PCA9670

Remote 8-bit I/O expander for Fm+ I²C-bus with reset

Rev. 3 — 30 May 2013 Product data sheet

1. General description

The PCA9670 provides general-purpose remote I/O expansion via the two-wire bidirectional I²C-bus (serial clock (SCL), serial data (SDA)).

The devices consist of eight quasi-bidirectional ports, 1 MHz 30 mA drive I²C-bus interface, three hardware address inputs and a reset input operating between 2.3 V and 5.5 V. 1 MHz I²C-bus Fast-mode Plus (Fm+) can support PWM dimming of LEDs, and higher I²C-bus drive 30 mA allows more devices to be on the bus without the need for bus buffers. The quasi-bidirectional port can be independently assigned as an input to monitor interrupt status or keypads, or as an output to activate indicator devices such as LEDs. The system master can read from the input port or write to the output port through a single register.

The low current consumption of 2.5 μA (typical, static) is great for mobile applications and the latched output ports have 25 mA high current sink drive capability for directly driving LEDs.

The PCA9670 has three hardware address pins and allows up to 64 of these PCA9670 I/O expanders on the same I²C-bus without the need for bus buffers, supporting up to 512 I/Os (for example, 512 LEDs).

The internal Power-On Reset (POR) and active LOW hardware reset pin ($\overline{\text{RESET}}$) initialize the I/Os as inputs with a weak internal pull-up 100 μA current source.

2. Features and benefits

- I²C-bus to parallel port expander
- 1 MHz I²C-bus interface (Fast-mode Plus I²C-bus)
- SDA with 30 mA sink capability for 4000 pF buses
- Operating supply voltage 2.3 V to 5.5 V with 5.5 V tolerant I/Os held to V_{DD} with 100 μA current source
- 8-bit remote I/O pins that default to inputs at power-up
- Latched outputs with 25 mA sink capability for directly driving LEDs
- Total package sink capability of 200 mA
- Active LOW reset input
- Sixty-four programmable slave addresses using three address pins
- Readable device ID (manufacturer, device type, and revision)
- Software reset
- Low standby current (2.5 μA typical)
- −40 °C to +85 °C operation

- ESD protection exceeds 2000 V HBM per JESD22-A114 and 1000 V CDM per JESD22-C101
- Latch-up testing is done to JEDEC standard JESD78 which exceeds 100 mA
- Packages offered: SO16, TSSOP16 and HVQFN16

3. Applications

- LED signs and displays
- Servers
- Keypads
- Industrial control
- Medical equipment
- PLCs
- Cellular telephones
- Mobile devices
- Gaming machines
- Instrumentation and test measurement

4. Ordering information

Table 1. Ordering information

Type number	Topside marking	Package		
		Name	Description	Version
PCA9670BS	670	HVQFN16	plastic thermal enhanced very thin quad flat package; no leads; 16 terminals; body 3 × 3 × 0.85 mm	SOT758-1
PCA9670D	PCA9670D	SO16	plastic small outline package; 16 leads; body width 7.5 mm	SOT162-1
PCA9670PW	PCA9670	TSSOP16	plastic thin shrink small outline package; 16 leads; body width 4.4 mm	SOT403-1

4.1 Ordering options

Table 2. Ordering options

Type number	Orderable part number	Package	Packing method	Minimum order quantity	Temperature range
PCA9670BS	PCA9670BS,118	HVQFN16	Reel 13” Q1/T1 *standard mark SMD	6000	T_{amb} = –40 °C to +85 °C
PCA9670D	PCA9670D,512	SO16	Standard marking * tube dry pack	1920	T_{amb} = –40 °C to +85 °C
	PCA9670D,518	SO16	Reel 13” Q1/T1 *standard mark SMD dry pack	1000	T_{amb} = –40 °C to +85 °C
PCA9670PW	PCA9670PW,112	TSSOP16	Standard marking * IC’s tube - DSC bulk pack	2400	T_{amb} = –40 °C to +85 °C
	PCA9670PW,118	TSSOP16	Reel 13” Q1/T1 *standard mark SMD	2500	T_{amb} = –40 °C to +85 °C

5. Block diagram

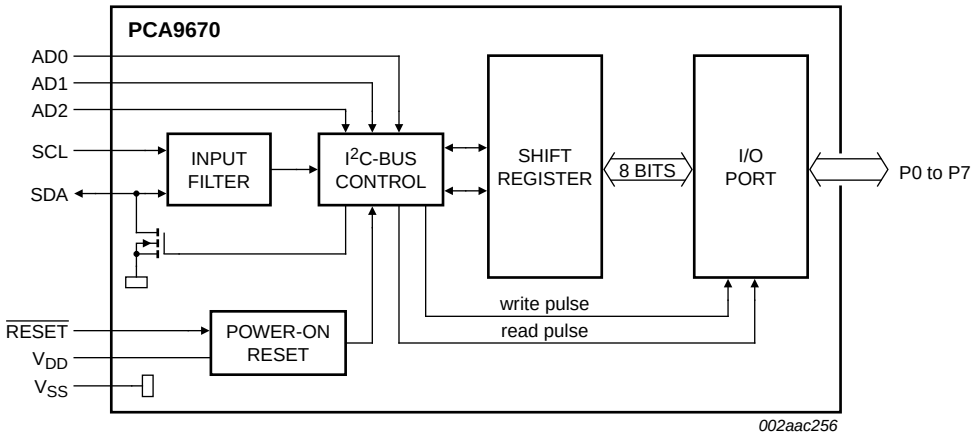


Fig 1. Block diagram of PCA9670

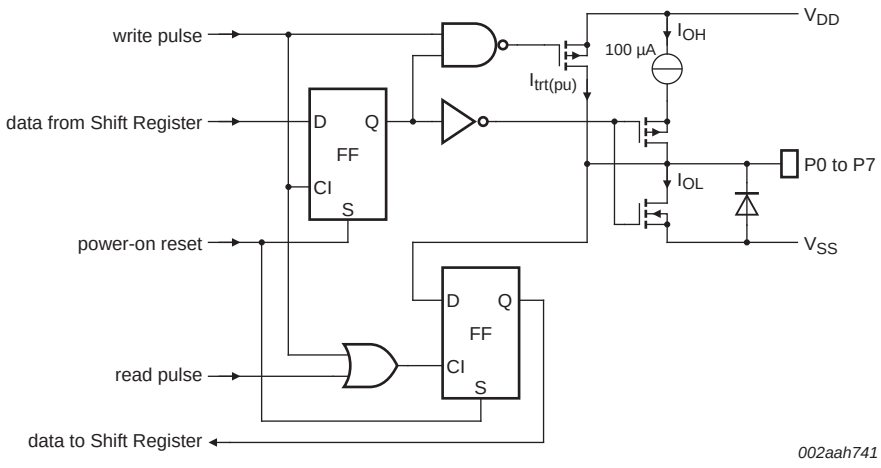


Fig 2. Simplified schematic diagram of P0 to P7

6. Pinning information

6.1 Pinning

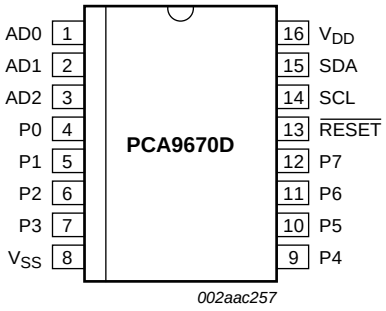


Fig 3. Pin configuration for SO16

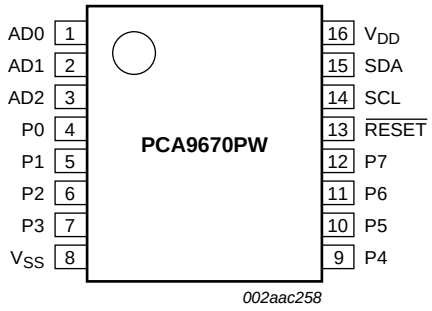


Fig 4. Pin configuration for TSSOP16

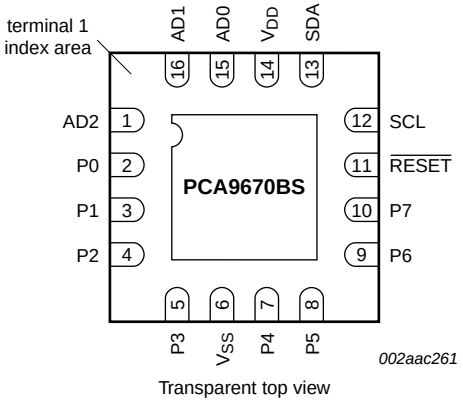


Fig 5. Pin configuration for HVQFN16

6.2 Pin description

Table 3. Pin description

Symbol	Pin		Description
	SO16, TSSOP16	HVQFN16	
AD0	1	15	address input 0
AD1	2	16	address input 1
AD2	3	1	address input 2
P0	4	2	quasi-bidirectional I/O 0
P1	5	3	quasi-bidirectional I/O 1
P2	6	4	quasi-bidirectional I/O 2
P3	7	5	quasi-bidirectional I/O 3
V_{SS}	8	6[1]	supply ground
P4	9	7	quasi-bidirectional I/O 4
P5	10	8	quasi-bidirectional I/O 5
P6	11	9	quasi-bidirectional I/O 6

Table 3. Pin description *...continued*

Symbol	Pin		Description
	SO16, TSSOP16	HVQFN16	
P7	12	10	quasi-bidirectional I/O 7
$\overline{\text{RESET}}$	13	11	reset input (active LOW)
SCL	14	12	serial clock line
SDA	15	13	serial data line
V_{DD}	16	14	supply voltage

[1] HVQFN16 package die supply ground is connected to both the V_{SS} pin and the exposed center pad. The V_{SS} pin must be connected to supply ground for proper device operation. For enhanced thermal, electrical, and board-level performance, the exposed pad needs to be soldered to the board using a corresponding thermal pad on the board, and for proper heat conduction through the board thermal vias need to be incorporated in the PCB in the thermal pad region.

7. Functional description

Refer to Figure 1 “Block diagram of PCA9670”.

7.1 Device address

Following a START condition, the bus master must send the address of the slave it is accessing and the operation it wants to perform (read or write). The address format of the PCA9670 is shown in Figure 6. Slave address pins AD2, AD1, and AD0 are used to choose one of 64 slave addresses. These devices can monitor the change in SDA or SCL in addition to the static levels of V_{DD} or V_{SS} to decode four states allowing a larger address range. To conserve power, no internal pull-up resistors are incorporated on AD2, AD1, or AD0 so they must be externally connected to V_{DD}, V_{SS} directly or through resistors, or to SCL or SDA directly. Address values depending on AD2, AD1, and AD0 can be found in Table 4 “PCA9670 address map”.

Remark: When using the PCA9670, reserved I²C-bus addresses must be used with caution since they can interfere with:

- “reserved for future use” I²C-bus addresses (0000 011, 1111 101, 1111 110, 1111 111)
- slave devices that use the 10-bit addressing scheme (1111 0xx)
- High speed mode (Hs-mode) master code (0000 1xx)

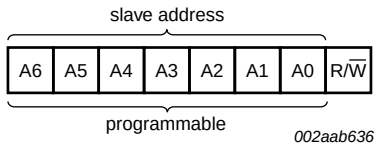


Fig 6. PCA9670 address

The last bit of the first byte defines the operation to be performed. When set to logic 1 a read is selected, while a logic 0 selects a write operation.

When AD2, AD1 and AD0 are held to V_{DD} or V_{SS}, the same address as the PCF8574 or newer PCA8574 is applied.

7.1.1 Address maps

Table 4. PCA9670 address map

Pin connectivity			Address of PCA9670								Address byte value		7-bit hexadecimal address without R/W
AD2	AD1	AD0	A6	A5	A4	A3	A2	A1	A0	R/W	Write	Read	
V_{SS}	SCL	V_{SS}	0	0	1	0	0	0	0	-	20h	21h	10h
V_{SS}	SCL	V_{DD}	0	0	1	0	0	0	1	-	22h	23h	11h
V_{SS}	SDA	V_{SS}	0	0	1	0	0	1	0	-	24h	25h	12h
V_{SS}	SDA	V_{DD}	0	0	1	0	0	1	1	-	26h	27h	13h
V_{DD}	SCL	V_{SS}	0	0	1	0	1	0	0	-	28h	29h	14h
V_{DD}	SCL	V_{DD}	0	0	1	0	1	0	1	-	2Ah	2Bh	15h
V_{DD}	SDA	V_{SS}	0	0	1	0	1	1	0	-	2Ch	2Dh	16h
V_{DD}	SDA	V_{DD}	0	0	1	0	1	1	1	-	2Eh	2Fh	17h
V_{SS}	SCL	SCL	0	0	1	1	0	0	0	-	30h	31h	18h
V_{SS}	SCL	SDA	0	0	1	1	0	0	1	-	32h	33h	19h
V_{SS}	SDA	SCL	0	0	1	1	0	1	0	-	34h	35h	1Ah
V_{SS}	SDA	SDA	0	0	1	1	0	1	1	-	36h	37h	1Bh
V_{DD}	SCL	SCL	0	0	1	1	1	0	0	-	38h	39h	1Ch
V_{DD}	SCL	SDA	0	0	1	1	1	0	1	-	3Ah	3Bh	1Dh
V_{DD}	SDA	SCL	0	0	1	1	1	1	0	-	3Ch	3Dh	1Eh
V_{DD}	SDA	SDA	0	0	1	1	1	1	1	-	3Eh	3Fh	1Fh
V_{SS}	V_{SS}	V_{SS}	0	1	0	0	0	0	0	-	40h	41h	20h
V_{SS}	V_{SS}	V_{DD}	0	1	0	0	0	0	1	-	42h	43h	21h
V_{SS}	V_{DD}	V_{SS}	0	1	0	0	0	1	0	-	44h	45h	22h
V_{SS}	V_{DD}	V_{DD}	0	1	0	0	0	1	1	-	46h	47h	23h
V_{DD}	V_{SS}	V_{SS}	0	1	0	0	1	0	0	-	48h	49h	24h
V_{DD}	V_{SS}	V_{DD}	0	1	0	0	1	0	1	-	4Ah	4Bh	25h
V_{DD}	V_{DD}	V_{SS}	0	1	0	0	1	1	0	-	4Ch	4Dh	26h
V_{DD}	V_{DD}	V_{DD}	0	1	0	0	1	1	1	-	4Eh	4Fh	27h
V_{SS}	V_{SS}	SCL	0	1	0	1	0	0	0	-	50h	51h	28h
V_{SS}	V_{SS}	SDA	0	1	0	1	0	0	1	-	52h	53h	29h
V_{SS}	V_{DD}	SCL	0	1	0	1	0	1	0	-	54h	55h	2Ah
V_{SS}	V_{DD}	SDA	0	1	0	1	0	1	1	-	56h	57h	2Bh
V_{DD}	V_{SS}	SCL	0	1	0	1	1	0	0	-	58h	59h	2Ch
V_{DD}	V_{SS}	SDA	0	1	0	1	1	0	1	-	5Ah	5Bh	2Dh
V_{DD}	V_{DD}	SCL	0	1	0	1	1	1	0	-	5Ch	5Dh	2Eh
V_{DD}	V_{DD}	SDA	0	1	0	1	1	1	1	-	5Eh	5Fh	2Fh

Table 4. PCA9670 address map *...continued*

Pin connectivity			Address of PCA9670								Address byte value		7-bit hexadecimal address without R/W
AD2	AD1	AD0	A6	A5	A4	A3	A2	A1	A0	R/W	Write	Read	
SCL	SCL	V_{SS}	1	0	1	0	0	0	0	-	A0h	A1h	50h
SCL	SCL	V_{DD}	1	0	1	0	0	0	1	-	A2h	A3h	51h
SCL	SDA	V_{SS}	1	0	1	0	0	1	0	-	A4h	A5h	52h
SCL	SDA	V_{DD}	1	0	1	0	0	1	1	-	A6h	A7h	53h
SDA	SCL	V_{SS}	1	0	1	0	1	0	0	-	A8h	A9h	54h
SDA	SCL	V_{DD}	1	0	1	0	1	0	1	-	AAh	ABh	55h
SDA	SDA	V_{SS}	1	0	1	0	1	1	0	-	ACh	ADh	56h
SDA	SDA	V_{DD}	1	0	1	0	1	1	1	-	AEh	AFh	57h
SCL	SCL	SCL	1	0	1	1	0	0	0	-	B0h	B1h	58h
SCL	SCL	SDA	1	0	1	1	0	0	1	-	B2h	B3h	59h
SCL	SDA	SCL	1	0	1	1	0	1	0	-	B4h	B5h	5Ah
SCL	SDA	SDA	1	0	1	1	0	1	1	-	B6h	B7h	5Bh
SDA	SCL	SCL	1	0	1	1	1	0	0	-	B8h	B9h	5Ch
SDA	SCL	SDA	1	0	1	1	1	0	1	-	BAh	BBh	5Dh
SDA	SDA	SCL	1	0	1	1	1	1	0	-	BCh	BDh	5Eh
SDA	SDA	SDA	1	0	1	1	1	1	1	-	BEh	BFh	5Fh
SCL	V_{SS}	V_{SS}	1	1	0	0	0	0	0	-	C0h	C1h	60h
SCL	V_{SS}	V_{DD}	1	1	0	0	0	0	1	-	C2h	C3h	61h
SCL	V_{DD}	V_{SS}	1	1	0	0	0	1	0	-	C4h	C5h	62h
SCL	V_{DD}	V_{DD}	1	1	0	0	0	1	1	-	C6h	C7h	63h
SDA	V_{SS}	V_{SS}	1	1	0	0	1	0	0	-	C8h	C9h	64h
SDA	V_{SS}	V_{DD}	1	1	0	0	1	0	1	-	CAh	CBh	65h
SDA	V_{DD}	V_{SS}	1	1	0	0	1	1	0	-	CCh	CDh	66h
SDA	V_{DD}	V_{DD}	1	1	0	0	1	1	1	-	CEh	CFh	67h
SCL	V_{SS}	SCL	1	1	1	0	0	0	0	-	E0h	E1h	70h
SCL	V_{SS}	SDA	1	1	1	0	0	0	1	-	E2h	E3h	71h
SCL	V_{DD}	SCL	1	1	1	0	0	1	0	-	E4h	E5h	72h
SCL	V_{DD}	SDA	1	1	1	0	0	1	1	-	E6h	E7h	73h
SDA	V_{SS}	SCL	1	1	1	0	1	0	0	-	E8h	E9h	74h
SDA	V_{SS}	SDA	1	1	1	0	1	0	1	-	EAh	EBh	75h
SDA	V_{DD}	SCL	1	1	1	0	1	1	0	-	ECh	EDh	76h
SDA	V_{DD}	SDA	1	1	1	0	1	1	1	-	EEh	EFh	77h

7.2 Software Reset Call, and device ID addresses

Two other different addresses can be sent to the PCA9670.

- General Call address: allows resetting the PCA9670 through the I²C-bus upon reception of the right I²C-bus sequence. See Section 7.2.1 “Software Reset” for more information.
- Device ID address: allows reading ID information from the device (manufacturer, part identification, revision). See Section 7.2.2 “Device ID (PCA9670 ID field)” for more information.

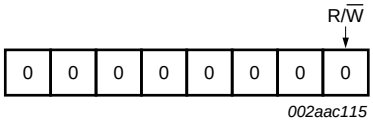


Fig 7. General Call address

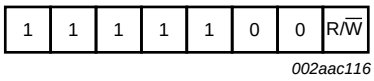


Fig 8. Device ID address

7.2.1 Software Reset

The Software Reset Call allows all the devices in the I²C-bus to be reset to the power-up state value through a specific formatted I²C-bus command. To be performed correctly, it implies that the I²C-bus is functional and that there is no device hanging the bus.

The Software Reset sequence is defined as following:

1. A START command is sent by the I²C-bus master.
2. The reserved General Call I²C-bus address ‘0000 000’ with the R/$\overline{W}$ bit set to 0 (write) is sent by the I²C-bus master.
3. The PCA9670 device(s) acknowledge(s) after seeing the General Call address ‘0000 0000’ (00h) only. If the R/$\overline{W}$ bit is set to 1 (read), no acknowledge is returned to the I²C-bus master.
4. Once the General Call address has been sent and acknowledged, the master sends 1 byte. The value of the byte must be equal to 06h.
   a. The PCA9670 acknowledges this value only. If the byte is not equal to 06h, the PCA9670 does not acknowledge it.

   If more than 1 byte of data is sent, the PCA9670 does not acknowledge any more.
5. Once the right byte has been sent and correctly acknowledged, the master sends a STOP command to end the Software Reset sequence: the PCA9670 then resets to the default value (power-up value) and is ready to be addressed again within the specified bus free time. If the master sends a Repeated START instead, no reset is performed.

The I²C-bus master must interpret a non-acknowledge from the PCA9670 (at any time) as a 'Software Reset Abort'. The PCA9670 does not initiate a reset of its registers.

The unique sequence that initiates a Software Reset is described in Figure 9.

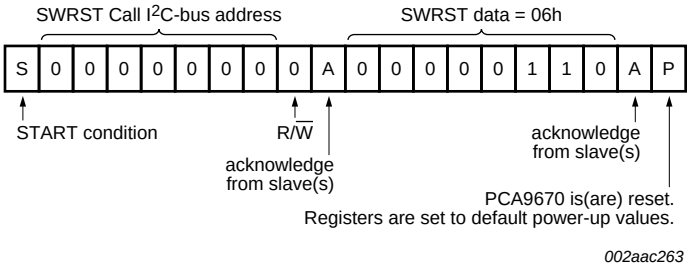


Fig 9. Software Reset sequence

Simple code for Software Reset:

<S> <00h> **<ACK>** <06h> **<ACK>** <P>

7.2.2 Device ID (PCA9670 ID field)

The Device ID field is a 3-byte read-only (24 bits) word giving the following information:

- 12 bits with the manufacturer name, unique per manufacturer (for example, NXP).
- 9 bits with the part identification, assigned by manufacturer.
- 3 bits with the die revision, assigned by manufacturer (for example, Rev X).

The Device ID is read-only, hardwired in the device and can be accessed as follows:

1. START command
2. The master sends the Reserved Device ID I²C-bus address '1111 100' with the R/$\overline{W}$ bit set to 0 (write).
3. The master sends the I²C-bus slave address of the slave device it needs to identify. The LSB is a 'Don't care' value. Only one device must acknowledge this byte (the one that has the I²C-bus slave address).
4. The master sends a Re-START command.

   Remark: A STOP command followed by a START command will reset the slave state machine and the Device ID read cannot be performed.

   Remark: A STOP command or a Re-START command followed by an access to another slave device will reset the slave state machine and the Device ID read cannot be performed.
5. The master sends the Reserved Device ID I²C-bus address '1111 100' with the R/$\overline{W}$ bit set to 1 (read).
6. The device ID read can be done, starting with the 12 manufacturer bits (first byte + 4 MSB of the second byte), followed by the 9 part identification bits and then the 3 die revision bits (3 LSB of the third byte).
7. The master ends the reading sequence by NACKing the last byte, thus resetting the slave device state machine and allowing the master to send the STOP command.

Remark: The reading of the Device ID can be stopped anytime by sending a NACK command.

Remark: If the master continues to ACK the bytes after the third byte, the PCA9670 rolls back to the first byte and keeps sending the Device ID sequence until a NACK has been detected.

For the PCA9670, the Device ID is as shown in Figure 10.

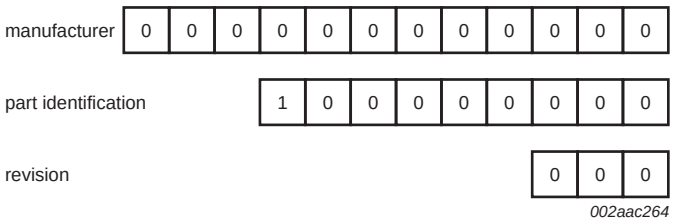
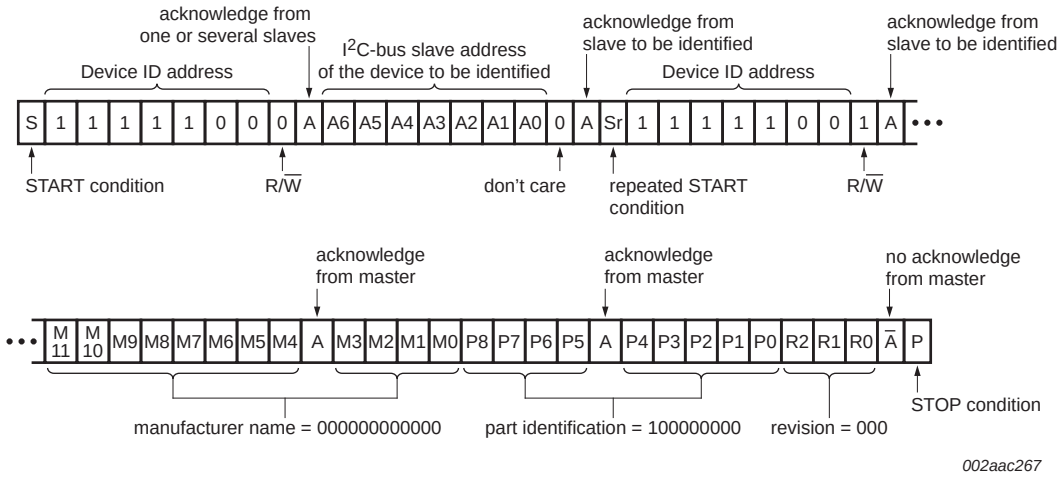


Fig 10. PCA9670 Device ID field



If more than 2 bytes are read, the slave device loops back to the first byte (manufacturer byte) and keeps sending data until the master generates a 'no acknowledge'.

Fig 11. Device ID field reading

Simple code for reading Device ID:

<S> <F8h> **<ACK>** <slave address> **<ACK>** <SR> <F9h > **<ACK> <DATA1>** <ACK> **<DATA2>** <ACK> **<DATA3>** <NACK> <P>

8. I/O programming

8.1 Quasi-bidirectional I/O architecture

A quasi-bidirectional I/O is an input or output port without using a direction control register. Whenever the master reads the register, the value returned to master depends on the actual voltage or status of the pin. At power-on, all the ports are HIGH with a weak 100 μA internal pull-up to V_{DD} but can be driven LOW by an internal transistor, or an external signal. The I/O ports are entirely independent of each other but each I/O octal is controlled by the same read or write data byte.

Advantages of the quasi-bidirectional I/O over totem pole I/O include:

- Better for driving LEDs since the p-channel (transistor to V_{DD}) is small, which saves die size and therefore cost. LED drive only requires an internal transistor to ground, while the LED is connected to V_{DD} through a current-limiting resistor. Totem pole I/O have both an n-channel and p-channel transistors, which allow solid HIGH and LOW output levels without a pull-up resistor — good for logic levels.
- Simpler architecture — only a single register and the I/O can be both input and output at the same time. Totem pole I/O have a direction register which specifies the port pin direction and it is always in that configuration unless the direction is explicitly changed.
- Does not require a command byte. The simplicity of one register (no need for the pointer register or technically, the command byte) is an advantage in some embedded systems where every byte counts because of memory or bandwidth limitations.

There is only one register to control four possibilities of the port pin: Input HIGH, input LOW, output HIGH or output LOW.

Input HIGH: The master needs to write 1 to the register to set the port as an input mode if the device is not in the default power-on condition. The master reads the register to check the input status. If the external source pulls the port pin up to V_{DD} or drives logic 1, then the master will read the value of 1.

Input LOW: The master needs to write 1 to the register to set the port to input mode if the device is not in the default power-on condition. The master reads the register to check the input status. If the external source pulls the port pin down to V_{SS} or drives logic 0, which sinks the weak 100 μA current source, then the master will read the value of 0.

Output HIGH: The master writes 1 to the register. There is an additional ‘accelerator’ or strong pull-up current when the master sets the port HIGH. The additional strong pull-up is only active during the HIGH time of the acknowledge clock cycle. This accelerator current helps the port’s 100 μA current source make a faster rising edge into a heavily loaded output, but only at the start of the acknowledge clock cycle to avoid bus contention if an external signal is pulling the port LOW to V_{SS}/driving the port with logic 0 at the same time. After the half clock cycle there is only the 100 μA current source to hold the port HIGH.

Output LOW: The master writes 0 to the register. There is a strong current sink transistor that holds the port pin LOW. A large current may flow into the port, which could potentially damage the part if the master writes a 0 to the register and an external source is pulling the port HIGH at the same time.

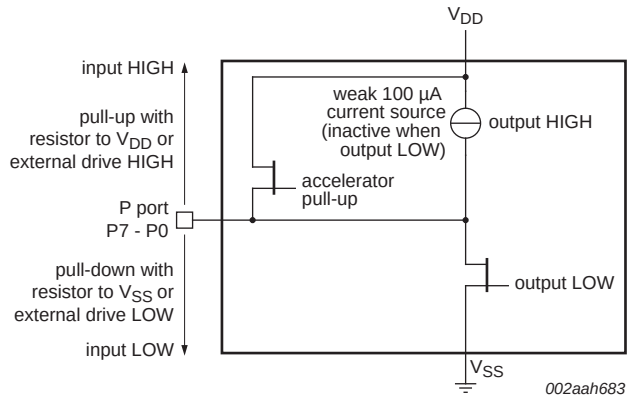


Fig 12. Simple quasi-bidirectional I/O

8.2 Writing to the port (Output mode)

The master (microcontroller) sends the START condition and slave address, setting the last bit of the address byte to logic 0 for the write mode. The PCA9670 acknowledges and the master then sends the data byte for P7 to P0 to the port register. As the clock line goes HIGH, the 8-bit data is presented on the port lines after it has been acknowledged by the PCA9670. If a LOW is written, the strong pull-down turns on and stays on. If a HIGH is written, the strong pull-up turns on for ½ of the clock cycle, then the line is held HIGH by the weak current source. The master can then send a STOP condition or continuing sending data. The number of data bytes that can be sent successively is not limited and the previous data is overwritten every time a data byte has been sent and acknowledged.

Ensure a logic 1 is written for any port that is being used as an input to ensure the strong external pull-down is turned off.

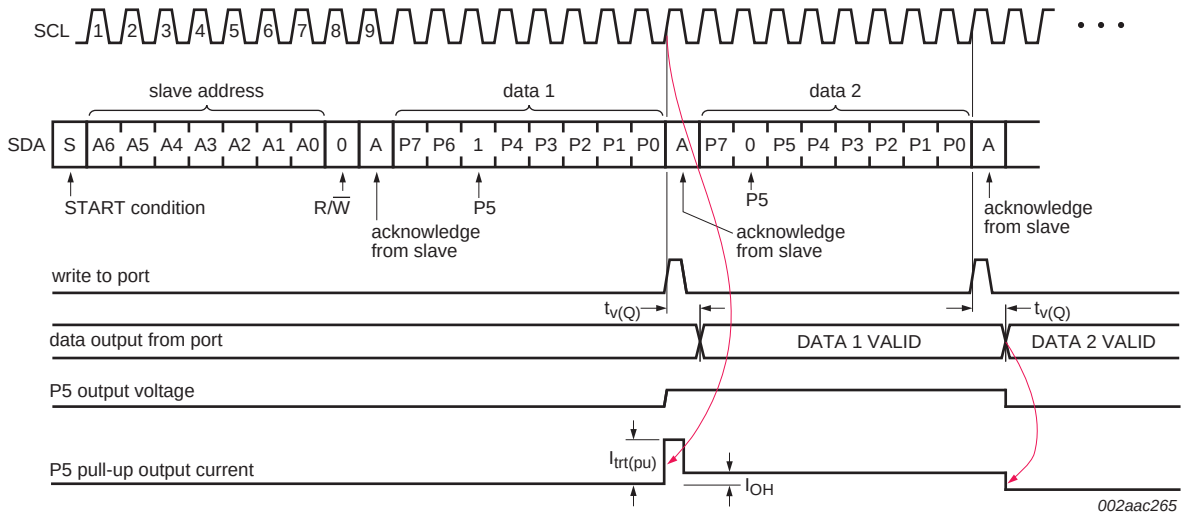


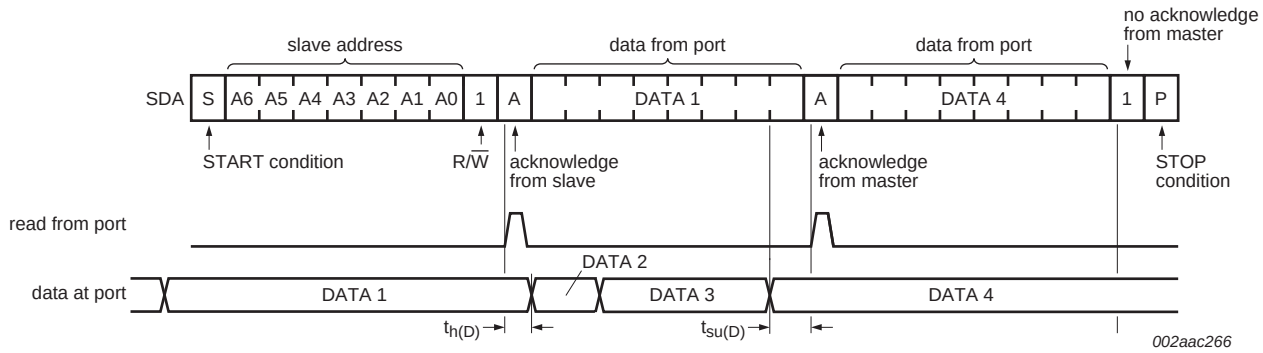
Fig 13. Write mode (output)

8.3 Reading from a port (Input mode)

The port must have been previously written to logic 1, which is the condition after power-on reset or hardware reset or software reset. To enter the Read mode the master (microcontroller) addresses the slave device and sets the last bit of the address byte to logic 1 (address byte read). The slave will acknowledge and then send the data byte to the master. The master will NACK and then send the STOP condition or ACK and read the input register again.

The read of any pin being used as an output will indicate HIGH or LOW depending on the actual state of the input pin.

If the data on the input port changes faster than the master can read, this data may be lost. The DATA 2 and DATA 3 are lost because these data did not meet the set-up time and hold time (see Figure 14).



A LOW-to-HIGH transition of SDA while SCL is HIGH is defined as the STOP condition (P). Transfer of data can be stopped at any moment by a STOP condition. When this occurs, data present at the last acknowledge phase is valid (Output mode). Input data is lost.

Fig 14. Read input port register

8.4 Power-on reset

When power is applied to V_{DD}, an internal Power-On Reset (POR) holds the PCA9670 in a reset condition until V_{DD} has reached V_{POR}. At that point, the reset condition is released and the PCA9670 registers and I²C-bus/SMBus state machine will initialize to their default states of all I/Os to inputs with weak current source to V_{DD}. Thereafter V_{DD} must be lowered below V_{POR} and back up to the operation voltage for power-on reset cycle.

8.5 $\overline{\text{RESET}}$ input

A reset can be accomplished by holding the $\overline{\text{RESET}}$ pin LOW for a minimum of $t_{w(rst)}$. The PCA9670 registers and I²C-bus state machine will be held in their default state until the $\overline{\text{RESET}}$ input is once again HIGH. This $\overline{\text{RESET}}$ input pin requires a pull-up resistor to V_{DD} if no active connection is used.

9. Characteristics of the I²C-bus

The I²C-bus is for 2-way, 2-line communication between different ICs or modules. The two lines are a serial data line (SDA) and a serial clock line (SCL). Both lines must be connected to a positive supply via a pull-up resistor when connected to the output stages of a device. Data transfer may be initiated only when the bus is not busy.

9.1 Bit transfer

One data bit is transferred during each clock pulse. The data on the SDA line must remain stable during the HIGH period of the clock pulse as changes in the data line at this time will be interpreted as control signals (see Figure 15).

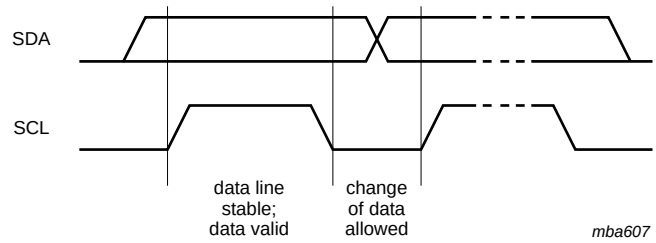


Fig 15. Bit transfer

9.1.1 START and STOP conditions

Both data and clock lines remain HIGH when the bus is not busy. A HIGH-to-LOW transition of the data line while the clock is HIGH is defined as the START condition (S). A LOW-to-HIGH transition of the data line while the clock is HIGH is defined as the STOP condition (P) (see Figure 16.)

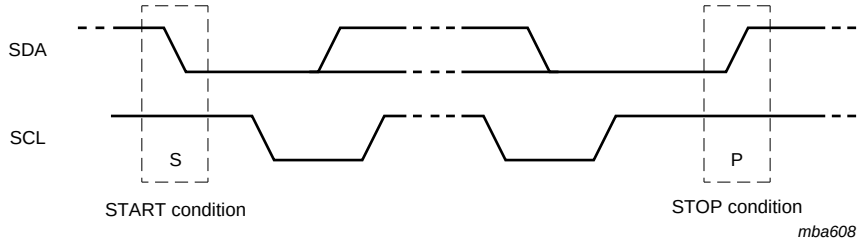


Fig 16. Definition of START and STOP conditions

9.2 System configuration

A device generating a message is a ‘transmitter'; a device receiving is the ‘receiver'. The device that controls the message is the ‘master' and the devices which are controlled by the master are the ‘slaves' (see Figure 17).

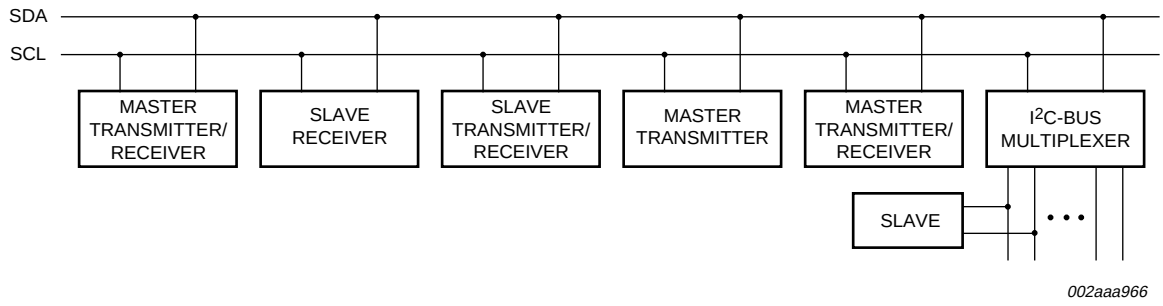


Fig 17. System configuration

9.3 Acknowledge

The number of data bytes transferred between the START and the STOP conditions from transmitter to receiver is not limited. Each byte of eight bits is followed by one acknowledge bit (see Figure 18). The acknowledge bit is an active LOW level (generated by the receiving device) that indicates to the transmitter that the data transfer was successful.

A slave receiver which is addressed must generate an acknowledge after the reception of each byte. Also a master must generate an acknowledge after the reception of each byte that has been clocked out of the slave transmitter. The device that wants to issue an acknowledge bit has to pull down the SDA line during the acknowledge clock pulse, so that the SDA line is stable LOW during the HIGH period of the acknowledge bit related clock pulse; set-up and hold times must be taken into account.

A master receiver must signal an end of data to the transmitter by not generating an acknowledge on the last byte that has been clocked out of the slave. In this event, the transmitter must leave the data line HIGH to enable the master to generate a STOP condition.

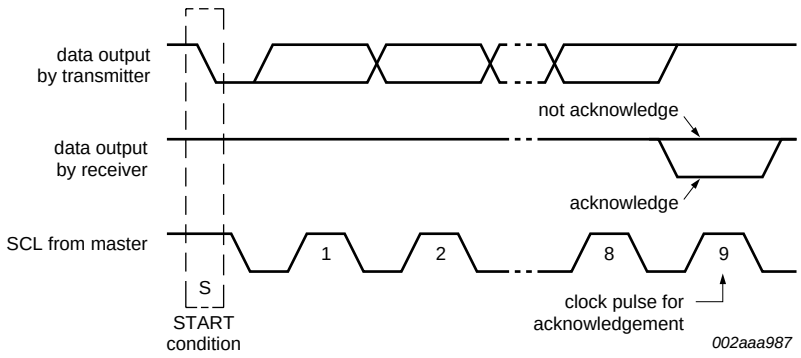


Fig 18. Acknowledgement on the I²C-bus

10. Application design-in information

10.1 Bidirectional I/O expander applications

In the 8-bit I/O expander application shown in Figure 19, P0 and P1 are inputs, and P2 to P7 are outputs. When used in this configuration, during a write, **the input (P0 and P1) must be written as HIGH so the external devices fully control the input ports**. The desired HIGH or LOW logic levels may be written to the I/Os used as outputs (P2 to P7). If 10 μA internal output HIGH is not enough current source, the port needs external pull-up resistor. During a read, the logic levels of the external devices driving the input ports (P0 and P1) and the previous written logic level to the output ports (P2 to P7) will be read.

The GPIO also has a reset line ($\overline{\text{RESET}}$) that can be connected to an output pin of the microprocessor. Since the device does not have an interrupt output, changes of the I/Os can be monitored by reading the input register. If both a $\overline{\text{RESET}}$ and $\overline{\text{INT}}$ are needed, use the PCA9672.

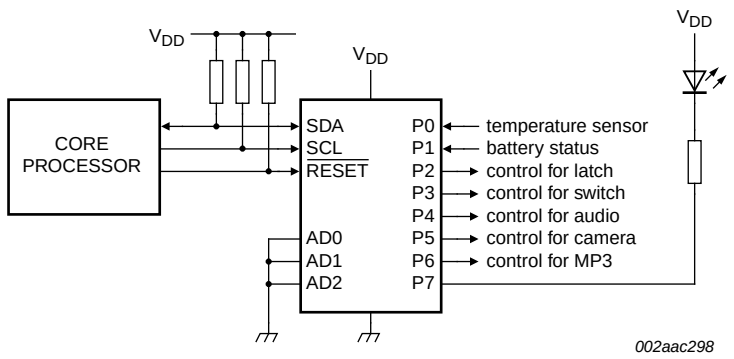


Fig 19. Bidirectional I/O expander application

10.2 How to read and write to I/O expander (example)

In the application example of PCA9670 shown in Figure 19, the microcontroller wants to control the P3 switch ON and the P7 LED ON when the temperature sensor P0 changes.

1. When the system power on:

   Core Processor needs to issue an initial command to set P0 and P1 as inputs and P[7:2] as outputs with value 1010 00 (LED off, MP3 off, camera on, audio off, switch off and latch off).

2. Operation:

   When the temperature changes above the threshold, the temperature sensor signal will toggle from HIGH to LOW. The INT will be activated and notifies the ‘core processor’ that there have been changes on the input pins. Read the input register. If P0 = 0 (temperature sensor has changed), then turn on LED and turn on switch.

3. Software code:

```
//System Power on
// write to PCA9670 with data 1010 0011b to set P[7:2] outputs and P[1:0] inputs
<S> <0100 0000> <ACK> <1010 0011> <ACK> <P>//Initial setting for PCA9670
while (1) //Looping look for P0 = 0
```

```
{
  <S> <0100 0001> <ACK> <1010 0010> <NACK> <P> //Read PCA9670 data
  If (P0 == 0) //Temperature sensor activated
  {
  // write to PCA9670 with data 0010 1011b to turn on LED (P7), on Switch (P3)
  and keep P[1:0] as input ports.
  <S> <0100 0000> <ACK> <0010 1011> <ACK> <P> // Write to PCA9670
  Exit the loop;
  }
}
```

10.3 High current-drive load applications

The GPIO has a minimum guaranteed sinking current of 25 mA per bit at 5.5 V. In applications requiring additional drive, two port pins may be connected together to sink up to 50 mA current. Both bits must then always be turned on or off together. Up to 8 pins can be connected together to drive 200 mA, which is the device recommended total limit. Each pin needs its own limiting resistor as shown in Figure 20 to prevent damage to the device should all ports not be turned on at the same time.

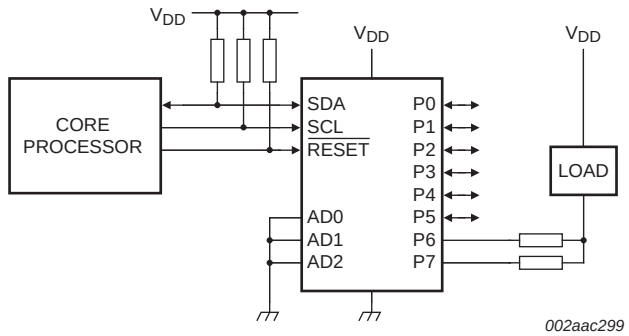


Fig 20. High current-drive load application

10.4 Migration path

NXP offers new, more capable drop-in replacements for the PCA9670 in newer space-saving packages.

Table 5. PCA9670 migration path

Type number	I²C-bus frequency	Voltage range	Number of addresses per device	Interrupt	Reset	Total package sink current
PCF8574/74A	100 kHz	2.5 V to 6 V	8	yes	no	80 mA
PCA8574/74A	400 kHz	2.3 V to 5.5 V	8	yes	no	200 mA
PCA9674/74A	1 MHz Fm+	2.3 V to 5.5 V	64	yes	no	200 mA
PCA9670	1 MHz Fm+	2.3 V to 5.5 V	64	no	yes	200 mA
PCA9672	1 MHz Fm+	2.3 V to 5.5 V	16	yes	yes	200 mA

PCA9670 replaces the interrupt output of the PCA9674 with hardware reset input to retain the maximum number of addresses. PCA9672 replaces address A2 of the PCA9674 with hardware reset input to retain the interrupt, but limit the number of addresses.

11. Limiting values

Table 6. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
V_{DD}	supply voltage		–0.5	+6	V
I_{DD}	supply current		-	±100	mA
I_{SS}	ground supply current		-	±400	mA
V_I	input voltage		V_{SS} – 0.5	5.5	V
I_I	input current		-	±20	mA
I_O	output current	[1]	-	±50	mA
P_{tot}	total power dissipation		-	400	mW
P/out	power dissipation per output		-	100	mW
$T_{j(max)}$	maximum junction temperature		-	125	°C
T_{stg}	storage temperature		–65	+150	°C
T_{amb}	ambient temperature	operating	–40	+85	°C

[1] Total package (maximum) output current is 400 mA.

12. Thermal characteristics

Table 7. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-a)}$	thermal resistance from junction to ambient	SO16 package	115	°C/W
		TSSOP16 package	160	°C/W
		HVQFN16 package	40	°C/W

13. Static characteristics

Table 8. Static characteristics

V_{DD} = 2.3 V to 5.5 V; V_{SS} = 0 V; T_{amb} = −40 °C to +85 °C; unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
Supplies							
V_{DD}	supply voltage			2.3	-	5.5	V
I_{DD}	supply current	Operating mode; no load; $V_I = V_{DD}$ or V_{SS}; f_{SCL} = 1 MHz; AD0, AD1, AD2 = static H or L		-	266	500	μA
I_{stb}	standby current	Standby mode; no load; $V_I = V_{DD}$ or V_{SS}; f_{SCL} = 0 kHz		-	2.5	10	μA
V_{POR}	power-on reset voltage		[1]	-	1.8	2.0	V
Input SCL; input/output SDA							
V_{IL}	LOW-level input voltage			−0.5	-	+0.3V_{DD}	V
V_{IH}	HIGH-level input voltage			0.7V_{DD}	-	5.5	V
I_{OL}	LOW-level output current	V_{OL} = 0.4 V; V_{DD} = 2.3 V		20	-	-	mA
		V_{OL} = 0.4 V; V_{DD} = 3.0 V		25	-	-	mA
		V_{OL} = 0.4 V; V_{DD} = 4.5 V		30	-	-	mA
I_L	leakage current	$V_I = V_{DD}$ or V_{SS}		−1	-	+1	μA
C_i	input capacitance	$V_I = V_{SS}$		-	4	10	pF
I/Os; P0 to P7							
V_{IL}	LOW-level input voltage			−0.5	-	+0.3V_{DD}	V
V_{IH}	HIGH-level input voltage			0.7V_{DD}	-	5.5	V
I_{OL}	LOW-level output current	V_{OL} = 0.5 V; V_{DD} = 2.3 V	[2]	12	27	-	mA
		V_{OL} = 0.5 V; V_{DD} = 3.0 V	[2]	17	35	-	mA
		V_{OL} = 0.5 V; V_{DD} = 4.5 V	[2]	25	41	-	mA
$I_{OL(tot)}$	total LOW-level output current	V_{OL} = 0.5 V; V_{DD} = 4.5 V	[2]	-	-	200	mA
I_{OH}	HIGH-level output current	$V_{OH} = V_{SS}$		−30	−250	−300	μA
$I_{trt(pu)}$	transient boosted pull-up current	$V_{OH} = V_{SS}$; see Figure 13		−0.5	−1.0	-	mA
C_i	input capacitance		[3]	-	3	10	pF
C_o	output capacitance		[3]	-	3	10	pF
Input $\overline{\text{RESET}}$							
V_{IL}	LOW-level input voltage			−0.5	-	+0.8	V
V_{IH}	HIGH-level input voltage			2	-	5.5	V
I_{LI}	input leakage current			−1	-	+1	μA
C_i	input capacitance			-	3	5	pF
Inputs AD0, AD1, AD2							
V_{IL}	LOW-level input voltage			−0.5	-	+0.3V_{DD}	V
V_{IH}	HIGH-level input voltage			0.7V_{DD}	-	5.5	V
I_{LI}	input leakage current			−1	-	+1	μA
C_i	input capacitance			-	3	5	pF

[1] The power-on reset circuit resets the I²C-bus logic with $V_{DD} < V_{POR}$ and set all I/Os to logic 1 (with current source to V_{DD}).

[2] Each bit must be limited to a maximum of 25 mA and the total package limited to 200 mA due to internal busing limits.

[3] The value is not tested, but verified on sampling basis.

14. Dynamic characteristics

Table 9. Dynamic characteristics

V_{DD} = 2.3 V to 5.5 V; V_{SS} = 0 V; T_{amb} = −40 °C to +85 °C; unless otherwise specified.

Symbol	Parameter	Conditions	Standard mode I²C-bus		Fast mode I²C-bus		Fast-mode Plus I²C-bus		Unit
			Min	Max	Min	Max	Min	Max	
f_{SCL}	SCL clock frequency		0	100	0	400	0	1000	kHz
t_{BUF}	bus free time between a STOP and START condition		4.7	-	1.3	-	0.5	-	µs
$t_{HD;STA}$	hold time (repeated) START condition		4.0	-	0.6	-	0.26	-	µs
$t_{SU;STA}$	set-up time for a repeated START condition		4.7	-	0.6	-	0.26	-	µs
$t_{SU;STO}$	set-up time for STOP condition		4.0	-	0.6	-	0.26	-	µs
$t_{HD;DAT}$	data hold time		0	-	0	-	0	-	ns
$t_{VD;ACK}$	data valid acknowledge time	[1]	0.3	3.45	0.1	0.9	0.05	0.45	µs
$t_{VD;DAT}$	data valid time	[2]	300	-	50	-	50	450	ns
$t_{SU;DAT}$	data set-up time		250	-	100	-	50	-	ns
t_{LOW}	LOW period of the SCL clock		4.7	-	1.3	-	0.5	-	µs
t_{HIGH}	HIGH period of the SCL clock		4.0	-	0.6	-	0.26	-	µs
t_f	fall time of both SDA and SCL signals	[4][5]	-	300	20 + 0.1C_b[3]	300	-	120	ns
t_r	rise time of both SDA and SCL signals		-	1000	20 + 0.1C_b[3]	300	-	120	ns
t_{SP}	pulse width of spikes that must be suppressed by the input filter	[6]	-	50	-	50	-	50	ns
Port timing; C_L ≤ 100 pF (see Figure 14 and Figure 13)									
$t_{v(Q)}$	data output valid time		-	4	-	4	-	4	µs
$t_{su(D)}$	data input set-up time		0	-	0	-	0	-	µs
$t_{h(D)}$	data input hold time		4	-	4	-	4	-	µs
Reset timing (see Figure 22)									
$t_{w(rst)}$	reset pulse width		4	-	4	-	4	-	µs
$t_{rec(rst)}$	reset recovery time		0	-	0	-	0	-	µs
t_{rst}	reset time		100	-	100	-	100	-	µs

[1] $t_{VD;ACK}$ = time for Acknowledgement signal from SCL LOW to SDA (out) LOW.

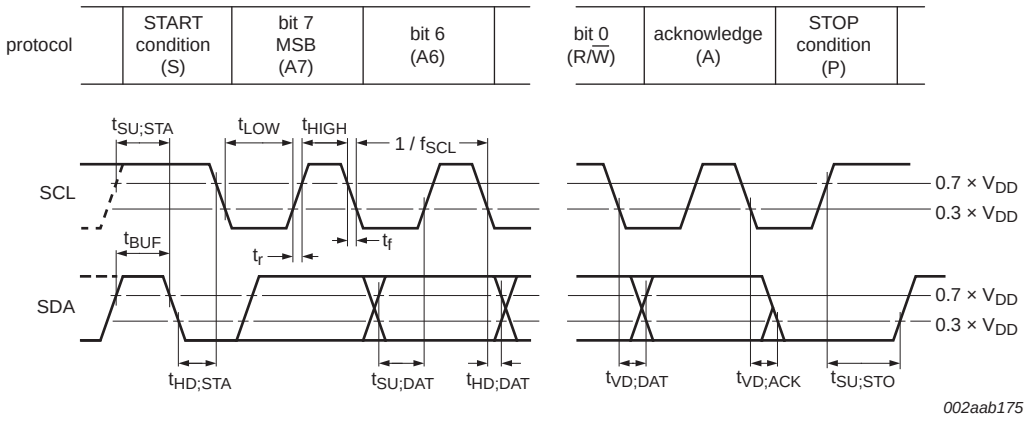
[2] $t_{VD;DAT}$ = minimum time for SDA data out to be valid following SCL LOW.

[3] C_b = total capacitance of one bus line in pF.

[4] A master device must internally provide a hold time of at least 300 ns for the SDA signal (refer to the V_{IL} of the SCL signal) in order to bridge the undefined region SCL's falling edge.

[5] The maximum t_f for the SDA and SCL bus lines is specified at 300 ns. The maximum fall time for the SDA output stage t_f is specified at 250 ns. This allows series protection resistors to be connected between the SDA and the SCL pins and the SDA/SCL bus lines without exceeding the maximum specified t_f.

[6] Input filters on the SDA and SCL inputs suppress noise spikes less than 50 ns.



Rise and fall times refer to V_{IL} and V_{IH}.

Fig 21. I²C-bus timing diagram

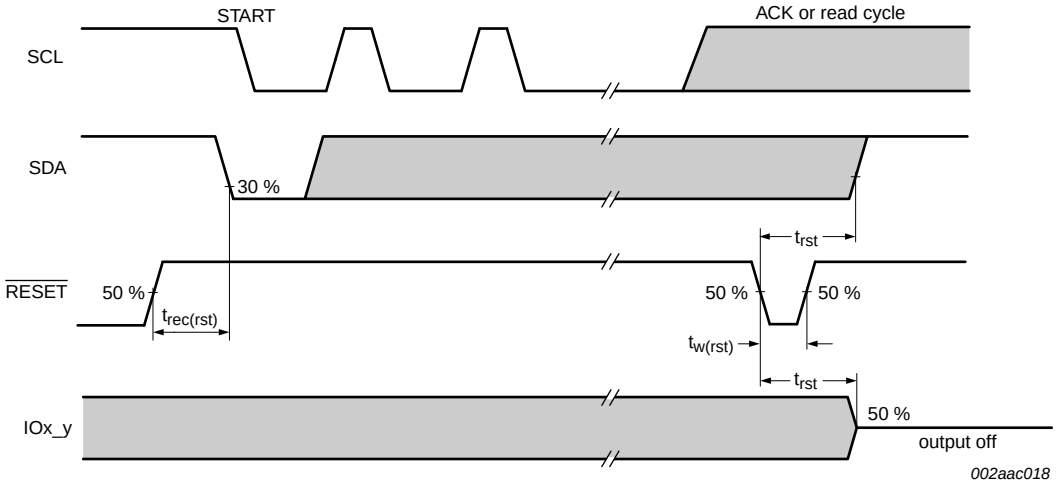
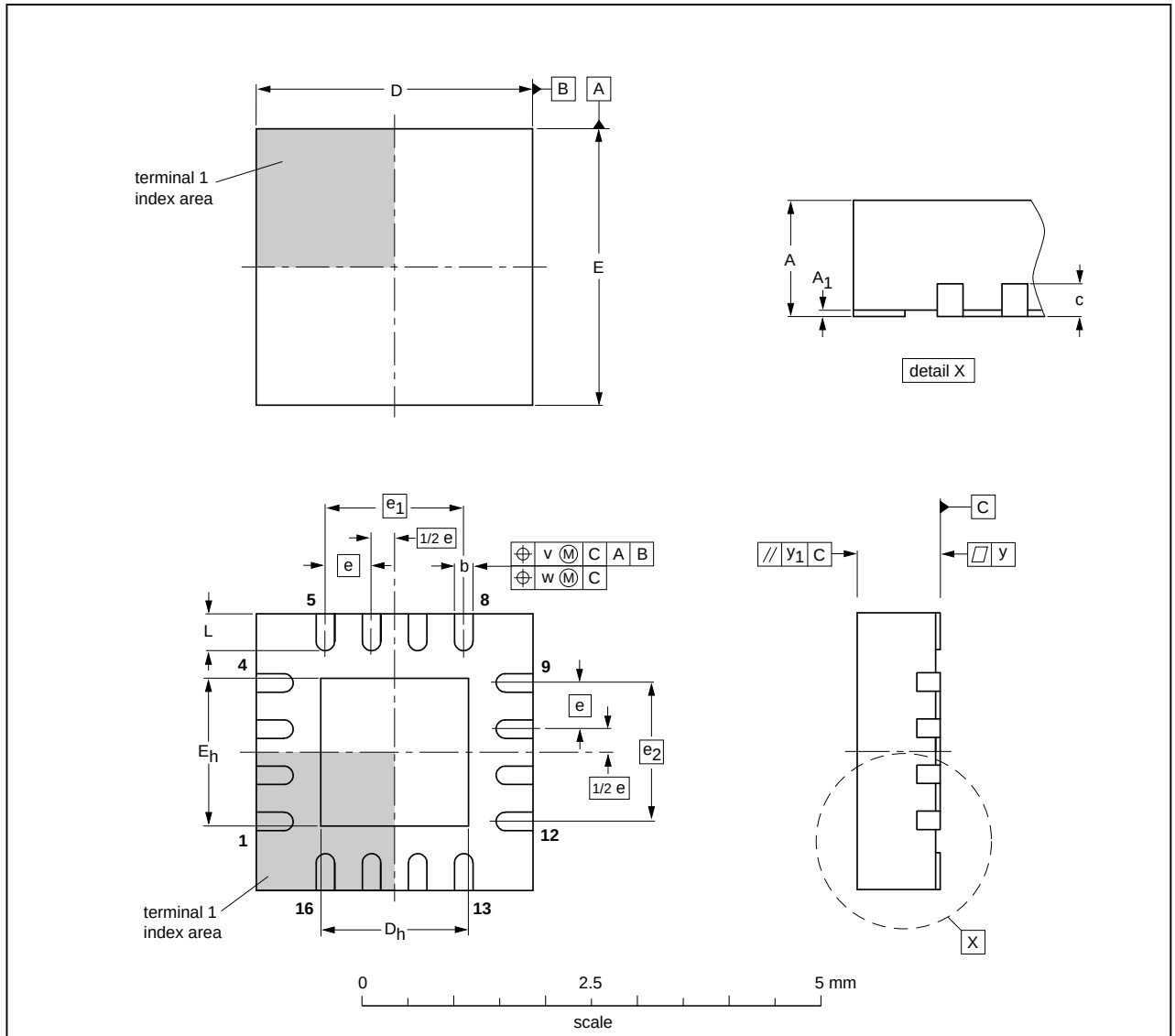


Fig 22. Reset timing

15. Package outline

HVQFN16: plastic thermal enhanced very thin quad flat package; no leads; 16 terminals; body 3 x 3 x 0.85 mm **SOT758-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A(1) max.	A_1	b	c	D(1)	D_h	E(1)	E_h	e	e_1	e_2	L	v	w	y	y_1
mm	1	0.05 0.00	0.30 0.18	0.2	3.1 2.9	1.75 1.45	3.1 2.9	1.75 1.45	0.5	1.5	1.5	0.5 0.3	0.1	0.05	0.05	0.1

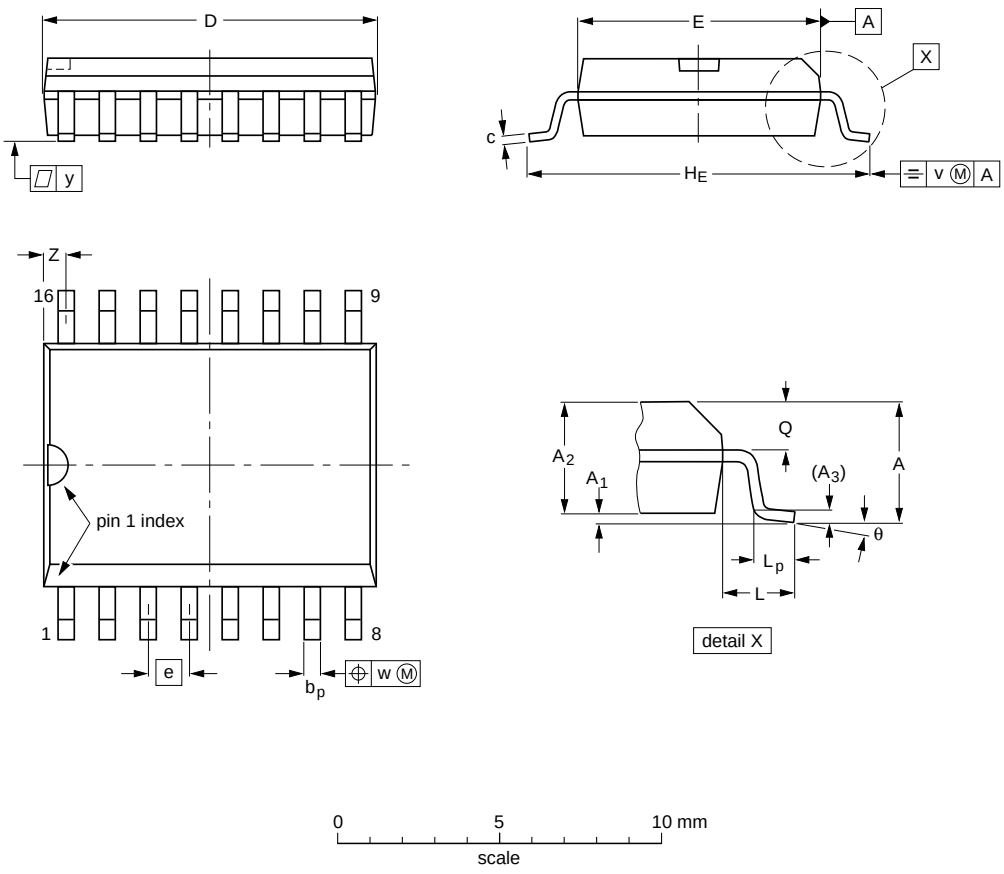
Note

1. Plastic or metal protrusions of 0.075 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT758-1	- - -	MO-220	- - -			~~02-03-25~~ 02-10-21

Fig 23. Package outline SOT758-1 (HVQFN16)

SO16: plastic small outline package; 16 leads; body width 7.5 mm **SOT162-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D (1)	E (1)	e	H_E	L	L_p	Q	v	w	y	Z (1)	θ
mm	2.65	0.3 0.1	2.45 2.25	0.25	0.49 0.36	0.32 0.23	10.5 10.1	7.6 7.4	1.27	10.65 10.00	1.4	1.1 0.4	1.1 1.0	0.25	0.25	0.1	0.9 0.4	8^o 0^o
inches	0.1	0.012 0.004	0.096 0.089	0.01	0.019 0.014	0.013 0.009	0.41 0.40	0.30 0.29	0.05	0.419 0.394	0.055	0.043 0.016	0.043 0.039	0.01	0.01	0.004	0.035 0.016	

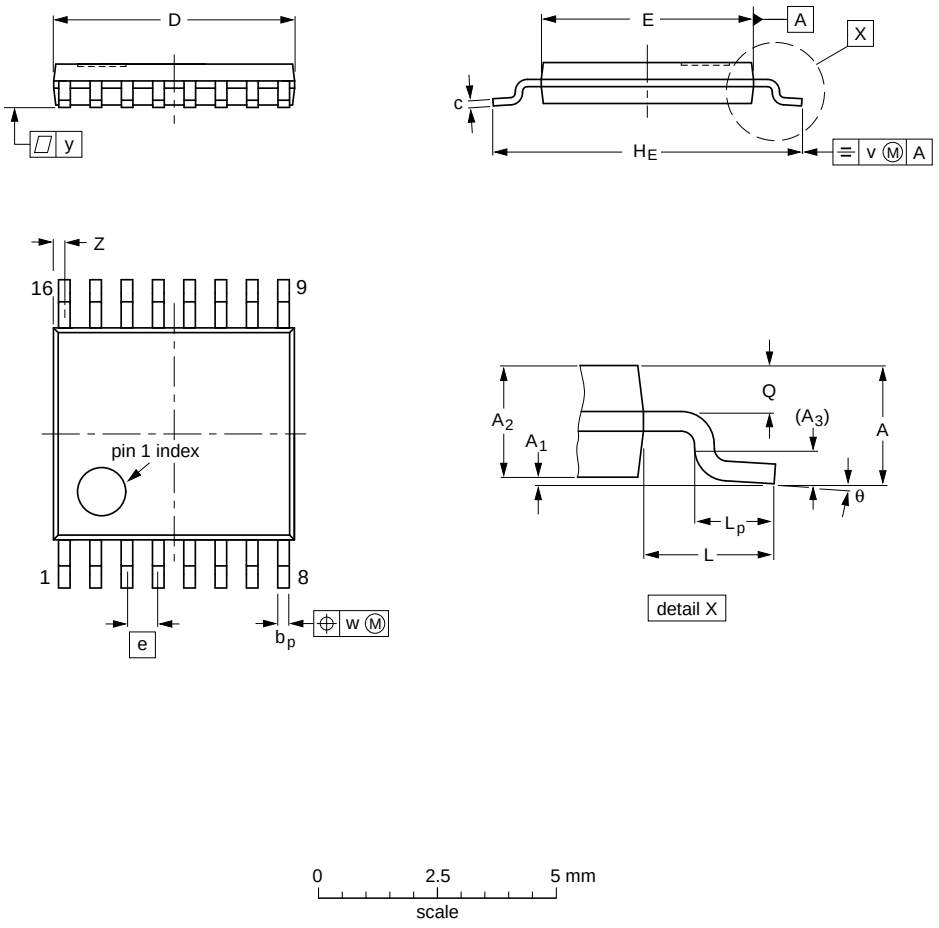
Note

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT162-1	075E03	MS-013				~~99-12-27~~ 03-02-19

Fig 24. Package outline SOT162-1 (SO16)

TSSOP16: plastic thin shrink small outline package; 16 leads; body width 4.4 mm **SOT403-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D (1)	E (2)	e	H_E	L	L_p	Q	v	w	y	Z (1)	θ
mm	1.1	0.15 0.05	0.95 0.80	0.25	0.30 0.19	0.2 0.1	5.1 4.9	4.5 4.3	0.65	6.6 6.2	1	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.40 0.06	8^o 0^o

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT403-1		MO-153				~~99-12-27~~ 03-02-18

Fig 25. Package outline SOT403-1 (TSSOP16)

16. Handling information

All input and output pins are protected against ElectroStatic Discharge (ESD) under normal handling. When handling ensure that the appropriate precautions are taken as described in *JESD625-A* or equivalent standards.

17. Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note *AN10365 "Surface mount reflow soldering description"*.

17.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

17.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

17.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

17.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see Figure 26) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with Table 10 and 11

Table 10. SnPb eutectic process (from J-STD-020D)

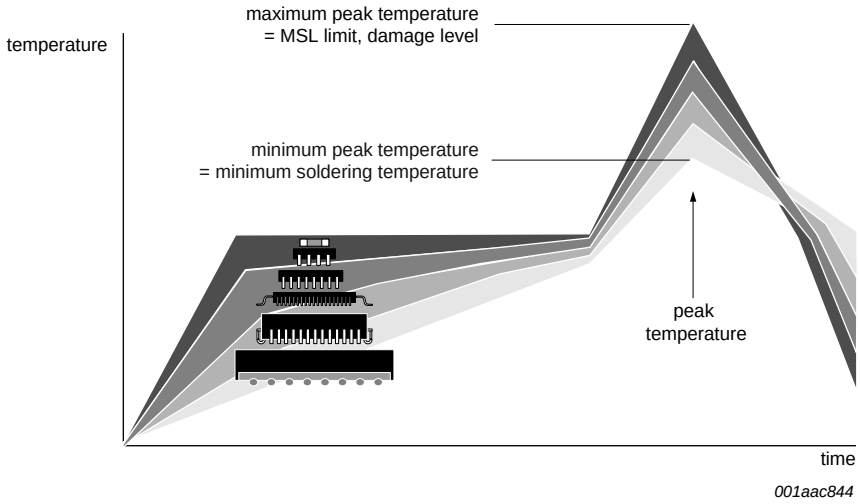
Package thickness (mm)	Package reflow temperature (°C)	
	Volume (mm³)	
	< 350	≥ 350
< 2.5	235	220
≥ 2.5	220	220

Table 11. Lead-free process (from J-STD-020D)

Package thickness (mm)	Package reflow temperature (°C)		
	Volume (mm³)		
	< 350	350 to 2000	> 2000
< 1.6	260	260	260
1.6 to 2.5	260	250	245
> 2.5	250	245	245

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see Figure 26.



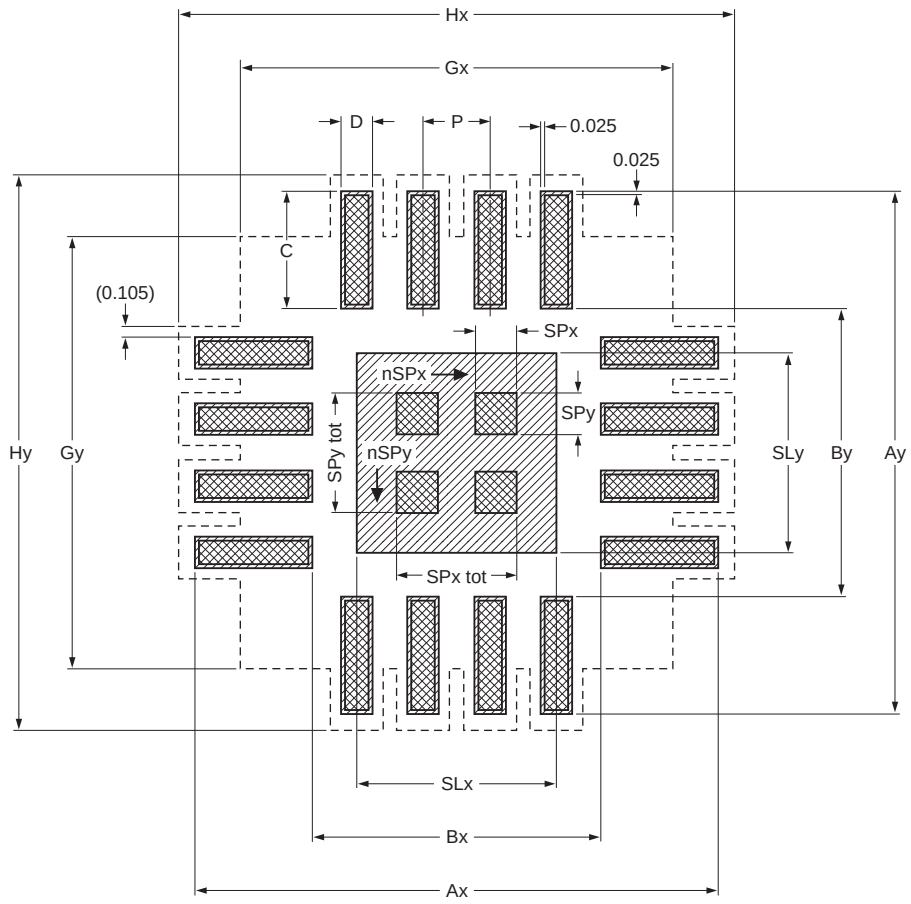
MSL: Moisture Sensitivity Level

Fig 26. Temperature profiles for large and small components

For further information on temperature profiles, refer to Application Note *AN10365 "Surface mount reflow soldering description"*.

18. Soldering: PCB footprints

Footprint information for reflow soldering of HVQFN16 package **SOT758-1**



solder land

solder paste deposit

solder land plus solder paste

occupied area

nSPx	nSPy
2	2

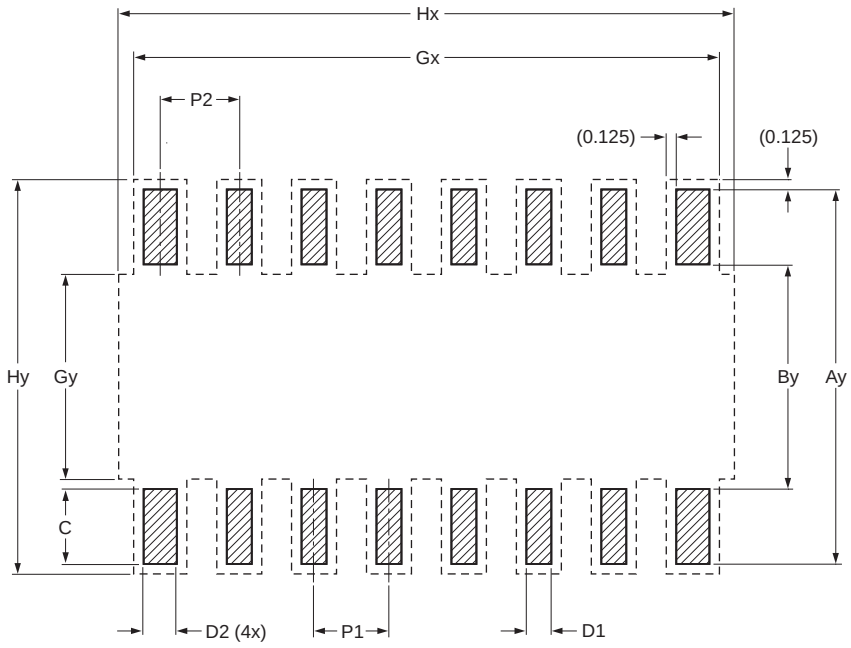
Dimensions in mm

P	Ax	Ay	Bx	By	C	D	SLx	SLy	SPx tot	SPy tot	SPx	SPy	Gx	Gy	Hx	Hy
0.50	4.00	4.00	2.20	2.20	0.90	0.24	1.50	1.50	0.90	0.90	0.30	0.30	3.30	3.30	4.25	4.25

Issue date ~~12-03-07~~ 12-03-08 *sot758-1_fr*

Fig 27. PCB footprint for SOT758-1 (HVQFN16); reflow soldering

Footprint information for reflow soldering of SO16 package **SOT162-1**



Generic footprint pattern
Refer to the package outline drawing for actual layout

solder land

occupied area

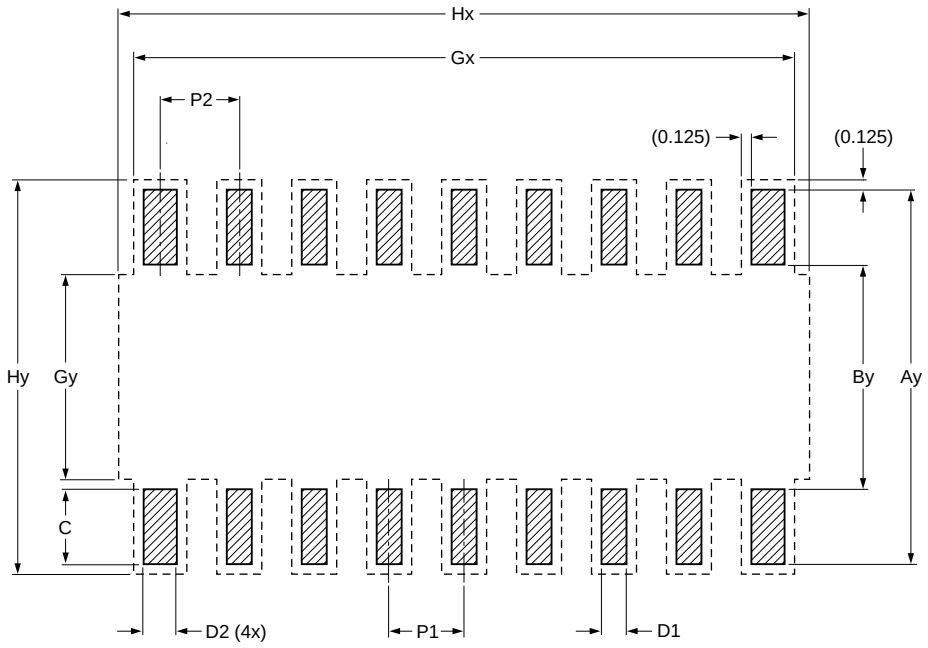
DIMENSIONS in mm

P1	P2	Ay	By	C	D1	D2	Gx	Gy	Hx	Hy
1.270	1.320	11.200	6.400	2.400	0.700	0.800	10.040	8.600	11.900	11.450

sot162-1_fr

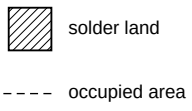
Fig 28. PCB footprint for SOT162-1 (SO16); reflow soldering

Footprint information for reflow soldering of TSSOP16 package **SOT403-1**



Generic footprint pattern

Refer to the package outline drawing for actual layout



DIMENSIONS in mm

P1	P2	Ay	By	C	D1	D2	Gx	Gy	Hx	Hy
0.650	0.750	7.200	4.500	1.350	0.400	0.600	5.600	5.300	5.800	7.450

sot403-1_fr

Fig 29. PCB footprint for SOT403-1 (TSSOP16); reflow soldering

19. Abbreviations

Table 12. Abbreviations

Acronym	Description
CDM	Charged-Device Model
CMOS	Complementary Metal-Oxide Semiconductor
ESD	ElectroStatic Discharge
GPIO	General Purpose Input/Output
HBM	Human Body Model
LED	Light Emitting Diode
IC	Integrated Circuit
I^2C-bus	Inter IC bus
ID	Identification
LSB	Least Significant Bit
MSB	Most Significant Bit
PLC	Programmable Logic Controller
RAID	Redundant Array of Independent Disks

20. Revision history

Table 13. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
PCA9670 v.3	20130530	Product data sheet	-	PCA9670 v.2

Modifications:

- Section 1 “General description” re-written
- Section 2 “Features and benefits” re-written
- Section 3 “Applications”:
  - Added (new) third bullet, “Keypads”
  - Added (new) eighth bullet, “Mobile devices”
- Added Section 4.1 “Ordering options”
- Figure 2 “Simplified schematic diagram of P0 to P7” modified: removed diode between “V_{DD}” and “P0 to P7”; removed exclusive-OR gate and signal “to interrupt logic”
- Section 7.1 “Device address”: re-written
- Table 4 “PCA9670 address map” updated: added separate columns for “Write” and “Read” under “Address byte value” column; added (new) column “7-bit hexadecimal address without R/$\overline{W}$”
- Section 7.2.1 “Software Reset”: added paragraph that follows Figure 9
- Section 7.2.2 “Device ID (PCA9670 ID field)”:
  - first bullet item following first paragraph changed from “8 bits with the manufacturer name” to “12 bits with the manufacturer name”
  - second bullet item re-written
  - List item 6. on page 9 changed from “starting with the 8 manufacturer bits ... , followed by the 13 part identification bits” to “starting with the 12 manufacturer bits ... , followed by the 9 part identification bits”
  - Figure 10 “PCA9670 Device ID field” modified
  - Figure 11 modified: added “Sr” bit
  - added paragraph that follows Figure 11

Table 13. Revision history *…continued*

Document ID	Release date	Data sheet status	Change notice	Supersedes
Modifications: (continued)	• Section 8.1 “Quasi-bidirectional I/O architecture” re-written • Section 8.2 “Writing to the port (Output mode)”, first paragraph: first, second and third sentences re-written • Figure 13 “Write mode (output)” updated • Section 8.3 “Reading from a port (Input mode)” re-written • Figure 14 “Read input port register” updated: label corrected from “data into port” to “data at port” • Section 8.4 “Power-on reset”: second and third sentences re-written • Section 8.5 “RESET input”: added new third sentence • Section 9.3 “Acknowledge”: – first paragraph: second and third sentences re-written – second paragraph: third sentence re-written • Section 10.1 “Bidirectional I/O expander applications”, second paragraph, second sentence changed from “use the PCA9671” to “use the PCA9672” • Added Section 10.2 “How to read and write to I/O expander (example)” • Section 10.3 “High current-drive load applications”: – first paragraph re-written – Figure 20 “High current-drive load application” modified: added resistors on P6 and P7 signals • Added Section 10.4 “Migration path” • Table 6 “Limiting values”: added $T_{j(max)}$ limits • Added Section 12 “Thermal characteristics” • Table 8 “Static characteristics”: – sub-section “I/Os; P0 to P7”: added V_{IL} characteristic – sub-section “I/Os; P0 to P7”: added V_{IH} characteristic – sub-section “Input $\overline{\text{RESET}}$” is corrected by removing I_{OH} row • Figure 21 “I²C-bus timing diagram” updated: added $0.7 \times V_{DD}$ and $0.3 \times V_{DD}$ reference lines • Added Section 18 “Soldering: PCB footprints”		
PCA9670 v.2	20070717	Product data sheet	-	PCA9670 v.1
PCA9670 v.1	20060620	Objective data sheet	-	-

21. Legal information

21.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

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