Voltage Level Translation Guide

TEXAS INSTRUMENTS

Auto-Direction Sensing

Direction Controlled

Application-Specific

Introduction

In today's complex and high-performance system environment, higher levels of functional integration have led to lower power consumption CMOS process technologies operating at lower supply voltage levels. The ability to mix, match and support the simultaneous use of different operating supply voltage levels on the same circuit board has led to the need for voltage-level translation.

To remedy this problem of logic-threshold incompatibility between the driver output thresholds and receiver input thresholds, a voltage-level translator device from Texas Instruments should be used to accomplish this.

To assist circuit design and system engineers with their operating speed and lower-operating voltage level-translation needs, Texas Instruments (TI) offers a comprehensive voltage translation portfolio including dual-supply level translators; auto-direction sensing translators for both push-pull buffered and open-drain applications; and hybrid application-specific translators optimized for today's constantly emerging signal standards. Translation devices are needed in various markets such as consumer electronic, portable, computing, and networking applications—wherever the need exists to interface lower operating processors with higher operating legacy peripherals.

Table of Contents

Portable electronic block diagram

Single-Power Supply Translator
SN74AUP1Txx

AUP technology is the industry's lowest-power logic technology designed. The SN74AUP1Txx is designed for logic-level translation applications with input switching levels that accept 1.8-V LVCMOS signals, while operating from either a single 3.3-V or 2.5-V V_{CC} supply.

The SN74AUP1Txx with configurable logic function ('57,'58,'97,'98) can be easily configured to perform a required gate function by connecting A, B, and C inputs to V_{CC} or ground (see datasheet).Up to nine commonly used logic gate functions can be performed.

SN74AUP1Txx functional block diagram

Get more information: **ti.com/product/SN74AUP1Txx**

Key Features
- Low power consumption: I_{CC} 0.5 µA
- Schmitt-Trigger input: ΔV_T = 210 mV, reject input noise
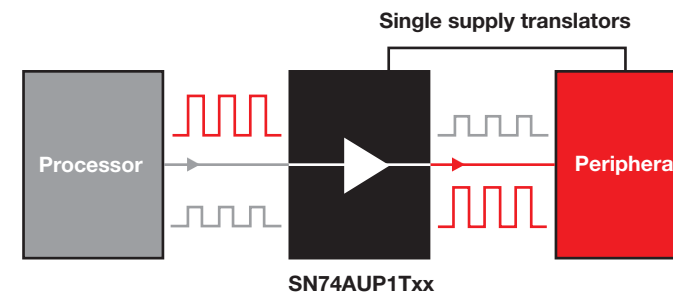- Nine configurable gate logic functions
- ESD performance tested per JESD 22
  - 2000-V human-body model (A114-B, Class II)
  - 1000-V charged-device model (C101)

Applications
- Personal electronics
- Computing
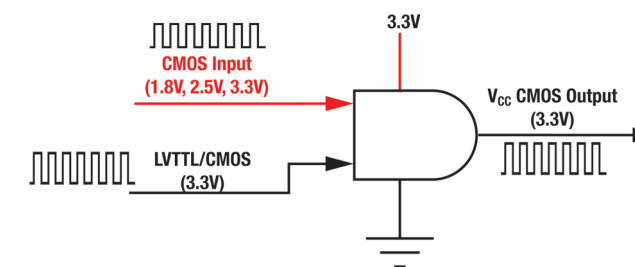- Industrial
- Automotive
- Telecom

Single-Power Supply Translator
SN74LVxTx

SN74LV1T00 is a low voltage CMOS gate logic that operates at a wider voltage range allowing generations of desired output levels to connect to controllers or processors. The output level is referenced to the supply voltage and is able to support 1.8 V/2.5 V/3.3/5 V CMOS levels.

The input is designed with a lower threshold circuit to match 1.8 V input logic at V_{CC} = 3.3 V and can be used in 1.8 V to 3.3 V level up translation. In addition, the 5 V tolerant input pins enable down translation (e.g. 3.3 V to 2.5 V output at V_{CC} = 2.5 V).

The SN74LV1T00 is designed with current-drive capability of 8 mA to reduce line reflections, overshoot, and undershoot caused by high-drive outputs.

SN74LVxTxx functional block diagram

Get more information: **ti.com/product/SN74LVxTxx**

Key Features
- Single-supply voltage 1.8-5.0 V V_{CC}
- Operating range of 1.8 V to 5.5 V
- Up translation
  - 1.2 V to 1.8 V; 1.8 V to 2.5 V
  - 1.8 V to 3.3 V; 3.3 V to 5.0 V
- Down translation
  - 3.3/2.5 V to 1.8 V; 5.0/3.3 V to 2.5 V
    5.0 V to 3.3 V
- –40°C to 125°C operating temperature range
- Packages available: SC-70 (DCK)
  - 2 mm × 1.25 mm (DCK)
  - 2.9 mm × 1.6 mm (DBV)
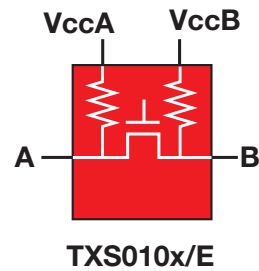- Supports standard logic pinouts

Applications
- Industrial controllers
- Telecom
- Portable applications
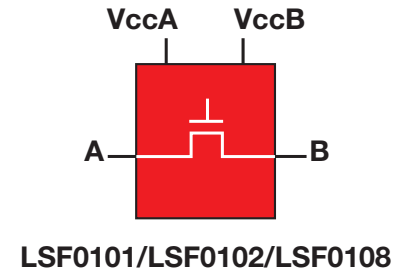- Servers
- PC and notebooks
- Automotive

Dual-Supply Translators
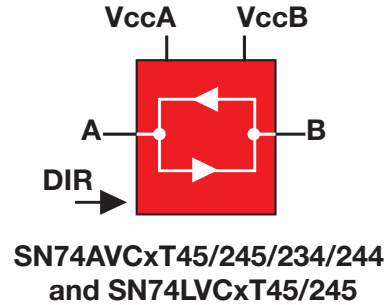Five Classes of Voltage Translators

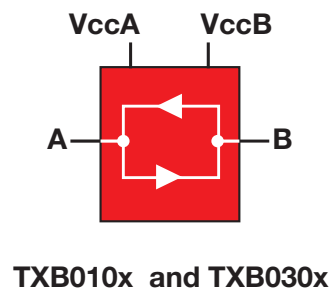### Auto-direction sensing translators for open-drain applications

VccA   VccB

A — B

TXS010x/E

Bidirectional multi-voltage for open-drain & push-pull translators

VccA   VccB

A — B

LSF0101/LSF0102/LSF0108

Dual-supply configurable translators

VccA   VccB

A — B

DIR

SN74AVCxT45/245/234/244 and SN74LVCxT45/245

Auto-direction sensing translators

VccA   VccB

A — B

TXB010x and TXB030x

Application-specific translators
(memory card and SIM card interfaces)

VccA   VccB

CMD_A 4   4 CMD_B
DATA_A   DATA_B
CLK_A   CLK_B

TXS02xxx and TXS45xx
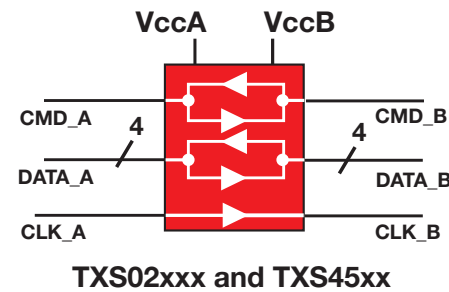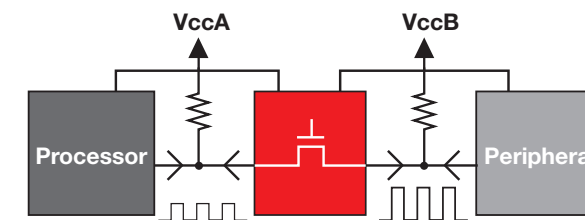

Dual-Supply Translators
Bidirectional Voltage Translators

Bidirectional Multi-Voltage Translator
LSF010x

The LSF family are bidirectional voltage level translators operational from 1.0 V to 4.5 V (V_{REF}_A) and 1.8 V to 5.5 V (V_{REF}_B). This allows bidirectional voltage translations between 1.0 V and 5.0 V without the need for a direction terminal in open-drain or push-pull applications. LSF family supports level translation applications with transmission speeds greater than 100 Mbps for open-drain systems utilizing a 30 pF capacitance and 250Ω pull-up resistor.

The low Ron of the switch allows connections to be made with minimal propagation delay and signal distortion. Assuming the higher voltage is on the Bn port.

VccA   VccB

Processor   Peripheral

LSF010x functional block diagram

Key Features
• Provides bidirectional voltage translation
• Less than 1.5 ns max propagation delay
• High speed translation > 100 MHz
• Supports hot insertion
• 5 V Tolerance I/O port to support TTL
• Low ron provides less signal distortion
• Flow-through pinout for ease PCB trace routing
• –40°C to 125°C operating temperature range
• ESD performance tested per JESD 22

Applications
• GPIO, MDIO, PMBus, SMBus, SDIO, UART, I^{2}C, and other interfaces in telecom infrastructure
• Industrial
• Personal computing
• Automotive

Get more information: **ti.com/product/LSF010x**

GTL2014 4-Bit LVTTL to GTL Bidirectional Transceiver
SN74GTL2014

The SN74GTL2014 is a 4-bits translator to interface between 3.3-V LVTTL chip set I/O and Xeon processor GTL–/GTL/GTL+ I/O. The SN74GTL2014 integrates ESD protection cells on all terminals and is available in a TSSOP package (5.0 mm × 4.4 mm). The device is characterized over the free air temperature range of –40°C to 85°C.

GTL2014PW

DIR   1   14 V_{cc}
B0   2   13 A0
B1   3   12 A1
V_{REF} 4   11 GDN
B2   5   10 A2
B3   6   9 A3
GND   7   8 GND

GTL2014PW

B0 — A0
B1 — A1
B2 — A2
B3 — A3

V_{REF} DIR
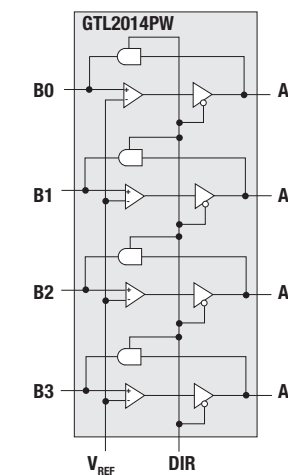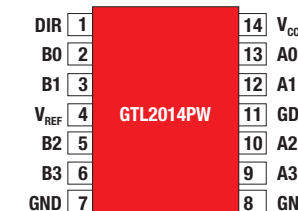
SN74GTL2014 functional block diagram

Key Features
• Operates as a GTL–/GTL/GTL+ to LVTTL or LVTTL to GTL–/GTL/GTL+ translator
• The LVTTL input are tolerant up to 5.5 V allowing direct access to TTL or 5V CMOS
• The GTL input/output operate up to 3.6 V, allowing the device to be used in high voltage open-drain applications
• V_{REF} goes down to 0.5 V for low voltage CPU usage
• Partial power-down permitted
• Latch-up protection exceed 500 mA per JESD78
• ESD protection on all terminals
   ○ 2k V HBM, JESD22-A114
   ○ 1k V CDM, IEC61000-4-2

Applications
• Server
• Base station
• Wireline communication

Get more information: **ti.com/product/SN74GTL2014**

Dual-Supply Translators
Auto-Direction Sensing Translators

Auto-Direction Sensing Translator Portfolio

TI's auto-direction sensing translation devices are ideal for point-to-point topologies when interfacing devices may be operating at different interface voltage levels. They improve connectivity between next-generation processors and peripheral devices by eliminating the requirement for direction-control signals used by traditional voltage-level translation devices. This decreases the control software complexity while saving valuable GPIO signals on core processors.

Auto-direction sensing translators

Key Features
- Auto-direction sensing — no direction control signal needed
- Automatic reconfigurable I/O buffers — each I/O port is configured as both an input and an output
- Integrated pull-up resistors — provides modest DC-bias and current sourcing capabilities while saving BOM costs
- Output slew-rate control circuitry — edge-rate accelerator circuitry detects and speeds up AC-transitions to maintain fast data rate throughput
- V_{CC} isolation feature — if either V_{CC} input is at GND, all outputs are in the high impedance state
- Highly integrated ESD protection — ±15-kV ESD protection on the B port
- Devices ending in E suffix include integrated IEC 61000-4-2 ESD protection.

Bidirectional, Auto-Direction Sensing Translators with 0.9 V Support
TXB030x

These non-inverting translators use two separate configurable power-supply rails. As voltage signal levels continue to decrease, a new set of low-voltage-level translators are needed. This is the reason why the TXB030x family of low-voltage auto-direction sensing translators were made.

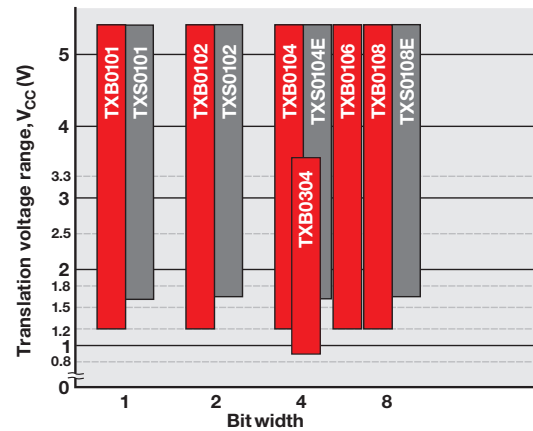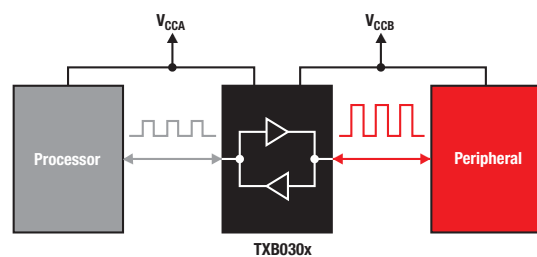When the output-enable (OE) input is low, all outputs are placed in the high-impedance state. To ensure the high-impedance state during power up or power down, OE should be tied to GND through a pulldown resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver. The TXB030x family is designed so that the OE input circuit is supplied by V_{CCA}. The devices are fully specified for partial-power-down applications using I_{OFF}. The I_{OFF} circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down.

TXB030x functional block diagram

Key Features
- Optimized for push-pull applications
- Fully symmetric supply voltages: 0.9 V to 3.6 V on both A-port and B-port
- V_{CC} isolation feature – If either V_{CC} input is at GND, all outputs are in the high-impedance state
- OE input circuit referenced to V_{CCA}
- Low power consumption, 5-µA max I_{CC}
- 8-kV Human-Body Model (HBM)

Applications
- Cell phones
- Tablets
- Portable GPS devices
- *Bluetooth*® headsets
- General portable consumer applications
- Computing
- Industrial
- Telecom

Get more information: **ti.com/product/TXB030x**

Dual-Supply Translators
Auto-Direction Sensing Translators

Bidirectional, Auto-Direction Sensing Translators
TXB010x

These non-inverting translators use two separate configurable power-supply rails. The A port is designed to track V_{CCA}. V_{CCA} accepts any supply voltage from 1.2 V to 3.6 V. The B port is designed to track V_{CCB}. V_{CCB} accepts any supply voltage from 1.65 V to 5.5 V. This allows for universal low-voltage bidirectional translation between any of the 1.2-V, 1.5-V, 1.8-V, 2.5-V, 3.3-V, and 5-V voltage nodes. V_{CCA} should not exceed V_{CCB}.

When the output-enable (OE) input is low, all outputs are placed in the high-impedance state. This device is fully specified for partial-power-down applications using I_{OFF}. The I_{OFF} circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down.

To ensure the high-impedance state during power up or power down, OE should be tied to GND through a pulldown resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

TXB010x functional block diagram

Key Features
- Optimized for push-pull drivers
- 100 Mbps max data rate transfer
- V_{CC} isolation feature
- OE input circuit referenced to V_{CCA}
- Low power consumption
- I_{OFF} supports operation in partial-power-down mode
- 1.2 V to 3.6 V on A-port and 1.65 V to 5.5 V on B-port ($V_{CCA} \leq V_{CCB}$)

Applications
- Cell phones
- SPI and GPIO level translation
- Computing
- Industrial
- Telecom
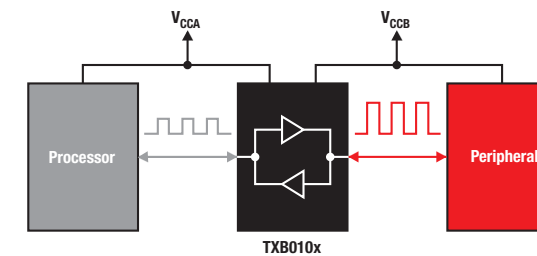
Get more information: **ti.com/product/TXB010x**

Bidirectional, Auto-Direction Sensing Translators for Open Drain Applications
TXS010x

These non-inverting translators use two separate configurable power-supply rails. The A port is designed to track V_{CCA}. V_{CCA} accepts any supply voltage from 1.65 V to 3.6 V. The B port is designed to track V_{CCB}. V_{CCA} must be less than or equal to V_{CCB}. V_{CCB} accepts any supply voltage from 2.3 V to 5.5 V. This allows for low-voltage bidirectional translation between any of the 1.8-V, 2.5-V, 3.3-V, and 5-V voltage nodes.

When the output-enable (OE) input is low, all outputs are placed in the high-impedance state. To ensure the high-impedance state during power up or power down, OE should be tied to GND through a pulldown resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

TXS010x functional block diagram

Key Features
- Works with both open-drain and push-pull drivers
- Max data rates:
  - 24 Mbps (push-pull)
  - 2 Mbps (open-drain)
- 1.65 V to 3.6 V on A-port and 2.3 V to 5.5 V on B-port ($V_{CCA} \leq V_{CCB}$)
- No power supply sequencing required
- IEC 61000-4-2 ESD protection on B-port for "E" suffix devices

Applications
- Cell phones
- I²C level translation
- MMC and SIM card level translations
- Telecom
- Computing
- Industrial
- Automotive

Get more information: **ti.com/product/TXS010x**

Dual-Supply Translators
Configurable Translators with Direction Control Portfolio

Dual-Supply Configurable Translators with Direction Control Portfolio

TI translators with direction control are designed for asynchronous communication between two buses or devices operating at different supply voltages: V_{CCA} to interface with the A side and V_{CCB} to interface with the B side. These devices are available in a variety of bit widths and cover nearly every supply-voltage node in use today. They are flexible, easy to use and can translate bidirectionally (up-translate and down-translate), which makes them an ideal choice for most level-translation applications.

Key Features
- Fully configurable rails — each V_{CC} rail is fully configurable from 1.2 V to 3.6 V (AVCxT devices) and from 1.65 V to 5.5 V (LVCxT devices)
- No power-up sequencing — either V_{CC} can be powered up first (AVCxT and LVCxT devices only)
- Standby mode — when one V_{CC} is switched off, all I/O ports are placed in the HiZ mode (AVCxT and LVCxT devices only).
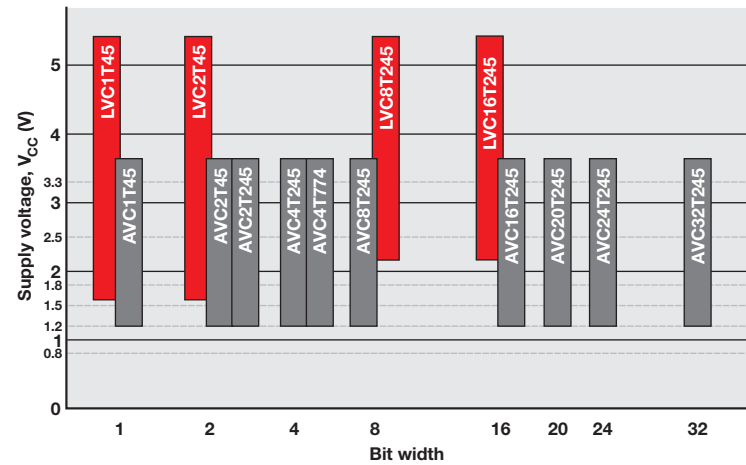
Direction-control translators

Configurable Translators with Configurable Voltage Translation and 3-State Outputs

Dual-Supply Bus Transceiver with Configurable Voltage Translation and 3-State Outputs
SN74LVCxT45/245

These devices are fully specified for partial-power-down applications using I_{OFF} The I_{OFF} circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down.

The V_{CC} isolation feature ensures that if either V_{CC} input is at GND, then both ports are in the high-impedance state. To ensure the high-impedance state during power up or power down, OE should be tied to V_{CC} through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.

Key Features
- Control input levels, V_{IH}/V_{IL}, are referenced to V_{CCA} voltage
- Fully configurable dual-rail design allows each port to operate over full 1.65-V to 5.5-V power-supply range
- I_{OFF} supports operation in partial-power-down mode

Applications
- Portables
- Telecom
- Computing
- Industrial
- Telecom
- Automotive
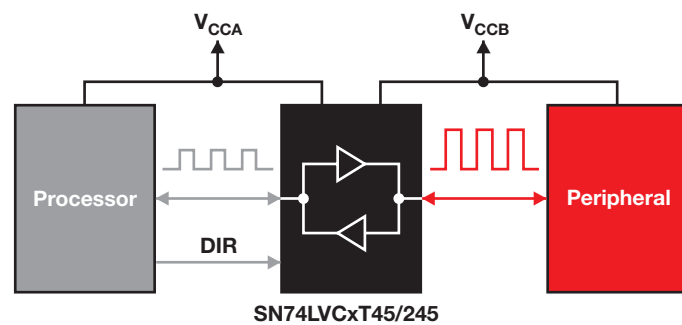
SN74LVCxT45/245 functional block diagram

Get more information: **ti.com/product/SN74LVCxT45/245**

Dual-Supply Translators
Configurable Unidirectional Translators

Dual-Supply Bus Transceiver with Configurable Voltage Translation and 3-State Outputs
SN74AVCxT45/245

These devices are designed for asynchronous communication between data buses. The devices transmit data from the A bus to the B bus or from the B bus to the A bus, depending on the logic level at the direction-control (DIR) input.

Key Features
- 380 Mbps max data rate
- Control input levels, VIH/VIL, are referenced to V_{CCA} voltage
- Fully configurable dual-rail design allows each port to operate over full 1.2-V to 3.6-V power-supply range
- I_{OFF} supports operation in partial-power-down mode

Applications
- Handsets
- PDAs
- Computing
- Smartphones
- Industrial
- Telecom
- Automotive
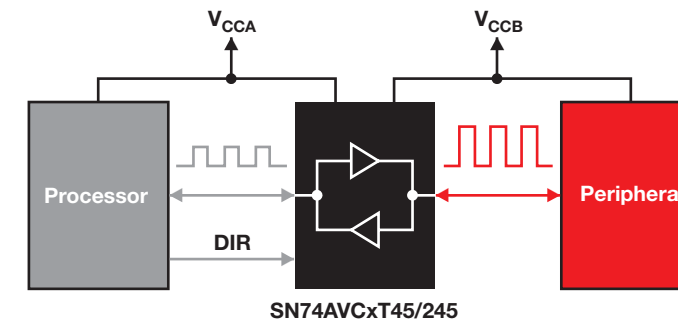
SN74AVCxT45/245 functional block diagram

Get more information: **ti.com/product/SN74AVCxT45/245**

Dual-Supply Unidirectional Voltage Level Translator
SN74AVC2T244/SN74AVC4T234

The unidirectional translator uses two separate configurable power-supply rails to enable asynchronous communication between B-port inputs and A-port outputs. The A port is designed to track V_{CCA} while the B port is designed to track V_{CCB}. Both V_{CCA} and V_{CCB} are configurable from 0.9 V to 3.6 V. The SN74AVC2T244/SN74AVC4T234 offers Input hysteresis to allow slow input transition and better switching noise immunity at Input. It offers very low static and dynamic power consumption across the entire V_{CC} range of 0.9 V to 3.6 V, making it the ideal translator for battery powered portable electronics applications.

Key Features
- 380 Mbps max data rate
- Wide operating V_{CC} range of 0.9 V to 3.6 V
- 3.6-V I/O tolerant to support mixed-mode signal operation
- Input hysteresis allows slow input transition and better

Applications
- Handsets
- PDAs
- Computing
- Smartphones
- Industrial
- Telecom
- Automotive
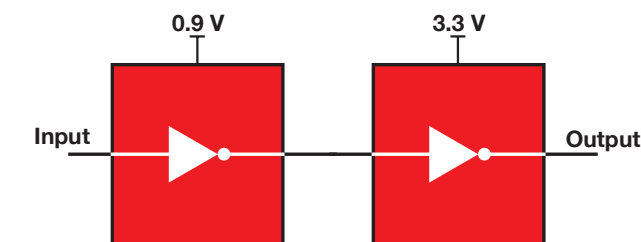
SN74AVC2T244/4T234 function block diagram

Get more information: **ti.com/product/SN74AVC2T244**
ti.com/product/SN74AVC4T234

Dual-Supply Translators
Application Specific Translators

SD Card, Memory Stick, and MMC Voltage-Translation Transceivers with ESD Protection and EMI Filtering
TXS0206, TXS0206A, TXS0206-29

Memory card standards recommend high-ESD protection for devices that connect directly to the external memory card. To meet this need, these devices incorporate ±8-kV Contact Discharge protection on the card side.

Key Features
- Voltage-translation transceiver for memory card interfaces (SD, Mini SD, MMC)
- Fully configurable dual-voltage supply architecture with both V_{CCA} and V_{CCB} operating range of 1.1 V to 3.6 V
- Six bidirectional channels capable of passing 60 Mbps data rates with 3 ns typical prop-delay
- No direction control needed on data/command paths
- Integrated pull-up resistors on card-side I/Os per SD specification
- SDIO-compliant integrated smart pull-up resistors — enables output drivers to maintain modest DC-bias current sourcing capabilities while maintaining low static power consumption

Applications
- Mobile phones
- PDAs
- Digital cameras
- Personal media players
- Camcorders
- Set-top boxes

Get more information: **ti.com/product/TXS0206-**
ti.com/product/TXS0206-29

SDIO Port Expander with Voltage-Level Translation
TXS02612

The TXS02612 is designed to interface the cell phone baseband with external SDIO peripherals. The device includes a 6-channel SPDT switch with voltage-level translation capability. This allows a single SDIO port to be interfaced with two SDIO peripherals. The TXS02612 has three separate supply rails that operate over the full range of 1.1 V to 3.6 V. This allows the baseband and SDIO peripherals to operate at different supply voltages if required. The high-performance ESD protection is designed for external memory card interface.

Key Features
- 1.1-V to 3.6-V range
- 6-to-12 demultiplexer/multiplexer allows SDIO port expansion
- Built-in level translator eliminates voltage mismatch between baseband and SDIO peripheral
- ±8-kV contact discharge IEC 61000-4-2 ESD performance (B Port)

Applications
- Personal electronics
- Computing
- Sever
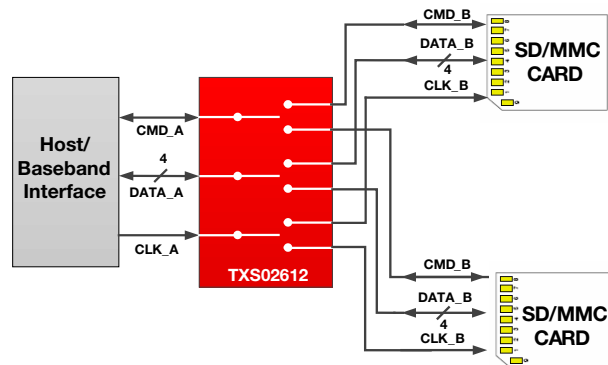
TXS02612 functional block diagram

Get more information: **ti.com/product/TXS02612**

Dual-Supply Translators
Application Specific Translators

Dual-supply SIM Card Translator and 2:1 Multiplexer
TXS02326

The TXS02326 is a dual-supply SIM card solution for interfacing wireless baseband processors with two SIM cards. The 2:1 multiplexer function extends the single SIM card interface to support two SIM cards. The dual-supply voltage translation function supports 1.7 V to 3.3 V range on the processor side and either 1.8 V or 2.95 V on the SIM card side. The two SIM card interface standards, Class-B (2.95 V) and Class-C (1.8 V) are supported by two integrated low-dropout (LDO) voltage regulators with selectable outputs. An integrated 400 kb/s I^{2}C interface offers several configuration options, including safe power-down of the two SIM cards.
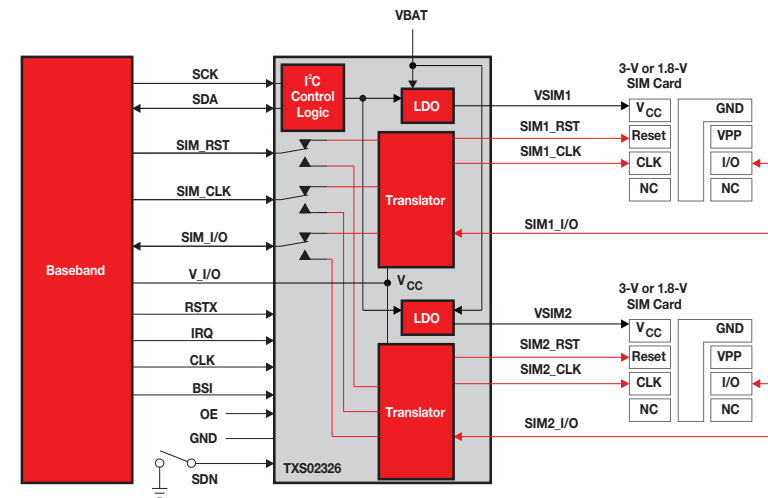
Key Features
- Dual-supply translator with voltage range of 1.7 V to 3.6 V
- 2:1 multiplexer function enables the use of a single SIM card interface to control two SIM cards
- Integrated dual-LDOs enable support of 1.8 V and 2.95 V SIM card standards
- Available in popular 24-pin QFN package

Applications
- Baseband processors
- Smart phones
- Netbooks

Get more information:
ti.com/product/TXS02326

Dual-Supply Translators
Translators by Application

Device	VCC Min. to Max. (V)		VCCA (V)									VCCB (V)									Smallest Package
	VCCA	VCCB	0.9	1.2	1.5	1.65	1.8	2.5	2.7	3.3	5	0.9	1.2	1.5	1.65	1.8	2.5	2.7	3.3	5	
Application Specific: SD Card Translators																					
SN74AVCA406L	1.2 to 3.6	1.2 to 3.6	✓	✓	✓		✓	✓	✓	✓		✓	✓			✓	✓	✓	✓		20-ball VFBGA
SN74AVCA406E	1.2 to 3.6	1.2 to 3.6	✓	✓	✓		✓	✓	✓	✓		✓	✓			✓	✓	✓	✓		20-ball VFBGA
TXS0206	1.1 to 3.6	1.1 to 3.6	✓	✓	✓		✓	✓	✓	✓		✓	✓			✓	✓	✓	✓		20-ball WCSP
TXS0206A	1.1 to 3.6	1.1 to 3.6	✓	✓	✓		✓	✓	✓	✓		✓	✓			✓	✓	✓	✓		20-ball WCSP
TXS0206-29	1.1 to 3.6	5V Max VBAT	✓		✓		✓	✓	✓	✓											20-ball DSBGA
TXS02612	1.1 to 3.6	1.1 to 3.6	✓	✓			✓	✓	✓	✓		✓	✓			✓	✓	✓	✓		24-ball VFBGA
TWL1200	1.1 to 3.6	1.1 to 3.6	✓		✓		✓	✓	✓	✓					✓	✓	✓	✓	✓		49-ball DSBGA
Application Specific: SIM Card Translators																					
TXS02612	1.1 to 3.6	1.1 to 3.6	✓	✓			✓	✓	✓	✓		✓	✓			✓	✓	✓	✓		24-ball VFBGA
TXS02324	1.7 to 3.3	2.3 to 5.5			✓	✓	✓									✓					20-pin WQFN
TXS02326	1.7 to 3.3	2.3 to 5.5			✓	✓	✓									✓					24-pin VQFN
TXS02326A	1.7 to 3.3	2.3 to 5.5			✓	✓	✓									✓					24-pin VQFN
TXS4555	1.65 to 3.3	2.3 to 5.5			✓	✓	✓	✓	✓							✓					12-pin UQFN
TXS4558	1.7 to 3.3	2.3 to 5.5				✓	✓	✓	✓	✓						✓					20-pin WQFN
Application Specific: Audio Codec																					
SN74AVC6T622	1.2 to 3.6	1.2 to 3.6	✓	✓			✓	✓	✓	✓											20-ball uBGA
Application Specific: CF Card																					
CF4320	1.65 to VCCB	3 to 5.5			✓		✓	✓	✓	✓	✓								✓	✓	114-ball LFBGA
Application Specific: IC-USB																					
SN74AVC2T872	1.1 to 3.6	1.1 to 3.6	✓	✓			✓	✓	✓	✓		✓	✓			✓	✓	✓	✓	✓	12-ball WCSP
TXS0202	1.65 to 3.6	1.65 to 3.6			✓		✓	✓	✓	✓	✓				✓	✓	✓	✓	✓		8-ball YZP
Application Specific: SPI																					
SN74AVC4T774	1.2 to 3.6	1.2 to 3.6	✓	✓			✓	✓	✓	✓		✓	✓			✓	✓	✓	✓		16-pin UQFN
TXB0104	1.2 to 3.6	1.65 to 5.5	✓	✓			✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	12-ball DSBGA
TXB0304	0.9 to 3.6	0.9 to 3.6	✓	✓	✓		✓	✓	✓	✓		✓	✓			✓	✓	✓	✓		12-pin UQFN
TXS0104E	1.65 to 3.6	2.3 to 5.5			✓		✓	✓	✓	✓							✓	✓	✓	✓	12-ball DSBGA
Application Specific: I2C																					
TXS0102	1.65 to 3.6	2.3 to 5.5			✓		✓	✓	✓	✓							✓	✓	✓	✓	8-ball DSBGA
Application Specific: UART																					
SN74AVC4T245	1.2 to 3.6	1.2 to 3.6	✓	✓			✓	✓	✓	✓		✓	✓			✓	✓	✓	✓		16-pin UQFN
SN74AVC4T774	1.2 to 3.6	1.2 to 3.6	✓	✓			✓	✓	✓	✓		✓	✓			✓	✓	✓	✓		16-pin UQFN

[1] Bus-hold option available

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

Dual-Supply Translators
Dual Supply Translators by Bit Count

Device	VCC Min. to Max. (V)		VCCA (V)									VCCB (V)									Smallest Package
	VCCA	VCCB	0.9	1.2	1.5	1.65	1.8	2.5	2.7	3.3	5	0.9	1.2	1.5	1.65	1.8	2.5	2.7	3.3	5	
1-Bit																					
SN74AUP1T34	0.9 to 3.6	0.9 to 3.6	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		SON-6
SN74AUP1T34-Q1	0.9 to 3.6	0.9 to 3.6	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		SC70-5
SN74AVC1T45[1]	1.2 to 3.6	1.2 to 3.6	✓	✓													✓	✓			NanoStar™/NanoFree™-6
SN74LVC1T45	1.65 to 5.5	1.65 to 5.5				✓	✓	✓	✓	✓	✓									✓	NanoStar/NanoFree-6
TXB0101	1.2 to 3.6	1.65 to 5.5	✓	✓												✓	✓	✓	✓	✓	6-ball NanoFree
TXS0101	1.65 to 3.6	2.3 to 5.5					✓	✓	✓									✓	✓	✓	6-ball NanoFree
2-Bit																					
SN74AVC2T45[1]	1.2 to 3.6	1.2 to 3.6		✓	✓		✓	✓	✓							✓	✓	✓			NanoStar/NanoFree-8
SN74AVC2T244	0.9 to 3.6	0.9 to 3.6	✓	✓	✓		✓	✓	✓	✓		✓	✓			✓	✓	✓	✓		µQFN-8
TXB0102	1.2 to 3.6	1.65 to 5.5		✓	✓											✓	✓	✓	✓	✓	NanoFree-8
TXS0102	1.65 to 3.6	2.3 to 5.5					✓	✓	✓								✓	✓	✓		NanoFree-8
TXS0102-Q1	1.65 to 3.6	2.3 to 5.5					✓	✓	✓								✓	✓	✓		VSSOP-8
4-Bit																					
SN74AVC4T234	1.1 to 3.6	1.1 to 3.6		✓		✓	✓	✓	✓	✓			✓			✓	✓	✓	✓	✓	ZSU
SN74AVC4T245[1]	1.2 to 3.6	1.2 to 3.6		✓	✓		✓	✓	✓					✓		✓	✓	✓			QFN-16
SN74AVC4T774	1.2 to 3.6	1.2 to 3.6		✓	✓		✓	✓	✓					✓		✓	✓	✓			QFN-16
TXB0104	1.2 to 3.6	1.65 to 5.5		✓	✓											✓	✓	✓	✓	✓	UFBGA-12
TXB0304	0.9 to 3.6	0.9 to 3.6	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	✓	✓		RSV
TXS0104E-Q1	1.65 to 3.6	2.3 to 5.5					✓	✓	✓								✓	✓	✓		TSSOP-14
TXS0104E	1.65 to 3.6	2.3 to 5.5					✓	✓	✓								✓	✓	✓	✓	UFBGA-12
6-Bit																					
TXB0106	1.2 to 3.6	1.65 to 5.5		✓	✓		✓	✓	✓							✓	✓	✓	✓	✓	QFN-16
8-Bit																					
SN74AVC8T245[1]	1.2 to 3.6	1.2 to 3.6		✓	✓		✓	✓	✓							✓	✓	✓			QFN-12
SN74LVC8T245[1]	1.65 to 5.5	1.65 to 5.5				✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	QFN-12
TXB0108	1.2 to 3.6	1.65 to 5.5		✓	✓		✓	✓	✓							✓	✓	✓	✓	✓	VFBGA-20
TXS0108E	1.65 to 3.6	2.3 to 5.5					✓	✓	✓								✓	✓	✓		VFBGA-20
16-Bit																					
SN74AVC16T245[1]	1.2 to 3.6	1.2 to 3.6		✓	✓		✓	✓	✓							✓	✓	✓			VFBGA-56
SN74LVC16T245[1]	1.65 to 5.5	1.65 to 5.5				✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	VFBGA-56
20-Bit																					
SN74AVC20T245[1]	1.2 to 3.6	1.2 to 3.6		✓	✓		✓	✓	✓							✓	✓	✓			VFBGA-56
24-Bit																					
SN74AVC24T245[1]	1.2 to 3.6	1.2 to 3.6		✓	✓		✓	✓	✓							✓	✓	✓	✓	✓	LFBGA-83
32-Bit																					
SN74AVC32T245[1]	1.2 to 3.6	1.2 to 3.6		✓	✓		✓	✓	✓							✓	✓	✓	✓	✓	LFBGA-96

Single and Dual Supply Translators
Translators by Bit Count

Device	Vcc Min. to Max. (V) VCCA	Vcc Min. to Max. (V) VCCB	Single Voltage	Dual Voltage	VCCA 0.9	1.2	1.5	1.65	1.8	2.3	2.5	2.7	3.0	3.3	5	VCCB 0.9	1.2	1.5	1.65	1.8	2.3	2.5	2.7	3.0	3.3	5	Smallest Package
1-Bit																											
Dual Supply																											
LSF0101	0 to 5.0	0 to 5.0		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X2SON
Single Supply																											
AUP1T00	2.3 to 3.6	—	X							X	X	X	X														SC-70
AUP1T02	2.3 to 3.6	—	X							X	X	X	X														SC-70
AUP1T04	2.3 to 3.6	—	X							X	X	X	X														SC-70
AUP1T08	2.3 to 3.6	—	X							X	X	X	X														SC-70
AUP1T14	2.3 to 3.6	—	X							X	X	X	X														SC-70
AUP1T17	2.3 to 3.6	—	X							X	X	X	X														SC-70
AUP1T32	2.3 to 3.6	—	X							X	X	X	X														SC-70
AUP1T34	0.9 to 3.6	0.9 to 3.6		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X2SON
AUP1T50	2.3 to 3.6	—	X							X	X	X	X														SC-70
AUP1T57	2.3 to 3.6	—	X							X	X	X	X														NanoStar™
AUP1T58	2.3 to 3.6	—	X							X	X	X	X														NanoStar
AUP1T86	2.3 to 3.6	—	X							X	X	X	X														SC-70
AUP1T87	2.3 to 3.6	—	X							X	X	X	X														SC-70
AUP1T97	2.3 to 3.6	—	X							X	X	X	X														NanoStar
AUP1T98	2.3 to 3.6	—	X							X	X	X	X														NanoStar
AUP1T157	2.3 to 3.6	—	X							X	X	X	X														SC-70
AUP1T158	2.3 to 3.6	—	X							X	X	X	X														SC-70
SN74LV1T00	1.60 to 5.5	—	X					X	X	X	X	X	X	X	X												SC-70
SN74LV1T04	1.60 to 5.5	—	X					X	X	X	X	X	X	X	X												SC-70
SN74LV1T08	1.60 to 5.5	—	X					X	X	X	X	X	X	X	X												SC-70
SN74LV1T02	1.60 to 5.5	—	X					X	X	X	X	X	X	X	X												SC-70
SN74LV1T32	1.60 to 5.5	—	X					X	X	X	X	X	X	X	X												SC-70
SN74LV1T34	1.60 to 5.5	—	X					X	X	X	X	X	X	X	X												SC-70
SN74LV1T125	1.60 to 5.5	—	X					X	X	X	X	X	X	X	X												SC-70
SN74LV1T126	1.60 to 5.5	—	X					X	X	X	X	X	X	X													SC-70
SN74LV1T86	1.60 to 5.5	—	X					X	X	X	X	X	X	X	X												SC-70
2-Bit																											
Dual Supply																											
LSF0102	0 to 5.0	0 to 5.0		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X2SON
4-Bit																											
Dual Supply																											
GTL2014	3 to 3.6	3 to 3.6		X								X													X		TSSOP
LSF0104	0 to 5.0	0 to 5.0		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X2SON
SN74LV4T125	1.60 to 5.5		X					X	X	X	X	X	X	X	X							X		X	X		VQFN
8-Bit																											
Single and Dual Supply																											
LSF0108	0 to 5.0	0 to 5.0		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X2SON

Additional Translators

FET Switches

Devices from TI's CBT, CBTD, CB3T and TVC families can be used in level-translation applications. The diagram shows a CB3T bus switch interfacing a 3-V bus with a 5-V (TTL) bus. The CB3T device down-translates the signals from the 5-V bus to 3-V levels.

No translation is necessary to transfer signals from the 3-V bus to the 5-V (TTL) bus, since the V_{OH} level from the CB3T switch is greater than the required V_{IL} of the 5-V (TTL) devices connected to the 5-V bus.

Advantage
- Fast propagation delays

FET switch for translation

Overvoltage-Tolerant Devices and TTL-Compatible Inputs and Open-Drain Output Devices

Overvoltage-Tolerant Devices

Devices with overvoltage-tolerant inputs can be used to perform down-translation as shown in the diagram. Logic families with overvoltage-tolerant inputs include:

- AHC
- AUC
- AVC
- LV-A
- LVC

Advantages
- Only one supply voltage needed
- Broad portfolio of AHC, AUC, AVC, LV-A and LVC devices

Devices with TTL-Compatible Inputs

Up-translation from 3.3-V LVCMOS/LVTTL to 5-V CMOS levels can be achieved with logic devices from TI's HCT, AHCT, ACT and AUP families.

Advantages
- Only one supply voltage needed
- Broad portfolio of HCT, AHCT, ACT and AUP devices

Devices with Open-Drain Outputs

Devices with open-drain outputs can be used to perform both up-translation and down-translation. The output voltage is determined by V_{CCB}. This output level can be higher than V_{CCA} (up-translation) or lower than V_{CCA} (down-translation).

Advantages
- Flexibility in translating to/from a variety of voltage nodes

Down-translation

TTL up-translation

Translation with open-drain buffers

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