS10224 is a 2:4 bidirectional multiplexer for high-speed differential and single ended signal applications (up to 720 Mbps). The TS3DS10224 can be used in a 1:4 or dual 1:2 multiplexer/demultiplexer configuration. The TS3DS10224 offers a high BW of 1.2 GHz with channel $R_{ON}$ of 13 Ω (typ). The TS3DS10224 can also be used to fan out a differential or single ended signal pair to two ports simultaneously (fan-out configuration). The BW performance is lower in this configuration. The TS3DS10224 operates with a 3 to 3.6V power supply. It features ESD protection of up to ±8-kV contact discharge and 2-kV human body model on its I/O pins. The TS3DS10224 provides fail-safe protection by isolating the I/O pins with high impedance when the power supply (VCC) is not present.




*TS3DS10224 block diagram.*

## Applications

### DP3T USB 2.0 High-Speed (480 Mbps) and Audio Switches with Negative Signal Capability

### TS3USBA225

NEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts3usba225**

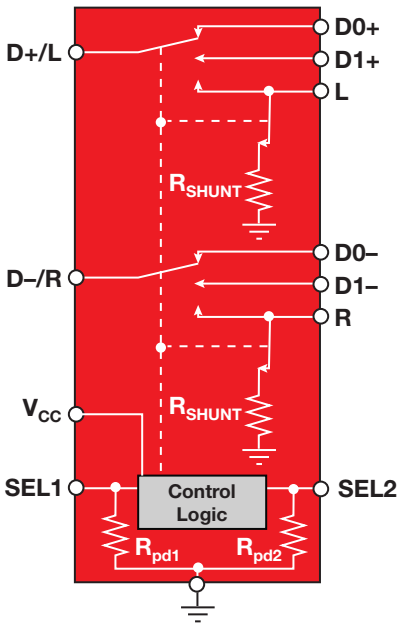
**Key Features**

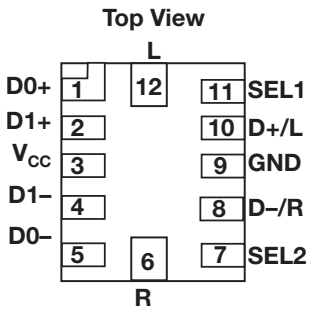
- High-speed USB switch (D0± and D1 ±)
  - 6.5 Ω $R_{DSON}$ maximum
  - 3 pF $C_{ON}$ maximum
  - 1.9 GHz bandwidth (-3 dB)
  - $V_{I/O}$ accepts signals up to 4.3 V (independent of $V_{CC}$)
- Audio switch (L&R)
  - 2.5 Ω $R_{DSON}$ typical
  - Negative rail capability
  - Low THD: <0.05%
  - Internal shunt resistors for click-and-pop reduction
- 2.7 V to 4.3 V operating power supply ($V_{CC}$)
- 1.8-V compatible control input (SEL1 and SEL2) threshold
- Minimized current consumption (~2 µA) in power-down mode
- Power-off protection: all I/O pins are high-Z when $V_{CC}$=0V
- ESD performance tested per JESD 22
  - 2000-V human body model (A114-B, Class II)
  - 1000 V charged device model (C101)
- 12-pin RUT package
  - 2×1.7 mm, 0.4 mm pitch

**Applications**

- Cell phones and smartphones
- Tablet PCs
- Media players
- Digital still cameras
- Portable navigation devices (GPS)

The TS3USBA225 is a double-pole, triple throw (DP3T) multiplexer that includes a low-distortion audio switch, and two USB 2.0 High-Speed (480 Mbps) switches in the same package. This configuration allows the system designer to use a common connector for audio, and USB data. The audio switch is designed to allow audio signals to swing negatively which makes this common connector configuration possible. The TS3USBA225 has a $V_{CC}$ range of 2.7 V to 4.3 V with the capability to pass true-ground audio signals down to $V_{CC}$-4.3 V. The device also supports a power-down mode that can be enabled when both SEL controls are low to minimize current consumption when no signal is transmitting. The TS3USBA225 also features internal shunt resistors on the audio path to reduce clicks and pops that may be heard when the audio switches are selected.



## Applications

### DPDT MHL™ (3 Gbps) and USB 2.0 High-Speed (480 Mbps) Switch with Integrated ID line Mux

### TS3USB3200

NEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts3usb3200**

**Key Features**

- MHLTM switch
  - Supports 5 Gbps data rate
  - High bandwidth of 6 GHz
  - 2.5 pF CON typical
- High-speed USB switch:
  - 6 GHz Bandwidth (-3 dB)
  - 3.0 pF CON
- 1.8-V compatible control input (SEL1 and SEL2) threshold
- Integrated USB/MHLTM ID line switch for easy information control
- Minimized current consumption (<~30uA) during normal operation
- Flexible power control: Device can be powered by $V_{BUS}$ without $V_{CC}$
- Over-Voltage Tolerance (OVT) on all I/O pins up to 5.5 V without external components
- ESD performance tested per JESD 22
  - 2000-V human body model (A114-B, Class II)
  - 1000-V charged device model (C101)
- 16-Pin RSV package
  - 2.6×1.8 mm, 0.4 mm pitch

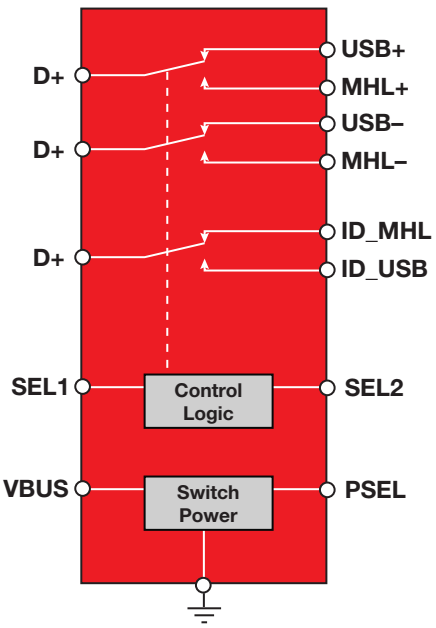
**Applications**

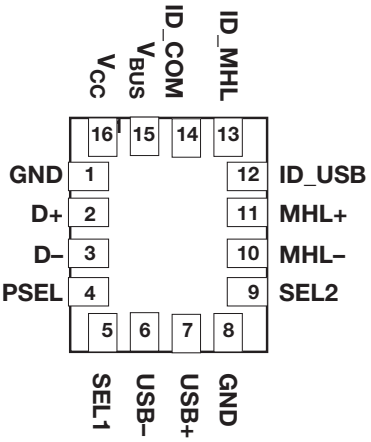
- Cell phones and smartphones
- Tablet PCs
- Portable instrumentation
- Digital still cameras

The TS3USB3200 is a Double-Pole, Double Throw (DPDT) multiplexer that includes a high-speed Mobile High-Definition Link (MHL) switch and an USB 2.0 high-speed (480Mbps) switches in the same package. Also included is a Single-Pole, Double Throw (SPDT) USB/MHL ID switch for easy information control. These configurations allow the system designer to use a common USB or Micro-USB connector for both MHL video signals and USB data.

The TS3USB3200 has a $V_{CC}$ range of 2.7 V to 4.3 V and also has the option to be powered by $V_{BUS}$ alone without $V_{CC}$. This device supports Over-Voltage Tolerance (OVT) feature, which allows the I/O pins to withstand over-voltage conditions (up to 5.5 V). The power-off protection feature forces all I/O pins to be in high-impedance mode when power is not present, allowing full isolation of the signals lines under such condition without excessive leakage current. The select pins of TS3USB3200 are compatible with 1.8 V control voltage, allowing them to be directly interfaced with the General Purpose I/O (GPIO) from a mobile processor.

The TS3USB3200 comes with a small 16-pin QFN package with only 2.6 mm x 1.8 mm in size, which makes it a perfect candidate to be used in mobile applications.



## Applications

### 12-channel 1:2 Mux/Demux for DDR3 Applications

### TS3DDR3812

NEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/ts3ddr3812**

**Key Features**

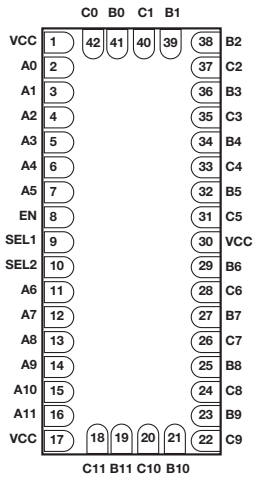
- Compatible with DDR3 SDRAM standard (JESD79-3D)
- Wide bandwidth of over 1.9 GHz (-3 dB)
- Low propagation delay (tpd = 40 ps)
- Low and flat ON-state resistance ($r_{ON}$ = 8 Ω typ)
- Low input/output capacitance (CON = 5.6 pF typ)
- Low crosstalk (XTALK = -43 dB typ)
- $V_{CC}$ operating range from 3 V to 3.6 V
- Rail-to-rail switching on data I/O Ports (0 to $V_{CC}$)
- $I_{OFF}$ protection prevents current leakage in powered-down state
- ESD performance tested per JESD22
  - 2-kV human body model (A114B, Class II)
  - 1-kV charged device model (C101)
- 42-pin RUA package (9 x 3.5 mm, 0.5 mm pitch)

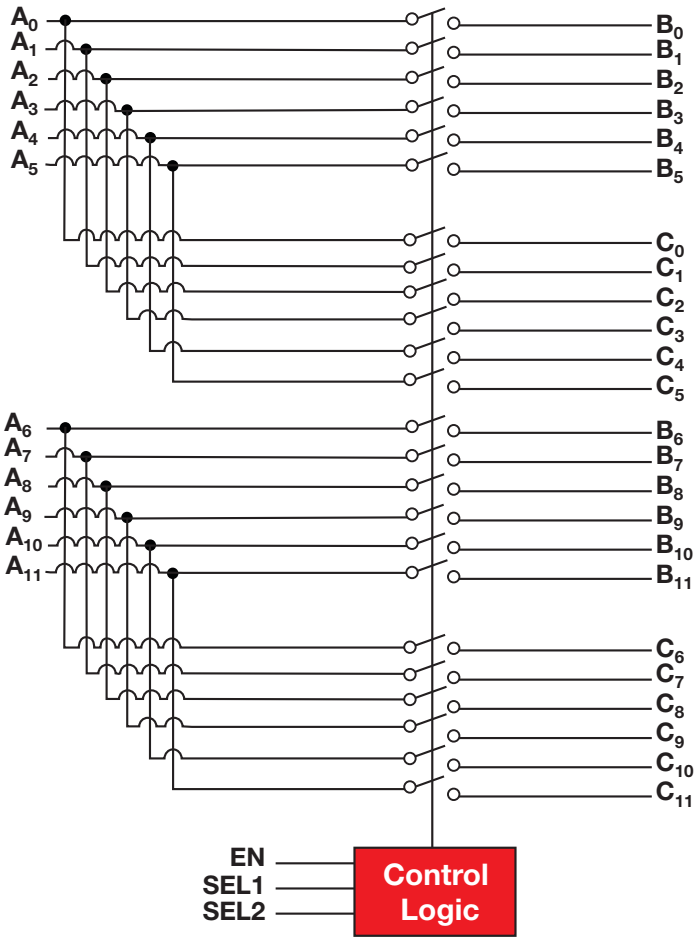
**Applications**

- DDR3 signal switching
- DIMM modules
- Notebook/desktop PCs
- Servers

The TS3DDR3812 is a 12-channel, 1:2 multiplexer/demultiplexer switch designed for DDR3 applications. It operates from a 3 to 3.6 V supply and offers low and flat ON-state resistance as well as low I/O capacitance which allow it to achieve a typical bandwidth of 1.675 GHz. Channels A0 through A11 are divided into two banks of six bits and are independently controlled via two digital inputs called SEL1 and SEL2. These select inputs control the switch position of each 6-bit DDR3 source and allow them to be routed to one of two end-points. Alternatively, the switch can be used to connect a single endpoint to one of two 6-bit DDR3 sources. For switching 12-bit DDR3 sources, simply connect SEL1 and SEL2 together externally and control all 12 channels with a single GPIO input. An EN input allows the entire chip to be placed into a high-impedance (Hi-Z) state while not in use. These characteristics make the TS3DDR3812 an excellent choice for use in memory, analog/digital video, LAN, and other high-speed signal switching applications.

**RUA Package**
**(Top View)**




*TS3DDR3812 block diagram.*

## Applications

### Dual SP2T (USB2.0 and UART) with Integrated Impedance and Charger Detection

### TSU6111/A

NEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/PARTnumber**

**Key Features**

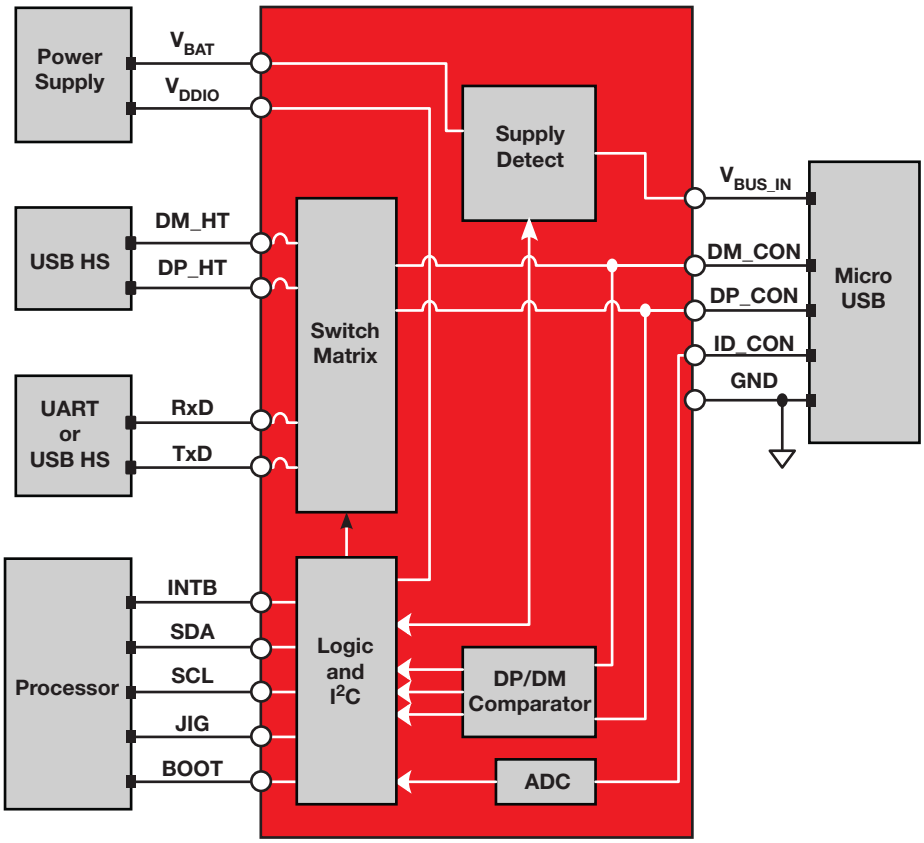
- Dual SP2T switch (both channels support USB2.0 speed) with impedance detection
- Micro-USB accessories and charger detection
  - Detection is compatible with CEA-936A (4-Wire Protocol, UART interface)
  - Plugin/unplug detection, impedance based accessory detection, charger type detection
- Low input/output capacitance $C_{ON}$=8pF typ.
- High bandwidth (920 MHz) and low $r_{ON}$ (8 Ω)
- Supports DSS for tablet PC application
- Integrated ESD and surge protection
  - IEC61000-4-2 ESD protection on VBUS, DP, DM, ID
  - Surge protection on $V_{BUS}$, DP and DM pins
- $I^2C$ interface with host processor
- 20-WCS (2.4mm × 1.9mm) package

**Applications**

- Cell phones, tablet computers
- Digital cameras, camcorders
- Portable navigation devices

The TSU6111A is a high performance differential autonomous SP2T switch with impedance detection. The switch supports the detection of various accessories that are attached through DP, DM, and ID. The charger detection satisfies USB charger specification v1.1 and VBUS_IN has a 28 V tolerance to eliminate the need for external protection. Power for this device is supplied through $V_{BAT}$ of the system or through $V_{BUS\_IN}$ when attached to a charger.

The SP2T switch is controlled by the automatic detection logic or through manual configuration of the $I^2C$. JIG and BOOT pins are used when a USB or UART JIG cable is used to test the device in the development and manufacturing. TSU6111A has open-drain JIG output (active low).



## Applications

### USB to USB-UART-Audio-Video Switch

### TSU6712/A

PREVIEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/PARTnumber**

**Key Features**

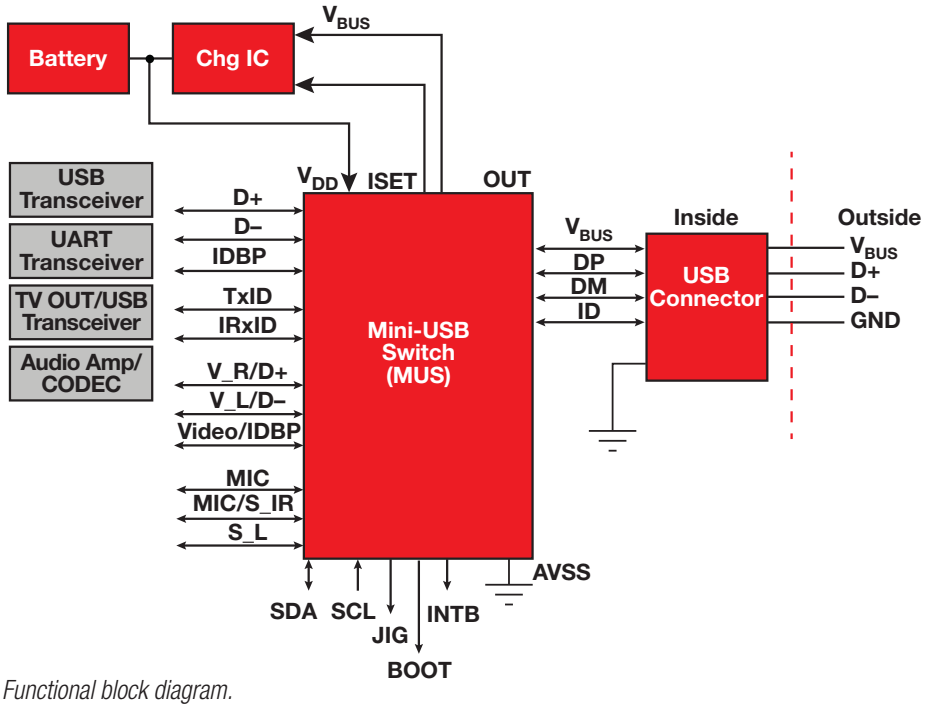
- USB to-USB,-UART,-audio, and video
- ESD performance DP/DM/ID/VBUS to GND
  - ±8-kV contact discharge
  - ±15-kV air gap discharge
- $I^2C$ control compatibility
- Built-in impedance detection
- 25-bump WCSP (1.97 mm × 1.97 mm) Package

**Applications**

- High-end smartphones
- Netbook
- Tablets
- Mobile internet devices
- Portable handheld device

The TSU6712A is a multiple SP4T switch with impedance detection. The switch features impedance detection, which supports the detection of various accessories that are attached through DP and DM. The TSU6712A is fully controlled using $I^2C$ and enables USB data, stereo and mono audio, video, microphone, and UART data to use a common connector port.

Power for this device is supplied through $V_{BAT}$ of the system or through $V_{BUS}$ when attached. The switch can be controlled through $I^2C$. JIG and BOOT pins are used when a USB, UART JIG cable is used to test during development and manufacturing.




*Functional block diagram.*

## Applications

### USB, Audio, and Charger detection

### TSU5611

NEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/tsu5611**

**Key Features**

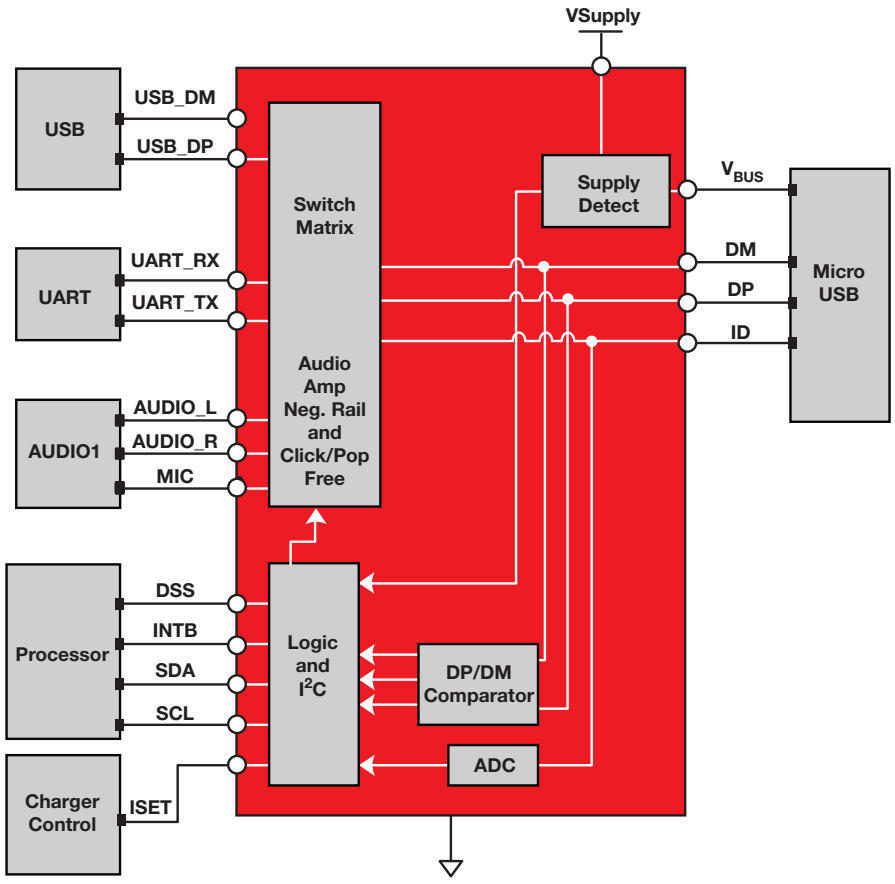
- Dual SP3T & SPST analog switch with impedance detection.
- New interface IC for various signaling in mobile phones
  - Audio switch
  - Two USB 2.0 high-speed switch
- Smart detection
  - Plug-in/un-plug detection
  - USB charger detection
  - Proprietary accessory detection with impedance sensing
- Additional protection
  - IEC61004 level 4 ESD protection
  - 4pins (VBUS, DP,DM, ID)
- $I^2C$ interface with host processor
- Low input/output capacitance CON=8pF typ.
- Supports DSS for tablet PC application
- 20-WCS(2.4mm × 1.9mm) package

**Applications**

- Cell phone, netbook, MID
- Portable handheld device

The TSU5611 is designed to interface the cellular phone UART, USB, and audio chips with external peripherals via a micro-USB connector. The switch features impedance detection for identification of various accessories that are attached through DP and DM of the micro-USB port. When an accessory is plugged into the micro-USB port, the switch uses a detection mechanism to identify the accessory (see the State Machine for details). It will then switch to the appropriate channel—data, audio, or UART.

The TSU5611 has an $I^2C$ interface for communication with the cellular phone baseband or applications processor. An interrupt is generated when anything plugged into the micro-USB is detected. Another interrupt is generated when the device is unplugged.




*Functional block diagram.*

## Applications

### Single-Cell Charger and SP2T Switch

### TSU8111

PREVIEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/tsu8111**

**Key Features**

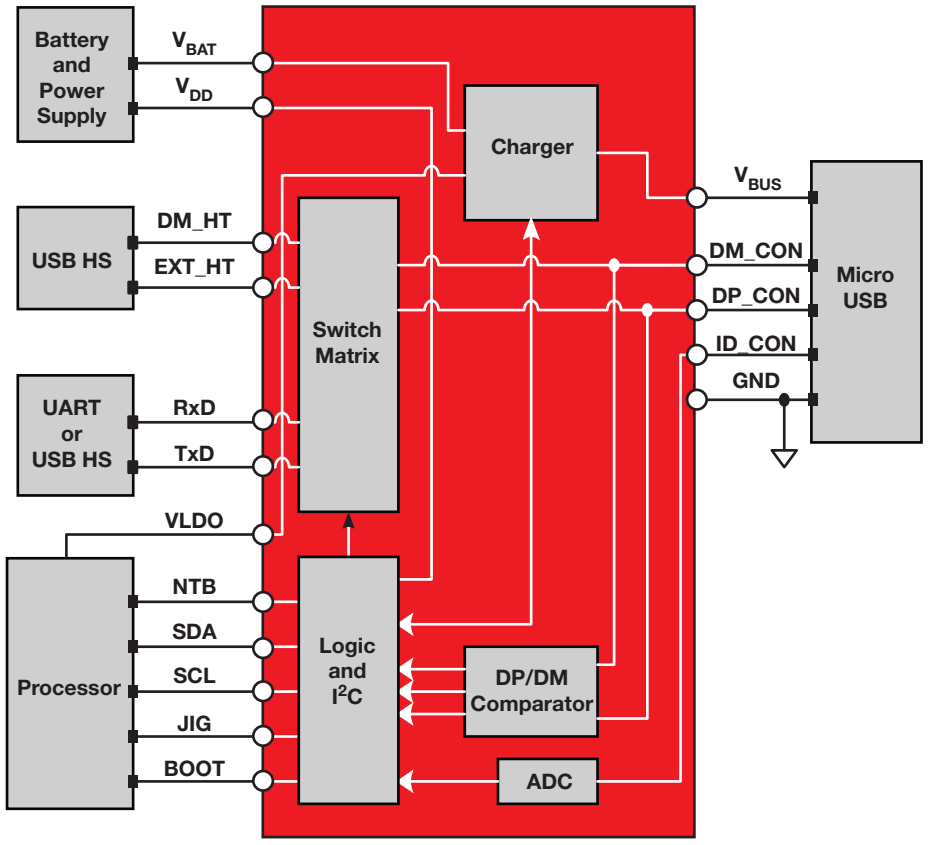
- Fully compliant USB single-cell charger
  - Input voltage dynamic power management
  - 50 mA integrated low dropout regulator (LDO)
  - 1% charge voltage regulation accuracy
  - 8% charge current accuracy
  - Programmable charging current limit up to 950 mA for wall adapters
- Dual SP2T
  - USB & UART support 2.0 high speed
  - Impedance detection
- Charger detection
  - USB BCDv1.1
  - $V_{BUS}$ & data contact detection
  - Primary & secondary detection
- Additional features
  - $I^2C$ interface with host processor
  - Support control signals used in manufacturing (JIG, BOOT)
  - Interrupt for attach & detach accessory
- Compatible accessories
  - USB cable
  - UART cable
  - USB charger BCDv1.1
- Additional protection
  - 28 V $V_{BUS}$ rating with OVP
  - Thermal regulation & shutdown
- ESD per JESD 22
  - 2000V HBM (A114-B Class II)
  - 1000V CDM (C101)
- ESD performance VBUS/DP/DM/ID to GND
  - ±8 kV contact discharge (IEC 61000-4-2)
- Package
  - 20-WCSP (2.0 mmx1.6 mm)

**Applications**

- Cell phones & smart phones
- Tablet PCs
- Digital cameras & camcorders
- GPS navigation systems
- MicroUSB interface with USB/UART

The TSU8111 is a differential high-performance automated SP2T switch with impedance detection and integrated Li-Ion linear charger device targeted at space-limited portable applications. The switch features impedance detection which supports the detection of various accessories that are attached through DP, DM and ID. The charger detection satisfies USB charger specification v1.1. $V_{BUS}$ has 28 V tolerance to avoid external protection. The device operates from either a USB port or dedicated charger and supports charge currents up to 950 mA. Power for this device is supplied through $V_{BAT}$ of the system or through $V_{BUS}$ when attached.

The switch is controlled by automatic detection logic or through $I^2C$ manually. JIG and BOOT pins are used when a USB, UART JIG cable is used to test in the development and manufacturing. TSU8111 has open-drain JIG output (active low) and TSU8112 has push-pull JIG output (active high).




*Functional block diagram.*

## Applications

### Charger-Detection Device
### BQ24392

NEW

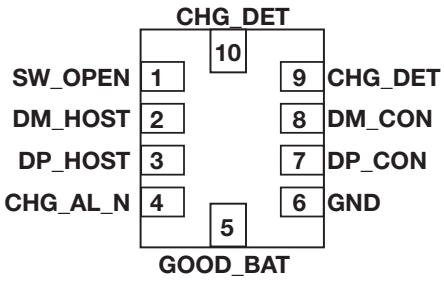
Get samples, data sheets and app reports at: **www.ti.com/sc/device/BQ24392**

**Key Features**

- Charger-detection device
  - USB BCv1.2 compliant
  - $V_{BUS}$ detection
  - Data contact detection
  - Primary & secondary detection
  - Dead battery provision. 32 min timer
- Switch
  - USB 2.0 high speed
- Compatible accessories
  - Dedicated charging port
  - Standard charging port
  - Charging port
- Other chargers detected
  - Apple charger
  - Tom Tom charger
  - Non-compliant USB charger
- Max voltage
  - 30V tolerance on $V_{BUS}$
- ESD on $V_{BUS}$, DP, DM to GND
  - ± 8-KV contact discharge (IEC 61000-4-2)
- Package
  - 10-pin uQFN RSE

The BQ24392 is a charger-detection device with an integrated isolation switch for use with a micro/mini USB port. The device is compliant with USB battery charging specification v1.2. This device allows cell phones & tablets to be charged from different adapters including USB BCv1.2 compliant and non-standard USB chargers. These non-standard chargers include Apple, TomTom & non-compliant USB chargers. The BQ24392 conforms to Dead Battery Provision (DBP) specified in BCv1.2. This includes a 32-min timer that cannot exceed 45 mins. This device has a USB 2.0 switch that supports high speed. In addition to USB connector and host pins, BQ24392 has one input and three output pins, resulting in minimum software workload for the system to interact with the device. $V_{BUS}$ has 28 V tolerance to avoid external protection. Power for this device is supplied via $V_{BUS}$ when accessory is attached.

**Top View**




**Applications**

- Smart-phones
- Cell phone
- Tablets
- GPS systems

## Applications

### USB, UART, AUDIO, ID, MIC, & Load Switch

### TSU6721

PREVIEW

Get samples, data sheets and app reports at: **www.ti.com/sc/device/tsu6721**

**Key Features**

- Switch matrix
  - USB & UART switch support USB 2.0 HS
  - Audio switch with negative signal capability
  - ID bypass switch
  - $V_{BUS}$ to MIC switch
  - DP to MIC switch to support MCPC
- Load switch
  - 100 mΩ load switch
  - OTG support
  - 28V $V_{BUS}$ rating with over-voltage protection
  - Programmable overcurrent limiter/protection
- Charger detection
  - USB BCDv1.2 compliant
  - $V_{BUS}$ detection
  - Data contact detection
  - Primary & secondary detection

  Compatible accessories
- USB chargers (DCP, CDP)
  - Apple charger
  - USB data port
  - Audio headset with MIC & remote
  - Docking support
  - Factory cable
- Surge Protection on $V_{BUS}$/DP/DM
  - USB connector pins without external component
  - $I^2C$ interface with host processor
  - Switches controlled by automatic detection or manual control
  - Interrupts generated for plug/unplug
  - Decoupling FET switch to $V_{BUS}$ added to reduce degradation on MIC line
  - Support control signals used In manufacturing (JIG, BOOT)

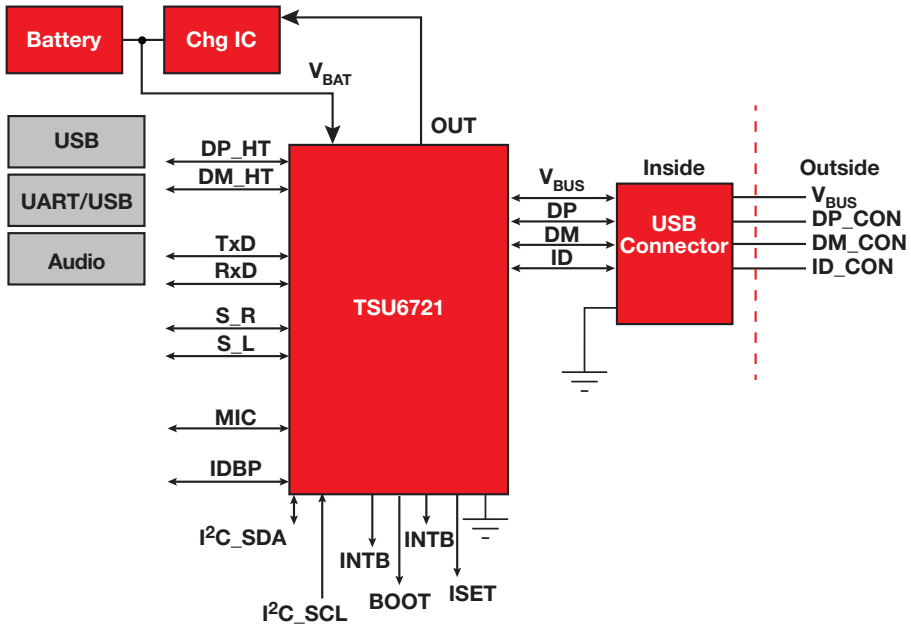
**Applications**

- Cell phones & smart phones
- Tablet PCs
- Digital cameras & camcorders
- GPS navigation systems
- Micro USB interface with USB/UART/AUDIO

TSU6721 is a high-performance USB port multimedia switch featuring automatic switching and accessory detection. The device connects a common USB port to pass audio, USB data, charging, On The Go (OTG) and factory mode signals. The audio path has negative signal capability includes left (mono/stereo), right (stereo) as well as microphone signals. Furthermore, TSU6721 is compatible with the MCPC specification.

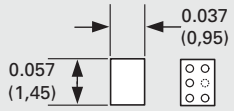
TSU6721 features impedance detection which supports the detection of various accessories that are attached through DP, DM and ID pins of the USB connector. The switch is controlled by automatic switching or manually through $I^2C$.

TSU6721 has an integrated, low-resistive, Load Switch that is used to isolate the charger from the external connector. Overvoltage protection and programmable overcurrent limiter/protection are additional features included to the load switch.
The charger detection satisfies USB charger specification v1.2. In addition to DCP, CDP & SDP, the device also detects Apple Chargers. Power for this device is supplied through $V_{BAT}$ of the system or through $V_{BUS}$ when attached. TSU6721 supports factory mode testing when a USB/UART JIG cable is used in development and manufacturing.

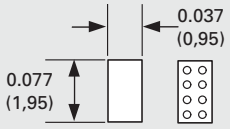



*Functional block diagram.*

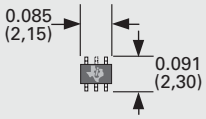
## Packages



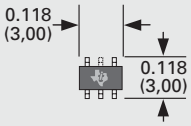

**5-ball/6-ball WCSP**
**NanoFree™ (YZP)**
Ball pitch = 0.020 (0,50)
Height = 0.020 (0,50)
Area = 0.002 (1,26)



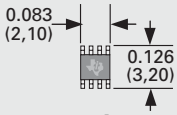

**8-ball WCSP**
**NanoFree™ (YZP)**
Ball pitch = 0.020 (0,50)
Height = 0.020 (0,50)
Area = 0.003 (1,85)



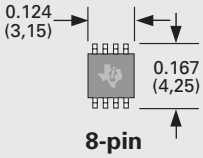

**5-pin/6-pin**
**SC-70 (DCK)**
Lead pitch = 0.026 (0,65)
Height = 0.037 (0,95)
Area = 0.008 (4,95)

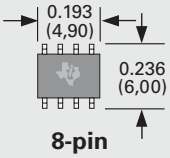

**5-pin/6-pin**
**SOT-23 (DBV)**
Lead pitch = 0.037 (0,95)
Height = 0.047 (1,20)
Area = 0.014 (9)



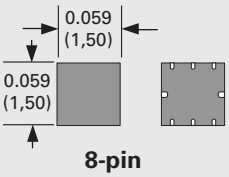

**8-pin**
**US8/VSSOP (DCU)**
Lead pitch = 0.020 (0,50)
Height = 0.035 (0,90)
Area = 0.010 (6,72)



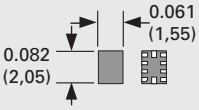

**8-pin**
**SM8/SSOP (DCT)**
Lead pitch = 0.026 (0,65)
Height = 0.051 (1,30)
Area = 0.010 (6,72)



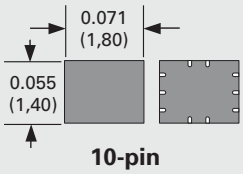

**8-pin**
**SOIC (D)**
Lead pitch = 0.050 (1,27)
Height = 0.069 (1,75)
Area = 0.045 (29,38)



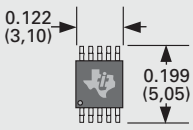

**8-pin**
**QFN (RSE)**
Lead pitch = 0.019 (0,50)
Height = 0.022 (0,55)
Area = 0.003 (2,25)



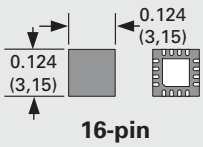

**10-pin**
**QFN (RSE)**
Lead pitch = 0.020 (0,50)
Height = 0.039 (0,60)
Area = 0.005 (3,18)



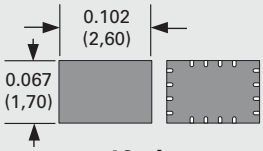

**10-pin**
**QFN (RSW)**
Lead pitch = 0.015 (0,40)
Height = 0.019 (0,50)
Area = 0.004 (2,52)



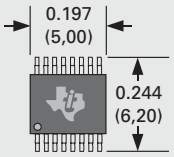

**10-pin**
**MSOP (DGS)**
Lead pitch = 0.020 (0,50)
Height = 0.043 (1,10)
Area = 0.024 (15,7)



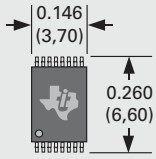

**16-pin**
**QFN (RGT)**
Lead pitch = 0.020 (0,50)
Height = 0.039 (1,00)
Area = 0.015 (9,9)



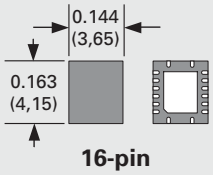

**16-pin**
**QFN (RSV)**
Lead pitch = 0.015 (0,40)
Height = 0.019 (0,50)
Area = 0.007 (4,42)



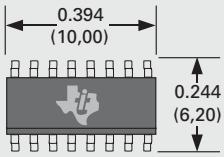

**16-pin**
**SSOP/QSOP (DBQ)**
Lead pitch = 0.025 (0,64)
Height = 0.069 (1,75)
Area = 0.048 (31,0)



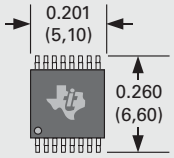

**16-pin**
**TVSOP (DGV)**
Lead pitch = 0.016 (0,40)
Height = 0.047 (1,20)
Area = 0.038 (24,4)



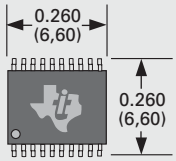

**16-pin**
**QFN (RGY)**
Lead pitch = 0.020 (0,50)
Height = 0.039 (1,00)
Area = 0.023 (15,1)




**16-pin**
**SOIC (D)**
Lead pitch = 0.050 (1,27)
Height = 0.069 (1,75)
Area = 0.096 (62)

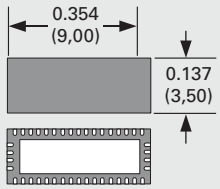



**16-pin**
**TSSOP (PW)**
Lead pitch = 0.026 (0,65)
Height = 0.047 (1,20)
Area = 0.052 (33,7)

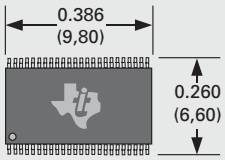



**20-pin**
**TSSOP (PW)**
Lead pitch = 0.026 (0,65)
Height = 0.047 (1,20)
Area = 0.068 (44)

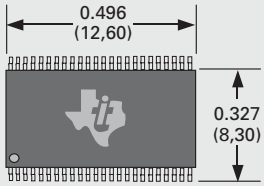
## Packages



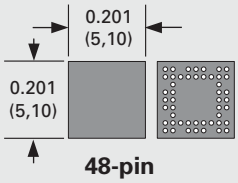

**42-pin**
**QFN (RUA)**
Lead pitch = 0.019 (0,50)
Height = 0.030 (0,75)
Area = 0.048 (3,15)



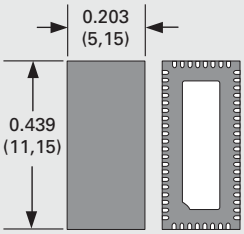

**48-pin Widebus™**
**TVSOP (DGV)**
Lead pitch = 0.016 (0,40)
Height = 0.047 (1,20)
Area = 0.100 (63)




**48-pin Widebus™**
**TSSOP (DGG)**
Lead pitch = 0.020 (0,50)
Height = 0.047 (1,20)
Area = 0.162 (105)




**48-pin**
**PBGA (ZAH)**
Lead pitch = 0.020 (0,50)
Height = 0.047 (1,20)
Area = 0.040 (26)




**56-pin**
**QFN (RHU)**
Lead pitch = 0.020 (0,50)
Height = 0.032 (0,80)
Area = 2.26 (57,4)

## Sample and Quality Information

### Signal Switch Sample Requests

**Working day and night and need a free TI product samplefast? Orders for material in stock received by 7 p.m. CST are shipped before midnight the same day.**

**We're waiting to take your order on-line 24/7.**

We'll help you. That's what our Product Sample program is all about. Helping you place your order for FREE product samples when you're ready to place it.

- 10,000 different devices plus package options.
- No waiting to talk to TI sales or distributors.
- Orders for material in stock received by 7 p.m. CST are shipped before midnight the same day.
- Shipping confirmation notice lets you track your order on the UPS Web site.
- Phone option—if you need help selecting a sample part, call your regional Product Information Center listed on the back page or visit

**support.ti.com**

### Quality Assurance

Continual focus on quality and reliability are elements of TI's commitment to customers. In 1995, TI's Semiconductor Group Quality System Program was launched. This comprehensive quality system is utilized to meet and exceed global customer and industry requirements.

TI recognizes the importance of advancing industry standards and is committed to working on regulatory as well as U.S. and international voluntary standards. As an active member of numerous global industry associations and with a strong commitment to the environment, TI has emerged as a leader with its Lead (Pb)-Free programs. An initiative begun in the 1980s to find alternative materials for products has resulted in the majority of TI products now being available Pb-free and Green.

For all of your lead (Pb)-free questions, visit:

**www.ti.com/quality**

# *TI Worldwide Technical Support*

## Internet

### TI Semiconductor Product Information Center Home Page
support.ti.com

### TI E2E™ Community Home Page
e2e.ti.com

## Product Information Centers

**Americas** Phone +1(972) 644-5580

**Brazil** Phone 0800-891-2616

**Mexico** Phone 0800-670-7544

Fax +1(972) 927-6377

Internet/Email support.ti.com/sc/pic/americas.htm

### Europe, Middle East, and Africa

Phone

| | |
|---|---|
| European Free Call | 00800-ASK-TEXAS<br>(00800 275 83927) |
| International | +49 (0) 8161 80 2121 |
| Russian Support | +7 (4) 95 98 10 701 |

**Note:** The European Free Call (Toll Free) number is not active in all countries. If you have technical difficulty calling the free call number, please use the international number above.

| | |
|---|---|
| Fax | +(49) (0) 8161 80 2045 |
| Internet | www.ti.com/asktexas |
| Direct Email | asktexas@ti.com |

### Japan

| | | |
|---|---|---|
| Phone | Domestic | 0120-92-3326 |
| Fax | International | +81-3-3344-5317 |
| | Domestic | 0120-81-0036 |
| Internet/Email | International | support.ti.com/sc/pic/japan.htm |
| | Domestic | www.tij.co.jp/pic |

### Asia

Phone

| | |
|---|---|
| International | +91-80-41381665 |
| Domestic | Toll-Free Number |

**Note:** Toll-free numbers do not support mobile and IP phones.

| | |
|---|---|
| Australia | 1-800-999-084 |
| China | 800-820-8682 |
| Hong Kong | 800-96-5941 |
| India | 1-800-425-7888 |
| Indonesia | 001-803-8861-1006 |
| Korea | 080-551-2804 |
| Malaysia | 1-800-80-3973 |
| New Zealand | 0800-446-934 |
| Philippines | 1-800-765-7404 |
| Singapore | 800-886-1028 |
| Taiwan | 0800-006800 |
| Thailand | 001-800-886-0010 |

| | |
|---|---|
| Fax | +8621-23073686 |
| Email | tiasia@ti.com or ti-china@ti.com |
| Internet | support.ti.com/sc/pic/asia.htm |



**A011012**

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

| **Products** | | **Applications** | |
|---|---|---|---|
| Audio | www.ti.com/audio | Automotive and Transportation | www.ti.com/automotive |
| Amplifiers | amplifier.ti.com | Communications and Telecom | www.ti.com/communications |
| Data Converters | dataconverter.ti.com | Computers and Peripherals | www.ti.com/computers |
| DLP® Products | www.dlp.com | Consumer Electronics | www.ti.com/consumer-apps |
| DSP | dsp.ti.com | Energy and Lighting | www.ti.com/energy |
| Clocks and Timers | www.ti.com/clocks | Industrial | www.ti.com/industrial |
| Interface | interface.ti.com | Medical | www.ti.com/medical |
| Logic | logic.ti.com | Security | www.ti.com/security |
| Power Mgmt | power.ti.com | Space, Avionics and Defense | www.ti.com/space-avionics-defense |
| Microcontrollers | microcontroller.ti.com | Video and Imaging | www.ti.com/video |
| RFID | www.ti-rfid.com | | |
| OMAP Applications Processors | www.ti.com/omap | **TI E2E Community** | e2e.ti.com |
| Wireless Connectivity | www.ti.com/wirelessconnectivity | | |

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265