I²C Bus Selection Guide

Texas Instruments (TI) has supported the highly efficient I²C BUS® interface for many years. This overview provides an updated look at I²C applications and how TI's I/O expanders, multiplexers, buffers and repeaters can help system designers achieve effective subsystem communications using proven I²C devices.

History

During the 1980s, Philips (Koninklijke Philips Electronics N.V.) developed the two-wire inter-integrated circuit (I²C) bus to provide an easy way to connect multiple peripheral circuits to a central processing unit (CPU/MCU) in TV applications.

As circuits became more complex with many peripheral connections, a method was needed to simplify designs and reduce costs. By limiting the number of printed circuit board (PCB) traces and lowering general-purpose input and output (GPIO) usage on the microprocessor, the I²C bus met this requirement.

Operation

The I²C bus is used in a wide range of applications because it is simple and quick to use. It consists of a two-wire communication bus that supports bidirectional data transfer between a master and several slaves. The master or processor controls the bus—in particular, the serial clock (SCL) line. Data is transferred between the master and slave through a serial data (SDA) line. This data can be transferred in three speeds or modes: standard (0 to 100 kbps), fast (0 to 400 kbps) and high-speed (0 to 3.4 Mbps). The most common speeds are the standard and fast modes. See block diagram below for a generic system.

There can be more than one master on a system; the software protocol uses arbitration and synchronization to manage data collisions and loss.

Since successive specification enhancements are backward-compatible, mixed-speed communication is possible with the bus speed being controlled by the bus master chip.

I²C Features

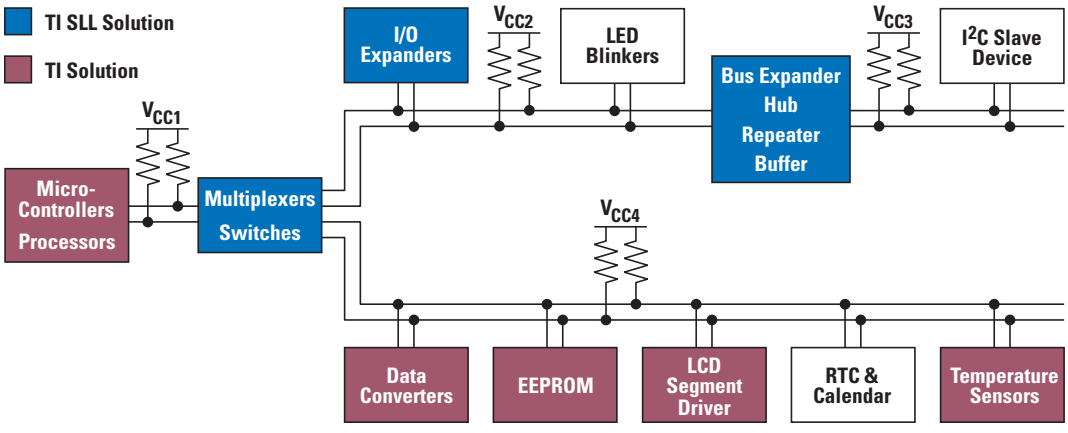
- Requires one master (processor) and one or more slave devices
- Each device on the bus generally has a unique address
- Bus capacitive load: 400 pF max
- Rise time: 1000 ns (standard mode) and 300 ns (fast mode)

I²C Applications

The I²C bus is useful for many of today's microcontroller- and microprocessor-based systems or other systems linking many I/O devices. These systems may include applications in the following fields:

- Automotive
- Consumer
- Industrial
- Telecom/networking
- PC/server
- Radio/TV
- Telephony

Many of the I²C bus products are designed to operate in the SMBus™ environment. The SMBus is similar to the I²C bus but has lower current and operates at a lower speed.



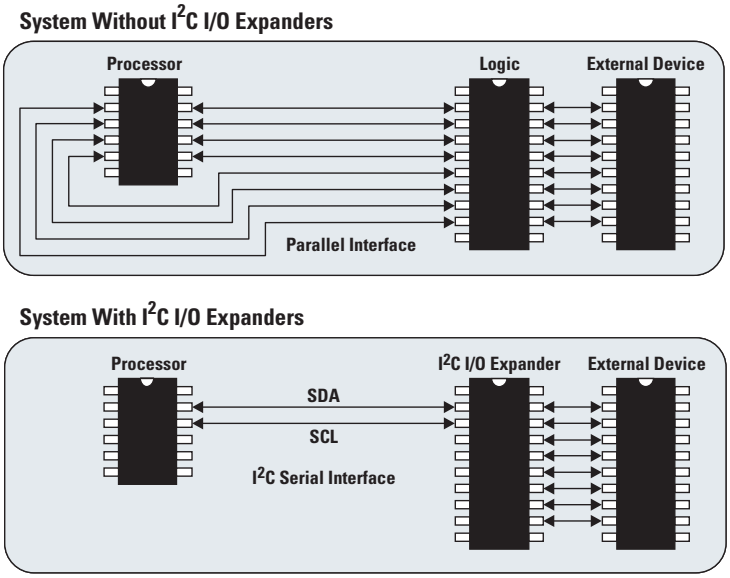
Block diagram of generic system using I²C devices

Expanders

The I²C I/O expander as shown in this diagram allows system layout to be greatly simplified. The two-wire bus reduces PCB complexity through trace reduction and routing simplification.

Advantages:

- Easy board routing
- Board-space savings
- Processor-pin savings
- Low cost
- Industry standard



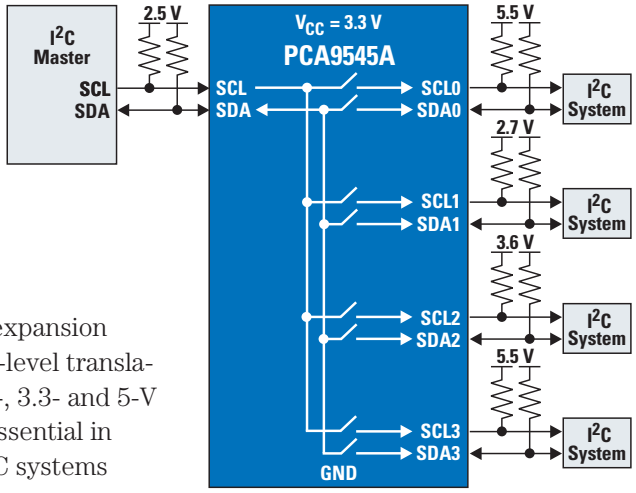
I/O expanders

Multiplexers and Switches

The I²C I/O multiplexer/switch shown in this diagram allows further expansion of I²C systems while maintaining the simple two-wire bus. It can also perform voltage translation and segment isolation.

Advantages:

- Resolves I²C address conflicts
- Can isolate a section on the I²C bus
- Pin savings on the I²C master, as each switch is activated or isolated through the I²C software
- Permits I²C bus expansion
- Supports voltage-level translation between 2.5-, 3.3- and 5-V buses, which is essential in mixed-voltage I²C systems



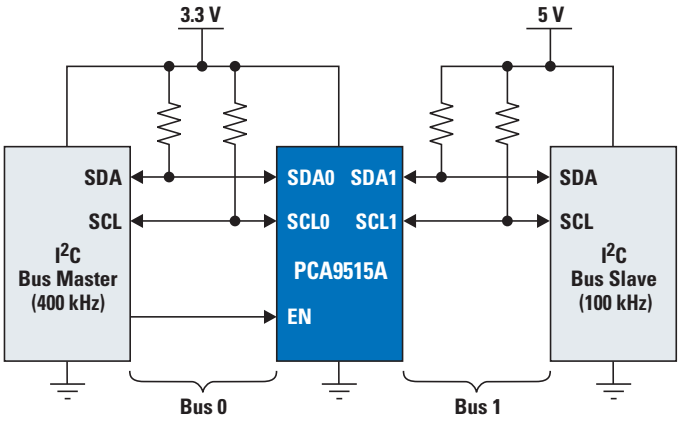
Multiplexers and switches

Bus Expanders, Hubs, Buffers and Repeaters

I²C bus expanders, hubs, buffers and repeaters permit bus expansion, sectional bus isolation, address conflict resolution and voltage-level translation as shown in this diagram.

Advantages:

- Can isolate a section on the I²C bus through enable (EN) pin
- Permits I²C bus expansion
- Resolves I²C address conflicts
- Supports voltage-level translation between 2.5-, 3.3- and 5-V buses, which is essential in mixed-voltage I²C systems



Bus expanders, hubs, buffers and repeaters

Translators

The PCA9306 bidirectional voltage-level translator enables voltage translation where interconnection between voltage levels is required as shown in this diagram.

Features:

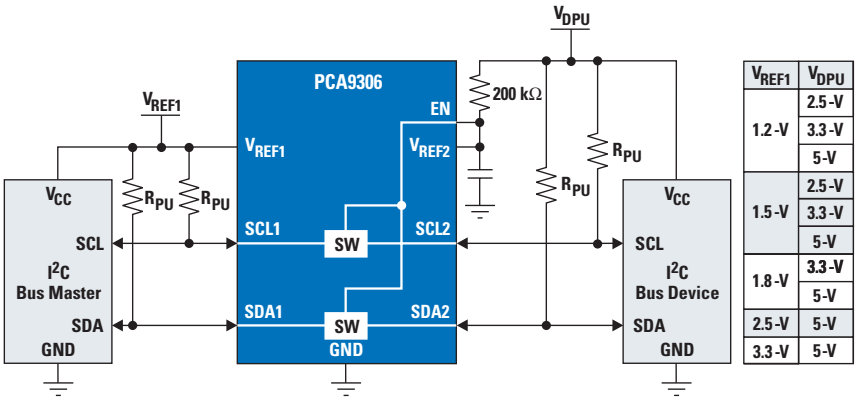
- Less than 1.5-ns maximum propagation delay
- Low 3.5-Ω on-state connection between I/O ports provides less signal distortion
- Open-drain I^2C I/O ports (SCL1, SDA1, SCL2, SDA2)
- 5-V-tolerant I^2C I/O port to support mixed-mode signal operation
- High-impedance SCL1, SDA1, SCL2 and SDA2 pins for EN = low

Advantages:

- Can interface between MSP430 microcontrollers and DSPs operating at 1.8 V and I^2C slave devices operating at V_{CC} of 2.5 V and higher
- Provides bidirectional voltage translation without a direction pin
- Accommodates standard- and fast-mode I^2C devices and multiple masters

Applications:

- Mixed-mode voltage applications
- Bus isolation



PCA9306 bidirectional voltage-level translator

Portfolio

TI is constantly developing new I^2C products. The Packages and Availability table includes TI's current portfolio of I^2C bus products and those planned for release during 1H06.

I^2C Selection Guide

Device	Max Frequency (kHz)	I^2C Address	V_{CC} Range (V)	Bit or Channel Width	Additional Features					I/O Type	
					Low Power	Interrupt	Reset	Configuration Registers	5-V-Tolerant I/O	Totem Pole	Open-Drain
I/O Expanders											
PCA9536	400	1000 001	2.3 to 5.5	4-bit				✔	✔	✔	
PCF8574	100	0100 xxx	2.5 to 6.0	8-bit		✔				✔	
PCF8574A	100	0111 xxx	2.5 to 6.0	8-bit		✔				✔	
PCA9557	400	0011 xxx	2.3 to 5.5	8-bit	✔		✔	✔	✔	✔	✔
PCF8575	400	0100 xxx	2.5 to 5.5	16-bit		✔				✔	
PCF8575C	400	0100 xxx	4.5 to 5.5	16-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		✔		✔	✔	✔	
Multiplexers											
PCA8550	400	1001 110	3.0 to 3.6	5-bit						✔	
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			✔		✔		✔
Buffer/Repeater											
PCA9515A	400	None	2.3 to 5.5	2-channel					✔		✔
Translator											
PCA9306	400	None	0 to 5.0	2-channel					✔		✔

Packages and Availability

Device	BGA	PDIP	QFN	MSOP	SM8	SOIC	SSOP	QSOP	TSSOP	TVSOP	US8	WCSP
PCA6107						✔[1]						
PCA8550						✔	✔		✔			
PCA9306					✔						✔	
PCA9515A				✔	✔	✔			✔			
PCA9535			✔			✔	✔	✔	✔	✔		
PCA9536				✔[2]		✔[2]					✔[2]	✔[2]
PCA9539			✔			✔	✔	✔	✔	✔		
PCA9544A	✔		✔			✔			✔	✔		
PCA9545A	✔		✔			✔			✔	✔		
PCA9546A			✔			✔			✔	✔		
PCA9555			✔			✔	✔	✔	✔	✔		
PCA9557			✔			✔	✔		✔			
PCF8574/A		✔	✔			✔			✔	✔		
PCF8575/C			✔			✔	✔	✔	✔	✔		

[1]Preview [2]Planned

Competitive Cross-Reference

TI Device	Philips	Maxim
PCA6107		
PCA8550	PCA8550	
PCA9306		
PCA9515A	PCA9515/A	
PCA9535	PCA9535	MAX7312
PCA9536	PCA9536	
PCA9539	PCA9539	
PCA9544A	PCA9544/A	
PCA9545A	PCA9545/A	
PCA9546A	PCA9546/A	
PCA9555	PCA9555	MAX7311
PCA9557	PCA9557	MAX7310
PCF8574/A	PCF8574/A	
PCF8575/C	PCF8575/C	

For More Information

For additional information, including application reports, application clips, articles and links to the product folders, please visit: **www.ti.com/i2c** or **www.ti.com/standardlinear**

For more information about TI "Must Have" linear solutions, visit: **www.ti.com/musthave**

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