



# PCA9539; PCA9539R

16-bit I<sup>2</sup>C-bus and SMBus low power I/O port with interrupt and reset

Rev. 05 — 28 July 2008

Product data sheet

## 1. General description

The PCA9539; PCA9539R is a 24-pin CMOS device that provides 16 bits of General Purpose parallel Input/Output (GPIO) expansion with interrupt and reset for I<sup>2</sup>C-bus/SMBus applications and was developed to enhance the NXP Semiconductors family of I<sup>2</sup>C-bus I/O expanders. I/O expanders provide a simple solution when additional I/O is needed for ACPI power switches, sensors, push buttons, LEDs, fans, etc.

The PCA9539; PCA9539R consists of two 8-bit configuration (input or output selection), input, output and polarity inversion (active HIGH or active LOW operation) registers. The system master can enable the I/Os as either inputs or outputs by writing to the I/O configuration bits. The data for each input or output is kept in the corresponding Input or Output register. The polarity of the read register can be inverted with the Polarity inversion register. All registers can be read by the system master.

The PCA9539; PCA9539R is identical to the PCA9555 except for the removal of the internal I/O pull-up resistor which greatly reduces power consumption when the I/Os are held LOW, replacement of A2 with  $\overline{\text{RESET}}$  and a different address range.

The PCA9539; PCA9539R open-drain interrupt output is activated when any input state differs from its corresponding input port register state and is used to indicate to the system master that an input state has changed.

The power-on reset sets the registers to their default values and initializes the device state machine. In the PCA9539, the  $\overline{\text{RESET}}$  pin causes the same reset/default I/O input configuration to occur without de-powering the device, holding the registers and I<sup>2</sup>C-bus state machine in their default state until the  $\overline{\text{RESET}}$  input is once again HIGH. This input requires a pull-up to  $V_{DD}$ . In the PCA9539R however, only the device state machine is initialized by the  $\overline{\text{RESET}}$  pin and the internal general-purpose registers remain unchanged. Using the PCA9539R  $\overline{\text{RESET}}$  pin will only reset the I<sup>2</sup>C-bus interface should it be stuck LOW to regain access to the I<sup>2</sup>C-bus. This allows the I/O pins to retain their last configured state so that they can keep any lines in their previously defined state and not cause system errors while the I<sup>2</sup>C-bus is being restored.

Two hardware pins (A0, A1) vary the fixed I<sup>2</sup>C-bus address and allow up to four devices to share the same I<sup>2</sup>C-bus/SMBus.

## 2. Features

- 16-bit I<sup>2</sup>C-bus GPIO with interrupt and reset
- Operating power supply voltage range of 2.3 V to 5.5 V
- 5 V tolerant I/Os
- Polarity inversion register

- Active LOW interrupt output
- Active LOW reset input
- Low standby current
- Noise filter on SCL/SDA inputs
- No glitch on power-up
- Internal power-on reset
- 16 I/O pins which default to 16 inputs
- 0 Hz to 400 kHz clock frequency
- ESD protection exceeds 2000 V HBM per JESD22-A114, 200 V MM per JESD22-A115, and 1000 V CDM per JESD22-C101
- Latch-up testing is done to JEDEC Standard JESD78 which exceeds 100 mA
- Offered in three different packages: SO24, TSSOP24, and HVQFN24

### 3. Ordering information

Table 1. Ordering information

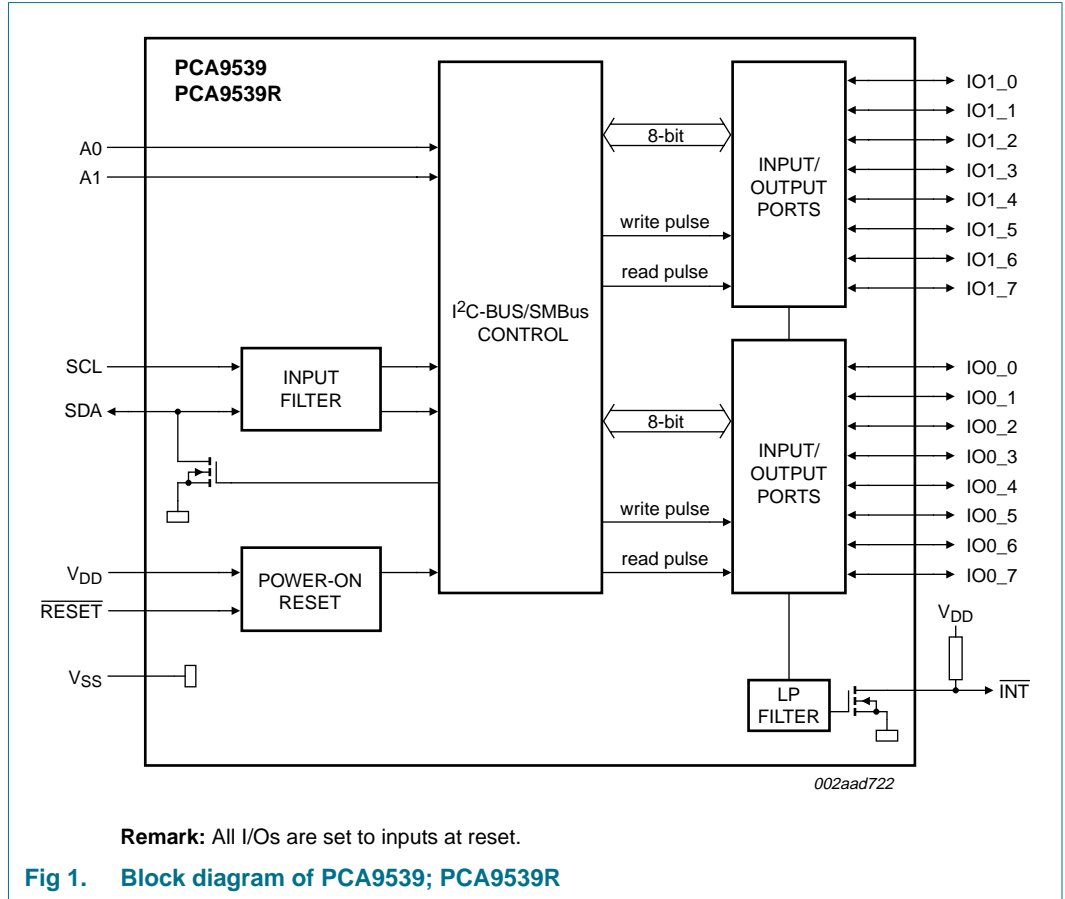
Type number	Package		Version
	Name	Description	
PCA9539D	SO24	plastic small outline package; 24 leads; body width 7.5 mm	SOT137-1
PCA9539PW	TSSOP24	plastic thin shrink small outline package; 24 leads; body width 4.4 mm	SOT355-1
PCA9539RPW			
PCA9539BS	HVQFN24	plastic thermal enhanced very thin quad flat package; no leads; 24 terminals; body 4 × 4 × 0.85 mm	SOT616-1
PCA9539RBS			

#### 3.1 Ordering options

Table 2. Ordering options

Type number	Topside mark	Temperature range
PCA9539D	PCA9539D	-40 °C to +85 °C
PCA9539PW	PCA9539PW	-40 °C to +85 °C
PCA9539RPW	PA9539RPW	-40 °C to +85 °C
PCA9539BS	9539	-40 °C to +85 °C
PCA9539RBS	539R	-40 °C to +85 °C

4. Block diagram



5. Pinning information

5.1 Pinning

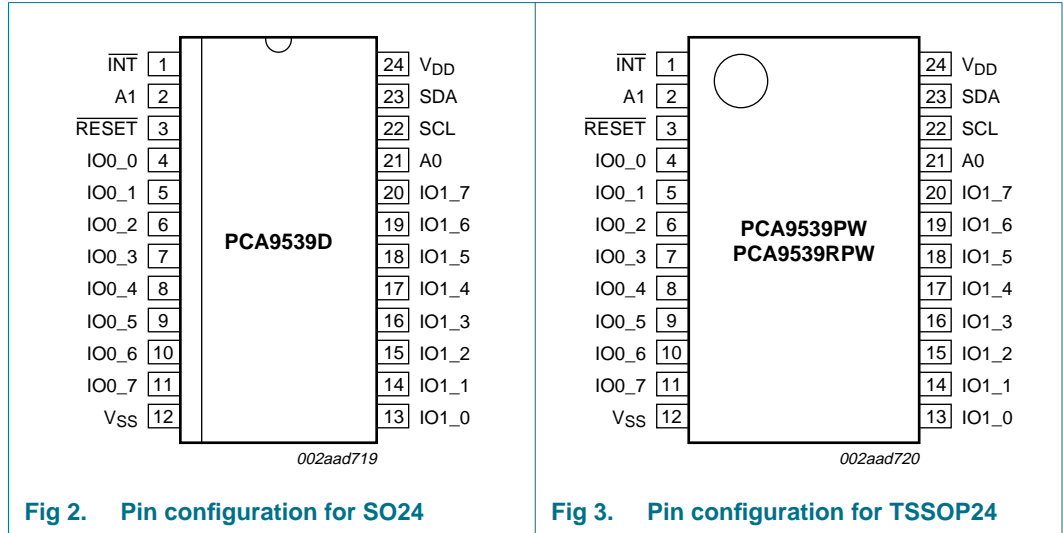


Fig 2. Pin configuration for SO24

Fig 3. Pin configuration for TSSOP24

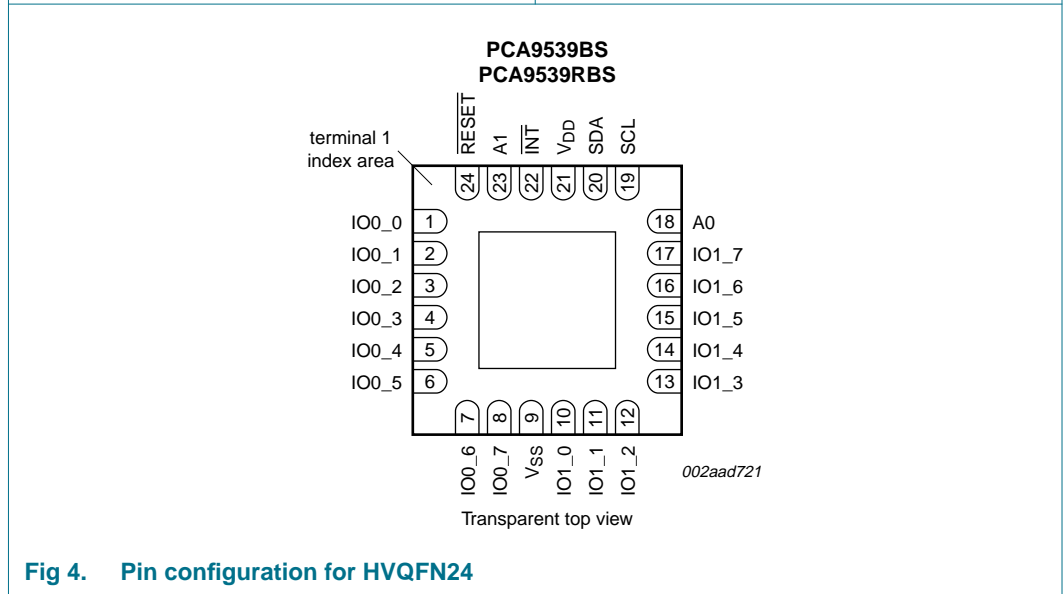


Fig 4. Pin configuration for HVQFN24

## 5.2 Pin description

Table 3. Pin description

Symbol	Pin		Description
	SO24, TSSOP24	HVQFN24	
$\overline{\text{INT}}$	1	22	interrupt output (open-drain)
A1	2	23	address input 1
$\overline{\text{RESET}}$	3	24	active LOW reset input. Driving this pin LOW causes: <ul style="list-style-type: none"> <li>• PCA9539 to reset its state machine and registers</li> <li>• PCA9539R to reset its state machine, but has no effect on its registers</li> </ul>
IO0_0	4	1	port 0 input/output 0
IO0_1	5	2	port 0 input/output 1
IO0_2	6	3	port 0 input/output 2
IO0_3	7	4	port 0 input/output 3
IO0_4	8	5	port 0 input/output 4
IO0_5	9	6	port 0 input/output 5
IO0_6	10	7	port 0 input/output 6
IO0_7	11	8	port 0 input/output 7
V <sub>SS</sub>	12	9 <sup>[1]</sup>	supply ground
IO1_0	13	10	port 1 input/output 0
IO1_1	14	11	port 1 input/output 1
IO1_2	15	12	port 1 input/output 2
IO1_3	16	13	port 1 input/output 3
IO1_4	17	14	port 1 input/output 4
IO1_5	18	15	port 1 input/output 5
IO1_6	19	16	port 1 input/output 6
IO1_7	20	17	port 1 input/output 7
A0	21	18	address input 0
SCL	22	19	serial clock line input
SDA	23	20	serial data line open-drain input/output
V <sub>DD</sub>	24	21	supply voltage

[1] HVQFN24 package die supply ground is connected to both V<sub>SS</sub> pin and exposed center pad. V<sub>SS</sub> 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.

## 6. Functional description

Refer to [Figure 1 “Block diagram of PCA9539; PCA9539R”](#).

### 6.1 Device address

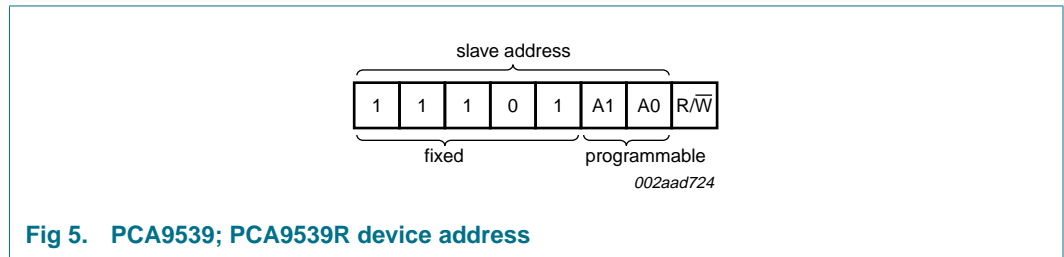


Fig 5. PCA9539; PCA9539R device address

### 6.2 Registers

#### 6.2.1 Command byte

The command byte is the first byte to follow the address byte during a write transmission. It is used as a pointer to determine which of the following registers will be written or read.

Table 4. Command byte

Command	Register
0	Input port 0
1	Input port 1
2	Output port 0
3	Output port 1
4	Polarity inversion port 0
5	Polarity inversion port 1
6	Configuration port 0
7	Configuration port 1

**6.2.2 Registers 0 and 1: Input port registers**

This register is an input-only port. It reflects the incoming logic levels of the pins, regardless of whether the pin is defined as an input or an output by Register 3. Writes to this register have no effect.

The default value 'X' is determined by the externally applied logic level.

**Table 5. Input port 0 register**

Bit	7	6	5	4	3	2	1	0
Symbol	I0.7	I0.6	I0.5	I0.4	I0.3	I0.2	I0.1	I0.0
Default	X	X	X	X	X	X	X	X

**Table 6. Input port 1 register**

Bit	7	6	5	4	3	2	1	0
Symbol	I1.7	I1.6	I1.5	I1.4	I1.3	I1.2	I1.1	I1.0
Default	X	X	X	X	X	X	X	X

**6.2.3 Registers 2 and 3: Output port registers**

This register is an output-only port. It reflects the outgoing logic levels of the pins defined as outputs by Registers 6 and 7. Bit values in this register have no effect on pins defined as inputs. In turn, reads from this register reflect the value that is in the flip-flop controlling the output selection, **not** the actual pin value.

**Table 7. Output port 0 register**

Bit	7	6	5	4	3	2	1	0
Symbol	O0.7	O0.6	O0.5	O0.4	O0.3	O0.2	O0.1	O0.0
Default	1	1	1	1	1	1	1	1

**Table 8. Output port 1 register**

Bit	7	6	5	4	3	2	1	0
Symbol	O1.7	O1.6	O1.5	O1.4	O1.3	O1.2	O1.1	O1.0
Default	1	1	1	1	1	1	1	1

**6.2.4 Registers 4 and 5: Polarity inversion registers**

This register allows the user to invert the polarity of the Input port register data. If a bit in this register is set (written with '1'), the Input port data polarity is inverted. If a bit in this register is cleared (written with a '0'), the Input port data polarity is retained.

**Table 9. Polarity inversion port 0 register**

Bit	7	6	5	4	3	2	1	0
Symbol	N0.7	N0.6	N0.5	N0.4	N0.3	N0.2	N0.1	N0.0
Default	0	0	0	0	0	0	0	0

**Table 10. Polarity inversion port 1 register**

Bit	7	6	5	4	3	2	1	0
Symbol	N1.7	N1.6	N1.5	N1.4	N1.3	N1.2	N1.1	N1.0
Default	0	0	0	0	0	0	0	0

### 6.2.5 Registers 6 and 7: Configuration registers

This register configures the directions of the I/O pins. If a bit in this register is set (written with '1'), the corresponding port pin is enabled as an input with high-impedance output driver. If a bit in this register is cleared (written with '0'), the corresponding port pin is enabled as an output. At reset, the device's ports are inputs.

Table 11. Configuration port 0 register

Bit	7	6	5	4	3	2	1	0
Symbol	C0.7	C0.6	C0.5	C0.4	C0.3	C0.2	C0.1	C0.0
Default	1	1	1	1	1	1	1	1

Table 12. Configuration port 1 register

Bit	7	6	5	4	3	2	1	0
Symbol	C1.7	C1.6	C1.5	C1.4	C1.3	C1.2	C1.1	C1.0
Default	1	1	1	1	1	1	1	1

### 6.3 Power-on reset

When power is applied to V<sub>DD</sub>, an internal power-on reset holds the PCA9539; PCA9539R in a reset condition until V<sub>DD</sub> has reached V<sub>POR</sub>. At that point, the reset condition is released and the PCA9539; PCA9539R registers and SMBus state machine will initialize to their default states. Thereafter, V<sub>DD</sub> must be lowered below 0.2 V to reset the device.

For a power reset cycle, V<sub>DD</sub> must be lowered below 0.2 V and then restored to the operating voltage.

### 6.4 RESET input

A reset can be accomplished by holding the  $\overline{\text{RESET}}$  pin LOW for a minimum of t<sub>w(rst)</sub>. In the PCA9539 the registers and SMBus/I<sup>2</sup>C-bus state machine will be held in their default state until the  $\overline{\text{RESET}}$  input is once again HIGH. This input typically requires a pull-up to V<sub>DD</sub>. In the PCA9539R, only the device state machine is initialized. The internal general-purpose registers remain unchanged. Using the PCA9539R hardware reset pin will only reset the I<sup>2</sup>C-bus interface should it be stuck LOW to regain access to the I<sup>2</sup>C-bus. This allows the I/O pins to retain their last configured state so that they can keep any lines in their previously defined state and not cause system errors while the I<sup>2</sup>C-bus is being restored.

### 6.5 I/O port

When an I/O is configured as an input, FETs Q1 and Q2 are off, creating a high-impedance input. The input voltage may be raised above V<sub>DD</sub> to a maximum of 5.5 V.

If the I/O is configured as an output, then either Q1 or Q2 is on, depending on the state of the Output port register. Care should be exercised if an external voltage is applied to an I/O configured as an output because of the low-impedance path that exists between the pin and either V<sub>DD</sub> or V<sub>SS</sub>.



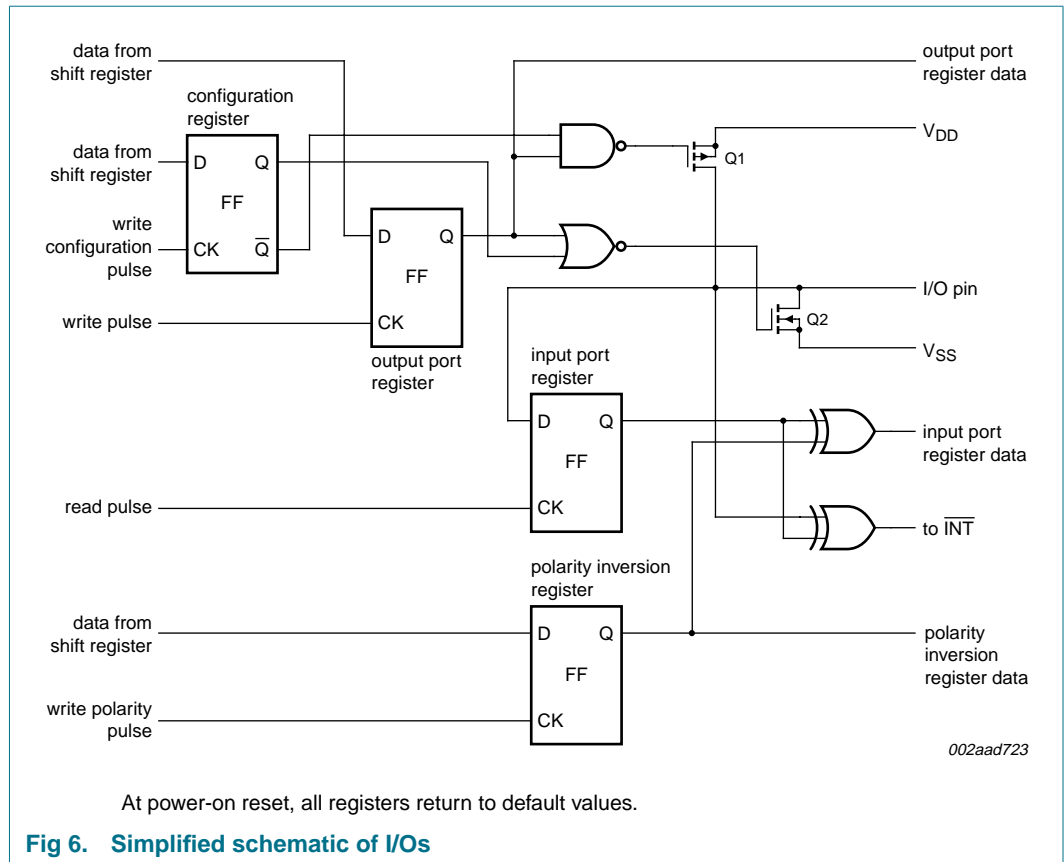


Fig 6. Simplified schematic of I/Os

## 6.6 Bus transactions

### 6.6.1 Writing to the port registers

Data is transmitted to the PCA9539; PCA9539R by sending the device address and setting the least significant bit to a logic 0 (see [Figure 5 "PCA9539; PCA9539R device address"](#)). The command byte is sent after the address and determines which register will receive the data following the command byte.

The eight registers within the PCA9539; PCA9539R are configured to operate as four register pairs. The four pairs are Input ports, Output ports, Polarity inversion ports, and Configuration ports. After sending data to one register, the next data byte will be sent to the other register in the pair (see [Figure 7](#) and [Figure 8](#)). For example, if the first byte is sent to Output port 1 (register 3), then the next byte will be stored in Output port 0 (register 2). There is no limitation on the number of data bytes sent in one write transmission. In this way, each 8-bit register may be updated independently of the other registers.

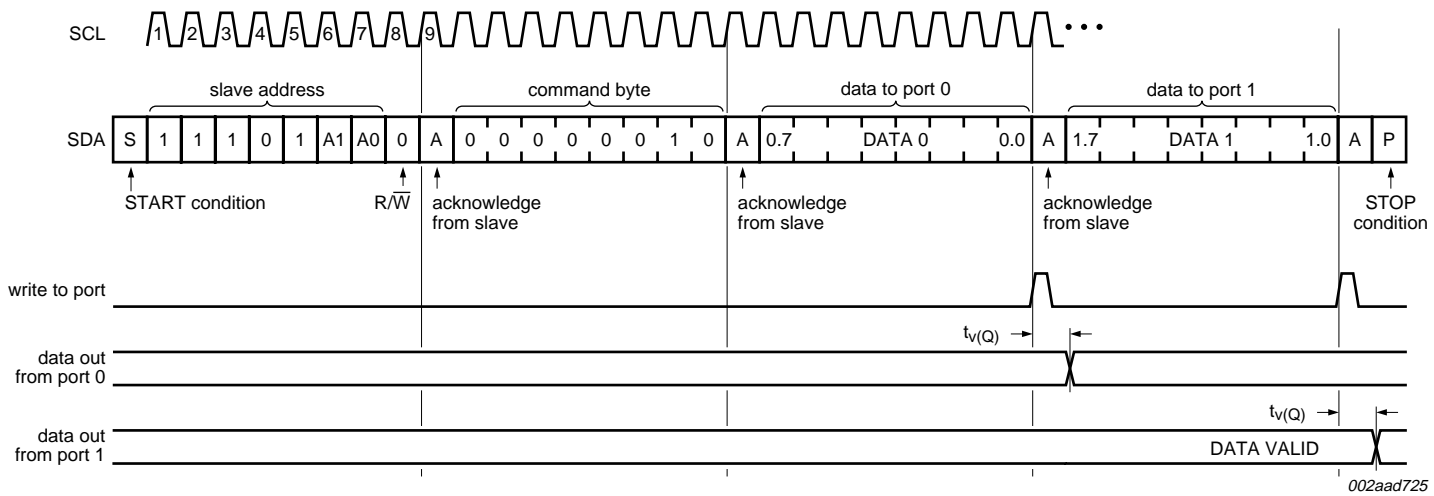


Fig 7. Write to output port registers

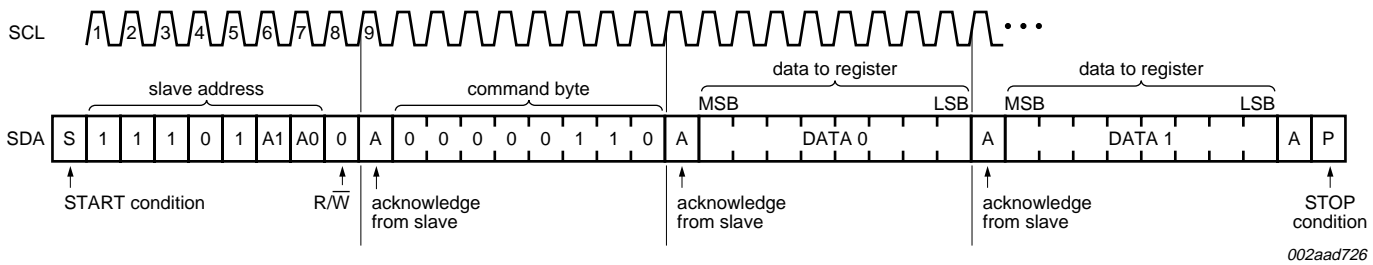
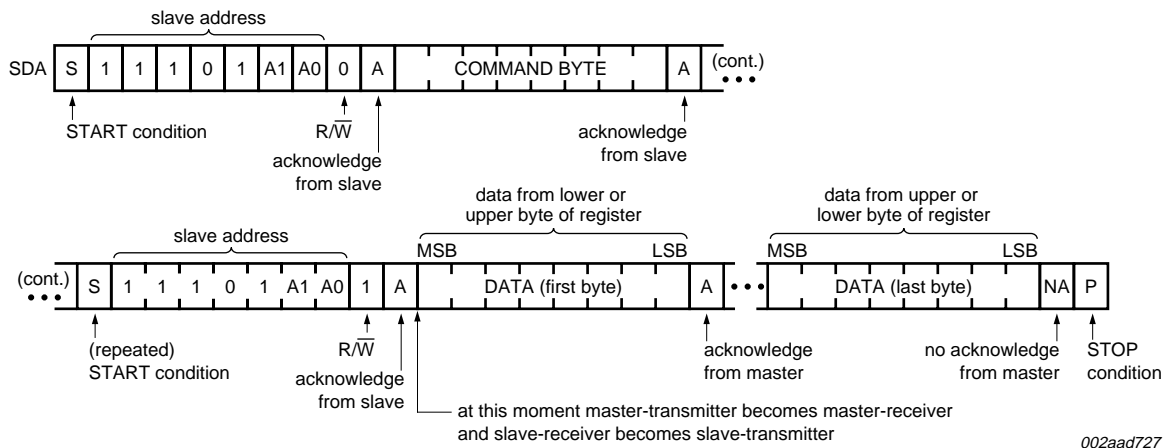


Fig 8. Write to configuration registers

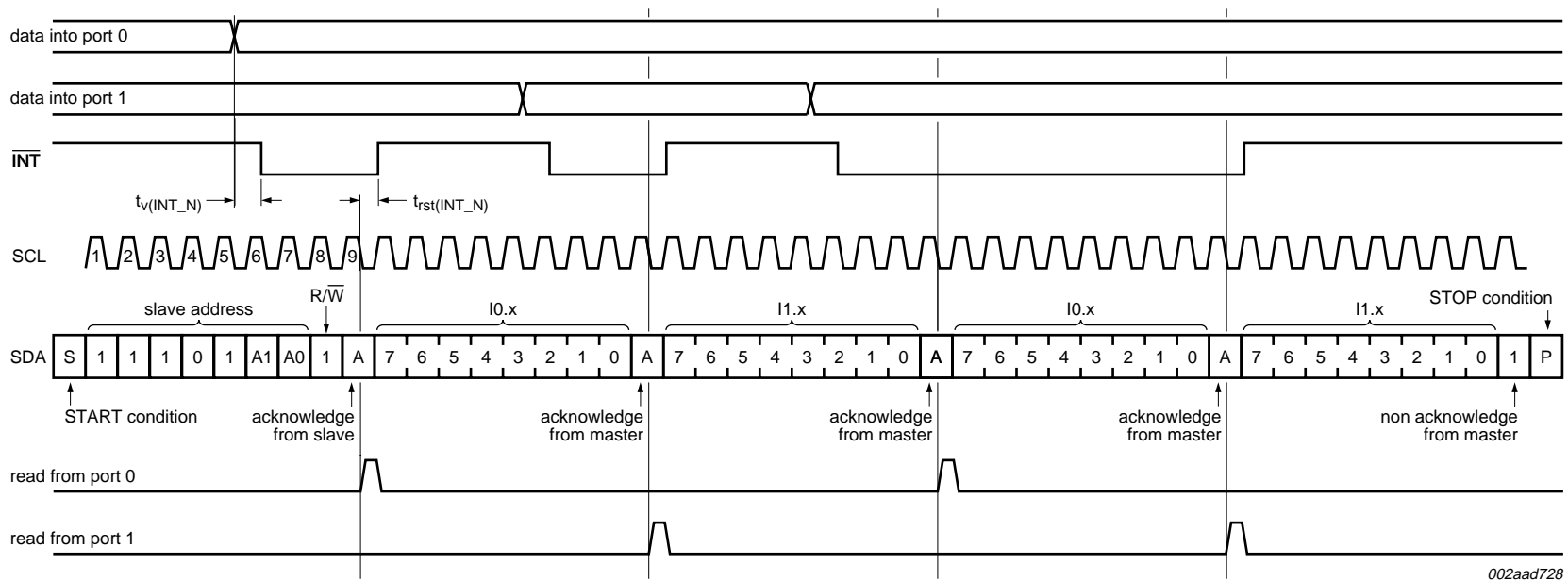
6.6.2 Reading the port registers

In order to read data from the PCA9539; PCA9539R, the bus master must first send the PCA9539; PCA9539R address with the least significant bit set to a logic 0 (see [Figure 5 “PCA9539; PCA9539R device address”](#)). The command byte is sent after the address and determines which register will be accessed. After a restart, the device address is sent again, but this time the least significant bit is set to a logic 1. Data from the register defined by the command byte will then be sent by the PCA9539; PCA9539R (see [Figure 9](#), [Figure 10](#) and [Figure 11](#)). Data is clocked into the register on the falling edge of the acknowledge clock pulse. After the first byte is read, additional bytes may be read but the data will now reflect the information in the other register in the pair. For example, if you read Input port 1, then the next byte read would be Input port 0. There is no limitation on the number of data bytes received in one read transmission but the final byte received, the bus master must not acknowledge the data.



**Remark:** Transfer can be stopped at any time by a STOP condition.

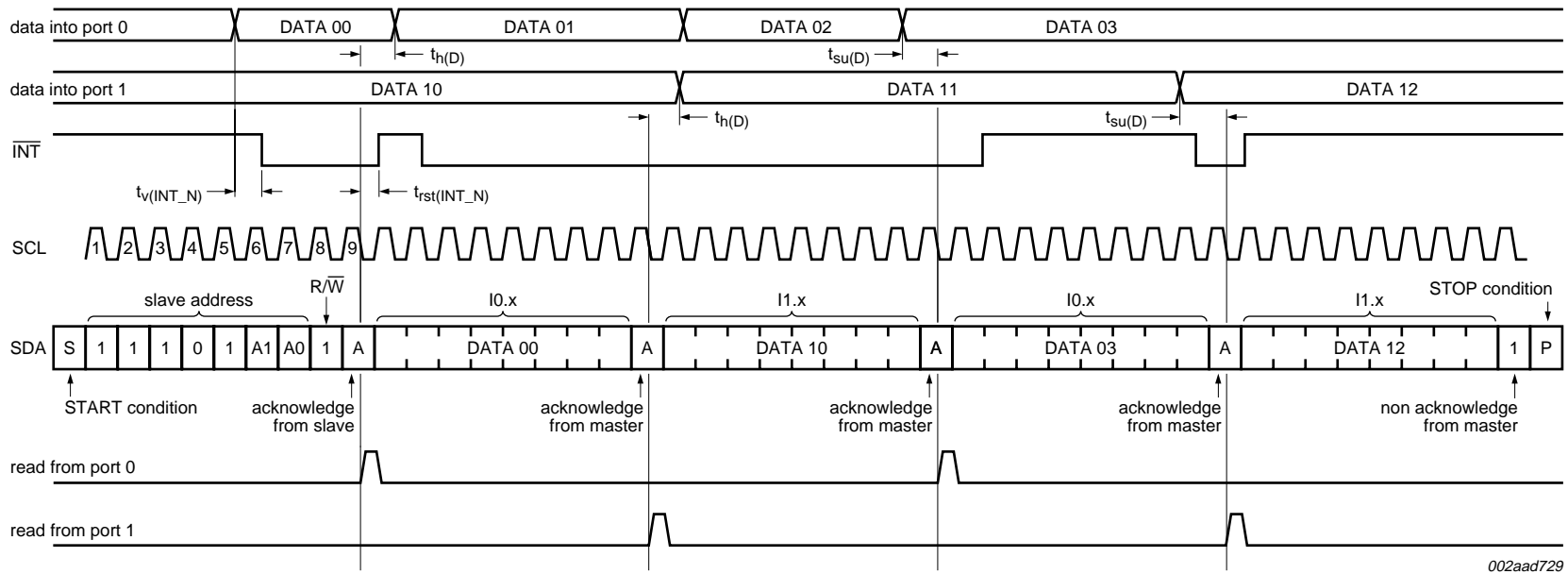
Fig 9. Read from register



002aad728

**Remark:** Transfer of data can be stopped at any moment by a STOP condition. When this occurs, data present at the latest acknowledge phase is valid (output mode). It is assumed that the command byte has previously been set to '00' (read input port register).

Fig 10. Read input port register, scenario 1



002aad729

**Remark:** Transfer of data can be stopped at any moment by a STOP condition. When this occurs, data present at the latest acknowledge phase is valid (output mode). It is assumed that the command byte has previously been set to '00' (read input port register).

Fig 11. Read input port register, scenario 2

6.6.3 Interrupt output

The open-drain interrupt output is activated when one of the port pins change state and the pin is configured as an input. The interrupt is deactivated when the input returns to its previous state or the Input port register is read (see Figure 10). A pin configured as an output cannot cause an interrupt. Since each 8-bit port is read independently, the interrupt caused by Port 0 will not be cleared by a read of Port 1 or the other way around.

**Remark:** Changing an I/O from an output to an input may cause a false interrupt to occur if the state of the pin does not match the contents of the Input port register.

7. Characteristics of the I<sup>2</sup>C-bus

The I<sup>2</sup>C-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.

7.1 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 12).

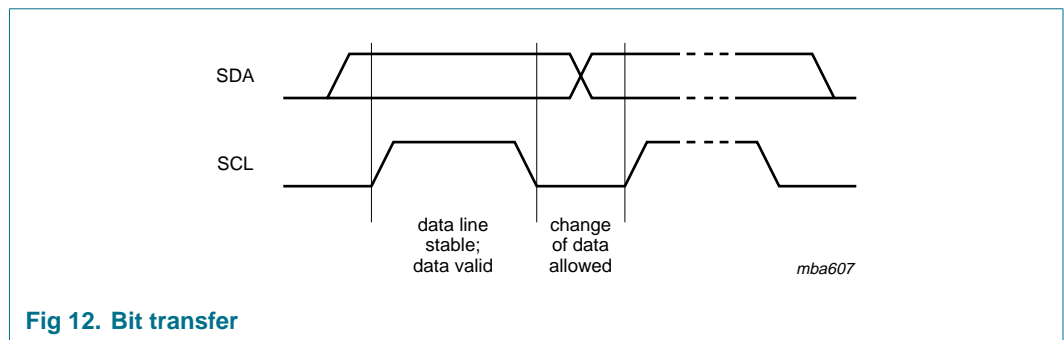


Fig 12. Bit transfer

7.1.1 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 13).

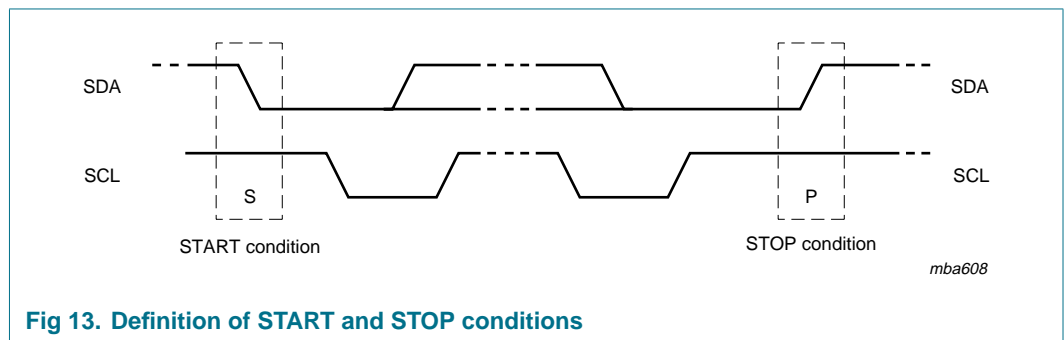


Fig 13. Definition of START and STOP conditions

### 7.2 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 14](#)).

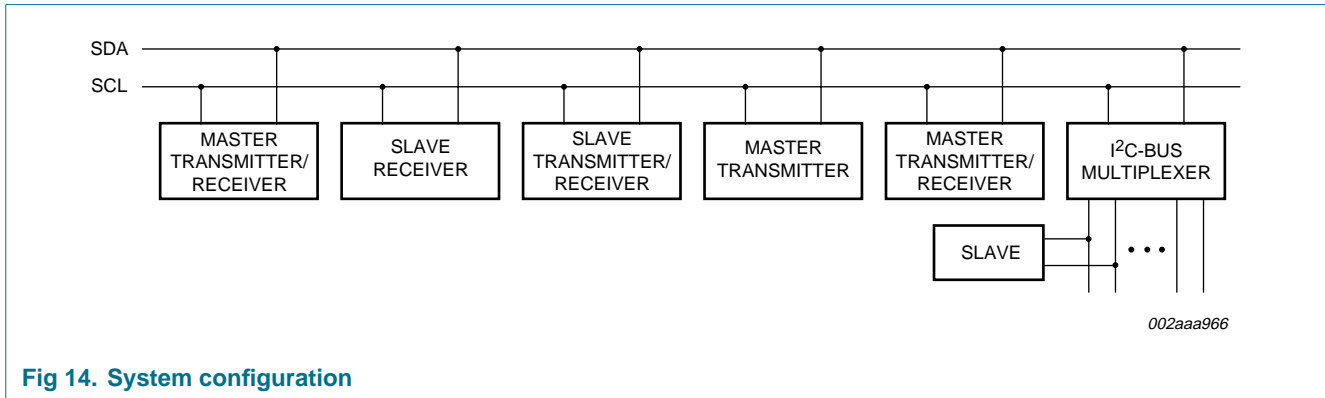


Fig 14. System configuration

### 7.3 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. The acknowledge bit is a HIGH level put on the bus by the transmitter, whereas the master generates an extra acknowledge related clock pulse.

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 acknowledges 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 related clock pulse; set-up time and hold time 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.

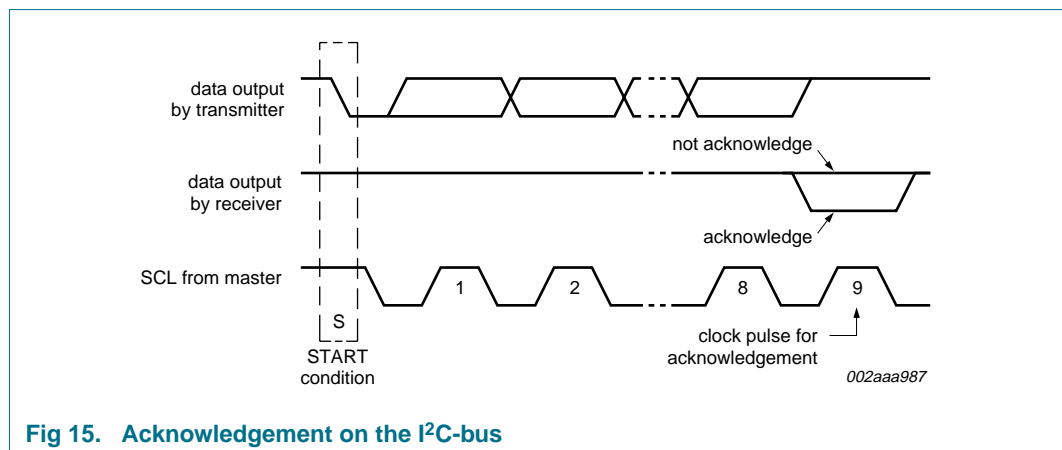


Fig 15. Acknowledgement on the I<sup>2</sup>C-bus

8. Application design-in information

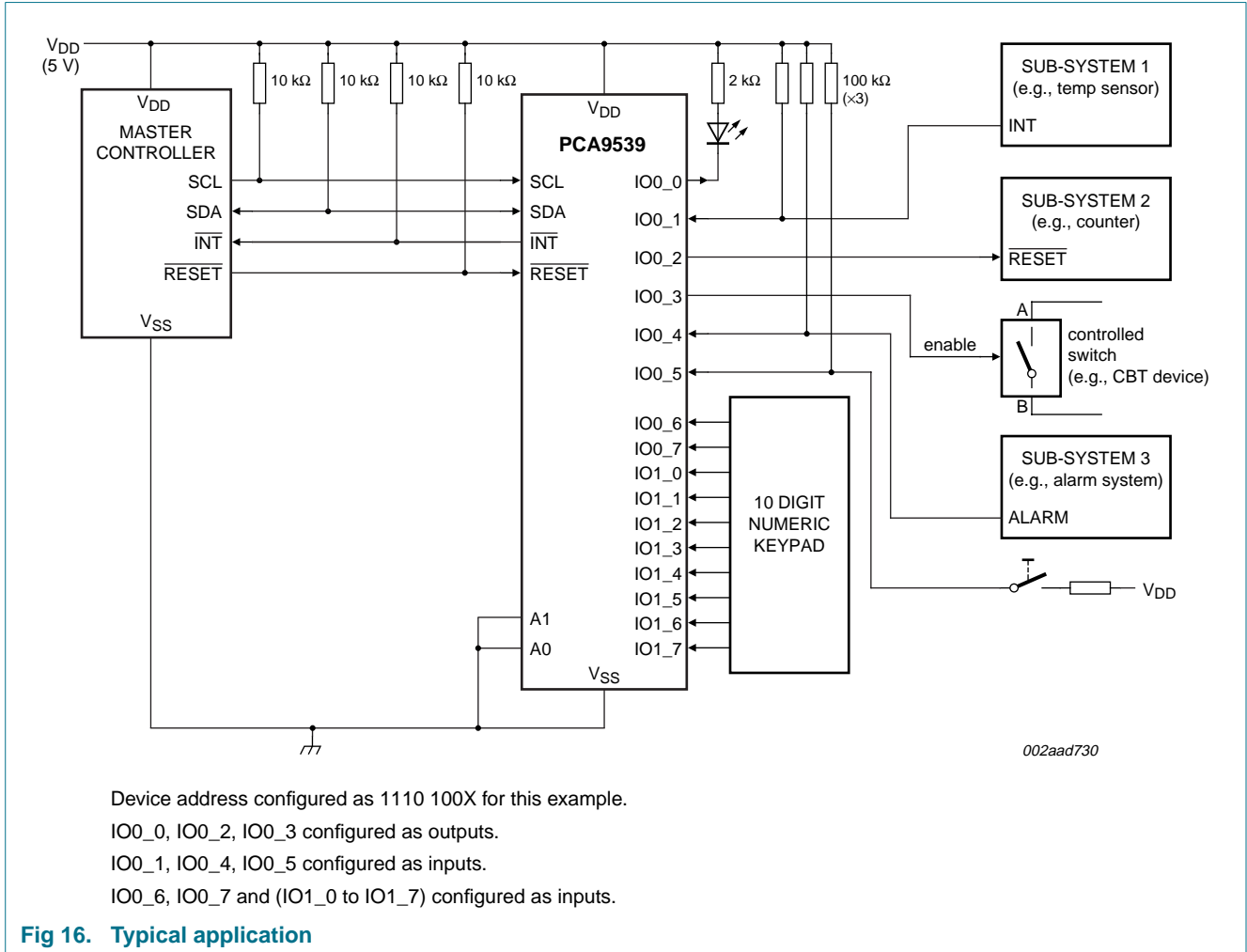


Fig 16. Typical application



8.1 Minimizing I<sub>DD</sub> when the I/Os are used to control LEDs

When the I/Os are used to control LEDs, they are normally connected to V<sub>DD</sub> through a resistor as shown in Figure 16. Since the LED acts as a diode, when the LED is off the I/O V<sub>I</sub> is about 1.2 V less than V<sub>DD</sub>. The supply current, I<sub>DD</sub>, increases as V<sub>I</sub> becomes lower than V<sub>DD</sub>.

Designs needing to minimize current consumption, such as battery power applications, should consider maintaining the I/O pins greater than or equal to V<sub>DD</sub> when the LED is off. Figure 17 shows a high value resistor in parallel with the LED. Figure 18 shows V<sub>DD</sub> less than the LED supply voltage by at least 1.2 V. Both of these methods maintain the I/O V<sub>I</sub> at or above V<sub>DD</sub> and prevents additional supply current consumption when the LED is off.

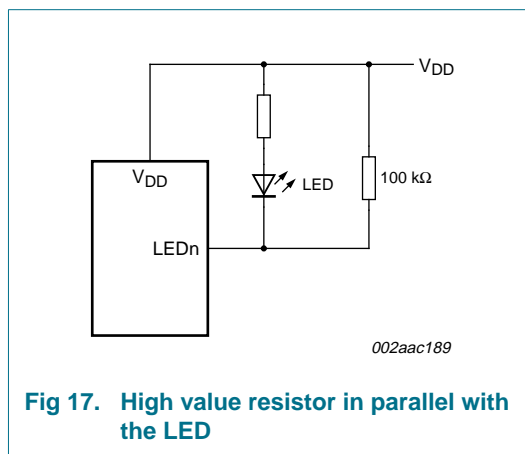


Fig 17. High value resistor in parallel with the LED

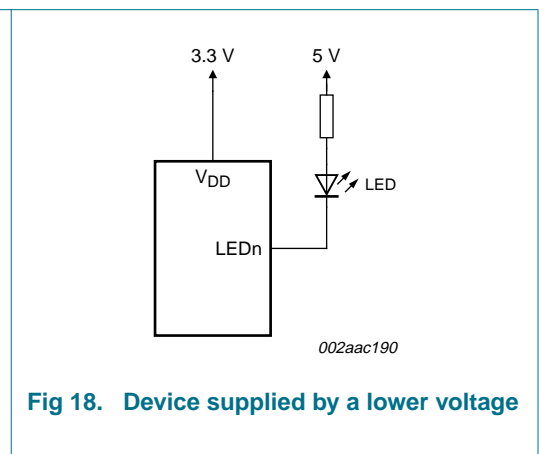


Fig 18. Device supplied by a lower voltage

9. Limiting values

Table 13. Limiting values

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

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>DD</sub>	supply voltage		-0.5	+6.0	V
V <sub>I/O</sub>	voltage on an input/output pin		V <sub>SS</sub> - 0.5	6	V
I <sub>O</sub>	output current	on an I/O pin	-	±50	mA
I <sub>I</sub>	input current		-	±20	mA
I <sub>DD</sub>	supply current		-	160	mA
I <sub>SS</sub>	ground supply current		-	200	mA
P <sub>tot</sub>	total power dissipation		-	200	mW
T <sub>stg</sub>	storage temperature		-65	+150	°C
T <sub>amb</sub>	ambient temperature	operating	-40	+85	°C
T <sub>j(max)</sub>	maximum junction temperature		-	125	°C

## 10. Static characteristics

**Table 14. Static characteristics**

$V_{DD} = 2.3\text{ V to }5.5\text{ V}$ ;  $V_{SS} = 0\text{ V}$ ;  $T_{amb} = -40\text{ }^{\circ}\text{C to }+85\text{ }^{\circ}\text{C}$ ; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Supplies</b>						
$V_{DD}$	supply voltage		2.3	-	5.5	V
$I_{DD}$	supply current	Operating mode; $V_{DD} = 5.5\text{ V}$ ; no load; $f_{SCL} = 100\text{ kHz}$ ; I/O = inputs	-	135	200	$\mu\text{A}$
$I_{stb}$	standby current	Standby mode; $V_{DD} = 5.5\text{ V}$ ; no load; $V_I = V_{SS}$ ; $f_{SCL} = 0\text{ kHz}$ ; I/O = inputs	-	0.25	1	$\mu\text{A}$
		Standby mode; $V_{DD} = 5.5\text{ V}$ ; no load; $V_I = V_{DD}$ ; $f_{SCL} = 0\text{ kHz}$ ; I/O = inputs	-	0.25	1	$\mu\text{A}$
$V_{POR}$	power-on reset voltage <sup>[1]</sup>	no load; $V_I = V_{DD}$ or $V_{SS}$	-	1.5	1.65	V
<b>Input SCL; input/output SDA</b>						
$V_{IL}$	LOW-level input voltage		-0.5	-	+0.3 $V_{DD}$	V
$V_{IH}$	HIGH-level input voltage		0.7 $V_{DD}$	-	5.5	V
$I_{OL}$	LOW-level output current	$V_{OL} = 0.4\text{ V}$	3	-	-	mA
$I_L$	leakage current	$V_I = V_{DD} = V_{SS}$	-1	-	+1	$\mu\text{A}$
$C_i$	input capacitance	$V_I = V_{SS}$	-	6	10	pF
<b>I/Os</b>						
$V_{IL}$	LOW-level input voltage		-0.5	-	+0.3 $V_{DD}$	V
$V_{IH}$	HIGH-level input voltage		0.7 $V_{DD}$	-	5.5	V
$I_{OL}$	LOW-level output current	$V_{DD} = 2.3\text{ V to }5.5\text{ V}$ ; $V_{OL} = 0.5\text{ V}$	<sup>[2]</sup> 8	9	-	mA
		$V_{DD} = 2.3\text{ V to }5.5\text{ V}$ ; $V_{OL} = 0.7\text{ V}$	<sup>[2]</sup> 10	11	-	mA
$V_{OH}$	HIGH-level output voltage	$I_{OH} = -8\text{ mA}$ ; $V_{DD} = 2.3\text{ V}$	<sup>[3]</sup> 1.8	-	-	V
		$I_{OH} = -10\text{ mA}$ ; $V_{DD} = 2.3\text{ V}$	<sup>[3]</sup> 1.7	-	-	V
		$I_{OH} = -8\text{ mA}$ ; $V_{DD} = 3.0\text{ V}$	<sup>[3]</sup> 2.6	-	-	V
		$I_{OH} = -10\text{ mA}$ ; $V_{DD} = 3.0\text{ V}$	<sup>[3]</sup> 2.5	-	-	V
		$I_{OH} = -8\text{ mA}$ ; $V_{DD} = 4.75\text{ V}$	<sup>[3]</sup> 4.1	-	-	V
		$I_{OH} = -10\text{ mA}$ ; $V_{DD} = 4.75\text{ V}$	<sup>[3]</sup> 4.0	-	-	V
$I_{LIH}$	HIGH-level input leakage current	$V_{DD} = 5.5\text{ V}$ ; $V_I = V_{DD}$	-	-	1	$\mu\text{A}$
$I_{LIL}$	LOW-level input leakage current	$V_{DD} = 5.5\text{ V}$ ; $V_I = V_{SS}$	-	-	-1	$\mu\text{A}$
$C_i$	input capacitance		-	3.7	5	pF
$C_o$	output capacitance		-	3.7	5	pF
<b>Interrupt INT</b>						
$I_{OL}$	LOW-level output current	$V_{OL} = 0.4\text{ V}$	3	-	-	mA
<b>Select inputs A0, A1 and RESET</b>						
$V_{IL}$	LOW-level input voltage		-0.5	-	+0.3 $V_{DD}$	V
$V_{IH}$	HIGH-level input voltage		0.7 $V_{DD}$	-	5.5	V
$I_{LI}$	input leakage current		-1	-	+1	$\mu\text{A}$

[1]  $V_{DD}$  must be lowered to 0.2 V for at least 5  $\mu\text{s}$  in order to reset part.

[2] Each I/O must be externally limited to a maximum of 25 mA and each octal (IO0\_0 to IO0\_7 and IO1\_0 to IO1\_7) must be limited to a maximum current of 100 mA for a device total of 200 mA.

[3] The total current sourced by all I/Os must be limited to 160 mA (80 mA for IO0\_0 through IO0\_7 and 80 mA for IO1\_0 through IO1\_7).

## 11. Dynamic characteristics

Table 15. Dynamic characteristics

Symbol	Parameter	Conditions	Standard-mode I <sup>2</sup> C-bus		Fast-mode I <sup>2</sup> C-bus		Unit
			Min	Max	Min	Max	
f <sub>SCL</sub>	SCL clock frequency		0	100	0	400	kHz
t <sub>BUF</sub>	bus free time between a STOP and START condition		4.7	-	1.3	-	μs
t <sub>HD,STA</sub>	hold time (repeated) START condition		4.0	-	0.6	-	μs
t <sub>SU,STA</sub>	set-up time for a repeated START condition		4.7	-	0.6	-	μs
t <sub>SU,STO</sub>	set-up time for STOP condition		4.0	-	0.6	-	μs
t <sub>VD,ACK</sub>	data valid acknowledge time	[1]	0.3	3.45	0.1	0.9	μs
t <sub>HD,DAT</sub>	data hold time		0	-	0	-	ns
t <sub>VD,DAT</sub>	data valid time	[2]	300	-	50	-	ns
t <sub>SU,DAT</sub>	data set-up time		250	-	100	-	ns
t <sub>LOW</sub>	LOW period of the SCL clock		4.7	-	1.3	-	μs
t <sub>HIGH</sub>	HIGH period of the SCL clock		4.0	-	0.6	-	μs
t <sub>f</sub>	fall time of both SDA and SCL signals	[3]	-	300	20 + 0.1C <sub>b</sub>	300	ns
t <sub>r</sub>	rise time of both SDA and SCL signals	[3]	-	1000	20 + 0.1C <sub>b</sub>	300	ns
t <sub>SP</sub>	pulse width of spikes that must be suppressed by the input filter		-	50	-	50	ns
<b>Port timing</b>							
t <sub>v(Q)</sub>	data output valid time	[4]	-	200	-	200	ns
t <sub>su(D)</sub>	data input set-up time		150	-	150	-	ns
t <sub>h(D)</sub>	data input hold time		1	-	1	-	μs
<b>Interrupt timing</b>							
t <sub>v(INT_N)</sub>	valid time on pin $\overline{\text{INT}}$		-	4	-	4	μs
t <sub>rst(INT_N)</sub>	reset time on pin $\overline{\text{INT}}$		-	4	-	4	μs
<b>RESET timing</b>							
t <sub>w(rst)</sub>	reset pulse width		4	-	4	-	ns
t <sub>rec(rst)</sub>	reset recovery time		0	-	0	-	ns
t <sub>rst</sub>	reset time	[5][6]	400	-	400	-	ns

[1] t<sub>VD,ACK</sub> = time for acknowledgement signal from SCL LOW to SDA (out) LOW.

[2] t<sub>VD,DAT</sub> = minimum time for SDA data out to be valid following SCL LOW.

[3] C<sub>b</sub> = total capacitance of one bus line in pF.

[4] t<sub>v(Q)</sub> measured from 0.7V<sub>DD</sub> on SCL to 50 % I/O output.

[5] Resetting the device while actively communicating on the bus may cause glitches or errant STOP conditions.

[6] Upon reset, the full delay will be the sum of t<sub>rst</sub> and the RC time constant of the SDA bus.

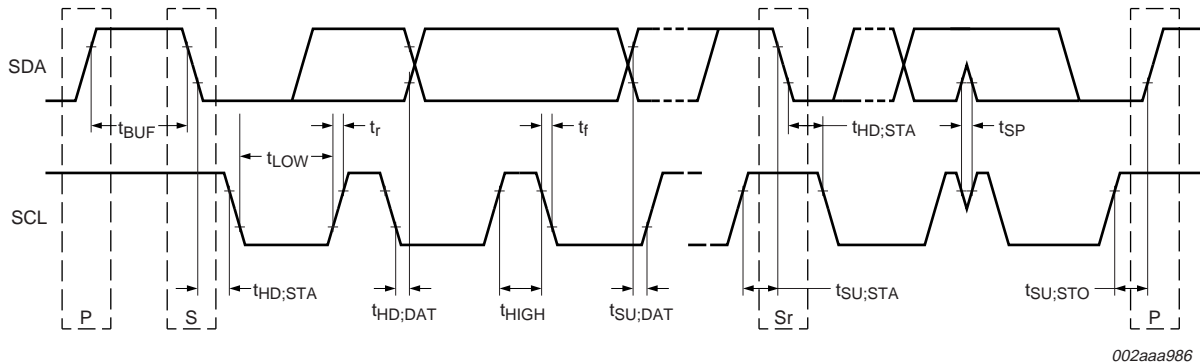


Fig 19. Definition of timing on the I<sup>2</sup>C-bus

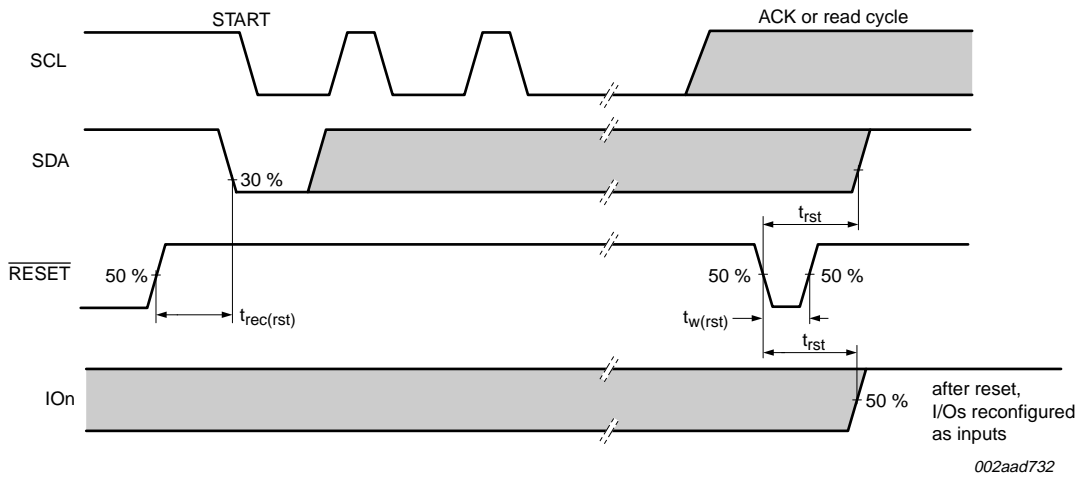


Fig 20. Definition of RESET timing in PCA9539

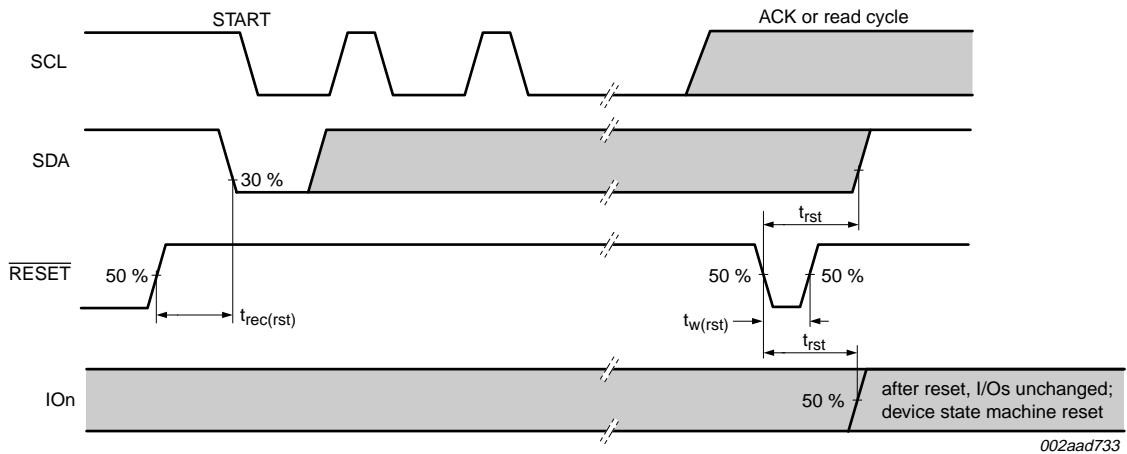


Fig 21. Definition of RESET timing in PCA9539R

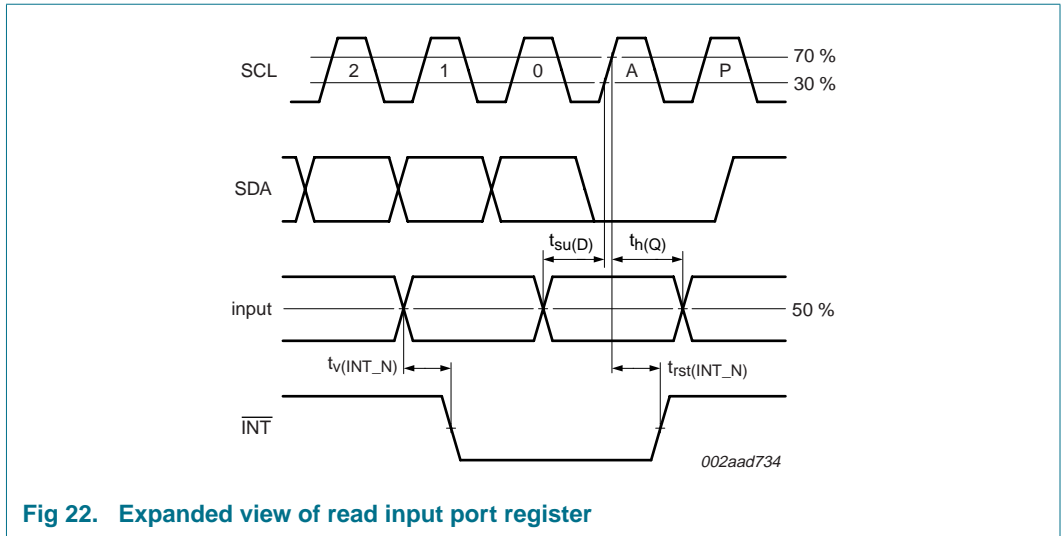


Fig 22. Expanded view of read input port register

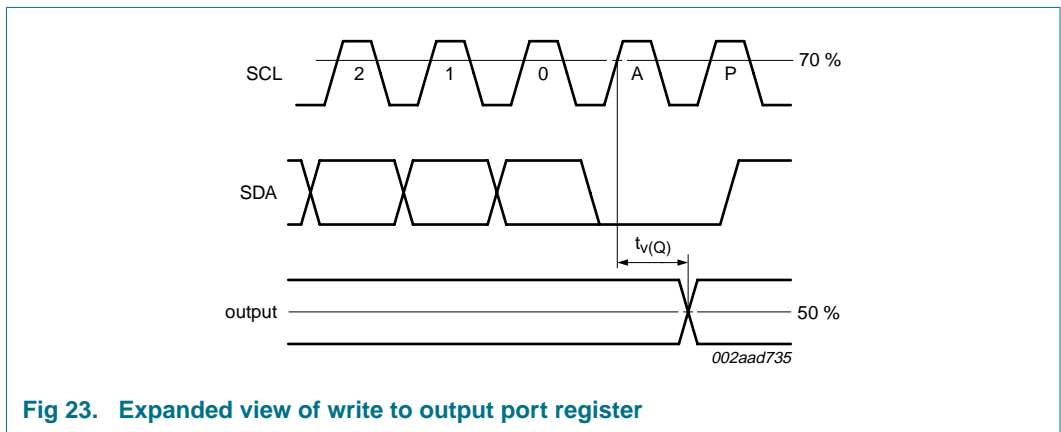


Fig 23. Expanded view of write to output port register

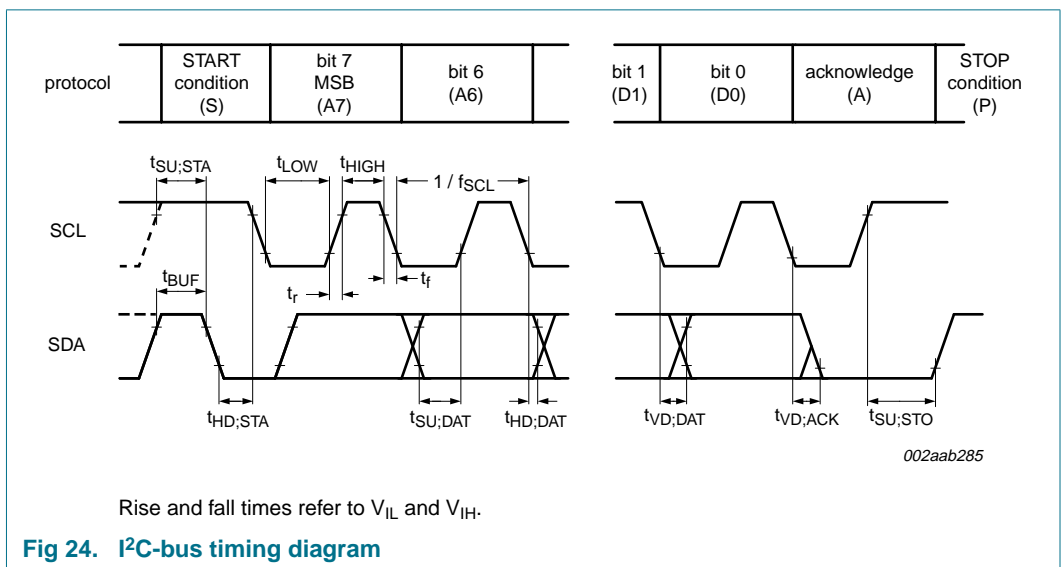


Fig 24. I<sup>2</sup>C-bus timing diagram

12. Test information

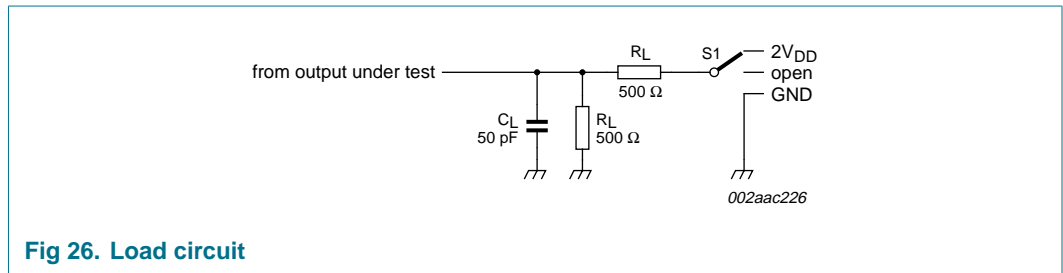
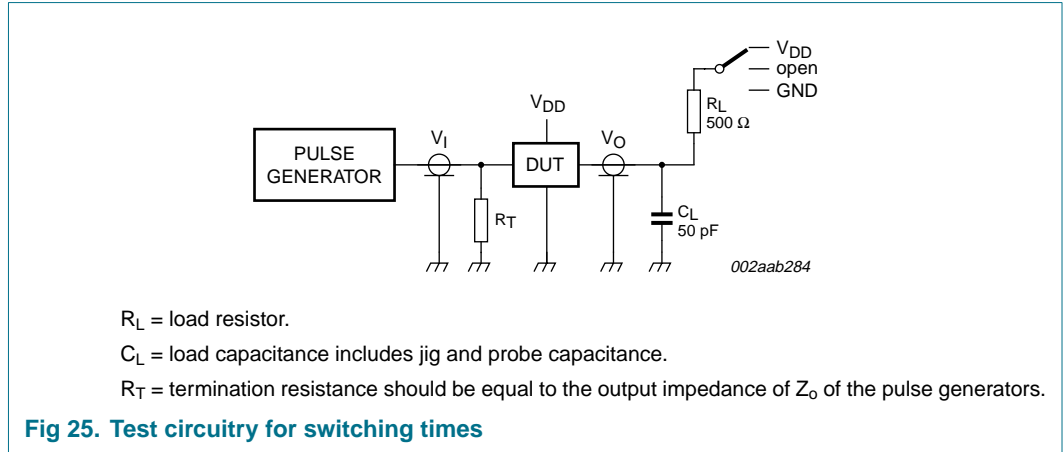


Table 16. Test data

Test	Load		Switch
	$C_L$	$R_L$	
$t_{v(Q)}$	50 pF	500 Ω	$2 \times V_{DD}$

13. Package outline

SO24: plastic small outline package; 24 leads; body width 7.5 mm

SOT137-1

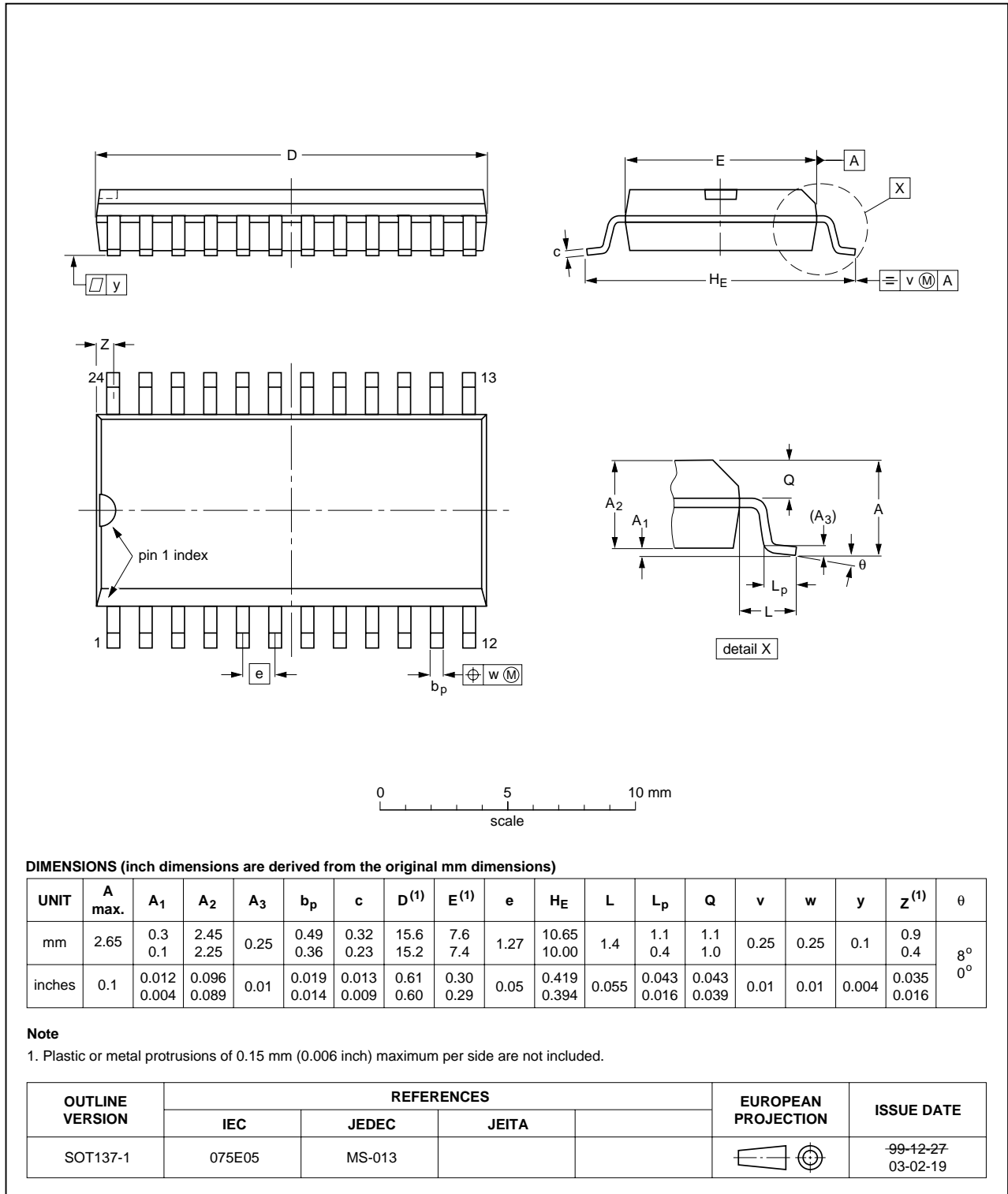


Fig 27. Package outline SOT137-1 (SO24)

TSSOP24: plastic thin shrink small outline package; 24 leads; body width 4.4 mm

SOT355-1

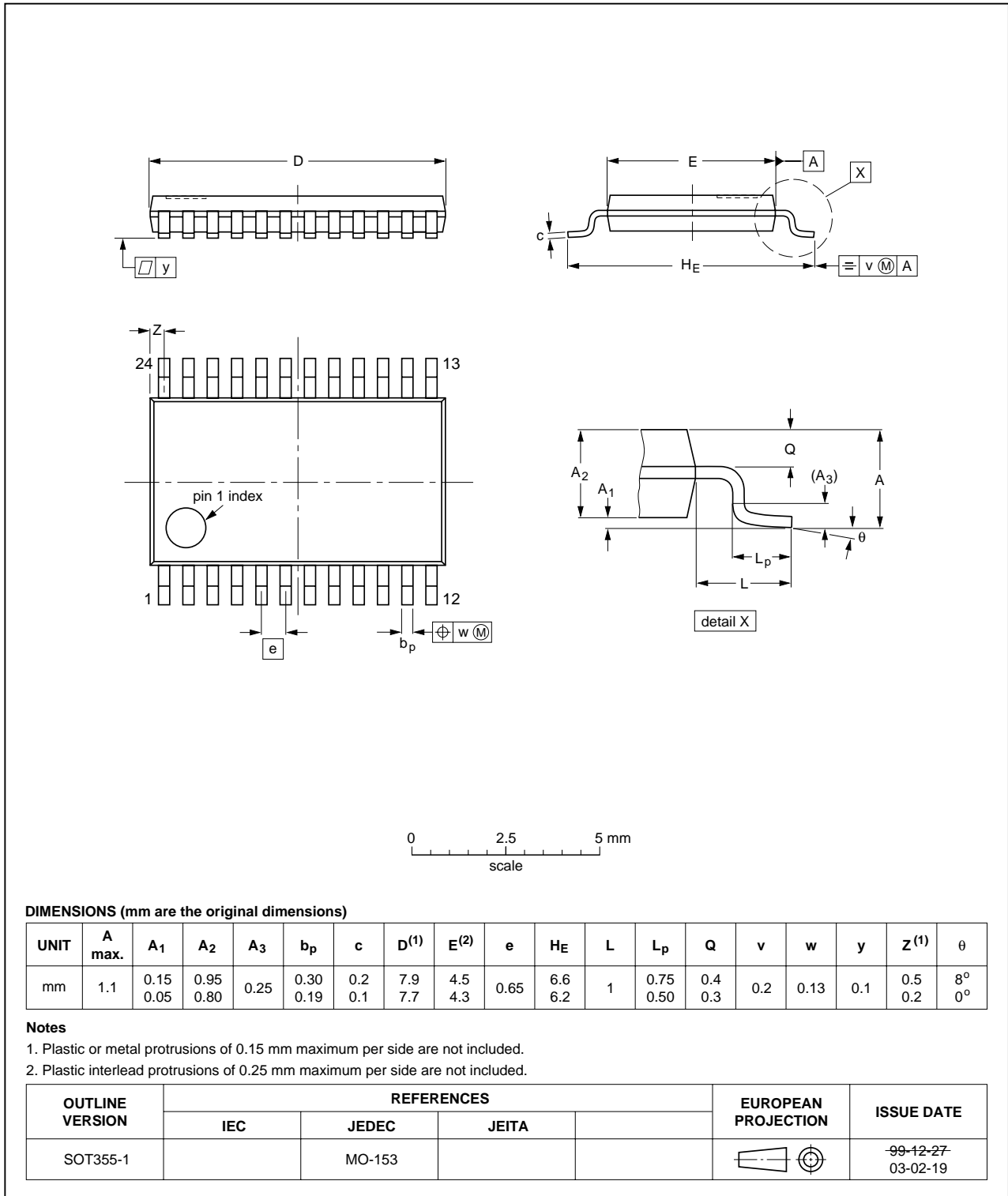


Fig 28. Package outline SOT355-1 (TSSOP24)



HVQFN24: plastic thermal enhanced very thin quad flat package; no leads; 24 terminals; body 4 x 4 x 0.85 mm

SOT616-1

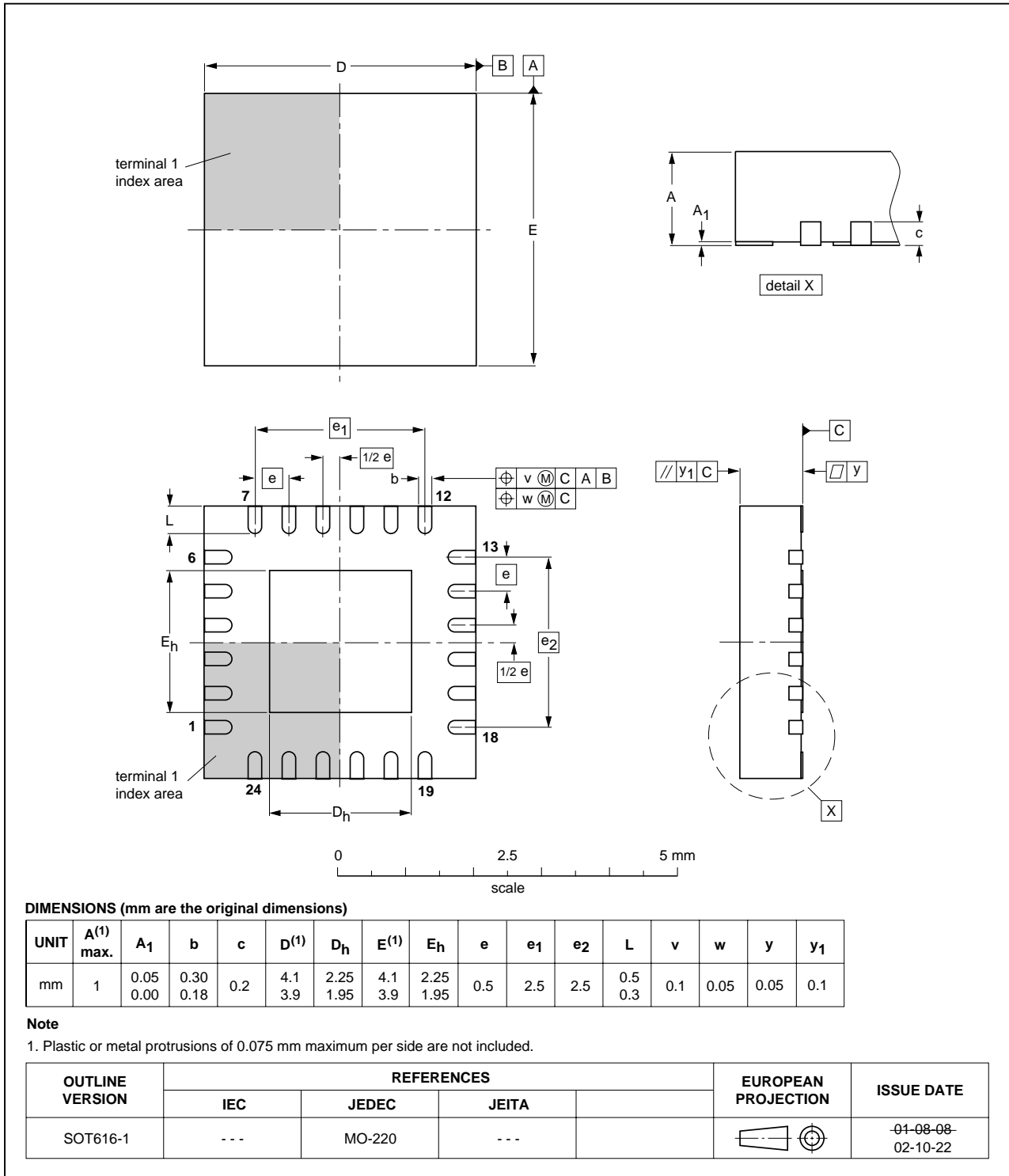


Fig 29. Package outline SOT616-1 (HVQFN24)

## 14. Handling information

Inputs and outputs are protected against electrostatic discharge in normal handling. However, to be completely safe you must take normal precautions appropriate to handling integrated circuits.

## 15. 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"*.

### 15.1 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.

### 15.2 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

### 15.3 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

### 15.4 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 30](#)) 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 17](#) and [18](#)

**Table 17. SnPb eutectic process (from J-STD-020C)**

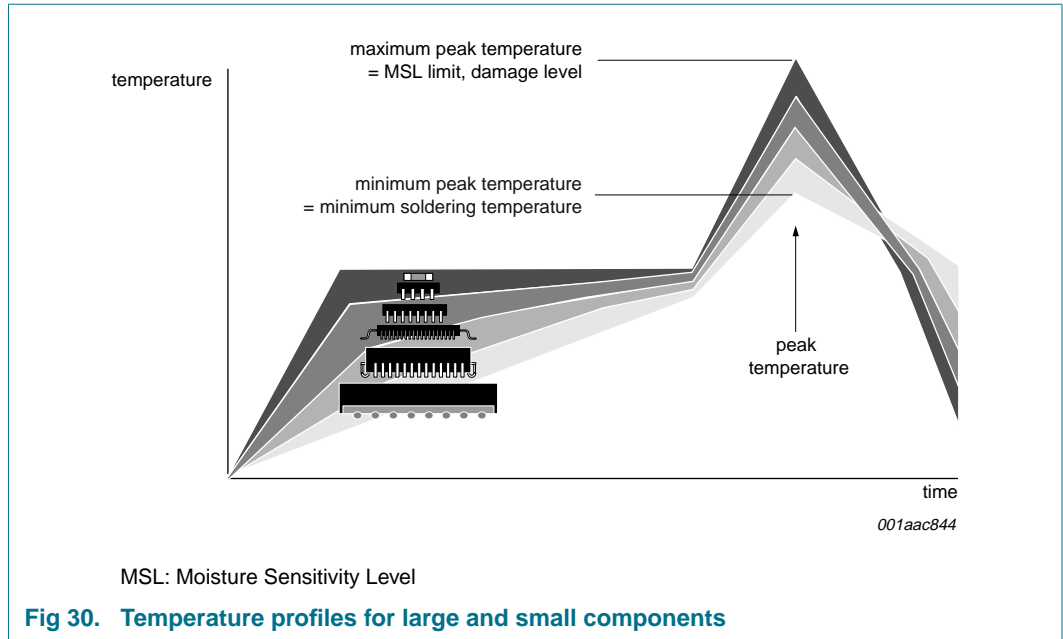
Package thickness (mm)	Package reflow temperature (°C)	
	Volume (mm <sup>3</sup> )	
	< 350	≥ 350
< 2.5	235	220
≥ 2.5	220	220

**Table 18. Lead-free process (from J-STD-020C)**

Package thickness (mm)	Package reflow temperature (°C)		
	Volume (mm <sup>3</sup> )		
	< 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 30](#).



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

## 16. Abbreviations

**Table 19. Abbreviations**

Acronym	Description
ACPI	Advanced Configuration and Power Interface
CBT	Cross-Bar Technology
CDM	Charged-Device Model
CMOS	Complementary Metal-Oxide Semiconductor
ESD	ElectroStatic Discharge
FET	Field-Effect Transistor
FF	Flip-Flop
GPIO	General Purpose Input/Output
HBM	Human Body Model
I <sup>2</sup> C-bus	Inter-Integrated Circuit bus
I/O	Input/Output
LED	Light Emitting Diode
MM	Machine Model
SMBus	System Management Bus

## 17. Revision history

**Table 20. Revision history**

Document ID	Release date	Data sheet status	Change notice	Supersedes
PCA9539_PCA9539R_5	20080728	Product data sheet	-	PCA9539_PCA9539R_4
Modifications:				
<ul style="list-style-type: none"> <li>• <a href="#">Section 1 “General description”</a>:           <ul style="list-style-type: none"> <li>– split (old) 4<sup>th</sup> paragraph to 2 (new) 4<sup>th</sup> and (new) 5<sup>th</sup> paragraphs</li> <li>– (new) 5<sup>th</sup> paragraph re-written</li> </ul> </li> <li>• <a href="#">Table 2 “Ordering options”</a>:           <ul style="list-style-type: none"> <li>– changed Topside mark for Type number PCA9539RPW from “PCA9539RPW” to “PA9539RPW”</li> <li>– changed Topside mark for Type number PCA9539RBS from “9539R” to “539R”</li> </ul> </li> </ul>				
PCA9539_PCA9539R_4	20080519	Product data sheet	-	PCA9539_3
PCA9539_3	20060921	Product data sheet	-	PCA9539_2
PCA9539_2 (9397 750 14048)	20040930	Product data sheet	-	PCA9539_1
PCA9539_1 (9397 750 12898)	20040827	Product data sheet	-	-

## 18. Legal information

### 18.1 Data sheet status

Document status <sup>[1][2]</sup>	Product status <sup>[3]</sup>	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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Date of release: 28 July 2008

Document identifier: PCA9539\_PCA9539R\_5