NXP I²C-bus buffers P82B96 and PCA9600

True I²C-bus buffering for long-distance communications

These rugged bipolar ICs make it easy to use the I²C-bus (and its derivatives) for long-distance communications or opto-electrical isolation. They interconnect several buses or can split a single bus into two unidirectional data streams.

Key features
▸ Dual, bi-directional buffers in 8-pin DIL/SO/MSOP packaging
▸ Bus speeds to 1 MHz
▸ Sx/Sy-side compatibility with I²C-bus, SMBus, and PMBus
▸ Tx/Rx-side compliance with 30-mA Fast-mode Plus I²C-bus specification
▸ Wide supply and bus voltage range to 15 V
▸ Can handle or level-shift logic signals (2 to 15 V)
▸ Connected buses are released if supply fails
▸ Low power-supply current
▸ Splits the I²C-bus into two unidirectional Tx and Rx data signals, or recombines them
▸ Safe isolation of the bus via simple interface to opto-couplers
▸ Optional x10 bus-impedance transformation

Applications
▸ Building large or distributed I²C-bus systems for automation/control/displays
▸ Transmitting I²C-bus signals over long-distance, twisted-pair cabling
▸ Galvanic/safety (opto) isolation of sections of the I²C-bus
▸ Interfacing between logic devices or buses on different voltages
▸ Hot-plugging bus interface protection
▸ Interfacing SMBus to I²C-bus
▸ Interfacing 3-mA I²C-bus devices to a 30-mA Fast-mode Plus bus, at speeds to 1 MHz
▸ I²C-bus signaling via differential bus hardware – CAN bus, RS485, etc.
▸ Preventing bus 'hang-ups' by isolating devices or modules if supply fails
▸ Sending I²C-bus signals over RF links

Designed for use with the I²C-bus and similar bidirectional buses, including SMBus and PMBus, the NXP P82B96 and PCA9600 provide true buffer functionality and extend the I²C-bus and its derivatives beyond the specification's maximum bus capacitance of 400 pF.

The buffers can be used to interconnect several buses or, using analog techniques, can be used to "split" the bidirectional bus signals into two conventional, unidirectional data streams, so data can be transmitted over a wider array of media. The buffers can also recombine two split data streams, to restore the original, bidirectional I²C-bus signal.

The buffers significantly improve a bus system's noise margin, since they have a guaranteed operating supply voltage

range up to 15 V and are able to process or level-shift logic signals anywhere within their range.

For better impedance matching over long runs of low-cost, twisted-pair cabling, the static-sink capabilities of the buffered outputs have been increased ten times, to 30 mA. The buffers dynamically support much higher outputs, up to at least 60 mA.

To meet safety requirements in demanding applications, including control equipment connected to the mains supply, telephone wiring, and medical monitoring equipment, a simple interface to low-cost opto-couplers supports galvanic isolation of portions of the I²C-bus system.

A "bus release" feature enhances the reliability of distributed bus systems with separate power supplies. This feature prevents system "hang-ups" by releasing all connected buses if the chip supply voltage is removed.

Several features, including bus disconnection, low supply current, and I/O that are tolerant to 15 V, are useful in resolving the problems associated with "hot plugging" or "plug-and-play" bus applications.

The PCA9600 provides guaranteed compatibility with the special TTL switching levels used by some derivative buses for the Sx/Sy bus interface, and maintains complete compliance with the I²C-bus on its Tx/Rx interface. Decreased delays also assist Fast-mode Plus applications up to 1 MHz. It supports the industrial temperature range (-40 to +85 °C), and is available in 8-pin SO and MSOP packages.

The P82B96 is offered as a dual buffer and has an extended temperature-range option that supports -40 to +125 °C. It is available in 8-pin DIL, SO, and MSOP packages.

P82B96 vs. PCA9600

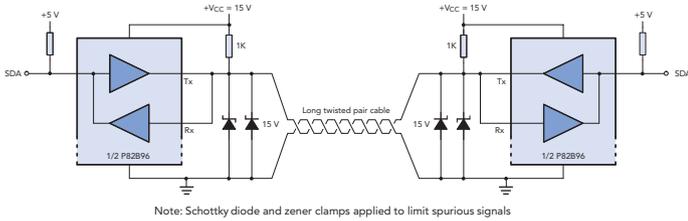|	P82B96	PCA9600
Supply voltage range (V_{CC})	2 – 15 V	2.5 – 15 V
Operating bus voltage (max, independent of V_{CC})	15 V	15 V
Operating supply current (I_{CC} typ)	1 mA	5 mA
Vinput low on I²C-bus (Sx/Sy side, typical)	0.65 V at 25 °C	0.5 V over –40 to +85 °C
Voutput low on I²C-bus (Sx/Sy side, 3-mA sink)	0.88 V typ at 25 °C	0.74 V max over –40 to +85 °C
Temperature coefficient of Vil/Vol	-2 mV/C	0
Logic voltage levels on Sx/Sy bus (independent of V_{CC})	Compatible with I²C-bus and similar buses using TTL levels (SMBus etc.)	Compatible with I²C-bus and similar buses using TTL levels (SMBus etc.)
Typical propagation delays	<200 ns	<100 ns
Tx/Rx switching specifications (I²C-bus compliant)	Yes, all classes including Fm+	Yes, all classes including 1-MHz Fm+
Rx logic levels with tighter control than I²C-bus limit of 30 / 70%	Yes, 42 / 58% (nominal 50%)	Yes, 40 / 55% (nominal 48%)
Maximum bus speed	>400 kHz	>1 MHz
ESD rating HBM per JESD22-A114	>3,500 V	>4,500 V
Packages	DIP8, SO8, TSSOP8 (MSOP8)	SO8, TSSOP8 (MSOP8)

Ordering information

| Part number	12NC	Packing	Package	Package drawing
P82B96PN	935262297112	Tube	DIP 8	SOT97-1
P82B96TD	935262295112	Tube	SO 8	SOT96-1
P82B96TD-T	935262295118	Reel	SO 8	SOT96-1
P82B96DP	935276269118	Reel	TSSOP (MSOP) 8	SOT505-1
PCA9600D	935285243112	Tube	SO 8	SOT96-1
PCA9600D	935285243118	Reel	SO 8	SOT96-1
PCA9600DP	935285244118	Reel	TSSOP (MSOP) 8	SOT505-1

The NXP I²C-bus 2005-1 evaluation board has an available P82B96/PCA9600 daughter board to generate Fast-mode Plus signals or to drive long cable signals via two RJ45 interface jacks. Refer to application note AN10658.

Driving a long-distance, high-voltage, low-impedance, I²C-bus

Note: Schottky diode and zener clamps applied to limit spurious signals

For long-distance communications between boxes or even between buildings, the P82B96/PCA9600 provides high ESD, high transient ruggedness, and can operate at up to 15-V signaling levels using four wires (e.g., SDA and GND on one pair; SCL and supply or GND on the other).

## Higher-speed transmission using a unidirectional signal path
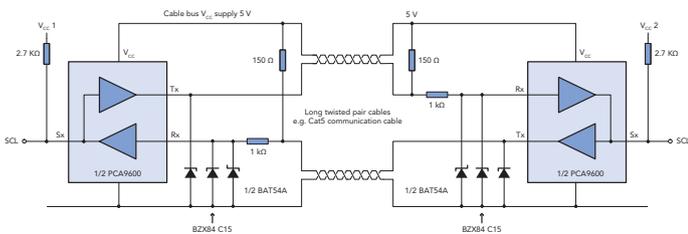
To drive longer cables and the highest speeds, a unidirectional signal path can be used to minimize time-of-flight delays. Splitting the Tx and Rx signals requires four pairs of cables for the SDA and SCL signals (e.g., SDA Tx and GND, SDA Rx and supply/GND, SCL Tx and GND, SCL Rx and supply/GND).

## Using normal I²C-bus devices on Fm+ buses
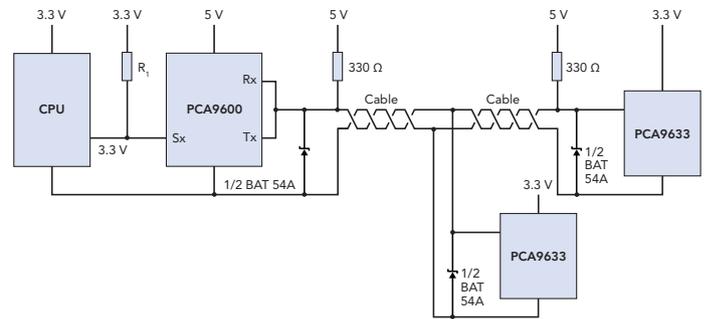
The P82B96/PCA9600 can be used in applications that use the higher-drive capability to drive long cables with multiple Fast-mode Plus slaves (e.g., using multiple PCA9633 LED drivers to build large architecture-lighting displays). In this case, the P82B96/PCA9600 is used to buffer a CPU with a 3-mA capability, so the CPU can drive the bus to its maximum frequency capability. The P82B96/PCA9600 can also be used to buffer normal slaves, capable of 3 mA, on buses with higher drive.

## High-speed differential signals are also possible
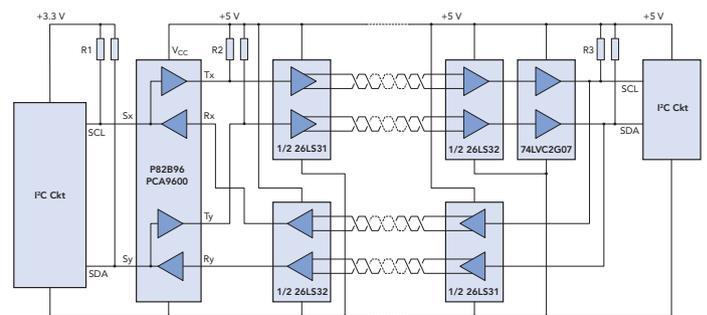
For increased common-mode rejection over balanced cables, the P82B96/PCA9600 provides a simple interface to low-cost, generic LSTTL differential line drivers. Multiplexing multiple signals is also possible, using LVDS serializers/deserializers.

Galvanic isolation of I²C nodes via opto-coupling
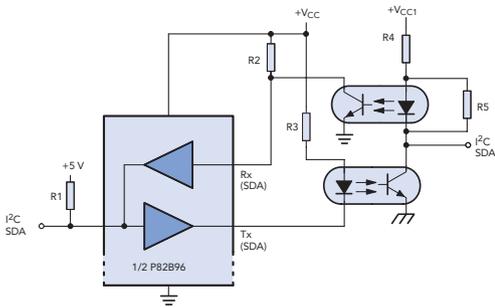
This example shows the simplicity of a low speed application.
For example: R1 = usual I²C pull–up   R2 = 10 K
                     R3 = 680   R4 = 2.2 K
                     R5 = 2.2 K   V_CC = 5 V
                     V_CC1 = 5 V

In this example of a simple low-speed opto-isolation application, opto-coupling electrically isolates the I²C-bus nodes from each other. Using simple isolators as shown results in slower opto-coupling, with typical speeds of only 5 kHz.
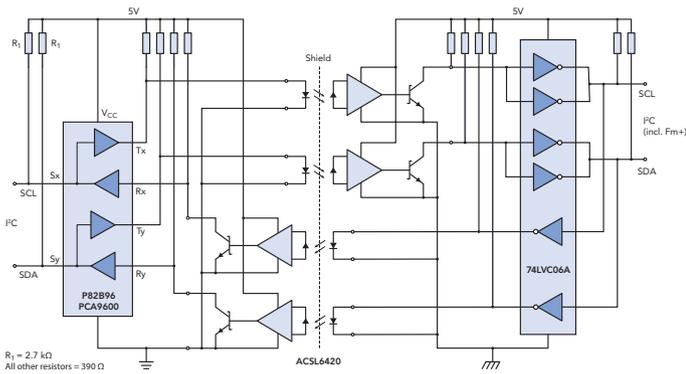
In this example of complex opto-isolation, the P82B96/ PCA9600 uses a simple interface to high-speed opto-couplers to achieve safety isolation and Fast-mode Plus drive capability on the right-hand bus. Using the PCA9600 and the quad isolator as shown, clock speeds in excess of 800 kHz are possible. Alternative opto-isolator drive configurations can greatly reduce current consumption with only a minor decrease in speed.