Totem Pole GPIO

Quasi-bidirectional GPIO

LED PWM open drain GPIO

GPIO Expander

Cost-effective, flexible options from the I²C-bus leader

NXP's general-purpose input/output (GPIO) expanders are a simple, cost-effective way to monitor and control several peripheral signals. They make it easy for designers to add extra I/O to their design and thereby free up the microprocessor's GPIO for other, more important functions. NXP is the industry leader in serial-interface GPIO expanders, and offers a broad selection of cost-effective, easy-to-use options.

I²C-Bus GPIO Expander Application Example
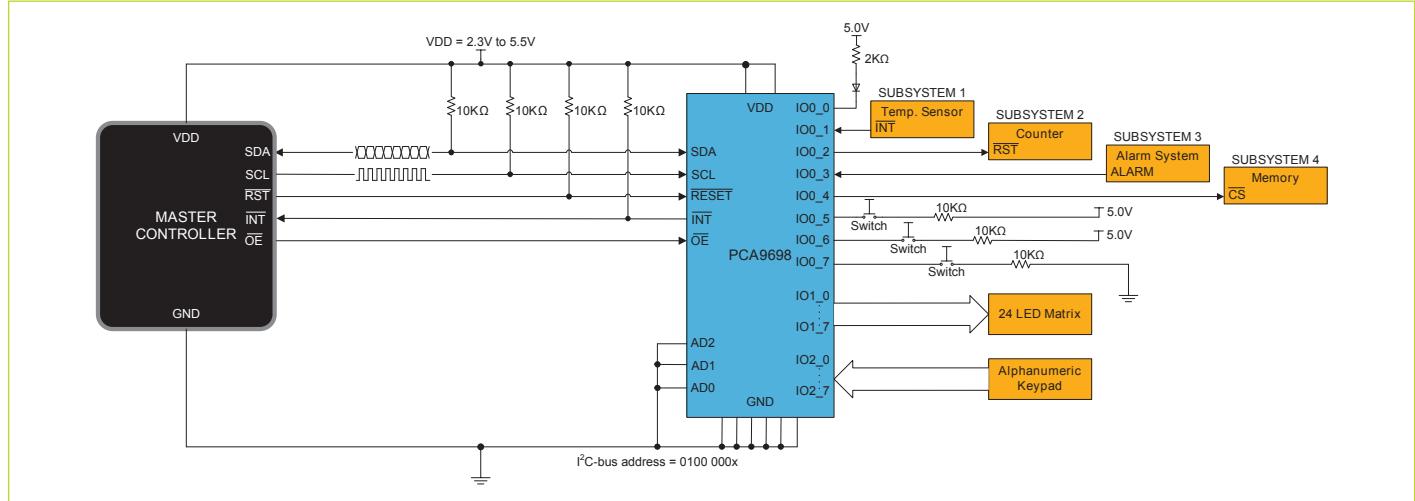
The I²C-bus allows easy two-line communication between two devices using a serial data line (SDA) and a serial clock line (SCL) and, as a result, is a popular choice for computing, consumer electronics, communication, and industrial systems.

I²C-Bus Communication Protocol and Timing Diagram
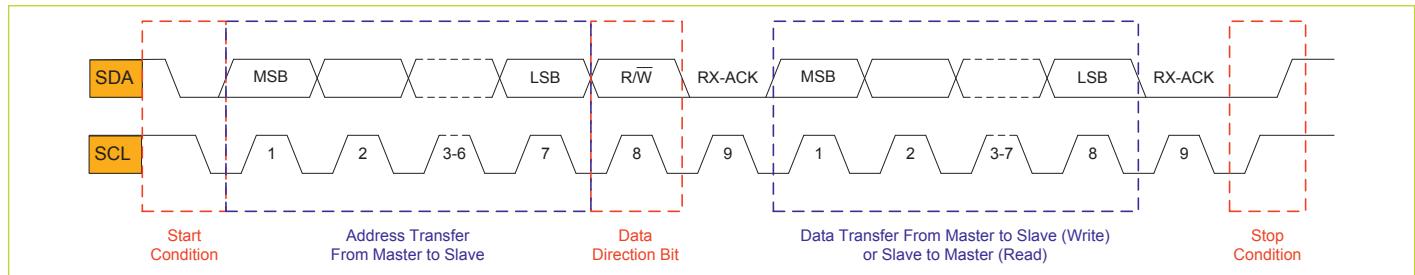
NXP's I²C-bus GPIO expanders support three operating modes for data transfer: Standard Mode, with data transfer rates from 0 kbps to 100 kbps, Fast Mode (Fm), with data transfer rates from 0 kbps to 400 kbps, and Fast-mode Plus (Fm+) with data rates from 0 kbps to 1 Mbps. Since the newer Fm+ GPIO are backward compatible all the way back to Standard Mode, it's easy to expand existing designs without changing the bus master device.

Application Support

NXP supports its GPIO expanders with several evaluation modules and demo boards that can be used to develop software and evaluate performance.

The I²C-bus Fm+ Development Kit and associated GPIO daughter cards provide a quick way to learn about the devices and the I²C-bus protocol. The cards are modular, so they increase design flexibility while providing easy access to the expander's I/O pins. For more information, visit ics.nxp.com/support/tools/interface
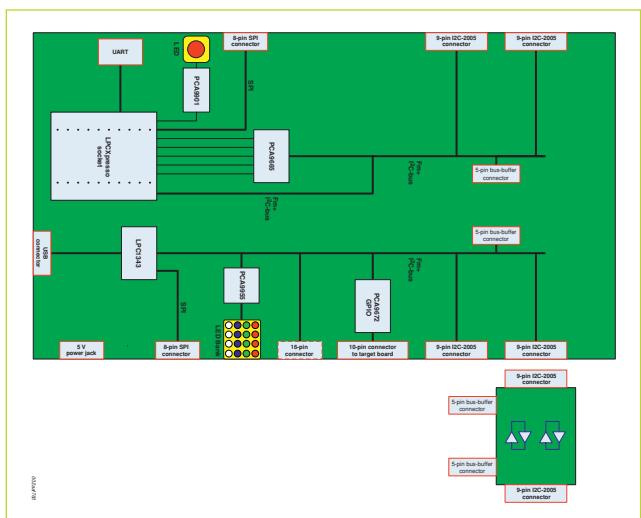
GPIO Expander Selection Guide

Device	Function	Output Type	Number of I/O's	Operating Voltage Range	Standby Current [1]	Max Output Drive Current	Max I/O Voltage Tolerance	Default POR Output State	Number of PWMs	Output Enable / PWM Control	Interface	Number of Device Addresses	Hardware Reset Input	Interrupt Output	I/O Pull-Up [2]	EEPROM	Status
PCA8574 (A) [3]	GPIO Expander	Quasi-Output	8	2.3 V - 5.5 V	4.5 µA	25 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	8	N	Y	Weak PU	N	In production
PCF8574 (A)	GPIO Expander	Quasi-Output	8	2.3 V - 6.0 V	2.5 µA	25 mA	5.5 V	Hi-Z Input	0	N	I²C, 100kHz	8	N	Y	Weak PU	N	In production
PCA9500	GPIO Expander	Quasi-Output	8	2.5 V - 3.6 V	60 µA	25 mA	5.5 V	High	0	N	I²C, Fm	8	N	N	Weak PU	2 Kbit	In production
PCA9501	GPIO Expander	Quasi-Output	8	2.5 V - 3.6 V	60 µA	25 mA	5.5 V	High	0	N	I²C, Fm	64	N	Y	Weak PU	2 Kbit	In production
PCA9558 [4]	GPIO Expander	Quasi-Output	8	3.0 V - 3.6 V	10 mA	4 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	2	N	N	Weak PU	2 Kbit	In production
PCA9670	GPIO Expander	Quasi-Output	8	2.3 V - 5.5 V	2.5 µA	25 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm+	64	Y	N	Weak PU	N	In production
PCA9672	GPIO Expander	Quasi-Output	8	2.3 V - 5.5 V	2.5 µA	25 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm+	16	Y	Y	Weak PU	N	In production
PCA9674 (A) [3]	GPIO Expander	Quasi-Output	8	2.3 V - 5.5 V	4.5 µA	25 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm+	64	N	Y	Weak PU	N	In production
PCF8575	GPIO Expander	Quasi-Output	16	2.3 V - 5.5 V	2.5 µA	25 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	8	N	Y	Weak PU	N	In production
PCF8575C	GPIO Expander	Quasi-Output	16	4.5 V - 5.5 V	2.5 µA	25 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	8	N	Y	-	N	In production
PCA8575	GPIO Expander	Quasi-Output	16	2.3 V - 5.5 V	2.5 µA	25 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	8	N	Y	Weak PU	N	In production
PCA9671	GPIO Expander	Quasi-Output	16	2.3 V - 5.5 V	2.5 µA	25 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm+	64	Y	N	Weak PU	N	In production
PCA9673	GPIO Expander	Quasi-Output	16	2.3 V - 5.5 V	2.5 µA	25 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm+	16	Y	Y	Weak PU	N	In production
PCA9675	GPIO Expander	Quasi-Output	16	2.3 V - 5.5 V	2.5 µA	25 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm+	64	N	Y	Weak PU	N	In production
PCA9536	GPIO Expander	Totem-Pole	4	2.3 V - 5.5 V	0.25 µA	10 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	1	N	N	100 kΩ	N	In production
PCA9537	GPIO Expander	Totem-Pole	4	2.3 V - 5.5 V	0.25 µA	10 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	1	Y	Y	-	N	In production
PCA9502	GPIO Expander	Totem-Pole	8	2.3 V - 3.6 V	600 µA	4 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm SPI 15MHz	16	Y	Y	-	N	In production
PCA9534	GPIO Expander	Totem-Pole	8	2.3 V - 5.5 V	0.25 µA	10 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	8	N	Y	-	N	In production
PCA9538	GPIO Expander	Totem-Pole	8	2.3 V - 5.5 V	0.25 µA	10 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	4	Y	Y	-	N	In production
PCA9554 (A)	GPIO Expander	Totem-Pole	8	2.3 V - 5.5 V	0.25 µA	10 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	8	N	Y	100 kΩ	N	In production
PCA9557	GPIO Expander	Totem-Pole [5]	8	2.3 V - 5.5 V	0.25 µA	8 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	8	Y	N	-	N	In production
PCA9574	GPIO Expander	Totem-Pole [6]	8	1.1 V - 3.6 V	0.25 µA	3 mA	3.6 V	Hi-Z Input	0	N	I²C, Fm	2	Y	Y [7]	100 kΩ [8]	N	In production
PCA9535	GPIO Expander	Totem-Pole	16	2.3 V - 5.5 V	0.25 µA	10 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	8	N	Y	-	N	In production
PCA9535C	GPIO Expander	Open-Drain	16	2.3 V - 5.5 V	0.25 µA	10 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	8	N	Y	-	N	In production
PCA9539 (R) [9]	GPIO Expander	Totem-Pole	16	2.3 V - 5.5 V	0.25 µA	10 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	4	Y	Y	-	N	In production

Device	Function	Output Type	Number of I/O's	Operating Voltage Range	Standby Current [1]	Max Output Drive Current	Max I/O Voltage Tolerance	Default POR Output State	Number of PWMs	Output Enable / PWM Control	Interface	Number of Device Addresses	Hardware Reset Input	Interrupt Output	I/O Pull-Up [2]	EEPROM	Status
PCA9555	GPIO Expander	Totem-Pole	16	2.3 V - 5.5 V	0.25 μA	10 mA	5.5 V	Hi-Z Input	0	N	I²C, Fm	8	N	Y	100 kΩ	N	In production
PCA9575	GPIO Expander	Totem-Pole [6]	16	1.1 V - 3.6 V	0.25 μA	3 mA	3.6 V	Hi-Z Input	0	N	I²C, Fm	16	Y	Y [7]	100 kΩ [8]	N	In production
PCA9505	GPIO Expander	Totem-Pole	40	2.3 V - 5.5 V	0.75 μA	15 mA	5.5 V	Hi-Z Input	0	Y	I²C, Fm	8	Y	Y	100 kΩ	N	In production
PCA9506	GPIO Expander	Totem-Pole	40	2.3 V - 5.5 V	0.75 μA	15 mA	5.5 V	Hi-Z Input	0	Y	I²C, Fm	8	Y	Y	-	N	In production
PCA9698	GPIO Expander	Totem-Pole [6]	40	2.3 V - 5.5 V	0.75 μA	25 mA	5.5 V	Hi-Z Input	0	Y	I²C, Fm+	64	Y	Y	-	N	In production
PCA9702	GPI Expander	-	8	2.5 V - 5.5 V	1 μA	-	18 V	-	0	N	SPI 5MHz	-	N	Y	-	N	In production
PCA9704	GPI Expander	-	8	4.5 V - 5.5 V	1 μA	-	18 V	-	0	N	SPI 5MHz	-	N	Y [7]	-	N	In Development
PCA9701	GPI Expander	-	16	2.5 V - 5.5 V	1 μA	-	18 V	-	0	N	SPI 5MHz	-	N	Y	-	N	In production
PCA9703	GPI Expander	-	16	4.5 V - 5.5 V	1 μA	-	18 V	-	0	N	SPI 5MHz	-	N	Y [7]	-	N	In production
PCA9550	Blinker	Open Drain	2	2.3 V - 5.5 V	1.9 μA	25 mA	5.5 V	Hi-Z Input	2	N	I²C, Fm	2	Y	N	-	N	In production
PCA9553	Blinker	Open Drain	4	2.3 V - 5.5 V	1.9 μA	25 mA	5.5 V	Hi-Z Input	2	N	I²C, Fm	2	N	N	-	N	In production
PCA9551	Blinker	Open Drain	8	2.3 V - 5.5 V	1.9 μA	25 mA	5.5 V	Hi-Z Input	2	N	I²C, Fm	8	Y	N	-	N	In production
PCA9552	Blinker	Open Drain	16	2.3 V - 5.5 V	2.1 μA	25 mA	5.5 V	Hi-Z Input	2	N	I²C, Fm	8	Y	N	-	N	In production
PCA9530	Dimmer	Open Drain	2	2.3 V - 5.5 V	1.9 μA	25 mA	5.5 V	Hi-Z Input	2	N	I²C, Fm	2	Y	N	-	N	In production
PCA9533	Dimmer	Open Drain	4	2.3 V - 5.5 V	1.9 μA	25 mA	5.5 V	Hi-Z Input	2	N	I²C, Fm	2	N	N	-	N	In production
PCA9531	Dimmer	Open Drain	8	2.3 V - 5.5 V	1.9 μA	25 mA	5.5 V	Hi-Z Input	2	N	I²C, Fm	8	Y	N	-	N	In production
PCA9532	Dimmer	Open Drain	16	2.3 V - 5.5 V	2.1 μA	25 mA	5.5 V	Hi-Z Input	2	N	I²C, Fm	8	Y	N	-	N	In production

[1] Typical value, measured with VDD = 5.5 V, no load, V_I = VDD or VSS, and F_{SCL} = 0 KHz.

[2] The Quasi-outputs have a strong pull-up (transistor) to VDD, during the low to high transition, to allow fast rising edges into heavy loaded outputs. The devices with weak pull-ups have a 100 μA current source to VDD.

[3] The difference between the A and the non-A device is the I²C-bus address.

[4] With 5-Bit Mux, 1-Bit Latch Dip Switch.

[5] IO0 is open-drain with a 1.1-kΩ pull-up resistor.

[6] Output may be configured as open-drain.

[7] Interrupt masking feature allows selected inputs to not generate interrupt.

[8] Programmable pull-up or pull-down resistor may be turned off.

[9] The difference between the R and the non-R device is the reset function.

Output Types

NXP's GPIO expanders are classified in different groups according to the output structure type: totem-pole (push-pull) output, quasi bidirectional I/O, and open-drain I/O.

Totem-Pole (Push-Pull) Output Expanders

Totem-pole outputs (consisting of upper and lower transistors) are ideal for fast switching applications (steep HIGH-LOW and LOW-HIGH transitions) where the output stage is required to source or sink current. To switch a pin between input and output, a Port Configuration Register must be programmed. An Output Port Register is used for storing the logic state of the signal driven to the output and a separate Input Port Register stores the logic state of input pins. Some totem-pole GPIO expanders are capable of input signal inversion, sparing the user the need of external inversion logic. Options with an internal pull-up resistor are also available.
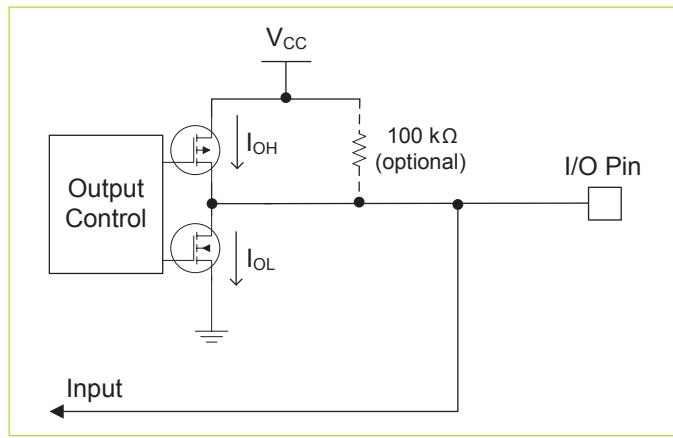
Quasi Bidirectional I/O Expanders

Quasi-bidirectional I/O ports are easy to use since they can be configured as an input or output without the need of a Port Configuration Register. They have a weak current-source pull-up to keep the port HIGH and are assisted by a strong pull-up for half a clock cycle during LOW-HIGH transitions. When driving a LOW, the lower transistor has a 25 mA current sinking capability. This configuration allows steep HIGH-LOW and LOW-HIGH transitions. When used as an input, the pull-up current source is easily overpowered by the driving circuit. Given the limited hold current capability, quasi-bidirectional I/O are not capable of driving devices that require over 100 µA of current.
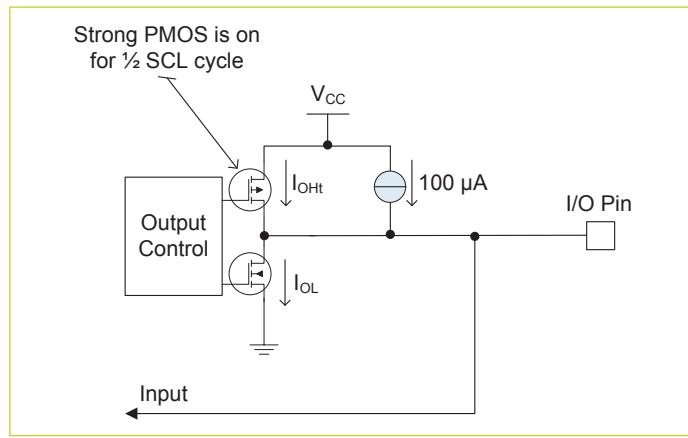
Open-Drain I/O Expanders

Open-drain I/O are only capable of sinking current and rely on a pull-up resistor to drive the line HIGH. Under heavy capacitive loading conditions, they have slower LOW-to-HIGH transitions compared to the totem-pole outputs, which have a steep HIGH-to-LOW transitions. Some of the GPIO expanders have an open-drain output option with no pull-up resistor and no current source on the output. This allows wired-AND connections or no current flow through parasitic diodes/LEDs when operated on different power supplies with one supply turned off. Other open-drain GPIO have integrated Pulse Width Modulation (PWM) that can be programmed to blink/dim LEDs according to the frequency and duty cycle stored in the PWM0 or PWM1 registers. Since they significantly reduce bus traffic, the GPIO with PWM controls are ideal for LED status applications where LEDs are switched off, on, blinked, or dimmed. These open-drain I/O typically have an input function.
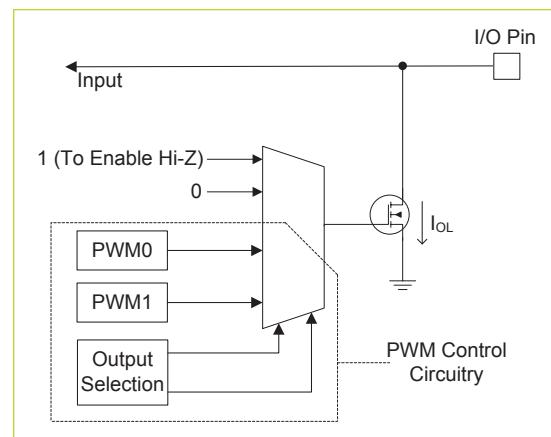
I²C Fast-mode Plus (Fm+):

The I²C-bus speed for the Fast-mode Plus devices go from zero (DC) to 1 MHz with ten times the normal drive but are fully compatible with slower bus-speed devices. The higher bandwidth allows more devices on the bus, for increased bus traffic and more complicated patterns. The I²C-bus drive strength of 30 mA allows for heavier capacitive load or longer cable lengths without the need for an additional buffer.

The GPIO Expandar Fm+ devices, identified with the part number PCA96xx, include other useful features like resetting the registers and I/O ports to the power-up default state via software, external hardware reset pin, 25 mA per pin with a total of 200 mA per octal, and supporting up to 64 addresses on the I²C bus.

For more information on the I²C-bus specification, visit www.nxp.com/documents/user_manual/UM10204.pdf

www.nxp.com/interface