Linear and Logic

5-Minute Guide

SLYB128A

Technology for Innovators™

Texas Instruments

Contents

SLYB128A

Linear and Logic New-Product Priorities

Linear **www.ti.com/linear**

- Differentiated new solutions—simple switchers, 1-V reference, ESD protection, op amps, LED drivers
- Leadership products for battery-powered portable electronics

Signal Switches **www.ti.com/signalswitches**

- New application-specific solutions for analog, video, LAN, USB, DVI, HDMI
- Higher-performance digital bus switches for mobile, computing and telecom

Translation **www.ti.com/trans**

- Application-specific solutions for memory-card interfaces and directionless architecture
- Broadest offering, with interfaces from 0.8 to 5.0 V and formats from 1 to 32 bits

I^2C Interface **www.ti.com/i2c**

- Two-wire, industry-standard communication interface
- Drop-in replacements for other supplier solutions
- Leadership products for battery-powered portable electronics

Package Development

- Smallest and most advanced packaging solutions: BGA, QFN, WCSP
- Pb-Free and Green conversion: **www.ti.com/ecoinfo**

Must-Have Devices

must have

Must-Have devices are premiere products in the Linear, Interface, Switch, Translation and I^2C segments of TI's broad Linear and Logic portfolio. These devices offer off-the-shelf availability and are available through TI's free sample program.

www.ti.com/musthave

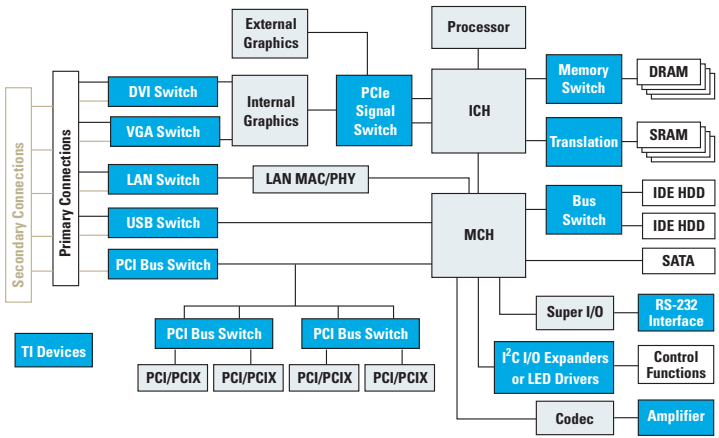
Overview

Top Computing Applications for Linear and Logic Devices

- PCI Express Multiplexing
- USB, LAN, Video Multiplexing
- I^2C I/O Expansion and LED Driver
- RS-232 Serial Port Interface
- ESD Protection

Top Linear and Logic Device Requirements for Computing

- **System Cost**
  Adding even a few pins to an already complex ASIC can increase die size and cost and raise the package price. Specialty switches and I/O expanders can be used to add functionality and features to the board while keeping ASIC costs down. The new RS-232 devices incorporate ESD protection, which also helps reduce total system cost while providing the bonus of space savings.
- **Feature Richness**
  Specialty switches allow designers to easily expand board functionality by adding an extra video port, USB port, LAN connection, PCI Express lane or I^2C GPIO port to free up processor ports for other functions.



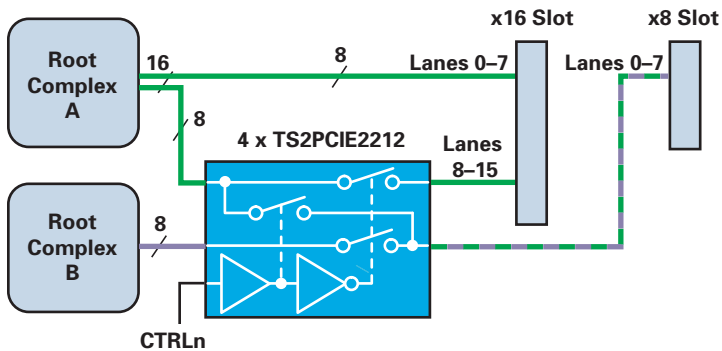
Resources

- *Notebook Computing Solutions Guide*: Lit. # SLYY016

PCI Express® Multiplexing

The TS2PCIE2212 can be used to multiplex/demultiplex two PCI Express® lanes. The switch operates at the PCI Express 2.5-Gbps signal-processing speed and is composed of two banks. Each bank accommodates two sources (A and B) and two destinations (A and B).

When a logic-level low is applied to the control pin (CTRL), source A is connected to destination A, and source B is connected to destination B. When a logic-level high is applied to CTRL, source A is connected to destination B, while source B and destination A are open.



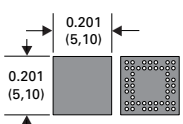
Applications

- Servers and workstations
- PCs and laptops
- Laptop docking stations

Resources

- *Analog Switch Selection Guide*: Lit. # SLYB125
  www.ti.com/analogswitchguide

Advanced Package Option



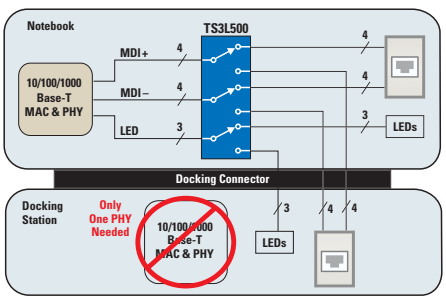
48-Ball BGA (ZAH)

Device Characteristics

Device	V_{DD} (min/max) (V)	No. of Lanes	r_{on} (typ) (Ω)	Data Rate (Gbps)	Description	I_{CC} (µA)	$C_{IO(ON)}$ (pF)	Crosstalk (dB)	Off Isolation (dB)
TS2PCIE2212	1.7/1.9	2:4	10	2.5	2-lane 1:2 PCI Express® MUX/DeMUX	160	3.5	–39	–38

USB, LAN, Video Multiplexing

These high-performance multiplexing switches allow designers to increase board functionality without paying for an additional port from ASICs like the LAN controller, USB controller or video chip. The multiplexing functionality also allows routing from one source to multiple destinations.



Multiplexing Applications

- 10/100/1000 Base-T Ethernet
- USB 1.0/1.1/2.0
- DVI
- RGB
- HDMI

Resources

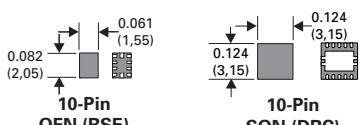
- Analog Switch Product Cast: **www.ti.com/casts**
- *Analog Switch Selection Guide*: Lit. # SLYB125 **www.ti.com/analogswitchguide**

Suggested Devices

Interface Type	Device	Description	Pins/Packages
DVI	TS3DV416	Gigahertz switch, low $r_{on(flat)}$ (8:16 MUX)	48/TSSOP, TVSOP
	TS3DV520/E	High-speed video switch (10:20 MUX)	52/QFN
VGA (R,G,B)	TS5V330	5-V video switch, lower r_{on} (4:8 MUX)	16/SOIC, SSOP, TSSOP, QFN
	TS3V330	3.3-V video switch, lower r_{on} (4:8 MUX)	
TV-Out	TS5A23157	S-video #2 bits (2:4 MUX)	10/MSOP
	TS5A623157	S-video #2 bits (2:4 MUX) with overshoot and undershoot protection	VSSOP, QFN
LAN Interface	TS3L110	3.3-V, 4:8 MUX (10/100 Base-T LAN)	16/SOIC, SSOP, TSSOP, TVSOP, QFN
	TS3L301	3.3-V, 8:16 MUX (1000 Base-T Gigabit LAN)	48/TSSOP, TVSOP
	TS3L500	3.3-V, 11:22 MUX (1000 Base-T Gigabit LAN including LED MUX)	52/QFN
	TS3L500E	High-ESD version	
USB	TS3USB221	2.5-V/3.3-V USB 2.0 1:2 MUX/DeMUX	10/QFN, SON
	TS3USB30	USB 2.0 1:2 MUX/DeMUX	10/QFN
	TS3USB31	USB 2.0 1-port switch	8/QFN

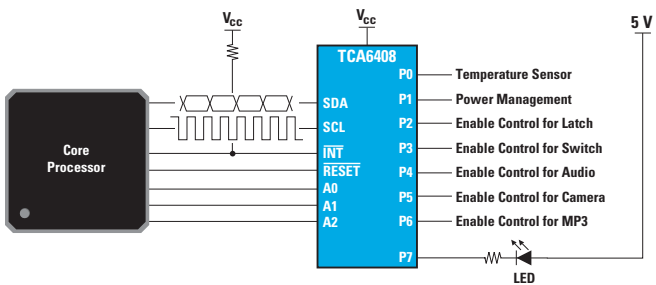
Advanced Package Options

(Additional packages may be available)



I²C I/O Expansion and LED Driver

As more features and processing requirements are added to computing applications, the limited number of GPIOs on microprocessors is becoming restricting. By implementing I²C I/O expanders from TI, designers can use the GPIOs for important functions and use the I²C I/O expanders for other duties like temperature sensing and keypad communications.



Applications

- Temperature, fan and audio control
- Humidity sensors
- LED status
- Hardware control monitor

Resources

- I²C Bus Solutions: **www.ti.com/i2c**
- I²C Product Casts: **www.ti.com/casts**
- *I²C Bus Selection Guide*: Lit. # SSZC003A
- Application Note: Lit. # SCPA032

Suggested Devices

Device	Max Frequency (kHz)	I²C Address	V_{CC} Range (V)	Bit or Channel Width
I/O Expanders				
PCA9536	400	1000 001	2.3 to 5.5	4-bit
PCA6107	400	0011 xxx	2.3 to 5.5	8-bit
PCA9534	400	0100 xxx	2.3 to 5.5	8-bit
PCA9534A	400	0111 xxx	2.3 to 5.5	8-bit
PCA9538	400	1110 0xx	2.3 to 5.5	8-bit
PCA9554A	400	0111 xxx	2.3 to 5.5	8-bit
PCA9554	400	0100 xxx	2.3 to 5.5	8-bit
PCA9557	400	0011 xxx	2.3 to 5.5	8-bit
PCA9535	400	0100 xxx	2.3 to 5.5	16-bit
PCA9539	400	1110 1xx	2.3 to 5.5	16-bit
PCA9555	400	0100 xxx	2.3 to 5.5	16-bit
PCF8575	400	0100 xxx	2.5 to 5.5	16-bit
PCF8575C	400	0100 xxx	4.5 to 5.5	16-bit
Low-Voltage I/O Expanders				
TCA6408	400	0100 00x	1.65 to 5.5	8-bit
TCA6416	400	0100 00x	1.65 to 5.5	16-bit
LED Driver				
TCA6507	400	100 0101	1.65 to 7.6	7-channel

RS-232 Serial Port Interface

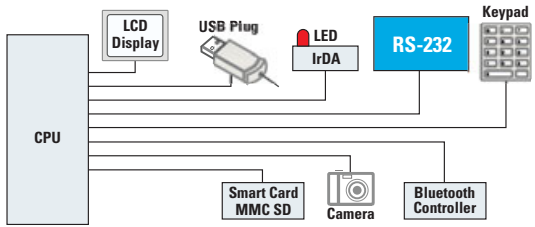
TI offers new RS-232 devices with system-level IEC61000-4-2 electrostatic discharge (ESD) protection. This protection makes the RS-232 interface immune to damage from ESD strikes that may occur while the system is up and running, such as when a connection to the RS-232 cable is made. These devices are drop-in replacements that are functionally identical to the existing industry-standard solutions, providing a seamless transition in the qualification process.

Advantages

- No external ESD protection needed with most devices
- Flexible power-saving options enable longer battery life
- NiPdAu Pb-Free solution provides whisker-free, reliable packages
- Space-saving QFN package options

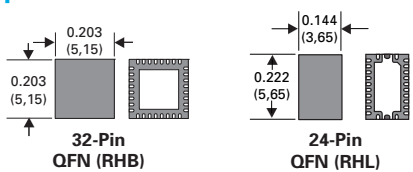
Resources

- RS-232: **www.ti.com/rs-232**
- RS-232 Product Cast: **www.ti.com/casts**
- *Interface Selection Guide*: Lit. # SSZT009C
- RS-232 Application Clip: Lit. # SLLB103A



Advanced Package Options

(Additional packages may be available)



Suggested Devices

Tx/Rx	Device (Speed)	
1/1	TRSF3221E (1 Mbps)	TRS3227E (1 Mbps)
2/2	TRSF3232E (1 Mbps)	TRSF3223E (1 Mbps)
	TRS3318E (500 kbps)	TRSF3222E (1 Mbps)
3/2	TRS3386E (250 kbps)	
3/5	TRSF3243 (1 Mbps)	TRS3243E (500 kbps)
4/5	TRS213 (120 kbps)	TRS211 (120 kbps)
5/3	TRSF3238E* (1 Mbps)	TRS3237E (1 Mbps)

**Preview*

ESD Protection

For any external interface connector port, an ESD strike is a constant threat to device reliability. Many low-voltage core chip or system ASICs offer only device-level human-body-model (HBM) ESD protection, which doesn't address system-level ESD. A stand-alone ESD solution is a space- and cost-effective solution to protect the system interconnects from external ESD strikes.

Advantages

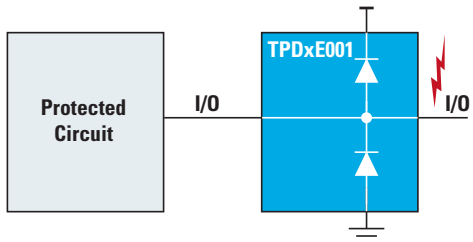
- System-level ESD protection for high-speed applications:
  - ±8-kV IEC 61000-4-2, contact discharge
  - ±15-kV IEC 61000-4-2, air-gap discharge
- Less than 1.5 pF I/O pin capacitance
- Ultra-low 1-nA leakage current
- Operating supply voltage range: +0.9 to +5.5 V
- Space-saving packages: DRY, DRL, DRS and RSF

Benefits

- System-level ESD protection for high-speed interconnects
- Low capacitance suitable for USB 2.0 high-speed devices
- Ultra-low 1-nA leakage current enables precision analog measurements like a glucose meter
- V_{CC} pin allows devices to work as a transient suppressor

Resources

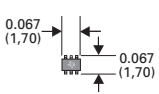
- *Interface Selection Guide*: Lit. # SSZT009C



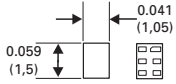
Suggested Devices

Device	No. of Channels	V_{DD} (V)	I/O Level (V)	Cap, Resistor (pF)	VBR (min) (V)	Packages
TPD2E001	2-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRY, DZD
TPD3E001	3-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRY
TPD4E001	4-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRS
TPD6E001	6-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	RSE, RSF
TPD4E002	4-channel ESD	No V_{DD} pin	0 to 6	11	6	DRL

Advanced Package Options



5-/6-Pin SOT-563 (DRL)



6-Pin SON (DRY)

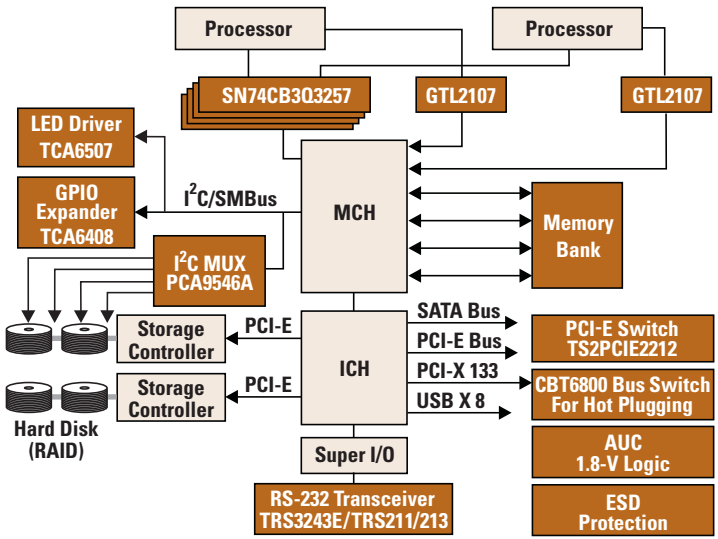
Overview

Top Server Applications for Linear and Logic Products

- GTL/GTL+ to LVTTL Translation
- PCI Express® Signal Switch MUX
- I^2C and SMBus Interface
- RS-232 Interface
- ESD Protection

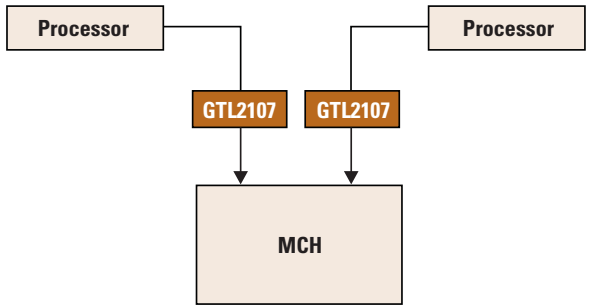
Top Linear and Logic Device Requirements for Server/Storage

- **System Cost**
  It is difficult to gauge overall system cost due to the volatility of the memory market. Specialty switches and I/O expanders can be used to add functionality and features to the system while keeping costs down. The new RS-232 devices incorporate ESD protection, which also helps reduce total system cost while providing the bonus of space savings.
- **Robust Design**
  High ESD exposure and high noise levels and temperatures make this environment harsher and less forgiving. TI offers a wide array of products with enhanced system-level ESD protection and better noise immunity. In addition, many of our standard products offer an extended temperature range of up to 125°C.



GTL/GTL+ to LVTTL Translation

Mixed-signal environments in this application are a common occurrence. In cases where processors are operating at GTL levels and peripheral chipsets at LVTTL levels, it is necessary to translate the signals for proper system operation. TI's GTL/GTL+ to LVTTL translator allows for proper interface.



Advantages

- Devices operate as GTL–/GTL/GTL+ to LVTTL or LVTTL to GTL–/GTL/GTL+ translators
- Series termination on TTL output of 30
- Latch-up testing done to JEDEC standard JESD 78
- ESD performance tested per JESD 22
  - 2000-V human-body model (A114-B, Class II)
  - 200-V machine model (A115-A)
  - 1000-V charged-device model (C101)

Resources

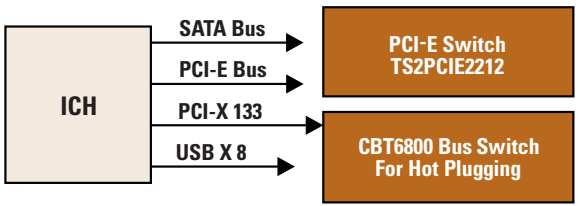
- Interface: **www.ti.com/interface**
- *Interface Selection Guide*: Lit. # SSZT009C

Suggested Devices

Device	Description	V_{CC} Range (V)	Smallest Footprint Pins/Packages
GTL2107	12-bit GTL–/GTL/GTL+ to LVTTL translator	3.0 to 3.3	28/TSSOP
GTL2006	13-bit GTL–/GTL/GTL+ to LVTTL translator	0.5 to 4.6	28/TSSOP
GTL2007	12-bit GTL–/GTL/GTL+ to LVTTL translator	3.0 to 3.6	28/TSSOP

PCI Express® Signal Switch MUX

The TS2PCIE2212 can be used to muxltiplex/demultiplex two PCI Express® lanes, each representing differential pairs of receive (Rx) and transmit (Tx) signals. The switch operates at the PCI Express bandwidth standard of 2.5-Gbps signal-processing speed. The device is composed of two banks, with each bank accommodating two sources (A and B) and two destinations (A and B).



Advantages

- Offers bandwidth allocation of PCI Express signal using two-lane 1:2 multiplexer/demultiplexer
- V_{CC} operating range from 1.7 to 1.9 V
- Supports data rates of 2.5 Gbps
- Port-port crosstalk (–39 dB at 1.25 GHz)
- Off-port isolation (–38 dB at 1.25 GHz)
- Low on-state resistance (10 Ω typ)
- Low input/output capacitance (3.5 pF typ)
- Excellent differential skew (5 ps max)

Suggested Device

Device	Description	V_{CC} Range (V)	Smallest Footprint Pins/Packages
TS2PCIE2212	PCI Express® signal switch	1.7 to 1.9	48/BGA

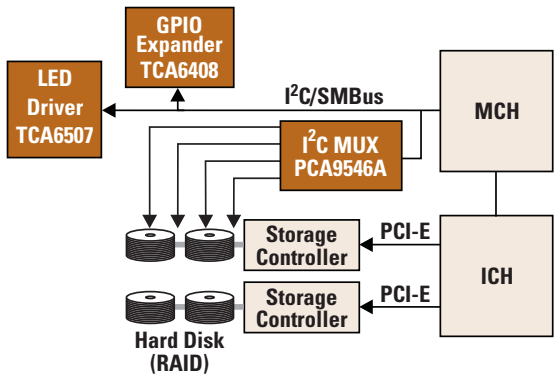
Resources

- Analog Switches: **www.ti.com/switches**
- *Analog Switch Selection Guide*: Lit. # SLYB125

I²C and SMBus Interface

As more features and processing requirements are added to computing applications, the limited number of GPIOs on microprocessors is becoming restricting. By implementing I²C I/O expanders from TI, designers can use the GPIOs for important functions and use the I²C I/O expanders for other duties.

Designers can also use I²C muxes and switches to resolve address conflicts on the I²C bus. In some server designs, multiple SFPs with the same I²C address are used, or there can be multiple temperature sensors with the same I²C address. I²C muxes and switches facilitate smooth operation by selecting which device the master or processor should communicate with at the appropriate time. I²C LED drivers are also essential for lighting functions such as indicator lights.



Applications

- Temperature and fan control
- LED status
- Hardware control monitor

Resources

- I²C Bus Solutions: **www.ti.com/i2c**
- *I²C Bus Selection Guide*: Lit. # SSZC003A
- I²C Product Casts: **www.ti.com/casts**

Suggested Devices

Device	Description	V_{CC} Range (V)	Applications
TCA6507	Low-voltage, 7-bit LED driver with intensity control and shutdown	1.65 to 3.6	Indicator lighting
TCA6408	Low-voltage, 8-bit I²C I/O expander with interrupt and reset	1.65 to 5.5	I/O expansion
PCA9539	16-bit I/O expander w/interrupt and reset	2.3 to 5.5	I/O expansion
PCA9546A	4-channel I²C multiplexer with reset and up translation	2.3 to 5.5	Resolves I²C address conflicts

RS-232 Interface

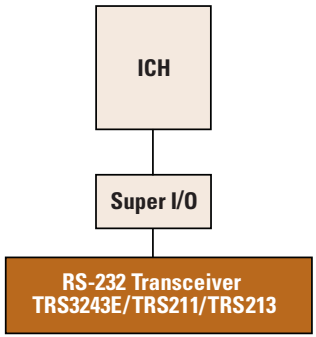
TI offers new RS-232 devices with system-level IEC61000-4-2 electrostatic discharge (ESD) protection. This protection makes the RS-232 interface immune to damage from ESD strikes that may occur while the system is up and running, such as when a connection to the RS-232 cable is made. These devices are drop-in replacements that are functionally identical to the existing industry-standard solutions, providing a seamless transition in the qualification process.

Advantages

- No external ESD protection needed with most devices
- Flexible power-saving options enable longer battery life
- NiPdAu Pb-Free solution provides whisker-free, reliable packages
- Space-saving QFN package options

Resources

- Interface: **www.ti.com/interface**
- *Interface Selection Guide*: Lit. # SSZT009C
- RS-232 Product Cast: **www.ti.com/casts**



Suggested Devices

Device	Description	Smallest Footprint Pins/Packages
TRS3243E	3.3-V, 3-Tx, 5-Rx, RS-232 transceiver with ESD air gap 15 kV, contact 8 kV	32/QFN
TRS211/E	5-V, 4-Tx, 5-Rx, RS-232 transceiver with 15-kV HBM ESD protection	28/SOIC
TRS213/E	5-V, 4-Tx, 5-Rx, RS-232 transceiver with 15-kV HBM ESD protection	28/SOIC

ESD Protection

For any external interface connector port, an ESD strike is a constant threat to device reliability. Many low-voltage core chip or system ASICs offer only device-level human-body-model (HBM) ESD protection, which doesn't address system-level ESD. A stand-alone ESD solution is a space- and cost-effective solution to protect the system interconnects from external ESD strikes.

Advantages

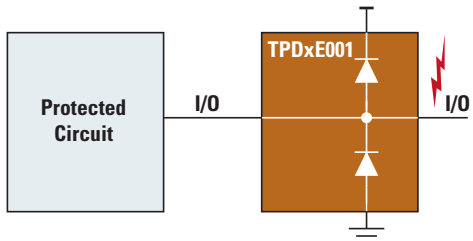
- System-level ESD protection for high-speed applications:
  - ±8-kV IEC 61000-4-2, contact discharge
  - ±15-kV IEC 61000-4-2, air-gap discharge
- Less than 1.5 pF I/O pin capacitance
- Ultra-low 1-nA leakage current
- Operating supply voltage range: +0.9 to +5.5 V
- Space-saving packages: DRY, DRL, DRS and RSF

Benefits

- System-level ESD protection for high-speed interconnects
- Low capacitance suitable for USB 2.0 high-speed devices
- Ultra-low 1-nA leakage current enables precision analog measurements like a glucose meter
- V_{CC} pin allows devices to work as a transient suppressor

Resources

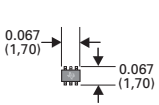
- *Interface Selection Guide*: Lit. # SSZT009C



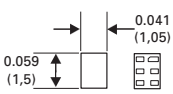
Suggested Devices

Device	No. of Channels	V_{DD} (V)	I/O Level (V)	Cap, Resistor (pF)	VBR (min) (V)	Packages
TPD2E001	2-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRY, DZD
TPD3E001	3-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRY
TPD4E001	4-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRS
TPD6E001	6-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	RSE, RSF
TPD4E002	4-channel ESD	No V_{DD} pin	0 to 6	11	6	DRL

Advanced Package Options



5-/6-Pin SOT-563 (DRL)



6-Pin SON (DRY)

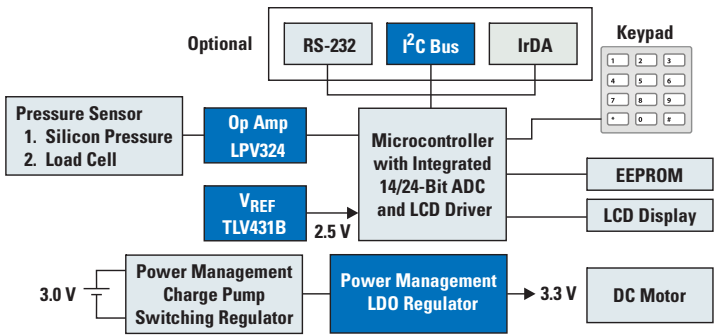
Overview

Top Consumer Medical Applications for Linear and Logic Devices

- Power Management
- Signal Conditioning
- I^2C Bus I/O Expansion
- Voltage-Level Translation
- ESD Protection

Top Linear and Logic Device Requirements for Consumer Medical

- **Size**
  Board real estate is at a premium on PCBs. Small-scale packaging is a requirement for linear and logic functions on the design. From WCSP and micro QFN packages to the industry-standard SC-70 and SOT-23 leadframe packages, TI offers the industry's broadest portfolio of small-scale packaging.
- **Power**
  Power consumption is critical in portable designs. Consumers require long battery life with increased functionality. TI's AUP technology requires 91% less static power and 83% less dynamic power than industry-standard 3.3-V logic.



www.ti.com/medical

Resources

- Medical: **www.ti.com/medical**
- *Medical Applications Guide*: Lit. # SLYB108B

Power Management

Various devices for low-power management are needed for battery-operated consumer medical applications. TI offers a broad portfolio of LDO regulators and voltage references ideal for this type of portable equipment.

Applications

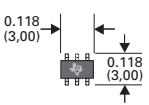
- Precision reference circuits
- Low-power voltage regulation

Resources

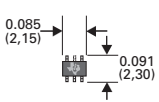
- Power Management: **power.ti.com**
- *Power Management Selection Guide*: Lit. # SLVT145F

Advanced Package Options

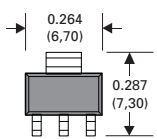
(Additional packages may be available)



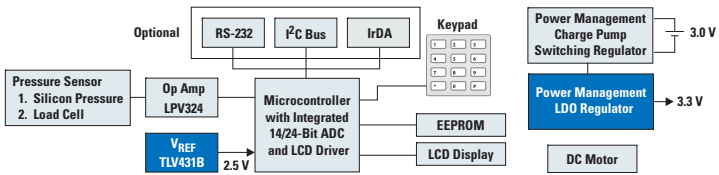
5-/6-Pin
SOT-23 (DBV)



5-/6-Pin
SC-70 (DCK)



4-Pin
TO/SOT (DCY)



Suggested Devices

Device Type	Device	Description
Power Management	LP2985-33	150-mA, low-noise LDO regulator with shutdown
	LP2985A-33	150-mA, low-noise LDO regulator with shutdown, 1% tolerance
	TLV2217-33	LDO 3.3-V PnP fixed-voltage regulator
	TLV1117-33	Fixed-LDO regulator
Voltage References	LM236-2.5	2.5-V integrated reference circuit
	LM285-2.5	µP V_{REF}
	LM336-2.5	2.5-V integrated reference circuit
	LM336B-2.5	Precision V_{REF}
	LM385B-2.5	µP V_{REF}
	LM4040A25	2.5-V precision µP shunt V_{REF}, 0.1% accuracy
	LM4040B25	2.5-V precision µP shunt V_{REF}, 0.2% accuracy
	LM4040C25	2.5-V precision µP shunt V_{REF}, 0.5% accuracy
	LM4040D25	2.5-V precision µP shunt V_{REF}, 1% accuracy
	LT1004-2.5	µP integrated precision V_{REF}
	LT1009	2.5-V integrated reference circuit
	TLV431B	Low-voltage, adjustable precision shunt regulator

Signal Conditioning

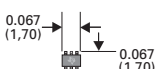
Blood pressure monitors can use the Korotkoff, oscillometric or pulse-transit-time methods to measure blood pressure, while a thermometer uses a thermopile/thermistor combination to measure temperature. It is common to use an op amp to condition these types of signals before interfacing them with the microcontroller.

Resources

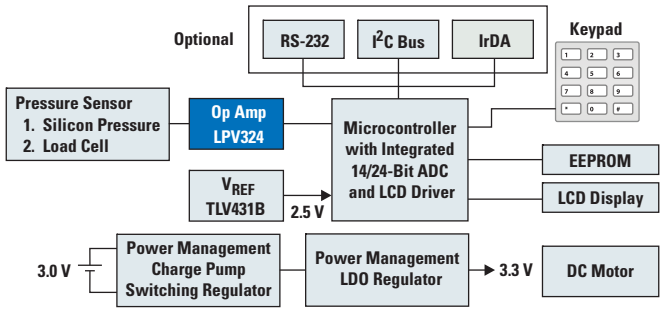
- Operational Amplifiers: **www.ti.com/standardlinear**
- *Operational Amplifiers Selection Guide*: Lit. # SLYB115A

Advanced Package Options

(Additional packages may be available)



5-/6-Pin
SOT-563 (DRL)

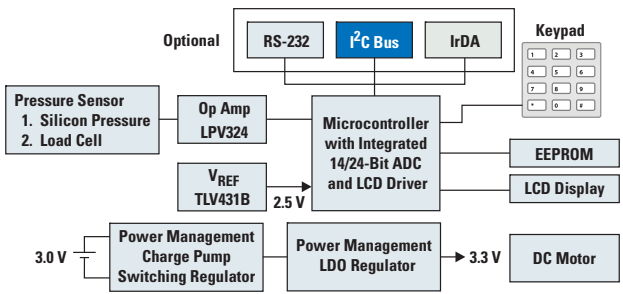


Suggested Devices

Family	Features	Device		
		Single	Dual	Quad
Op Amps	Low-voltage, RRO	LMV321	LMV358	LMV324
	CMOS, RRO, shutdown	LMV341	LMV342	LMV344
Low-Power Op Amps	Low-voltage, low-power, RRO	LPV321	LPV358	LPV324
	Ultra low-power, wide supply range	—	LP358	LP324
High-Speed Op Amps	Low-voltage, low-power, RRO	LMV821	LMV822	LMV824
	Low-power, RRIO, high output-current, shutdown	LMV710	—	—
		LMV711	—	—
		LMV715	—	—
	Low-noise, low-voltage, low-power, RRO	LMV721	LMV722	—
1.8-V Op Amps	RRIO	LMV931	LMV932	LMV934
	CMOS, RRO, shutdown	TLV341	TLV342	TLV344

I²C Bus I/O Expansion

Often there are not enough GPIOs available on the microcontroller to control all the desired peripherals. An I²C bus expander can increase the number of GPIOs in the system. The PCA9536 expands to four GPIOs while taking up minimal board space with the 8-pin WCSP.



Advantages

- Processor pin savings
- Improved board routing
- Reduced board space

Applications

- Keypad control
- LED control
- Temperature sensing

Resources

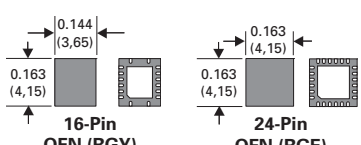
- I²C Bus Solutions: **www.ti.com/i2c**
- I²C Product Casts: **www.ti.com/casts**
- *I²C Bus Selection Guide*: Lit. # SSZC003A
- Application Note: Lit. # SCPA032

Suggested Devices

Device	Max Frequency (kHz)	I²C Address	V_{CC} Range (V)	Bit or Channel Width
I/O Expanders				
PCA9536	400	1000 001	2.3 to 5.5	4-bit
PCA6107	400	0011 xxx	2.3 to 5.5	8-bit
PCA9534	400	0100 xxx	2.3 to 5.5	8-bit
PCA9534A	400	0111 xxx	2.3 to 5.5	8-bit
PCA9538	400	1110 0xx	2.3 to 5.5	8-bit
PCA9554A	400	0111 xxx	2.3 to 5.5	8-bit
PCA9554	400	0100 xxx	2.3 to 5.5	8-bit
PCA9557	400	0011 xxx	2.3 to 5.5	8-bit
PCA9535	400	0100 xxx	2.3 to 5.5	16-bit
PCA9539	400	1110 1xx	2.3 to 5.5	16-bit
PCA9555	400	0100 xxx	2.3 to 5.5	16-bit
PCF8575	400	0100 xxx	2.5 to 5.5	16-bit
PCF8575C	400	0100 xxx	4.5 to 5.5	16-bit
Low-Voltage I/O Expanders				
TCA6408	400	0100 00x	1.65 to 5.5	8-bit
TCA6416	400	0100 00x	1.65 to 5.5	16-bit

Advanced Package Options

(Additional packages may be available)



Voltage-Level Translation

As operating voltage levels in microcontrollers continue to drop, a void may be created between peripheral devices and processors that disrupts interfacing between the devices. TI's translators enable communication between incompatible I/Os with level translation between the 1.2-V, 1.5-V, 1.8-V, 2.5-V and 3.3-V nodes.

Applications

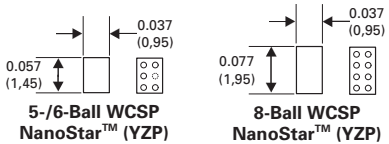
- LCD interface
- Interface devices with different supply voltages

Resources

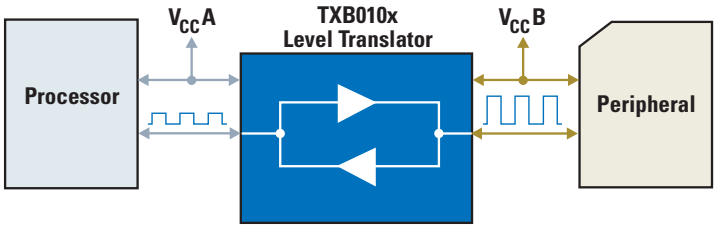
- Voltage-Level Translation: **www.ti.com/translation**
- Translation Selection Tool: **www.ti.com/transtool**
- Translation Product Cast: **www.ti.com/casts**
- *Translation Selection Guide*: Lit. # SCYB018C
- Application Note: Lit. # SCEA035

Advanced Package Options

(Additional packages may be available)



5-/6-Ball WCSP NanoStar™ (YZP) **8-Ball WCSP NanoStar™ (YZP)**



Suggested Devices

Device	Description	Max I_{CC} (µA)	Smallest Footprint Pins/Packages
TXS0102	2-bit bidirectional voltage-level translator for open-drain applications	14.4	8/WCSP
TXB0102	2-bit bidirectional voltage-level translator with auto direction sensing	8	8/WCSP
SN74AUP1T97	Single-supply voltage translator	0.9	6/WCSP (NanoStar™)
SN74AUP1T98	Single-supply voltage translator	0.9	6/WCSP (NanoStar)
SN74AVC1T45*	Single-bit dual-supply bus transceiver	20	6/WCSP (NanoStar)
SN74AVC2T45*	Dual-bit dual-supply transceiver	20	8/WCSP (NanoStar)
SN74LVC1T45	Single-bit dual-supply bus transceiver	4	6/WCSP (NanoStar)
SN74LVC2T45	Dual-bit dual-supply transceiver	4	8/WCSP (NanoStar)

**Bus-hold option available.*

ESD Protection

For any external interface connector port, an ESD strike is a constant threat to device reliability. Many low-voltage core chip or system ASICs offer only device-level human-body-model (HBM) ESD protection, which doesn't address system-level ESD. A stand-alone ESD solution is a space- and cost-effective solution to protect the system interconnects from external ESD strikes.

Advantages

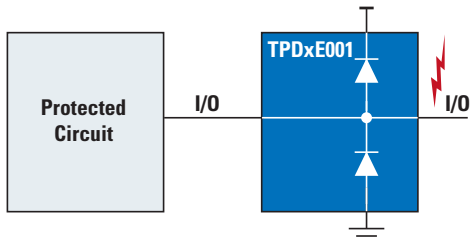
- System-level ESD protection for high-speed applications:
  - ±8-kV IEC 61000-4-2, contact discharge
  - ±15-kV IEC 61000-4-2, air-gap discharge
- Less than 1.5 pF I/O pin capacitance
- Ultra-low 1-nA leakage current
- Operating supply voltage range: +0.9 to +5.5 V
- Space-saving packages: DRY, DRL, DRS and RSF

Benefits

- System-level ESD protection for high-speed interconnects
- Low capacitance suitable for USB 2.0 high-speed devices
- Ultra-low 1-nA leakage current enables precision analog measurements like a glucose meter
- V_{CC} pin allows devices to work as a transient suppressor

Resources

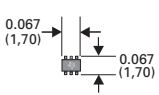
- *Interface Selection Guide*: Lit. # SSZT009C



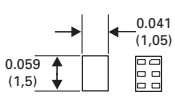
Suggested Devices

Device	No. of Channels	V_{DD} (V)	I/O Level (V)	Cap, Resistor (pF)	VBR (min) (V)	Packages
TPD2E001	2-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRY, DZD
TPD3E001	3-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRY
TPD4E001	4-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRS
TPD6E001	6-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	RSE, RSF
TPD4E002	4-channel ESD	No V_{DD} pin	0 to 6	11	6	DRL

Advanced Package Options



5-/6-Pin
SOT-563 (DRL)



6-Pin
SON (DRY)

Overview

Top Handset Applications for Linear and Logic Devices

- Voltage-Level Translation
- Audio Signal Routing
- I^2C Baseband I/O Expansion
- Configurable Little Logic
- ESD Protection
- Keypad Control
- Fun Light Display
- USB Interface

Top Linear and Logic Device Requirements for Handsets

- **Size**
  Board real estate is at a premium on PCBs. Small-scale packaging is a requirement for linear and logic functions on the design. From WCSP and micro QFN packages to the industry-standard SC-70 and SOT-23 leadframe packages, TI offers the industry's broadest portfolio of small-scale packaging.
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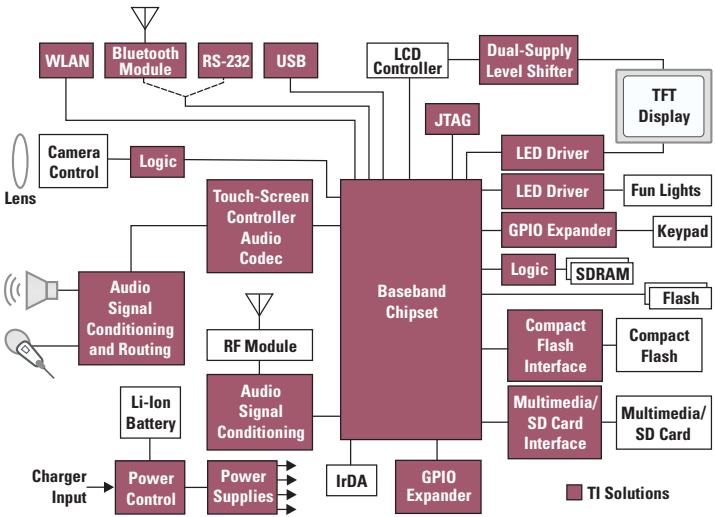


Voltage-Level Translation

As operating voltage levels in baseband processors continue to drop, a void may be created between peripheral devices and processors that disrupts interfacing between the devices. TI's translators enable communication between incompatible I/Os with level translation between the 1.2-V, 1.5-V, 1.8-V, 2.5-V, 3.3-V and 5-V nodes.

Applications

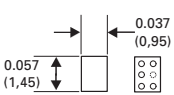
- LCD interface
- SD memory or SDIO interface
- Interface devices with different supply voltages

Resources

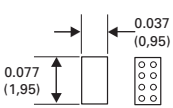
- Voltage-Level Translation: **www.ti.com/translation**
- Translation Selection Tool: **www.ti.com/transtool**
- Application Note: Lit. # SCEA035

Advanced Package Options

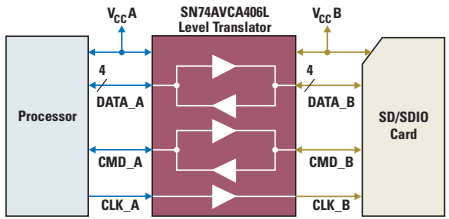
(Additional packages may be available)



5-/6-Ball WCSP NanoStar™ (YZP)



8-Ball WCSP NanoStar™ (YZP)



Suggested Devices

Device	Bit Width	V_{CC} Range (V)	Description	Pins/ Packages*
TXB0101	1	1.2 to 3.6/1.65 to 5.5	Bidirectional	6/WCSP
TXS0102	2	1.65 to 3.6/2.3 to 5.5	Bidirectional for open-drain app.	8/WCSP
TXB0102	2	1.2 to 3.6/1.65 to 5.5	Bidirectional	8/WCSP
SN74AUP1T97	1	2.3 to 3.6	Single-supply	6/WCSP
SN74AUP1T98	1	2.3 to 3.6	Single-supply	6/WCSP
SN74AVC1T45†	1	1.2 to 3.6	Dual-supply bus transceiver	6/WCSP
SN74LVC1T45	1	1.65 to 5.5	Dual-supply bus transceiver	6/WCSP
SN74AVC2T45†	2	1.2 to 3.6	Dual-supply bus transceiver	8/WCSP
SN74LVC2T45	2	1.65 to 5.5	Dual-supply bus transceiver	8/WCSP
SN74AVCA406	—	1.4 to 3.6	MMC, SD card, Memory Stick,™ SmartMedia, and XD-Picture card	48/BGA
SN74AVCA406L	—	0.5 to 4.6	MMC, SD card, Memory Stick	20/BGA
CF4320H	—	0.5 to 6.5	CompactFlash™ bus-interface chip	114/BGA

**Smallest footprint package shown.* †*Bus-hold option available.*

Audio Signal Routing

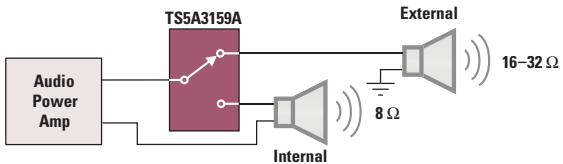
One of the most common applications for analog switches is signal routing. This may be routing from one source to multiple destinations or from several sources to a single destination. A single-pole, double-throw analog switch can be used for either situation. For example, the switch could be used to reroute the output of the audio power amplifier to two different speakers. Another common application is switching from an audio amplifier in the baseband of a mobile to an audio power amplifier for higher power output.

Applications

- DeMUX internal/external speakers
- MUX audio power amplifier
- Low-power routing (<100 mA)
- Amplifier gain adjustment

Resources

- Analog Switch: **www.ti.com/switches**
- Analog Switch Product Cast: **www.ti.com/casts**
- *Analog Switch Selection Guide*: Lit. # SLYB125 **www.ti.com/analogswitchguide**

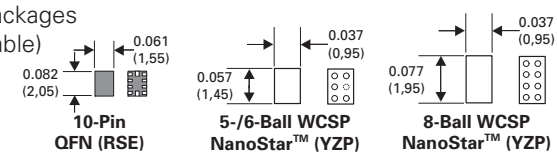


Suggested Devices

Device	Configuration	V+ (V)	r_{on} (Ω)	Smallest Footprint Pins/Packages
TS3A24157	2 x SPDT	1.65 to 3.6	0.65	10/QFN
TS3A24159	2 x SPDT	1.65 to 3.6	0.34	10/WCSP
TS5A3159A	1 x SPDT	1.65 to 5.5	0.9	6/WCSP
TS5A3166	1 x SPST	1.65 to 5.5	0.9	6/WCSP
TS5A23166	2 x SPST	1.65 to 5.5	0.9	6/WCSP
TS5A3153	1 x SPDT	1.65 to 5.5	0.9	8/WCSP
TS5A6542	1 x SPDT	1.65 to 5.5	0.75	8/WCSP
TS5A23159	2 x SPDT	1.65 to 5.5	0.9	10/QFN
TS5A26542	2 x SPDT	1.65 to 5.5	0.75	12/WCSP
TS5A3359	1 x SP3T	1.65 to 5.5	0.9	8/WCSP

Advanced Package Options

(Additional packages may be available)



I²C Baseband I/O Expansion

As more features and processing requirements are added to applications such as LED control and camera interfaces in handsets, the limited number of GPIOs on microprocessors is becoming restricting. By implementing I²C I/O expanders from TI, designers can use the GPIOs for important functions and use the I/O expanders for other duties like temperature sensing and keypad communications.

Advantages

- Processor pin savings
- Improved board routing
- Reduced board space

Applications

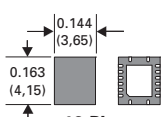
- Keypad control
- LED control
- Temperature sensing

Resources

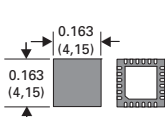
- I²C Bus Solutions: **www.ti.com/i2c**
- I²C Product Casts: **www.ti.com/casts**
- *I²C Bus Selection Guide*: Lit. # SSZC003A
- Application Note: Lit. # SCPA032

Advanced Package Options

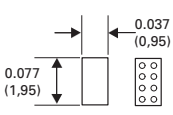
(Additional packages may be available)



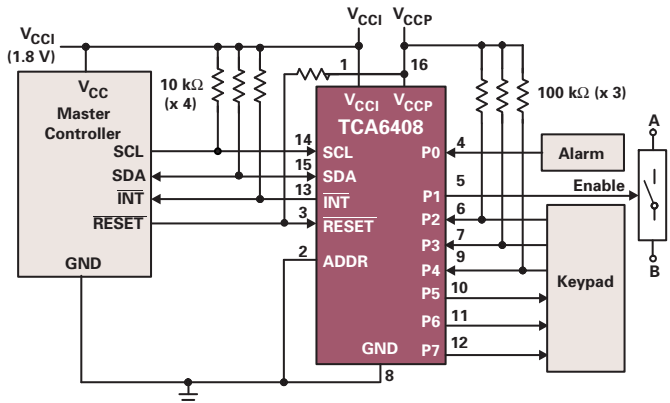
16-Pin
QFN (RGY)



24-Pin
QFN (RGE)



8-Ball WCSP
NanoStar™ (YZP)



Suggested Devices

Device	Description	V_{CC} (V)	Smallest Footprint Pins/Packages
TCA6408	Low-voltage 8-bit I²C and SMBus I/O expander with interrupt output, reset, and configuration registers	1.65 to 5.5	20/BGA
PCA9536	Remote 4-bit I²C and SMBus I/O expander with configuration registers	2.3 to 5.5	8/WCSP
PCA9557	Remote 8-bit I²C and SMBus low-power I/O expander with reset and configuration registers	2.3 to 5.5	16/QFN
PCA9539	Remote 16-bit I²C and SMBus low-power I/O expander with interrupt output and configuration registers	2.3 to 5.5	24/QFN

Configurable Little Logic

Little Logic devices are needed on handsets to implement simple logic functions, signal conditioning or bug fixing. With TI's configurable Little Logic devices, a single device can be configured to perform up to nine different logic functions. This reduces costs since a single device, rather than multiple logic parts, needs to be qualified, sourced and inventoried.

Advantages

- Improved board routing
- Reduced board space
- Lower inventory costs

Applications

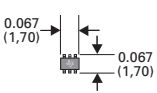
- Bug fixes
- Voltage translation
- Logic implementation

Resources

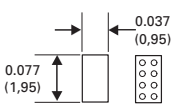
- Little Logic: **www.ti.com/littlelogic**
- Configurable Little Logic Product Clip: Lit. # SCYB010A
- Application Note: Lit. # SCPA010

Advanced Package Options

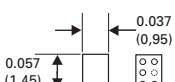
(Additional packages may be available)



5-/6-Pin SOT-563 (DRL)

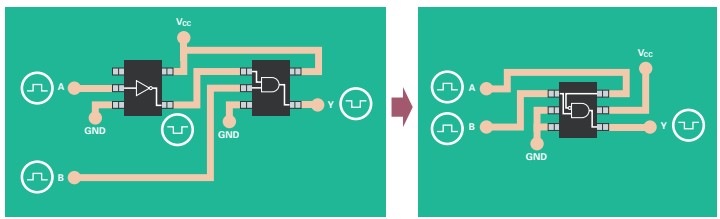


8-Ball WCSP NanoStar™ (YZP)



5-/6-Ball WCSP NanoStar™ (YZP)

Board-Space Reduction



Inverter (04/14) + AND (08) **1G97/98**

Suggested Devices

Device	Description	V_{CC} (V)	Smallest Footprint Pins/Packages
SN74AUP1G97	Low-power configurable multiple-function gate	0.8 to 3.6	6/WCSP
SN74AUP1G98	Low-power configurable multiple-function gate	0.8 to 3.6	6/WCSP
SN74AUP1G99	Low-power ultra-configurable multiple-function gate with 3-state outputs	0.8 to 3.6	8/WCSP
SN74AUP1T97	Single-supply voltage-level translator with nine configurable gate logic functions	2.3 to 3.6	6/WCSP
SN74AUP1T98	Single-supply voltage-level translator with nine configurable gate logic functions	2.3 to 3.6	6/WCSP

ESD Protection

For any external interface connector port, an ESD strike is a constant threat to device reliability. Many low-voltage core chip or system ASICs offer only device-level human-body-model (HBM) ESD protection, which doesn't address system-level ESD. A stand-alone ESD solution is a space- and cost-effective solution to protect the system interconnects from external ESD strikes.

Advantages

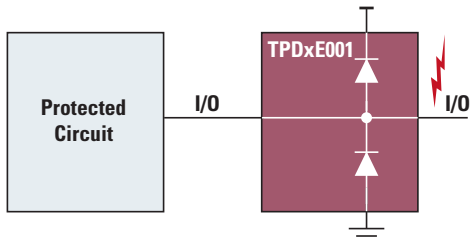
- System-level ESD protection for high-speed applications:
  - ±8-kV IEC 61000-4-2, contact discharge
  - ±15-kV IEC 61000-4-2, air-gap discharge
- Less than 1.5 pF I/O pin capacitance
- Ultra-low 1-nA leakage current
- Operating supply voltage range: +0.9 to +5.5 V
- Space-saving packages: DRY, DRL, DRS and RSF

Benefits

- System-level ESD protection for high-speed interconnects
- Low capacitance suitable for USB 2.0 high-speed devices
- Ultra-low 1-nA leakage current enables precision analog measurements like a glucose meter
- V_{CC} pin allows devices to work as a transient suppressor

Resources

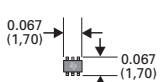
- *Interface Selection Guide*: Lit. # SSZT009C



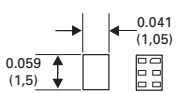
Suggested Devices

Device	No. of Channels	V_{DD} (V)	I/O Level (V)	Cap, Resistor (pF)	VBR (min) (V)	Packages
TPD2E001	2-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRY, DZD
TPD3E001	3-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRY
TPD4E001	4-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRS
TPD6E001	6-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	RSE, RSF
TPD4E002	4-channel ESD	No V_{DD} pin	0 to 6	11	6	DRL

Advanced Package Options



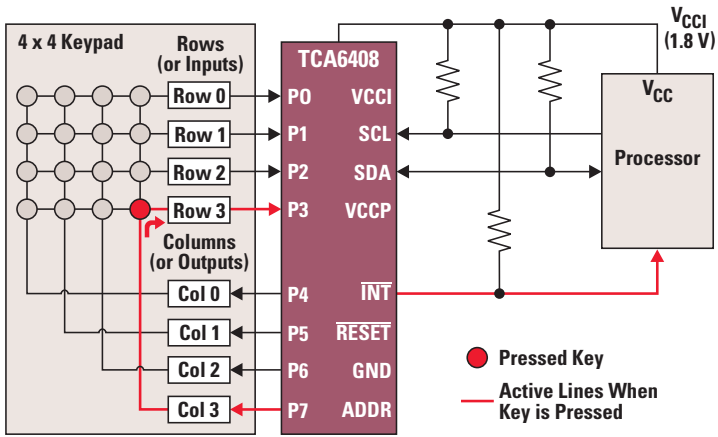
5-/6-Pin SOT-563 (DRL)



6-Pin SON (DRY)

Keypad Control

Keypad control is one of the new application areas for I²C I/O expanders. It is useful in end applications like PDA phones that may need more than one keypad controller. For example, some PDA phones include a software keypad and a hardware keypad. In these cases, the processor can support one keypad and the second keypad can be controlled by an I²C I/O expander like the TCA6408. The TCA6408 can also be used in portable medical devices where the microcontroller is overloaded with several tasks. Here, the keypad function can be transferred to the I²C I/O expander, which can then support the few keys required in this application.



Advantages

- Operating power-supply voltage range of 1.65 to 5.5 V
- Allows bidirectional voltage-level translation and GPIO expansion between:
  - 1.8-V SCL/SDA and 1.8-, 2.5-, 3.3- or 5-V P port
  - 2.5-V SCL/SDA and 1.8-, 2.5-, 3.3- or 5-V P port
  - 3.3-V SCL/SDA and 1.8-, 2.5-, 3.3- or 5-V P port
  - 5-V SCL/SDA and 1.8-, 2.5-, 3.3- or 5-V P port
- I²C to parallel port expander
- Low standby current consumption of 1 µA

Resources

- I²C Bus Solutions: **www.ti.com/i2c**
- *I²C Bus Selection Guide*: Lit. # SSZC003A
- I²C Product Casts: **www.ti.com/casts**

Suggested Device

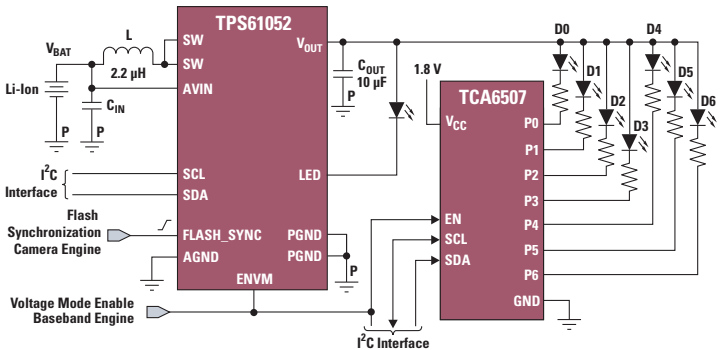
Device	Description	V_{CC} Range (V)	Smallest Footprint Pins/Packages
TCA6408	Low-voltage, 8-bit I²C and SMBus I/O expander	1.65 to 5.5	20/BGA

Fun Light Display

The TCA6507 is a 7-bit LED dimmer for the two-line bidirectional (I^2C) bus designed to control (or dim) LEDs via the I^2C interface (serial clock [SCL]/serial data [SDA]). Without this device, the microprocessor or microcontroller must be actively involved in turning on and off the LEDs (per the required dimming rate), which uses valuable processor time and overloads the I^2C bus. The TCA6507 alleviates this issue by limiting the number of operations the processor requires to blink the LEDs, thus helping to create a more efficient system.

Advantages

- 7 LED driver outputs with on, off, blinking, and fading at programmable rates
- Supports simultaneous brightness control and blink modes
- Open-drain outputs that directly drive LEDs to 40 mA max
- Configurable into two independent banks of LED drivers
- Widely programmable blink rates, fade-on and fade-off rates and maximum intensity
- LED intensity set with pulse-width modulation (PWM)
- Outputs not used as LED drivers can be used as general-purpose open-drain outputs
- 16 steps of maximum intensity control from fully off to fully on states



- 256 intensity levels during fade on or fade off for perceived smooth transition
- Operating power-supply voltage range of 1.65 to 3.6 V

Resources

- I^2C Bus Solutions: **www.ti.com/i2c**
- *I^2C Bus Selection Guide*: Lit. # SSZC003A
- I^2C Product Casts: **www.ti.com/casts**

Suggested Device

Device	Description	V_{CC} Range (V)	Smallest Footprint Pins/Packages
TCA6507	Low-voltage, 7-bit I^2C and SMBus LED driver with intensity control and shutdown	1.65 to 3.6	12/RUE

USB Interface

Many handsets offer the USB interface for battery charging as well as for connectivity to download multimedia files such as MP3, MPEG, etc. TI offers a broad portfolio of USB peripheral ICs, including multiplexers and transceivers.

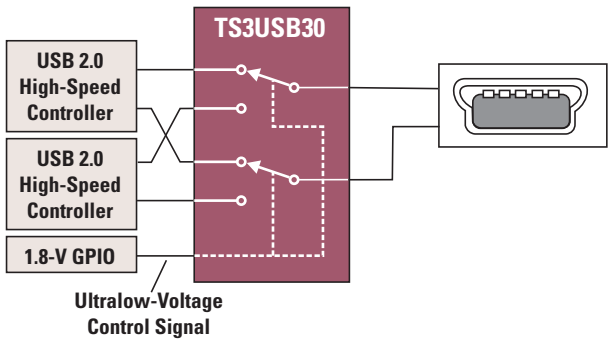
Advantages

- Wide V_{CC} range (3.0 to 4.3 V)
- 1.8-V-compatible control-pin inputs
- I_{OFF} supports operation in partial power-down mode to conserve power
- Low insertion losses (r_{on} = 10 Ω max)
- High bandwidth supports USB 2.0 (480 Mbps):
  - TS3USB30: > 950 MHz
  - TS3USB31: >1.2 GHz
- Low power consumption (1 µA max)
- Ultrasmall packaging options: RSW-10 (1.8 x 1.4) and RSE-8 (1.5 x 1.5) QFN

Resources

Interface: **www.ti.com/interface**

Interface Selection Guide: Lit. # SSZT009C



Suggested Devices

Device	Description	Speed (Mbps)	Voltage (V)	Single-Ended Input	Smallest Footprint Pins/Packages
TS3USB221	1:2 USB MUX/DeMUX	480	2.5 to 3.3	Yes	10/QFN (RSE)
TS3USB30	1:2 USB MUX/DeMUX	480	3 to 4.3	Yes	10/QFN (RSW)
TS3USB31	1-port switch	480	3 to 4.3	Yes	10/QFN (RSE)

Overview

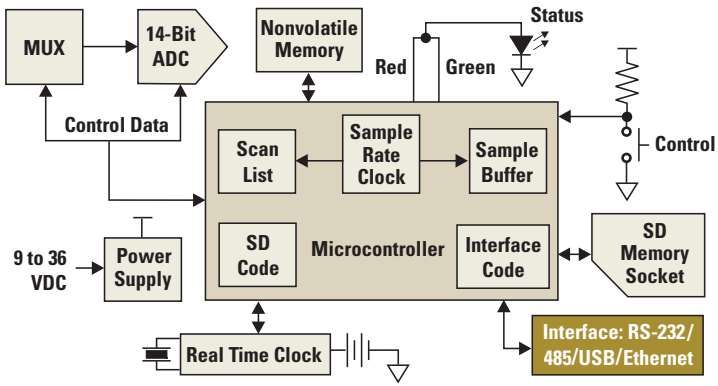
Top Industrial Automation Applications for Linear and Logic Devices

- Interface—RS-232, USB, RS-485/422
- Relay and Motor Control
- Maintenance and Control: I^2C I/O Expansion
- Signal Conditioning

Top Linear and Logic Device Requirements for Industrial Automation

- **Robust Design**
  Higher ESD exposure and higher noise levels and temperatures make the industrial environment harsher and less forgiving. TI offers a wide array of products with enhanced system-level ESD protection and better noise immunity. In addition, many of our standard products offer an extended temperature range of up to 125°C.
- **Reliable Supply**
  The typical lifetime for industrial applications is very long, and TI has one of the best product obsolescence policies in the market.

Industrial Data Acquisition



Interface—RS-232, USB, RS-485/422

RS-232: The TIA/EIA-232 devices provide a single-ended interface between data terminal equipment (DTE) and data communication equipment (DCE).

USB: The TUSB1105/6 and TUSB2551 provide an analog USB interface along with flexible voltage-level translation and system-level ESD protection.

RS-485/422: TI's robust TIA/EIA-485/422-compliant devices are specially designed for harsh industrial environments that can require differential signal transmission at up to 50 Mbps or as far as 1.2 km.

Advantages

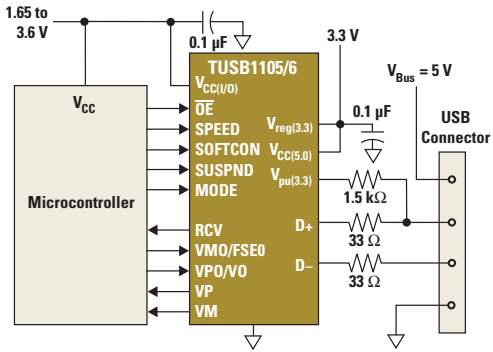
- System-level ESD protection
- NiPdAu Pb-Free solution for whisker-free, reliable packages
- Space-saving QFN package options

Resources

- Interface: **www.ti.com/interface**
- RS-232 Product Cast: **www.ti.com/casts**
- *Interface Selection Guide*: Lit. # SSZT009C

Advanced Package Options

Technology available in a variety of package options.



Suggested Devices

Type	Tx/Rx	Device (Speed)	
RS-232	1/1	TRSF3221E (1 Mbps)	
	2/2	TRSF3222E (1 Mbps)	TRSF3223E (1 Mbps)
		TRSF3232E (1 Mbps)	
	3/2	TRS3386E (250 kbps)	
	3/5	TRS3243E (500 kbps)	
RS-485	1/1	SN65ALS176/A/B (35 Mbps)	
	2/2	TRSF1167 (10 Mbps)	TRSF1168 (10 Mbps)
	0/4	AM26LS32A (10 Mbps)	AM26LV32 (10 Mbps)
	4/0	AM26LV31 (10 Mbps)	SN75ALS192 (20 Mbps)
USB 2.0	1/1	TUSB1105/6* and TUSB2551* (Full and low speed)	

**Preview*

Relay and Motor Control

TI's TPL920x devices are ideal for systems using a microcontroller to drive relays, LEDs, stepper motors, solenoids, MOSFETs, buzzers, etc. The devices can also provide microcontroller power and offer brownout protection and reset features.

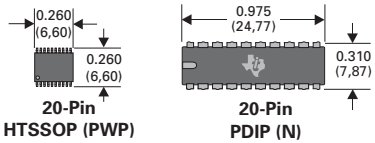
Applications

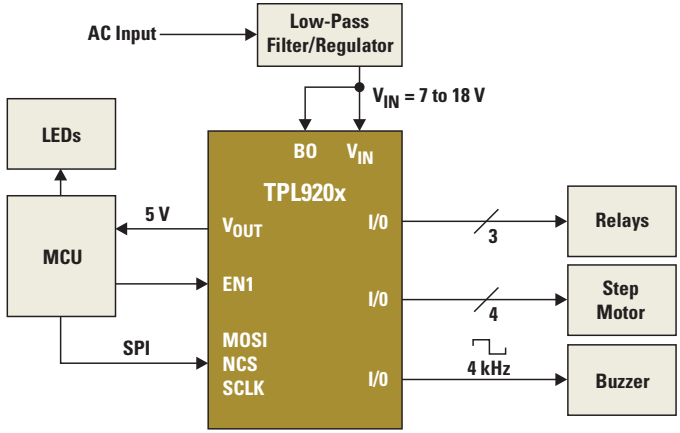
- Stepper motor control
- Relay driver
- Microcontroller power supply

Resources

- TPL920x Product Cast: **www.ti.com/casts**
- TPL920x Product Clip: Lit. # SCYB045A

Advanced Package Options



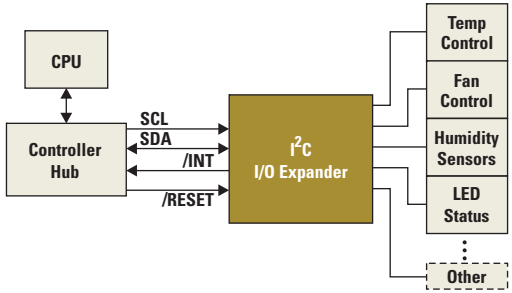


Suggested Devices

Device	Description	LDO Output (V)
TPL9201	Integrated 8-output relay driver with zero-volt detect	5
TPL9202	Integrated 8-output relay driver with brownout detect	5

Maintenance and Control: I²C I/O Expansion

Designers can make better use of their scarce GPIOs by using TI's I²C I/O expanders and multiplexers to time-share multiple peripherals to a single I²C port. For example, the I/O expanders and multiplexers can be used to monitor and control a total system by taking advantage of the already available I²C bus.



Advantages

- Processor pin savings
- Improved board routing
- Reduced board space

Applications

- LED control
- Temperature sensing
- Fan control

Resources

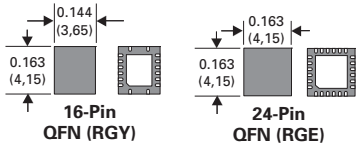
- I²C Bus Solutions: **www.ti.com/i2c**
- I²C Product Casts: **www.ti.com/casts**
- *I²C Bus Selection Guide*: Lit. # SSZC003A

Suggested Devices

Device	Max Frequency (kHz)	I²C Address	V_{CC} Range (V)	Bit or Channel Width
I/O Expanders				
PCA9536	400	1000 001	2.3 to 5.5	4-bit
PCA6107	400	0011 xxx	2.3 to 5.5	8-bit
PCA9534	400	0100 xxx	2.3 to 5.5	8-bit
PCA9534A	400	0111 xxx	2.3 to 5.5	8-bit
PCA9538	400	1110 0xx	2.3 to 5.5	8-bit
PCA9554A	400	0111 xxx	2.3 to 5.5	8-bit
PCA9554	400	0100 xxx	2.3 to 5.5	8-bit
PCA9557	400	0011 xxx	2.3 to 5.5	8-bit
PCA9535	400	0100 xxx	2.3 to 5.5	16-bit
PCA9539	400	1110 1xx	2.3 to 5.5	16-bit
PCA9555	400	0100 xxx	2.3 to 5.5	16-bit
PCF8575	400	0100 xxx	2.5 to 5.5	16-bit
PCF8575C	400	0100 xxx	4.5 to 5.5	16-bit
Low-Voltage I/O Expanders				
TCA6408	400	0100 00x	1.65 to 5.5	8-bit
TCA6416	400	0100 00x	1.65 to 5.5	16-bit

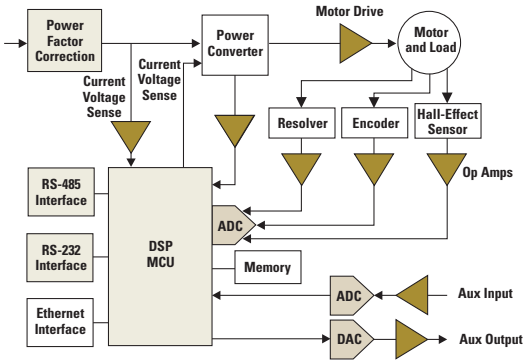
Advanced Package Options

(Additional packages may be available)



Signal Conditioning

Condition signals prior to interfacing with the system's microcontroller.



Applications

- Switch-mode power supplies and battery chargers
- Voltage and current sensing—Power Good, overvoltage, undervoltage, overcurrent
- Window comparators
- Alarms, detectors and sensors

Resources

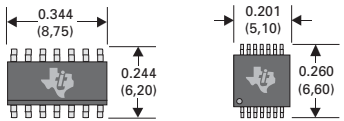
- Operational Amplifiers: **www.ti.com/standardlinear**
- *Operational Amplifiers Selection Guide*: Lit. # SLYB115A

Suggested Devices

Family	Device	Description	No. of Channels	Power Supply (V)	V_{REF} V_Z (V)
Wide-Voltage Op Amps	LP324	Ultra-low-power quad op amps	4	3 to 32	—
	LP2902	Ultra-low-power quad op amps	4	3 to 32	—
	LP358	Ultra-low-power dual op amp	2	3 to 32	—
	LP2904	Ultra-low-power dual op amp	2	3 to 32	—
	TS321	Low-power single op amp	1	3 to 30	—
Low-Noise Op Amps	MC33078	Dual high-speed low-noise op amp	2	10 to 36	—
	TL5580	Dual low-noise wide-bandwidth precision amp	2	4 to 36	—
	TL5580A	Dual low-noise wide-bandwidth precision amp	2	4 to 36	—
Op Amps with V_{REF}	TL103W	Dual op amp with internal reference	2	3 to 32	2.5
	TL103WA	Dual op amp with internal reference	2	3 to 32	2.5
	TSM102	Dual op amp, dual comparator w/voltage ref.	2	3 to 30	2.5 to 36
	TSM102A	Dual op amp, dual comparator w/voltage ref.	2	3 to 30	2.5 to 36
	TSM104W	Quad op amp and programmable voltage ref.	4	3 to 32	2.5 to 36
	TSM104WA	Quad op amp and programmable voltage ref.	4	3 to 32	2.5 to 36

Package Options

(Additional packages may be available)



14-Pin SOIC (D) **14-Pin TSSOP (PW)**

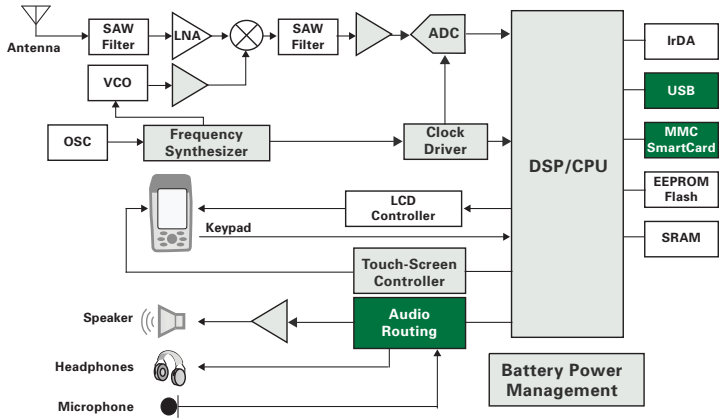
Overview

Top Portable Industrial Applications for Linear and Logic Devices

- Multiplexing USB Peripherals
- Card Interface
- Interface—RS-232, USB, RS-485/422
- I^2C Control
- ESD Protection

Top Linear and Logic Device Requirements for Portable Industrial

- **Size**
  Board real estate is at a premium on PCBs. Small-scale packaging is a requirement for linear and logic functions on the design. From WCSP and micro QFN packages to the industry-standard SC-70 and SOT-23 leadframe packages, TI offers the industry's broadest portfolio of small-scale packaging.
- **Power**
  Power consumption can be critical in designs for portable industrial applications. TI offers a variety of low-power Linear and Logic technologies.



Multiplexing USB Peripherals

Industrial handheld units contain multiple USB ports to support additional connections. USB-specific and digital bus switches can be used to expand a single USB 2.0 port to multiple ports.

Applications

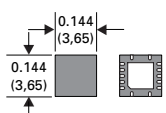
- Multiplexing multiple external ports

Resources

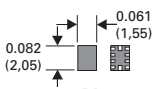
- Analog Switch: **www.ti.com/switches**
- Bus Switch: **www.ti.com/busswitches**
- *Analog Switch Selection Guide*: Lit. # SLYB125 **www.ti.com/analogswitchguide**
- *Bus Switch Selection Guide*: Lit. # SCDB006

Advanced Package Options

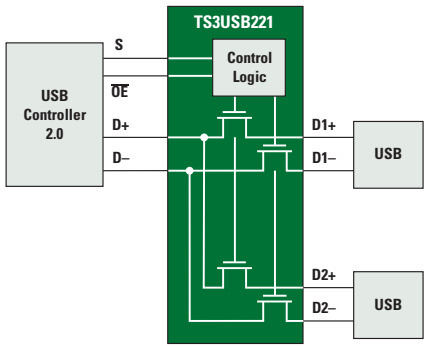
(Additional packages may be available)



14-Pin
QFN (RGY)



10-Pin
QFN (RSE)



Suggested Devices

Device	Description	V_{CC} Range (V)	r_{on} (max) (Ω)	Pins/ Packages
TS3USB30	High-speed USB 2.0 1:2 MUX/DeMUX switch	3 to 4.3	10	10/QFN
TS3USB31	High-speed USB 2.0 1-port switch	3 to 4.3	10	8/QFN
TS3USB221	High-speed USB 2.0 (480-Mbps) 1:2 MUX/DeMUX switch	2.3 to 3.6	7	10/QFN, SON
SN74CB3Q3306A	Dual FET 2.5/3.3-V low-voltage, high-bandwidth bus switch	2.3 to 3.6	9	8/TSSOP, US8
SN74CB3Q3125	Quad FET 2.5/3.3-V low-voltage, high-bandwidth bus switch	2.3 to 3.6	9	14/QFN

Card Interface

The AVCA406 series of transceivers provides a convenient interface when there is a voltage mismatch between the microcontroller and memory card. These transceivers support MultiMediaCard (MMC), Secure Digital (SD), Memory Stick, SmartMedia and xD-Picture Card.

Applications

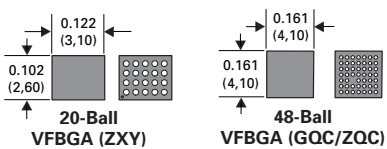
- Memory-card interface
- SDIO card interface (WLAN, Bluetooth, GPS)
- CF/CF+ interface (WLAN, MicroDrive, CF memory card)

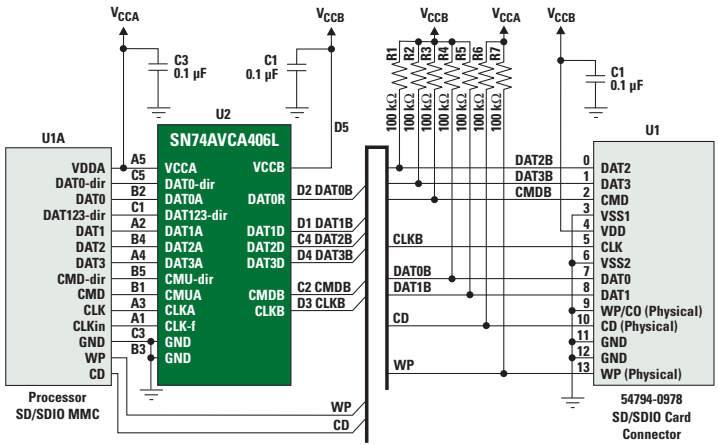
Resources

- Translation: **www.ti.com/trans**
- *Translation Selection Guide*: Lit. # SCYB018B

Advanced Package Options

(Additional packages may be available)





Suggested Devices

Device	Description	Voltage Nodes (V)	t_{pd} (max) (ns)	Pins/Packages
SN74AVCA406	Voltage translation transceiver	1.5, 1.8, 2.5, 3.3	5	48/BGA
SN74AVCA406L	Voltage translation transceiver	3.3	2.7	20, 24/BGA
CF4320H	CompactFlash bus interface chip	1.65 to 5.5	5.5	114/LFBGA

Interface—RS-232, USB, RS-485/422

RS-232: The TIA/EIA-232 devices provide a single-ended interface between data terminal equipment (DTE) and data communication equipment (DCE).

USB: The TUSB1105/6 and TUSB2551 provide an analog USB interface along with flexible voltage-level translation and system-level ESD protection.

RS-485/422: TI's robust TIA/EIA-485/422-compliant devices are specially designed for harsh industrial environments that can require differential signal transmission at up to 50 Mbps or as far as 1.2 km.

Advantages

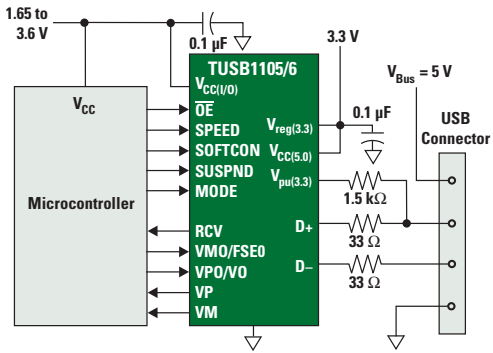
- System-level ESD protection
- NiPdAu Pb-Free solution for whisker-free, reliable packages
- Space-saving QFN package options

Resources

- Interface: **www.ti.com/interface**
- RS-232 Product Cast: **www.ti.com/casts**
- *Interface Selection Guide*: Lit. # SSZT009C

Advanced Package Options

Technology available in a variety of package options.



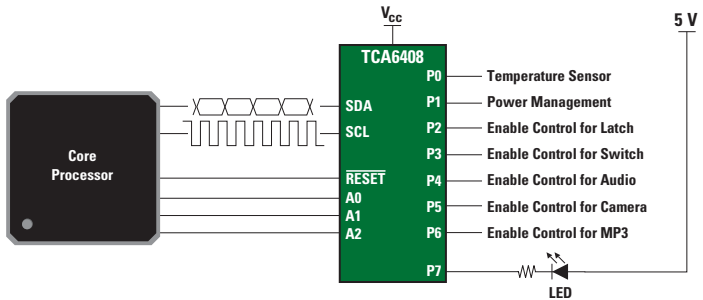
Suggested Devices

Type	Tx/Rx	Device (Speed)	
RS-232	1/1	TRSF3221E (1 Mbps)	
	2/2	TRSF3222E (1 Mbps)	TRSF3223E (1 Mbps)
		TRSF3232E (1 Mbps)	
	3/2	TRS3386E (250 kbps)	
	3/5	TRS3243E (500 kbps)	
RS-485	1/1	SN65ALS176/A/B (35 Mbps)	
	2/2	TRSF1167 (10 Mbps)	TRSF1168 (10 Mbps)
	0/4	AM26LS32A (10 Mbps)	AM26LV32 (10 Mbps)
	4/0	AM26LV31 (10 Mbps)	SN75ALS192 (20 Mbps)
USB 2.0	1/1	TUSB1105/6 and TUSB2551* (Full and low speed)	

**Preview*

I²C Control

As more features and processing requirements are added to applications such as LED control and camera interfaces in handsets, the limited number of GPIOs on microprocessors is becoming restricting. By implementing I²C I/O expanders from TI, designers can use the GPIOs for important functions and use the I/O expanders for other duties like temperature sensing and keypad communications.



Advantages

- Processor pin savings
- Improved board routing
- Reduced board space

Applications

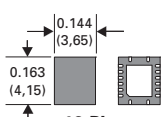
- Keypad control
- LED control
- Temperature sensing

Resources

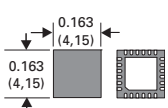
- I²C Bus Solutions: **www.ti.com/i2c**
- I²C Product Casts: **www.ti.com/casts**
- *I²C Bus Selection Guide*: Lit. # SSZC003A
- Application Note: Lit. # SCPA032

Advanced Package Options

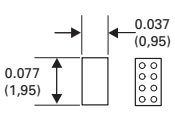
(Additional packages may be available)



16-Pin
QFN (RGY)



24-Pin
QFN (RGE)



8-Ball WCSP
NanoStar™ (YZP)

Suggested Devices

Device	Description	V_{CC} (V)	Smallest Footprint Pins/Packages
TCA6408	Low-voltage 8-bit I²C and SMBus I/O expander with interrupt output, reset and configuration registers	1.65 to 5.5	20/BGA
PCA9536	Remote 4-bit I²C and SMBus I/O expander with configuration registers	2.3 to 5.5	8/WCSP
PCA9557	Remote 8-bit I²C and SMBus low-power I/O expander with reset and configuration registers	2.3 to 5.5	16/QFN
PCA9539	Remote 16-bit I²C and SMBus low-power I/O expander with interrupt output and configuration registers	2.3 to 5.5	24/QFN

ESD Protection

For any external interface connector port, an ESD strike is a constant threat to device reliability. Many low-voltage core chip or system ASICs offer only device-level human-body-model (HBM) ESD protection, which doesn't address system-level ESD. A stand-alone ESD solution is a space- and cost-effective solution to protect the system interconnects from external ESD strikes.

Advantages

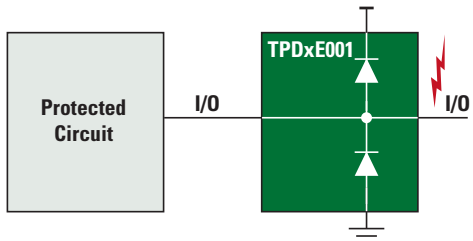
- System-level ESD protection for high-speed applications:
  - ±8-kV IEC 61000-4-2, contact discharge
  - ±15-kV IEC 61000-4-2, air-gap discharge
- Less than 1.5 pF I/O pin capacitance
- Ultra-low 1-nA leakage current
- Operating supply voltage range: +0.9 to +5.5 V
- Space-saving packages: DRY, DRL, DRS and RSF

Benefits

- System-level ESD protection for high-speed interconnects
- Low capacitance suitable for USB 2.0 high-speed devices
- Ultra-low 1-nA leakage current enables precision analog measurements like a glucose meter
- V_{CC} pin allows devices to work as a transient suppressor

Resources

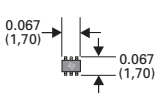
- *Interface Selection Guide*: Lit. # SSZT009C



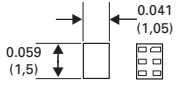
Suggested Devices

Device	No. of Channels	V_{DD} (V)	I/O Level (V)	Cap, Resistor (pF)	VBR (min) (V)	Packages
TPD2E001	2-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRY, DZD
TPD3E001	3-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRY
TPD4E001	4-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	DRL, DRS
TPD6E001	6-channel ESD	0.9 to 5.5	0 to V_{DD}	1.5	12	RSE, RSF
TPD4E002	4-channel ESD	No V_{DD} pin	0 to 6	11	6	DRL

Advanced Package Options



5-/6-Pin
SOT-563 (DRL)



6-Pin
SON (DRY)

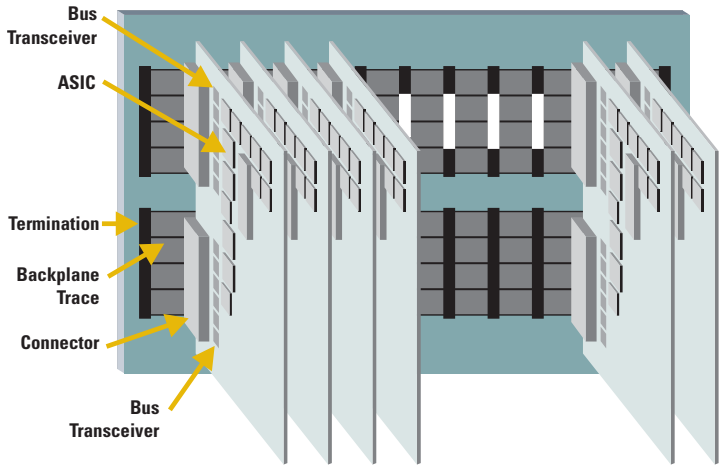
Overview

Top Telecom Applications for Linear and Logic Devices

- Voltage-Level Translation
- Maintenance and Control: I^2C I/O Expansion, Switches and Buffers
- Backplane Signaling
- Interface—RS-232, USB, RS-485/422

Top Linear and Logic Device Requirements for Telecom

- **Power Consumption**
  Power consumption is critical in large telecom designs. The more power an IC consumes, the more the hardware designer is concerned about heat dissipation and how to cool the system to acceptable levels. Leading solutions from TI offer the required low-power performance.
- **Performance**
  Total system performance is of utmost importance in the design of network switches, routers and hubs. Whether you are using high-speed serial interfaces on single-ended parallel buses or transmitting data along the backplane, TI has the solutions to do the job.



www.ti.com/telecom

Voltage-Level Translation

As operating voltage levels in microprocessors continue to drop, a void may be created between peripheral devices and processors that disrupts interfacing between the devices. TI's translators enable communication between incompatible I/Os with level translation between the 1.2-V, 1.5-V, 1.8-V, 2.5-V, 3.3-V and 5-V nodes.

Applications

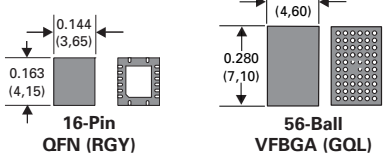
- Interface microprocessors to peripherals with different supply voltages
- Interface between various logic families

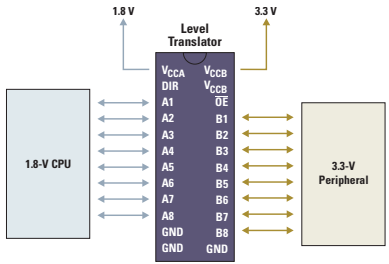
Resources

- Voltage-Level Translation: **www.ti.com/translation**
- Translation Selection Tool: **www.ti.com/transtool**
- Application Note: Lit. # SCEA035

Advanced Package Options

(Additional packages may be available)





Suggested Devices

Device	Bit Width	V_{CCA} (V)	V_{CCB} (V)	Smallest Footprint Pins/Packages
TXB0104	4	1.2 to 3.6	1.65 to 5.5	12/BGA
TXB0108	8	1.2 to 3.6	1.65 to 5.5	20/BGA
SN74AVC4T245*	4	1.2 to 3.6	1.2 to 3.6	16/QFN
SN74AVC8T245*	8	1.2 to 3.6	1.2 to 3.6	24/QFN
SN74LVC8T245*	8	1.65 to 5.5	1.65 to 5.5	24/QFN
SN74AVC16T245*	16	1.2 to 3.6	1.2 to 3.6	56/VFBGA
SN74LVC16T245*	16	1.65 to 5.5	1.65 to 5.5	56/VFBGA
SN74AVC20T245*	20	1.2 to 3.6	1.2 to 3.6	56/VFBGA
SN74AVC24T245*	24	1.2 to 3.6	1.2 to 3.6	83/LFBGA
SN74AVC32T245*	32	1.2 to 3.6	1.2 to 3.6	96/LFBGA

Bus-hold option available.

Maintenance and Control: I²C I/O Expansion, Switches and Buffers

Designers can make better use of their scarce GPIOs by using TI's I²C I/O expanders and multiplexers to time-share multiple peripherals to a single I²C port. For example, the I/O expanders and multiplexers can be used to monitor and control a total system by taking advantage of the already available I²C bus.

Designers can also use I²C muxes and switches to resolve address conflicts on the I²C bus. In some server designs, multiple SFPs with the same I²C address are used, or there can be multiple temperature sensors with the same I²C address. I²C muxes and switches facilitate smooth operation by selecting which device the master or processor should communicate with at the appropriate time.

Advantages

- Resolves I²C address conflicts
- Processor pin savings
- Improved board routing
- Reduced board space

Applications

- I²C bus isolation
- LED control
- Temperature sensing
- Fan control

Resources

- I²C Bus Solutions: **www.ti.com/i2c**
- I²C Product Casts: **www.ti.com/casts**
- *I²C Bus Selection Guide*: Lit. # SSZC003A

Suggested Devices

Device	Max Frequency (kHz)	I²C Address	V_{CC} Range (V)	Bit or Channel Width
I/O Expanders				
PCA9536	400	1000 001	2.3 to 5.5	4-bit
PCA6107	400	0011 xxx	2.3 to 5.5	8-bit
PCA9534	400	0100 xxx	2.3 to 5.5	8-bit
PCA9534A	400	0111 xxx	2.3 to 5.5	8-bit
PCA9538	400	1110 0xx	2.3 to 5.5	8-bit
PCA9554A	400	0111 xxx	2.3 to 5.5	8-bit
PCA9554	400	0100 xxx	2.3 to 5.5	8-bit
PCA9557	400	0011 xxx	2.3 to 5.5	8-bit
PCA9535	400	0100 xxx	2.3 to 5.5	16-bit
PCA9539	400	1110 1xx	2.3 to 5.5	16-bit
PCA9555	400	0100 xxx	2.3 to 5.5	16-bit
PCF8575	400	0100 xxx	2.5 to 5.5	16-bit
PCF8575C	400	0100 xxx	4.5 to 5.5	16-bit
Low-Voltage I/O Expanders				
TCA6408	400	0100 00x	1.65 to 5.5	8-bit
TCA6416	400	0100 00x	1.65 to 5.5	16-bit
Multiplexers and Switches				
PCA8550	400	1001 110	3.0 to 3.6	5-bit
PCA9543A	400	1110 0xx	2.3 to 5.5	2-channel
PCA9544A	400	1110 xxx	2.3 to 5.5	4-channel
PCA9545A	400	1110 0xx	2.3 to 5.5	4-channel
PCA9546A	400	1110 xxx	2.3 to 5.5	4-channel
PCA9548A	400	1110 xxx	2.3 to 5.5	8-channel
Hubs, Buffers and Repeaters				
PCA9515A	400	None	2.3 to 5.5	2-channel
PCA9517	400	None	0.9 to 5.5	2-channel
PCA9518	400	None	3.0 to 3.6	5-channel
P82B96	400	None	2 to 15	2-channel

Backplane Signaling

Data that is sent along the backplane must arrive at the intended destination without any corruption or degradation in signal integrity. TI offers the largest selection of bus-interface devices in the industry. Drivers, receivers and transceivers are available for all bus technologies to support single-ended, differential, point-to-point, multidrop and multipoint signal distribution.

Advantages

- Improved signal integrity
- Flow-through pinouts

Applications

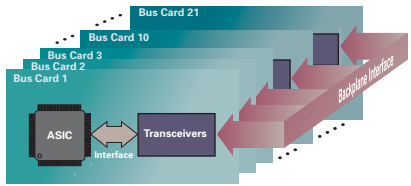
- Mass storage
- ISDN remote access
- Internet routers
- ATM switches
- Wireless base stations

Resources

- Interface: **www.ti.com/interface**
- **www.ti.com/gtlp**
- **www.ti.com/vme**
- *Interface Selection Guide*: Lit. # SSZT009C

Advanced Package Options

Technology available in a variety of package options.



Suggested Technologies

Process Technology	Family	Supply Voltage (V)	Controlled Slew Rates	Maximum High-Drive Capability (mA)	Maximum Low-Drive Capability (mA)	Maximum Power Consumption per Output (mW)
Bipolar	ALS	5	No	–15	24	48.5
	F	5	No	–15	64	90.1
BiCMOS	ABT	5	Yes	–32	64	65.6
	ABTE	5	Yes	–64	90	136
	BCT	5	No	–15	64	40.1
	CDFCT	5	No	–15	64	37.1
	CYFCT	5	No	–32	64	65.6
	FB	5	Yes	—	100	115
	LVT	3.3	Yes	–32	64	38.4
	VME	3.3	Yes	–48	48	50.4
CMOS	ALVT	3.3	Yes	–32	64	38.4
	GTLP	3.3	Yes	—	100	55
					50	27.5

Interface—RS-232, USB, RS-485/422

RS-232: The TIA/EIA-232 devices provide a single-ended interface between data terminal equipment (DTE) and data communication equipment (DCE).

USB: The TUSB1105/6 and TUSB2551 provide an analog USB interface along with flexible voltage-level translation and system-level ESD protection.

RS-485/422: TI's robust TIA/EIA-485/422-compliant devices are specially designed for harsh industrial environments that can require differential signal transmission at up to 50 Mbps or as far as 1.2 km.

Advantages

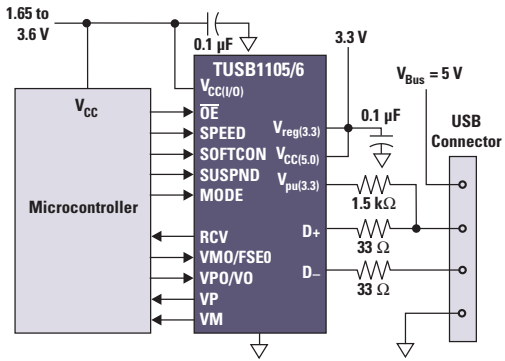
- System-level ESD protection
- NiPdAu Pb-Free solution for whisker-free, reliable packages
- Space-saving QFN package options

Resources

- Interface: **www.ti.com/interface**
- RS-232 Product Cast: **www.ti.com/casts**
- *Interface Selection Guide*: Lit. # SSZT009C

Advanced Package Options

Technology available in a variety of package options.



Suggested Devices

Type	Tx/Rx	Device (Speed)	
RS-232	1/1	TRSF3221E (1 Mbps)	
	2/2	TRSF3222E (1 Mbps)	TRSF3223E (1 Mbps)
		TRSF3232E (1 Mbps)	
	3/2	TRS3386E (250 kbps)	
	3/5	TRS3243E (500 kbps)	
RS-485	1/1	SN65ALS176/A/B (35 Mbps)	
	2/2	TRSF1167 (10 Mbps)	TRSF1168 (10 Mbps)
	0/4	AM26LS32A (10 Mbps)	AM26LV32 (10 Mbps)
	4/0	AM26LV31 (10 Mbps)	SN75ALS192 (20 Mbps)
USB 2.0	1/1	TUSB1105/6 and TUSB2551* (Full and low speed)	

**Preview*

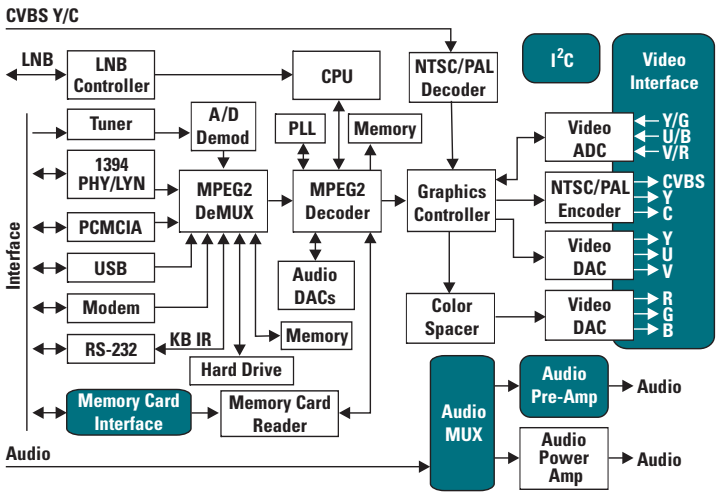
Overview

Top TV and Stereo Applications for Linear and Logic Devices

- Video Input Multiplexer/Port Expansion
- Audio Signal Routing
- Video Controller I/O Expansion
- RS-232 Interface
- USB Interface
- System-Level ESD Protection

Top Linear and Logic Device Requirements for TV and Stereo

- **Bandwidth**
  TI offers a wide portfolio of high-bandwidth switches for high-frequency video signals; a low insertion loss switch is required to pass, or reroute, these video signals.
- **System Cost**
  TI's specialty switches provide a cost-effective solution for port expansion in designs.



Video Input Multiplexer/Port Expansion

One of the most common applications for switches is routing video signals. A typical television or other video system may need the ability to switch between multiple sources to a single receiver. This is a cost savings as a single receiver can essentially be expanded into two or more ports with a relatively inexpensive video switch. Each video switch has a specific application depending on its characteristics. The most common applications are component video, composite video, S-video and emerging HDMI. HDMI is a fully digital interface that includes high-definition video and 5.1 audio.

Applications

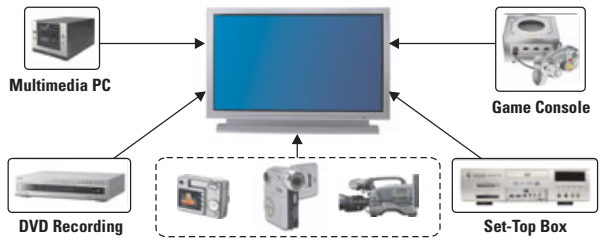
- Expand a single video receiver into multiple video receivers to handle multiple sources

Resources

- Specialty Switch: **www.ti.com/switches**
- Analog Switch Product Cast: **www.ti.com/casts**
- *Analog Switch Selection Guide*: Lit. # SLYB125
- TS5V330 Application Clip: Lit. # SCYB027
- *Audio Solutions Guide*: Lit. # SLYY013

Advanced Package Options

Options include 80-pin TQFP, 56- and 16-pin QFN.



Suggested Devices

Device	Description	Signal Rate	Applications
TS3DV416	4-channel differential 8:16 MUX switch	900 MHz to support 1.8 Gbps	DVI, HDMI
TS3DV520E	5-channel differential 10:20 MUX switch	1200 MHz to support 2.4 Gbps	DVI, HDMI
TMDS341/A	3-to-1 DVI/HDMI switch with pre-emphasis and input equalization	1.65 Gbps	DVI, HDMI
TS3V330	Quad SPDT wide-BW video switch with low r_{on}	300 MHz	S-video, composite video, analog component video
TS3V340	Quad SPDT high-BW video switch with low $r_{on(flat)}$	500 MHz	S-video, composite video, analog/digital component video
TS5V330	Quad SPDT wide-BW video switch with low r_{on}	300 MHz	S-video, composite video, analog component video
TL52055	Wide-BW, 2-input, 1-output, 3-circuit video switch	40 MHz	Component video

Audio Signal Routing

One of the most common applications for analog switches is signal routing. This may be routing from several sources to various destinations. A single-pole, quadruple-throw analog switch can be used in this situation. The switch can reroute the output of multiple sources to a common audio processor.

Applications

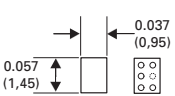
- Route MUX or deMUX audio signals from multiple sources

Resources

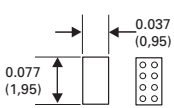
- Analog Switch Product Cast: **www.ti.com/casts**
- *Analog Switch Selection Guide*: Lit. # SLYB125
- TS5V330 Application Clip: Lit. # SCYB027
- *Audio Solutions Guide*: Lit. # SLYY013

Advanced Package Options

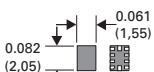
(Additional packages may be available)



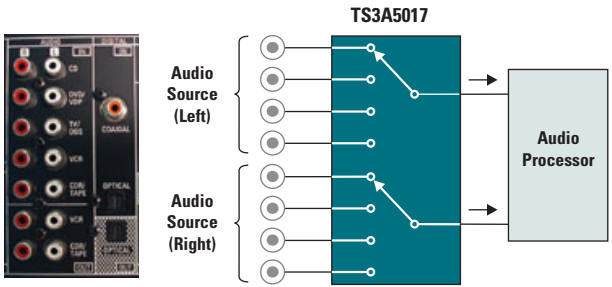
5-/6-Ball WCSP NanoStar™ (YZP)



8-Ball WCSP NanoStar™ (YZP)



10-Pin QFN (RSE)



Suggested Devices

Configuration	Device (r_{on})		
SPST	TS5A3166 (0.9 Ω) TS5A3167 (0.9 Ω) TS5A4594 (8 Ω)	TS5A4595 (8 Ω) TS5A4596 (8 Ω)	TS5A4597 (8 Ω) TS5A1066 (10 Ω)
SPST x 2	TS5A23166 (0.9 Ω)	TS5A23167 (0.9 Ω)	TS5A2066 (10 Ω)
SPST x 4	TS3A4751 (0.9 Ω)		
SPDT	TS5A3154 (0.9 Ω) TS5A3153 (1 Ω) TS5A3159/A (1.1 Ω)	TS5A4624 (1.1 Ω) TS5A2053 (7.5 Ω) TS5A3157 (10 Ω)	TS5A63157 (12 Ω) TS5A3160 (1 Ω)
SPDT x 2	TS5A23159 (0.9 Ω) TS5A623157	TS5A23160 (0.9 Ω)	TS5A23157 (10 Ω)
SPDT x 4	TS3A5018 (10 Ω)		
SP3T	TS5A3359 (0.9 Ω)	TS5A3357 (15 Ω)	
SP4T x 2	TS3A5017 (12 Ω)		

Video Controller I/O Expansion

As the video chipset becomes increasingly more complex, more pins on a typical video controller are being used by new features offered in that chipset. At the same time, reducing the number of GPIOs that control external devices such as video switches, receivers and other peripherals helps reduce the video chipset's cost. I^2C I/O expanders allow for the expansion of these GPIOs when more are needed.

Applications

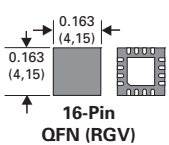
- Processor pin savings
- Improved board routing
- Reduced board space

Resources

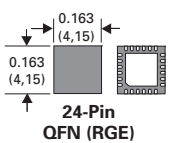
- I^2C Bus Solutions: **www.ti.com/i2c**
- I^2C Product Casts: **www.ti.com/casts**
- *I^2C Bus Selection Guide*: Lit. # SSZC003A

Advanced Package Options

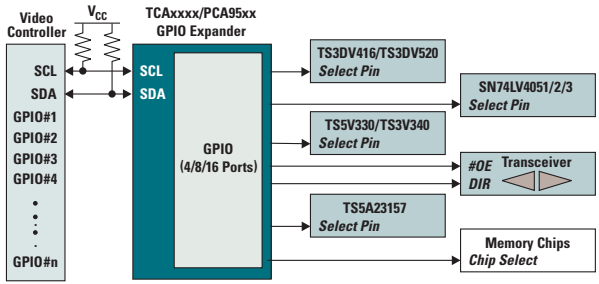
(Additional packages may be available)



16-Pin
QFN (RGV)



24-Pin
QFN (RGE)



Suggested Devices

Device	Description	Standby Mode Power I_{CC} (µA)	Maximum Frequency (kHz)	Pins/ Packages
TCA6408	Low-voltage 8-bit I^2C and SMBus I/O expander with interrupt output, reset and configuration registers	1	400	20/BGA
PCA9536	Remote 4-bit I^2C and SMBus I/O expander with configuration registers	1	400	8/MSOP
PCA9557	Remote 8-bit I^2C and SMBus low-power I/O expander with reset and configuration registers	1	400	16/QFN
PCA9539	Remote 16-bit I^2C and SMBus low-power I/O expander with interrupt output and configuration registers	1	400	24/QFN

RS-232 Interface

The TIA/EIA-232 devices provide a single-ended interface between data terminal equipment (DTE) and data communication equipment (DCE).

Advantages

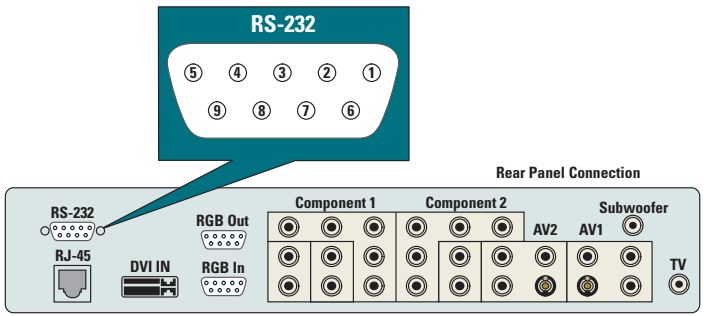
- System-level ESD protection
- NiPdAu Pb-Free solution for whisker-free, reliable packages
- Space-saving QFN package options

Resources

- Interface: **www.ti.com/interface**
- RS-232 Product Cast: **www.ti.com/casts**
- *Interface Selection Guide*: Lit. # SSZT009C
- RS-232 Application Clip: Lit. # SLLB103A

Advanced Package Options

Technology available in a variety of package options.



Suggested Devices

Device	V_{CC} (V)	Rate	Number of Capacitors	HBM ESD (kV)
TRS232E	5	120 kbps	4 x 1 µF	15
TRS202E	5	120 kbps	4 x 0.1 µF	15
TRS3232E	3/5	250 kbps	4 x 0.1 µF	15
TRSF3232	3/5	1 Mbps	4 x 0.1 µF	15

USB Interface

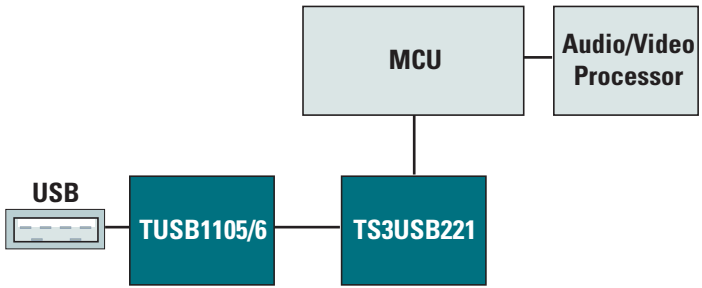
Many new televisions offer the USB interface that allows consumers to view photos, videos, etc. on the larger TV screen. TI offers a broad portfolio of USB peripheral ICs, including multiplexers and transceivers.

Advantages

- Broad portfolio of USB peripheral devices
- Complies with USB 2.0 specification
- Advanced package offerings

Resources

- Interface: **www.ti.com/interface**
- *Interface Selection Guide*: Lit. # SSZT009C



Suggested Devices

Device	Description	Speed	Voltage (V)	Single-Ended Input	Smallest Footprint Pins/Packages
USB Transceivers					
TUSB1105	USB transceivers	Full, low	1.6 to 3.6	Yes	16/QFN (RTZ)
TUSB1106	USB transceivers	Full, low	1.6 to 3.6	No	16/QFN (RTZ)
USB MUX					
TS3USB221	1:2 USB MUX/DeMUX	480 Mbps	2.5 to 3.3	Yes	10/QFN (RSE)
TS3USB30	1:2 USB MUX/DeMUX	480 Mbps	3 to 4.3	Yes	10/QFN (RSW)
TS3USB31	1-port switch	480 Mbps	3 to 4.3	Yes	10/QFN (RSE)

System-Level ESD Protection

For any external HDMI interface connector port, an ESD strike is a constant threat to device reliability. Many low-voltage core ICs offer only device-level human-body-model (HBM) ESD protection, which doesn't address system-level ESD. A stand-alone ESD solution is a space- and cost-effective solution to protect the system interconnects from external ESD strikes.

Advantages

- System-level ESD protection (IEC61000-4-2 Level 4) for high-speed applications
- HDMI 1.3 and display port data rate support

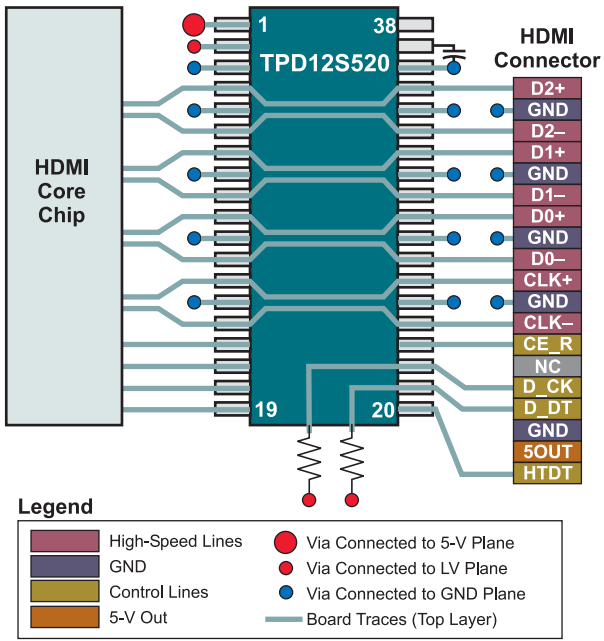
Resources

- Interface: **www.ti.com/interface**
- *Interface Selection Guide*: Lit. # SSZT009C

Suggested Devices

Device	Description
TPD12S520*	12-channel HDMI receiver ESD protection with level shifting for DDC channel and HPC
TPD12S521*	12-channel HDMI driver ESD protection with level shifting for DDC channel and HPC
TPD8S009*	8-channel HDMI/display port ESD protection

**Preview*



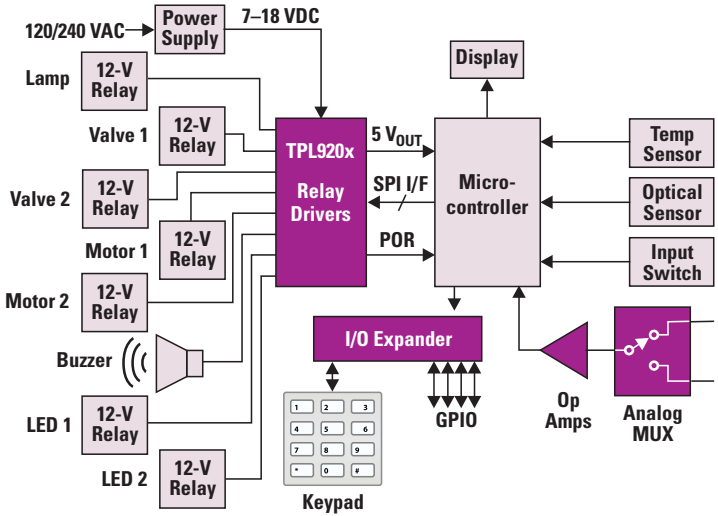
Overview

Top White Goods Applications for Linear and Logic Devices

- Relay or Motor Control
- Analog Signal Routing
- Microcontroller I/O Expansion
- Signal Conditioning

Top Linear and Logic Device Requirements for White Goods

- **Size**
  Board real estate is at a premium on PCBs. Small-scale packaging is a requirement for linear and logic functions on the design. From WCSP and micro QFN packages to the industry-standard SC-70 and SOT-23 leadframe packages, TI offers the industry's broadest portfolio of small-scale packaging.
- **Relay Control**
  Most microcontrollers are not capable of withstanding the large transients incurred during relay switching. The TPL920x series of relay drivers integrates eight low-side drivers, features power-on reset and an on-board 5-V regulator, and is controlled with a serial interface that simplifies system design and part count.



Relay or Motor Control

TI's TPL920x devices are ideal for systems using a microcontroller to drive relays, LEDs, stepper motors, solenoids, MOSFETs, buzzers, etc. The devices can also provide microcontroller power and offer brownout protection and reset features.

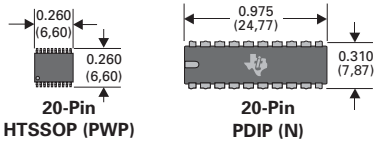
Applications

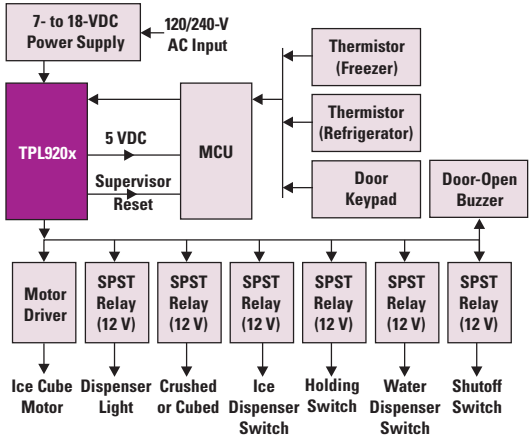
- Electrical appliances
- HVAC
- Security systems
- Automotive

Resources

- TPL920x Product Cast: **www.ti.com/casts**
- TPL920x Product Clip: Lit. # SCYB045A

Advanced Package Options



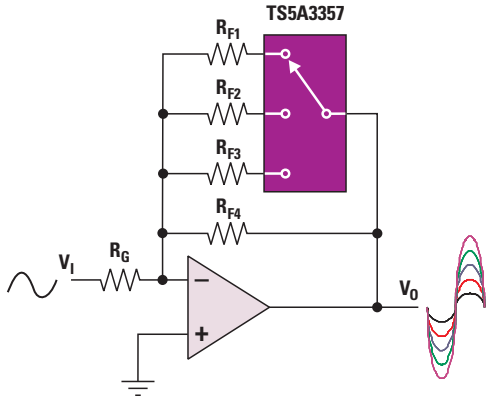


Suggested Devices

Device	Description	LDO Output (V)
TPL9201	Integrated 8-output relay driver with zero-volt detect	5
TPL9202	Integrated 8-output relay driver with brownout detect	5

Analog Signal Routing

One of the most common applications for analog switches is signal routing. This may be routing from one source to multiple destinations or from several sources to a single destination. A single-pole, double-throw analog switch can be used for either situation. For example, the switch could be used to select different gain settings on an operational amplifier.



Applications

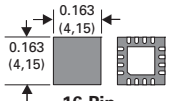
- DeMUX inputs for microcontroller
- Op amp gain adjustment
- Op amp filter selection

Resources

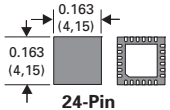
- Analog Switch: **www.ti.com/switches**
- Analog Switch Product Cast: **www.ti.com/casts**
- *Analog Switch Selection Guide*: Lit. # SLYB125 **www.ti.com/analogswitchguide**

Advanced Package Options

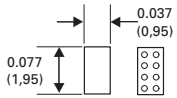
(Additional packages may be available)



16-Pin QFN (RGV)



24-Pin QFN (RGE)



8-Ball WCSP NanoStar™ (YZP)

Suggested Devices

Device	Configuration	V+ (V)	r_{on} (Ω)	Packages
TS5A1066	1 x SPST	1.65 to 5.5	10	SOT-23, SC-70, WCSP
TS5A2066	2 x SPST	1.65 to 5.5	10	SOT-23, SC-70, WCSP
TS5A2053	1 x SPDT	1.65 to 5.5	10	SM8, US8
TS5A3157	1 x SPDT	1.65 to 5.5	10	SOT-23, SC-70, WCSP
TS5A23157	2 x SPDT	1.65 to 5.5	10	MSOP, QFN
TS5A3357	1 x SP3T	1.65 to 5.5	5	SM8, US8
TS5A623157*	2 x SPDT	1.65 to 5.5	10	VSSOP, QFN

**Preview*

Microcontroller I/O Expansion

Today's appliances have more features and processing requirements than those of previous generations. I²C I/O expanders allow new features to be added without the need to upgrade to more expensive microcontrollers. TI's I²C I/O expanders are well suited for LED control, keypad communications, increasing digital inputs and controlling new peripherals.

Advantages

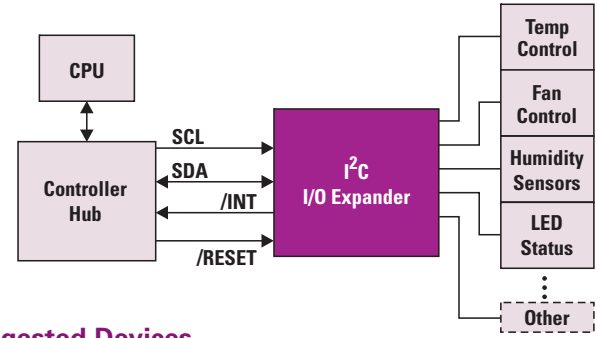
- Processor pin savings
- Improved board routing
- Reduced board space

Applications

- Keypad control
- LED control
- Temperature sensing

Resources

- I²C Bus Solutions: **www.ti.com/i2c**
- I²C Product Casts: **www.ti.com/casts**
- *I²C Bus Selection Guide*: Lit. # SSZC003A
- Application Note: Lit. # SCPA032

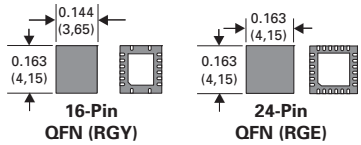


Suggested Devices

Device	Description	V_{CC} (V)	Pins/Packages
PCA9536	Remote 4-bit I²C and SMBus I/O expander with configuration registers	2.3 to 5.5	8/WCSP
PCA9557	Remote 8-bit I²C and SMBus low-power I/O expander with reset and configuration registers	2.3 to 5.5	16/SOIC, SSOP, TSSOP, TVSOP, QFN
PCA9539	Remote 16-bit I²C and SMBus low-power I/O expander with interrupt output and configuration registers	2.3 to 5.5	24/SOIC, SSOP, TSSOP, TVSOP, QFN

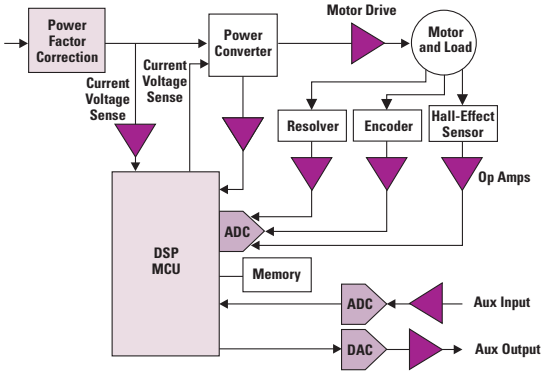
Advanced Package Options

(Additional packages may be available)



Signal Conditioning

Condition signals prior to interfacing with the system's microcontroller.



Applications

- Switch-mode power supplies and battery chargers
- Voltage and current sensing—Power Good, overvoltage, undervoltage, overcurrent
- Window comparators
- Alarms, detectors and sensors

Resources

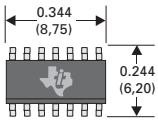
- Operational Amplifiers: **www.ti.com/standardlinear**
- *Operational Amplifiers Selection Guide*: Lit. # SLYB115A

Suggested Devices

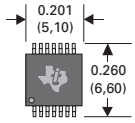
Family	Device	Description	No. of Channels	Power Supply (V)	V_{REF} V_Z (V)
Wide-Voltage Op Amps	LP324	Ultra-low-power quad op amps	4	3 to 32	—
	LP2902	Ultra-low-power quad op amps	4	3 to 32	—
	LP358	Ultra-low-power dual op amp	2	3 to 32	—
	LP2904	Ultra-low-power dual op amp	2	3 to 32	—
	TS321	Low-power single op amp	1	3 to 30	—
Low-Noise Op Amps	MC33078	Dual high-speed low-noise op amp	2	10 to 36	—
	TL5580	Dual low-noise wide-bandwidth precision amp	2	4 to 36	—
	TL5580A	Dual low-noise wide-bandwidth precision amp	2	4 to 36	—
Op Amps with V_{REF}	TL103W	Dual op amp with internal reference	2	3 to 32	2.5
	TL103WA	Dual op amp with internal reference	2	3 to 32	2.5
	TSM102	Dual op amp, dual comparator w/voltage ref.	2	3 to 30	2.5 to 36
	TSM102A	Dual op amp, dual comparator w/voltage ref.	2	3 to 30	2.5 to 36
	TSM104W	Quad op amp and programmable voltage ref.	4	3 to 32	2.5 to 36
	TSM104WA	Quad op amp and programmable voltage ref.	4	3 to 32	2.5 to 36

Package Options

(Additional packages may be available)



14-Pin SOIC (D)



14-Pin TSSOP (PW)

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Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
RFID	www.ti-rfid.com	Telephony	www.ti.com/telephony
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