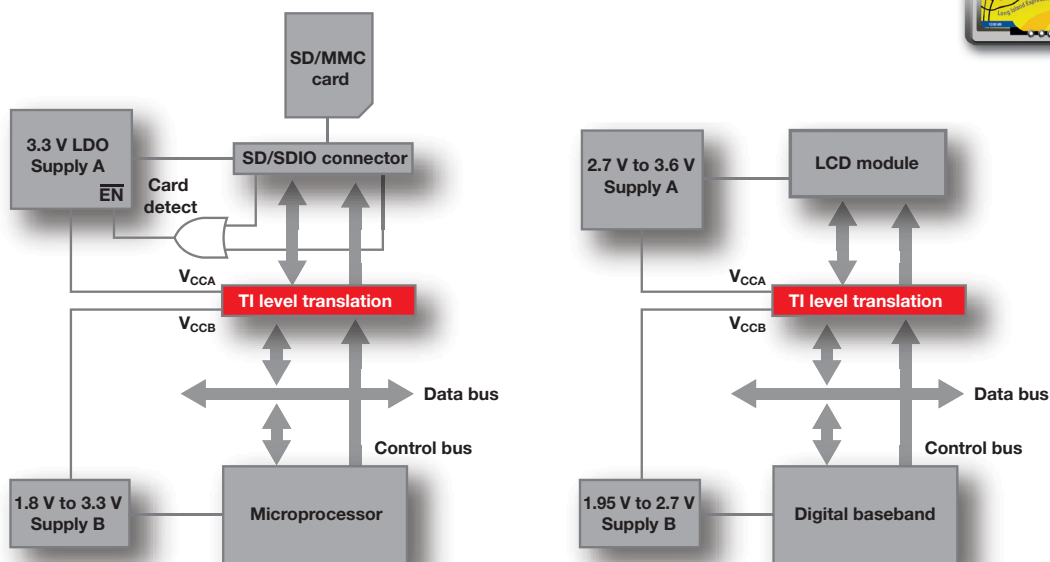




Translation Guide



Auto-Direction Sensing
Direction Control
Application-Specific



→ Table of Contents

Introduction

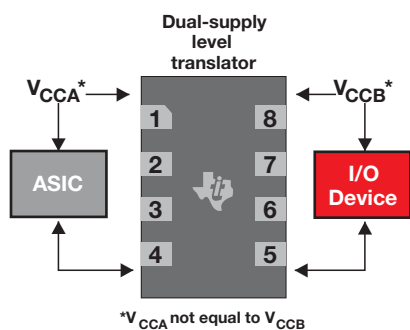
In today's complex and high-performance system environment, higher levels of functional integration have led to lower power consumption CMOS process technologies operating at lower supply voltage levels. The ability to mix, match and support the simultaneous use of different operating supply voltage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

To remedy this interface mixed-voltage switching incompatibility and facilitate logic-threshold switching compatibility between disparate voltage levels, the driver output thresholds must be compatible with the receiver input thresholds, and a level-translator device can be used 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.

A typical level-translator situation



Overview

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Dual-Supply Translators

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Additional Translators

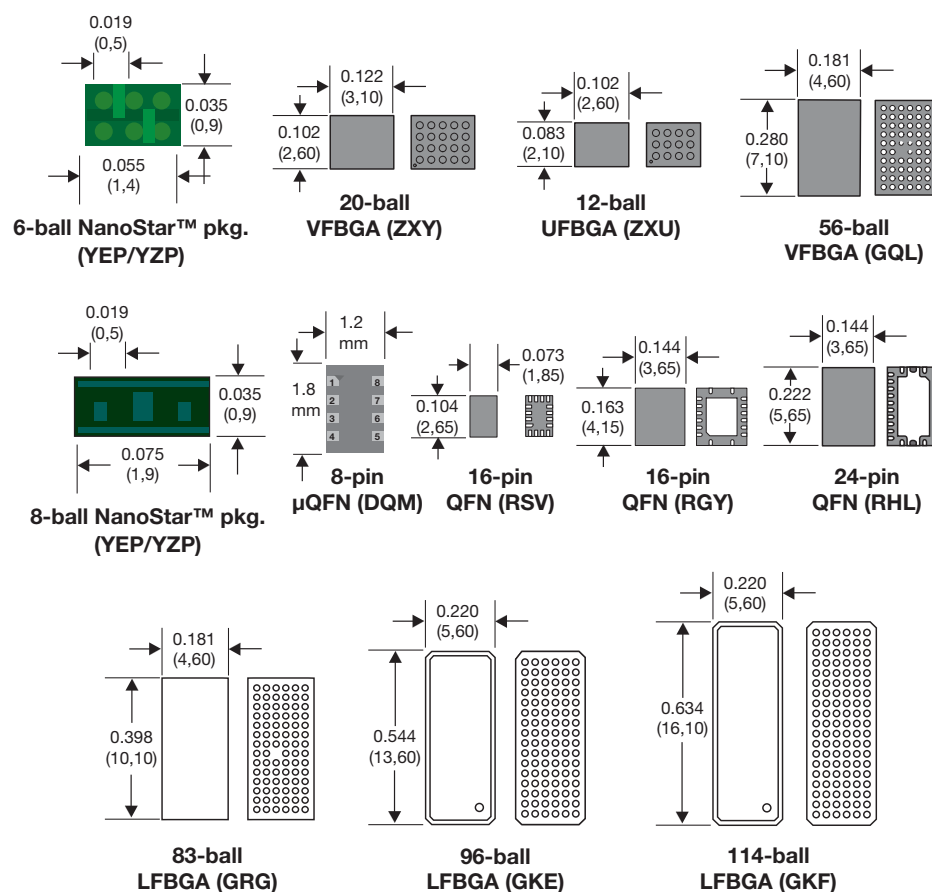
FET Switches	9
Overvoltage-Tolerant Devices	10
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Resources

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Packages

Dimensions are in inches (millimeters)



Auto Direction Sensing

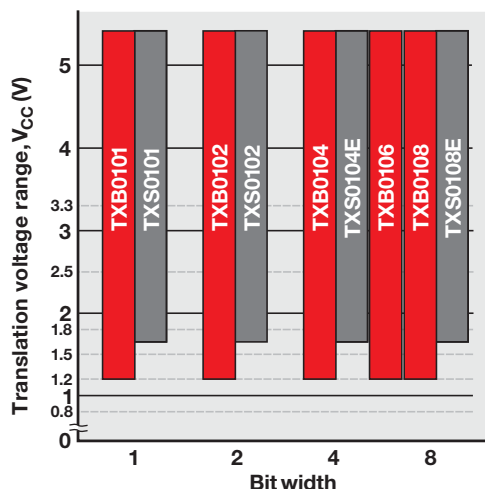


Auto-Direction Sensing

TI's auto-direction sensing translation devices are ideal for point-to-point topologies when interfacing devices that may or may not 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.

Key features

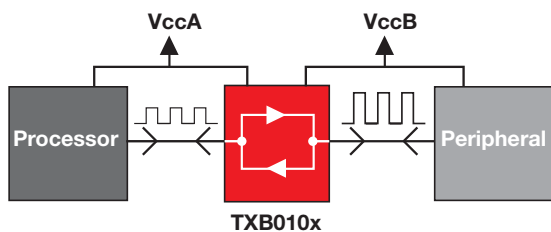
- Auto-direction sensing — no direction control signal needed
- Automatic reconfigurable I/O buffers — each I/O port is configured as both an input and an output
- Integrated pull-up resistors — provides modest DC-bias and current sourcing capabilities while saving BOM costs
- Output slew-rate control 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.



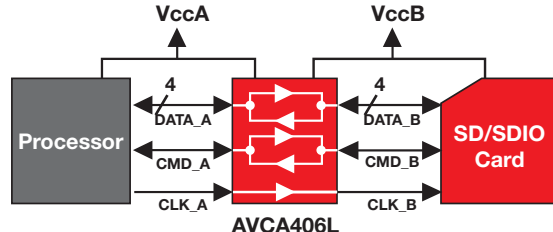
Auto direction-sensing translators

Four Classes of Voltage Translators

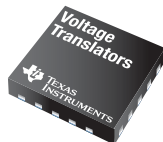
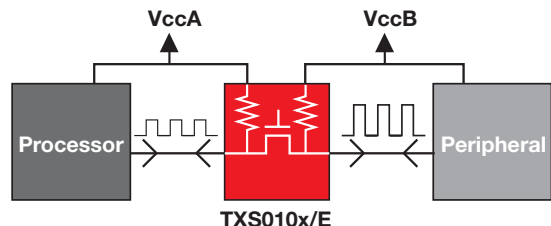
Auto-direction sensing translators



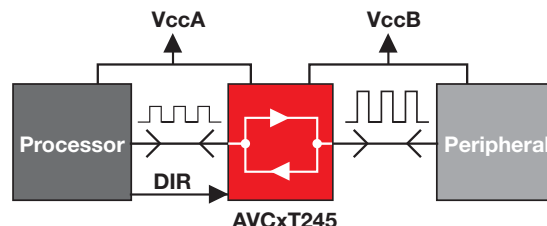
Application-specific translators (memory card interface)



Auto-direction sensing translators for open-drain applications



Dual-supply configurable translators





Auto-Direction Sensing

Bidirectional Voltage-Level Translator with Auto Direction Sensing and ± 15 -kV ESD Protection

TXB010x

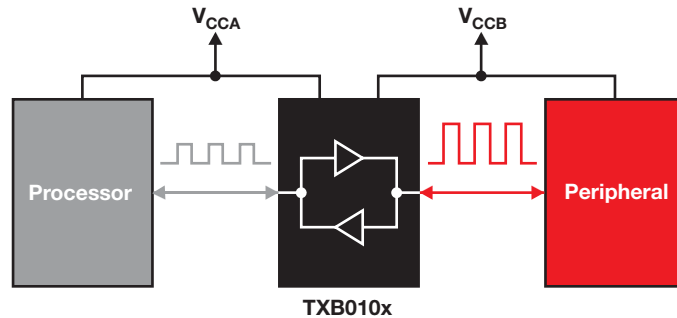
Get samples, data sheets, EVMs and app reports at: www.ti.com/sc/device/TXB010x

Key features

- 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
- SD/SDIO level translation
- SPI and GPIO level translation



TXB010x functional block diagram

Bidirectional Voltage-Level Translator for Open-Drain Applications

TXS010x

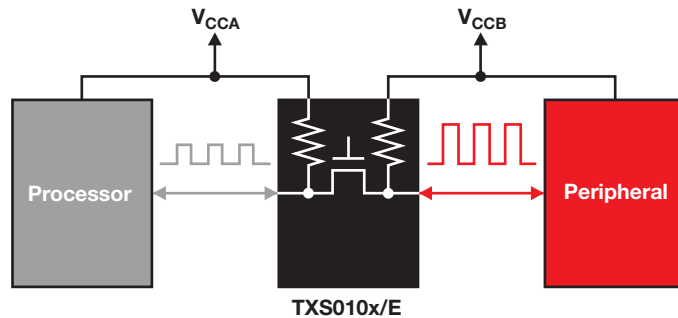
Get samples, data sheets, EVMs and app reports at: www.ti.com/sc/device/TXS010x

Key features

- 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



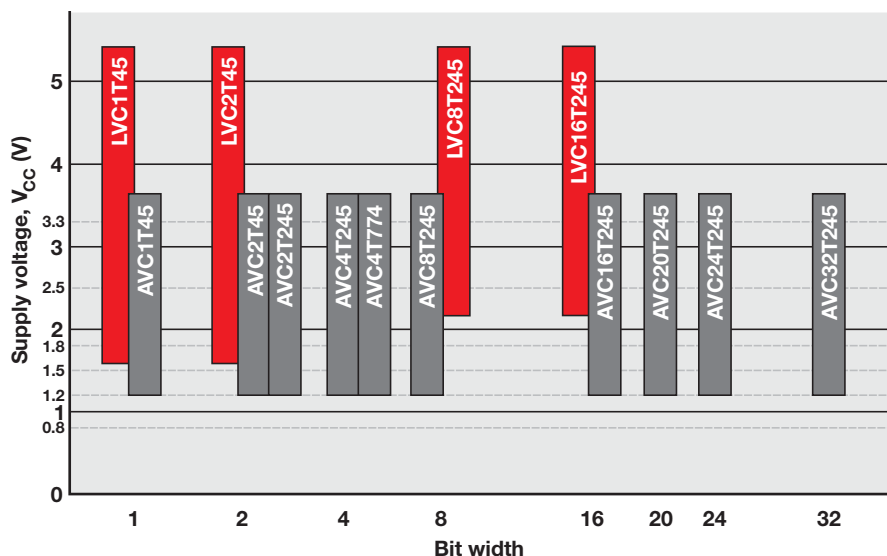
TXS010x functional block diagram



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

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

SN74AVCxT

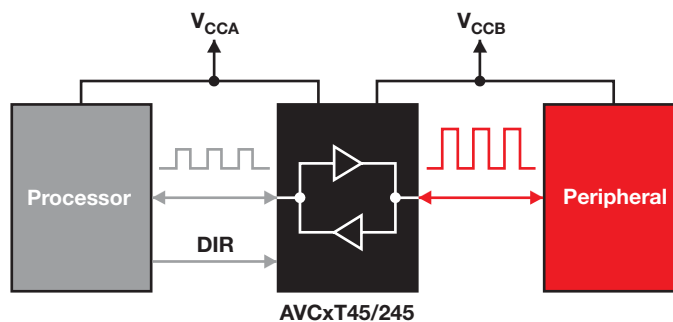
Get samples, data sheets, EVMs and app reports at: www.ti.com/sc/device/SN74AVCxT

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 1.2-V to 3.6-V power-supply range
- I_{OFF} supports operation in partial-power-down mode

Applications

- Handsets
- PDAs
- Computing
- Smart phones



SN74AVCxT functional block diagram

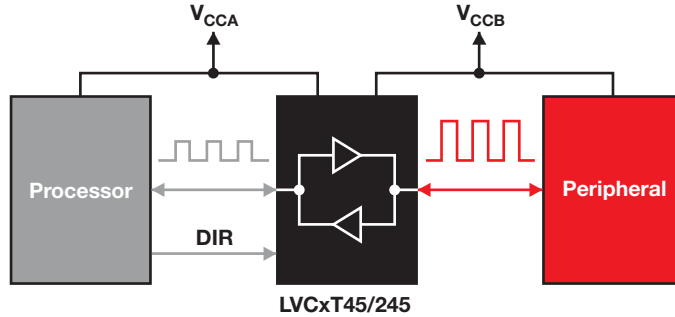
→ Direction Control

Dual-Supply Bus Transceiver with Configurable Voltage Translation and 3-State Outputs
SN74LVCxT

Get samples, data sheets, EVMs and app reports at: www.ti.com/sc/device/SN74AVCxT

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



SN74LVCxT functional block diagram

Applications

- Portables
- Telecom
- Computing
- Translation from 3.3 V to 5 V

→ Application Specific

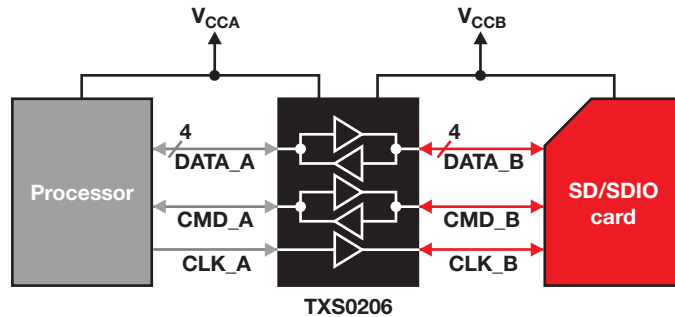


SD Card, Memory Stick, and MMC Voltage-Translation Transceivers with ESD Protection and EMI Filtering
TXS0206 and TXS0206-29

Get samples, data sheets, EVMs and app reports at: www.ti.com/sc/device/TXS0206; www.ti.com/sc/device/TXS0206-29

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



TXS0206 functional block diagram

Applications

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



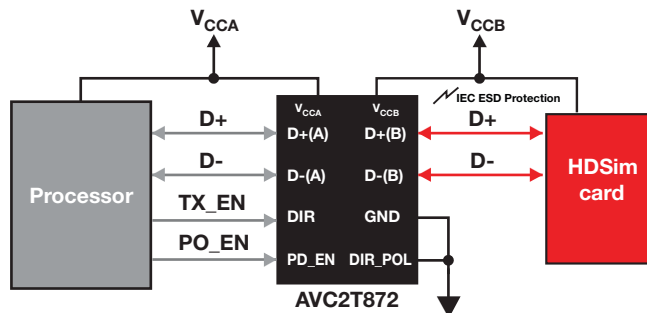
High-Density SIM Cards

SN74AVC2T872

Get samples, data sheets, EVMs and app reports at: www.ti.com/sc/device/SN74AVC2T872

Key features

- 2-bit inter-chip USB-compliant translator — meets IC-USB cross-over channel-to-channel skew of <math><1\text{ nsec}</math>
- Integrated pull-up/down resistors — saves BOM costs
- <math><2\mu\text{A}</math> of I_{CC} current — ideal for handheld applications
- IEC 61000-4-2 (Level 4) integrated ESD protection — $\pm 15\text{-kV}$ air-gap ESD protection on the B port



SN74AVC2T872 functional block diagram

Applications

- Mobile phones

Selection Guide

Device	Bit width	V_{CC} Min. to Max. (V)		V_{CCA} (V)							V_{CCB} (V)							Smallest package
		V_{CCA}	V_{CCB}	1.2	1.5	1.8	2.5	2.7	3.3	5	1.2	1.5	1.8	2.5	2.7	3.3	5	
Application Specification																		
CF4320H	—	1.65 to V_{CCB}	3 to 5.5			✓	✓	✓	✓	✓						✓	✓	114-ball LFBGA
SN74AVCA406L	—	1.2 to 3.6	1.2 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		20-ball VFBGA
SN74AVC2T872	2	1.1 to 3.6	1.1 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		12-ball WCSP
SN74AVC6T622	6	1.2 to 3.6	1.2 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		20-ball UFBGA
TXS0206	—	1.1 to 3.6	1.1 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		20-ball WCSP
TXS02612	—	1.1 to 3.6	1.1 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		24-ball VFBGA

 Selection Guide

Device	Bit width	V _{CC} Min. to Max. (V)		V _{CCA} (V)								V _{CCB} (V)						Smallest package
		V _{CCA}	V _{CCB}	1.2	1.5	1.8	2.5	2.7	3.3	5	1.2	1.5	1.8	2.5	2.7	3.3	5	
1-Bit																		
SN74AVC1T45 ¹	1	1.2 to 3.6	1.2 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		6-ball NanoStar™/NanoFree™	
SN74LVC1T45	1	1.65 to 5.5	1.65 to 5.5			✓	✓	✓	✓	✓			✓	✓	✓	✓	6-ball NanoStar/NanoFree	
TXB0101	1	1.2 to 3.6	1.65 to 5.5	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	6-ball NanoFree	
TXS0101	1	1.65 to 3.6	2.3 to 5.5			✓	✓	✓	✓				✓	✓	✓	✓	6-ball NanoFree	
2-Bit																		
SN74AVC2T45 ¹	2	1.2 to 3.6	1.2 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	8-ball NanoStar/NanoFree	
SN74LVC2T45	2	1.65 to 5.5	1.65 to 5.5			✓	✓	✓	✓	✓			✓	✓	✓	✓	8-ball NanoStar/NanoFree	
SN74LVC2T245	2	1.2 to 3.6	1.2 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	10-pin QFN	
TXB0102	2	1.2 to 3.6	1.65 to 5.5	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	8-ball NanoFree	
TXS0102	2	1.65 to 3.6	2.3 to 5.5			✓	✓	✓	✓				✓	✓	✓	✓	8-ball NanoFree	
4-Bit																		
SN74AVC4T245 ¹	4	1.2 to 3.6	1.2 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	16-pin QFN	
SN74AVC4T774	4	1.2 to 3.6	1.2 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	16-pin QFN	
TXB0104	4	1.2 to 3.6	1.65 to 5.5	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	12-ball UFBGA	
TXS0104E	4	1.65 to 3.6	2.3 to 5.5			✓	✓	✓	✓				✓	✓	✓	✓	12-ball UFBGA	
6-Bit																		
TXB0106	6	1.2 to 3.6	1.65 to 5.5	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	16-pin QFN	
8-Bit																		
SN74AVC8T245 ¹	8	1.2 to 3.6	1.2 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	24-pin QFN	
SN74LVC8T245 ¹	8	1.65 to 5.5	1.65 to 5.5			✓	✓	✓	✓	✓			✓	✓	✓	✓	24-pin QFN	
TXB0108	8	1.2 to 3.6	1.65 to 5.5	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	20-ball VFBGA	
TXS0108E	8	1.65 to 3.6	2.3 to 5.5			✓	✓	✓	✓				✓	✓	✓	✓	20-ball VFBGA	
16-Bit																		
SN74AVC16T245 ¹	16	1.2 to 3.6	1.2 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	56-ball VFBGA	
SN74LVC16T245 ¹	16	1.65 to 5.5	1.65 to 5.5			✓	✓	✓	✓	✓			✓	✓	✓	✓	56-ball VFBGA	
20-Bit																		
SN74AVC20T245 ¹	20	1.2 to 3.6	1.2 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	56-ball VFBGA	
24-Bit																		
SN74AVC24T245 ¹	24	1.2 to 3.6	1.2 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	83-ball LFBGA	
32-Bit																		
SN74AVC32T245 ¹	32	1.2 to 3.6	1.2 to 3.6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	96-ball LFBGA	

¹Bus-hold option available

Translator Nomenclature



Translator nomenclature

	TX	S	01	04	E	RGY	R
Prefix: TX = TI translator							
Device type: S = Switch, B = Buffer							
Grade							
Bit width							
ESD protection: E = IEC Level 4							
TI package designator							
Tape and reel: R or none = Standard reel, T = Small reel							

Translator nomenclature

	SN74	AVC	20	T	245	DGV	R
TI prefix:							
Technology family: AHC, AHCT, AVC, AUC, CBT, CBTD, CB3T, HCT, LVC, TVC							
Bit width							
Device type: T = Translation							
Function identifier							
TI package designator							
Tape and reel: R or none = Standard reel, T = Small reel							

FET Switches

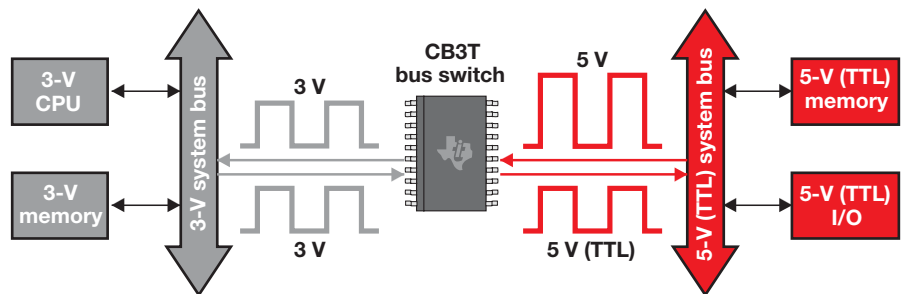
Devices from TI's CBT, CBTD, CB3T and TVC families can be used in level-translation applications. The diagram shows a CB3T bus switch interfacing a 3-V bus with a 5-V (TTL) bus. The CB3T device down-translates the signals from the 5-V bus to 3-V levels.

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

Additional Translators and Resources



FET switch for translation

→ Additional Translators and Resources (continued)

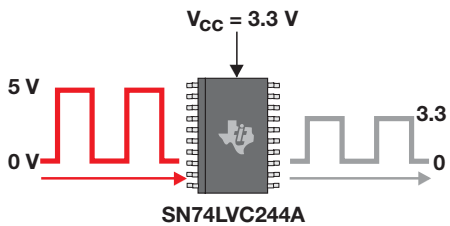
Overvoltage-Tolerant Devices

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
- LV-A
- AUC
- LVC
- AVC

Advantages

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



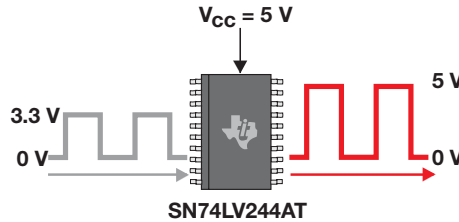
Down-translation

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



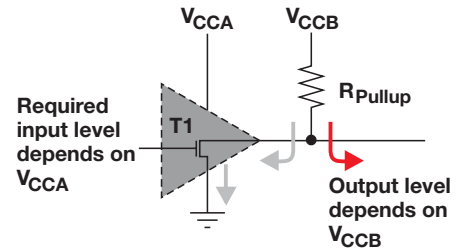
TTL up-translation

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



Translation with open-drain buffers

Translation Sample Requests

Working day and night and need a free TI product sample fast? We're waiting to take your order online 24/7.

We'll help you. That's what our product-sample program is all about.

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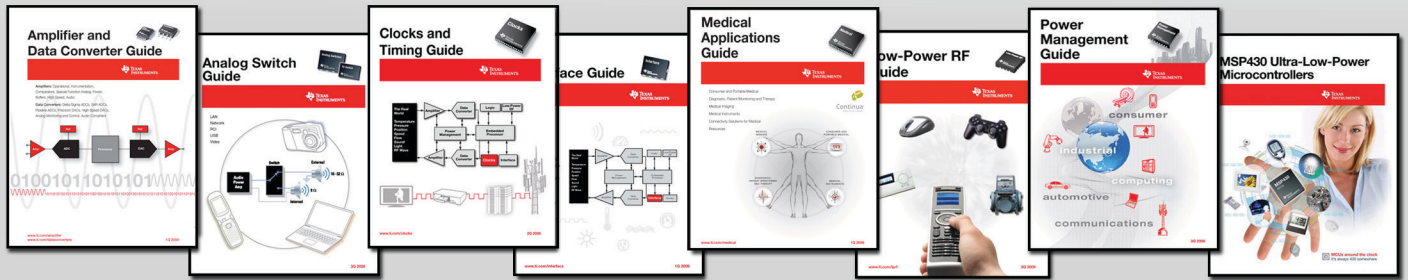
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