

# DATA SHEET

## **PCA9540** 2-channel I<sup>2</sup>C multiplexer

Product specification

1999 Dec 15

## 2-channel I<sup>2</sup>C multiplexer

# PCA9540

### FEATURES

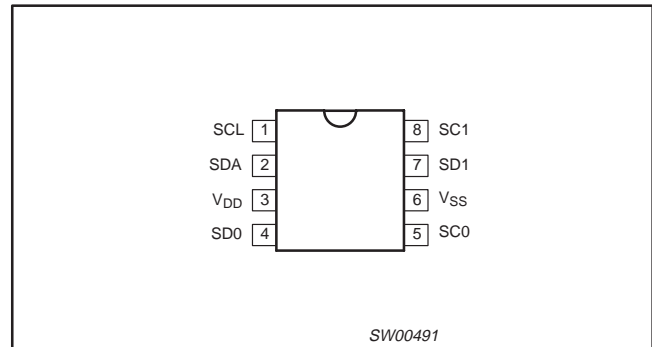
- 1-of-2 bi-directional translating multiplexer
- Channel selection via I<sup>2</sup>C bus
- Operating supply voltage 2.5 to 3.6 V
- Operating temperature range 0°C to 70°C
- Power-up with all multiplexer channels deselected
- Low on resistance

### DESCRIPTION

The PCA9540 is a 1-of-2 bi-directional translating multiplexer, controlled via the I<sup>2</sup>C bus. The SCL/SDA upstream pair fans out to two SCx/SDx downstream pairs, or channels. Only one SCx/SDx channel is selected at a time, determined by the contents of the programmable control register.

The pass gates of the multiplexer are constructed such that the V<sub>DD</sub> pin can be used to limit the maximum high voltage which will be passed by the PCA9540. This allows the use of different bus voltages on each SCx/SDx pair, so that 3.3 V parts can communicate with 5 V parts without any additional protection. External pull-up resistors can pull the bus up to the desired voltage level for this channel.

### PIN CONFIGURATION



### PIN DESCRIPTION

| PIN NUMBER | SYMBOL          | FUNCTION          |
|------------|-----------------|-------------------|
| 1          | SCL             | Serial clock line |
| 2          | SDA             | Serial data line  |
| 3          | V <sub>DD</sub> | Supply voltage    |
| 4          | SD0             | Serial data 0     |
| 5          | SC0             | Serial clock 0    |
| 6          | V <sub>SS</sub> | Supply ground     |
| 7          | SD1             | Serial data 1     |
| 8          | SC1             | Serial clock 1    |

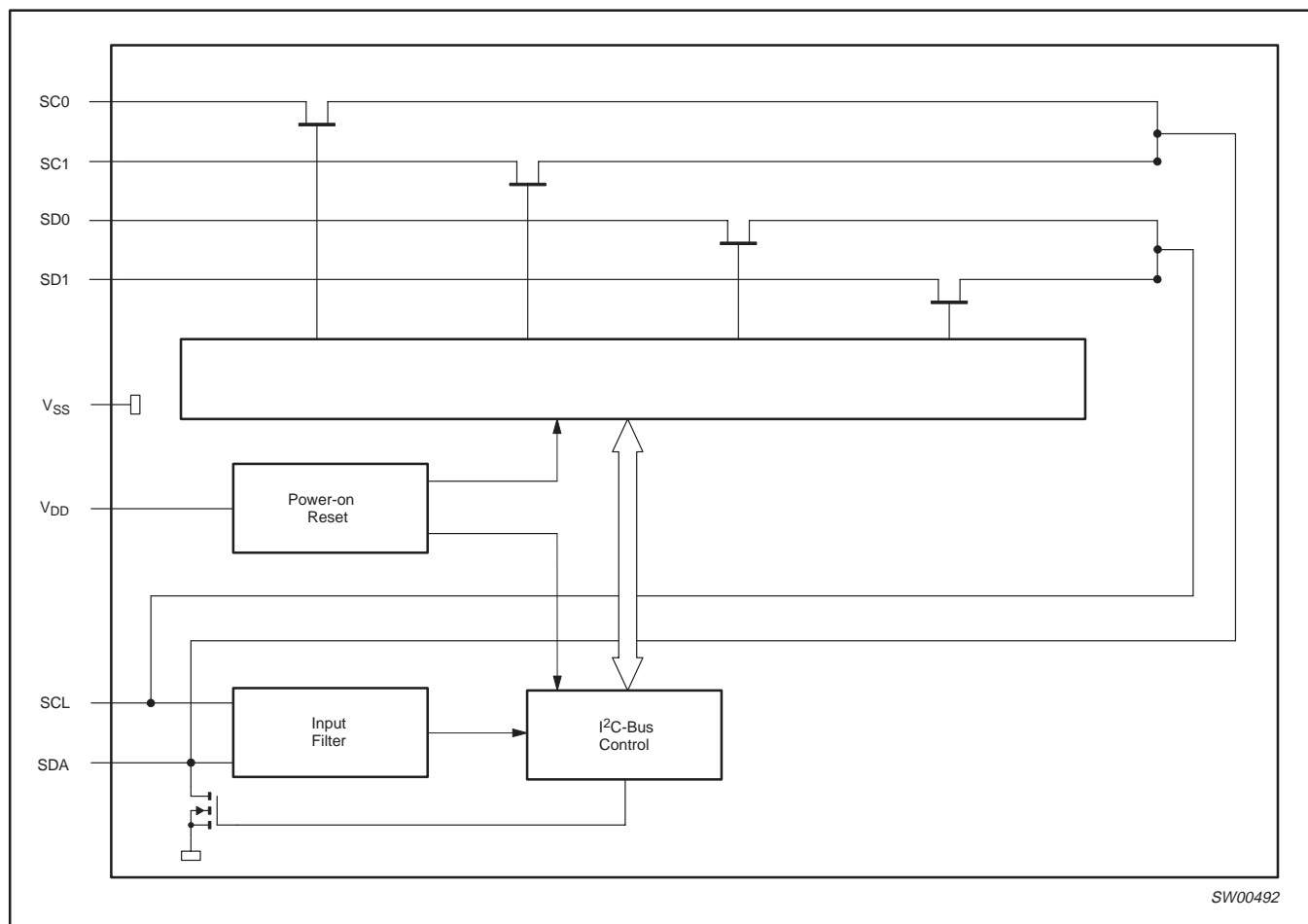
### ORDERING INFORMATION

| PACKAGES            | TEMPERATURE RANGE | ORDER CODE   | DRAWING NUMBER |
|---------------------|-------------------|--------------|----------------|
| 8-Pin Plastic SO    | 0°C to +70°C      | PCA9540D     | SOT96-1        |
| 8-Pin Plastic TSSOP | 0°C to +70°C      | PCA9540PW DH | SOT505-1       |

# 2-channel I<sup>2</sup>C multiplexer

# PCA9540

## BLOCK DIAGRAM



# 2-channel I<sup>2</sup>C multiplexer

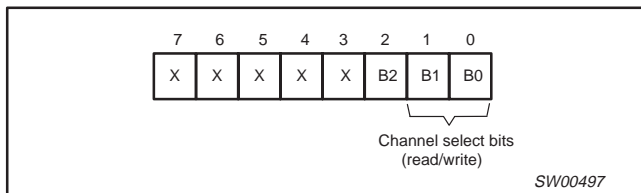
# PCA9540

## CHANNEL SELECTION

A SC0x/SD0x downstream pair, or channel, is selected by the contents of the control register. This register is written after the PCA9540 has been addressed. The 2 LSBs of the control byte are used to determine which channel is to be selected. When a channel is selected, the channel will become active after a stop condition has been placed on the I<sup>2</sup>C bus. This ensures that all SCx/SDx lines will be in a HIGH state when the channel is made active, so that no false conditions are generated at the time of connection.

| CONTROL BYTE |   |   |   |   |   |   |   | SELECTED CHANNEL |
|--------------|---|---|---|---|---|---|---|------------------|
| 7            | 6 | 5 | 4 | 3 | 2 | 1 | 0 |                  |
| X            | X | X | X | X | 0 | X | X | none             |
| X            | X | X | X | X | 1 | 0 | 0 | 0 (SC0/SD0)      |
| X            | X | X | X | X | 1 | 0 | 1 | 1 (SC1/SD1)      |

## CONTROL REGISTER



## POWER-ON RESET

During power-up the control register defaults to all zeroes causing all the channels to be deselected.

## 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.

### 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 1).

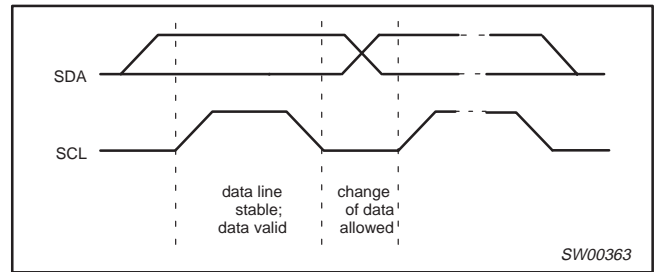


Figure 1. Bit transfer

### 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 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 3).

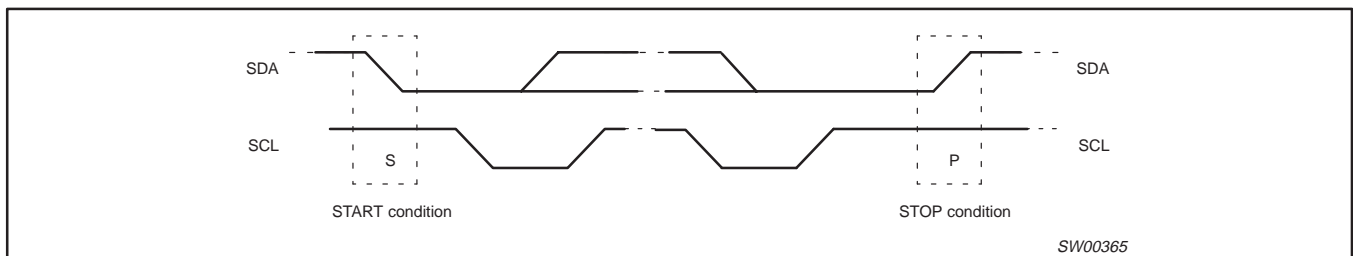


Figure 2. Definition of start and stop conditions

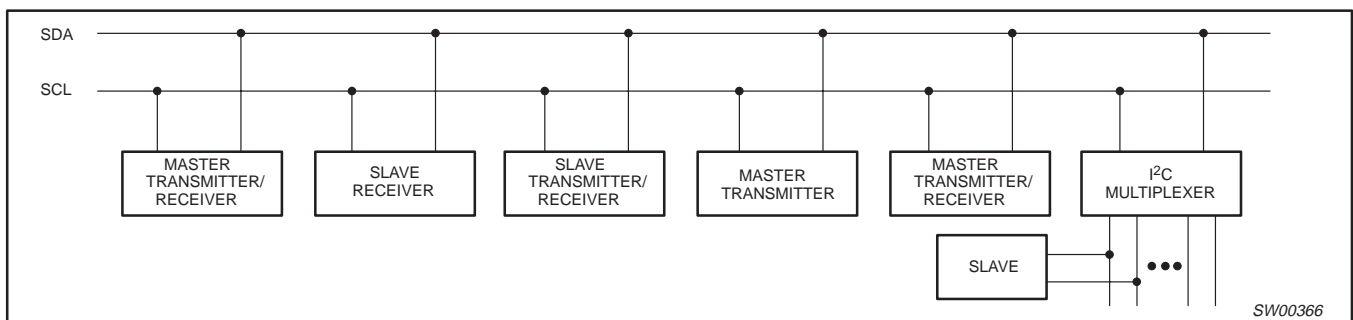


Figure 3. System configuration

# 2-channel I<sup>2</sup>C multiplexer

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## 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 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.

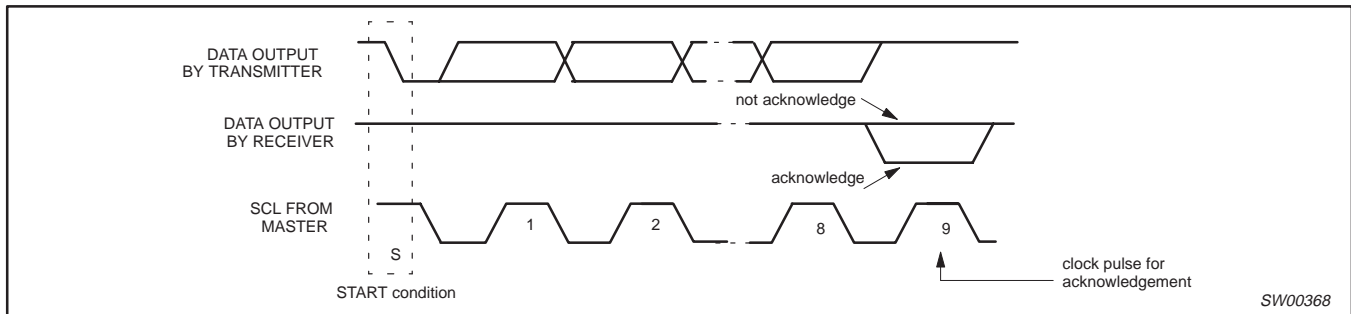


Figure 4. Acknowledgement on the I<sup>2</sup>C-bus

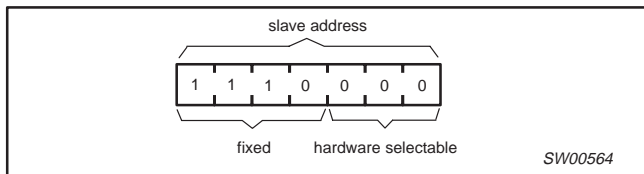


Figure 5. Slave address

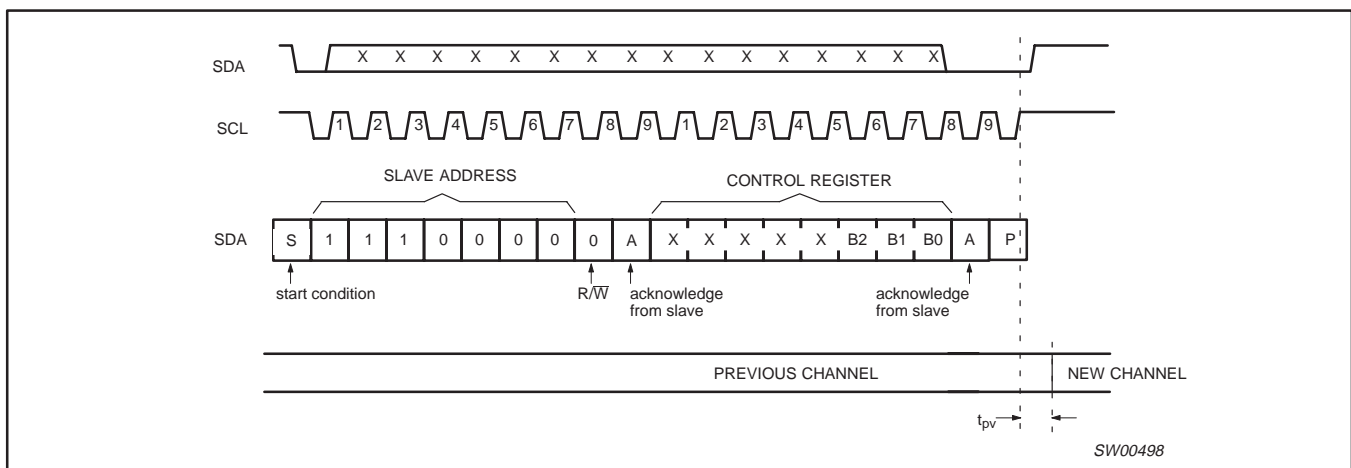


Figure 6. WRITE control register

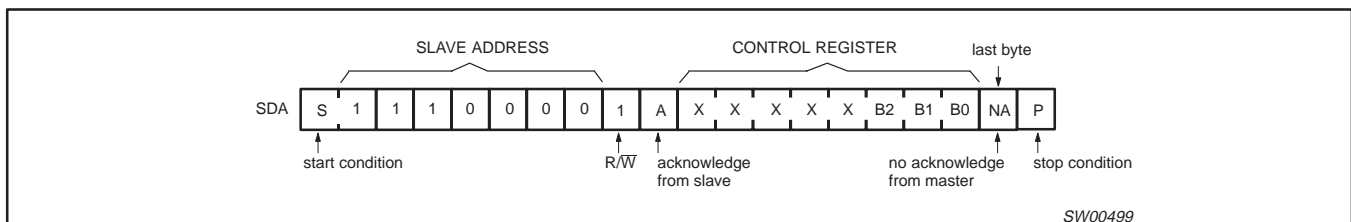


Figure 7. READ control register

2-channel I<sup>2</sup>C multiplexer

PCA9540

**ABSOLUTE MAXIMUM RATINGS<sup>1, 2</sup>**

In accordance with the Absolute Maximum Rating System (IEC 134). Voltages are referenced to GND (ground = 0 V).

| SYMBOL           | PARAMETER                     | CONDITIONS | RATING       | UNIT |
|------------------|-------------------------------|------------|--------------|------|
| V <sub>DD</sub>  | DC supply voltage             |            | -0.5 to +7.0 | V    |
| V <sub>I</sub>   | DC input voltage              |            | -0.5 to +7.0 | V    |
| I <sub>I</sub>   | DC input current              |            | ±20          | mA   |
| I <sub>O</sub>   | DC output current             |            | ±25          | mA   |
| I <sub>DD</sub>  | Supply current                |            | ±100         | mA   |
| I <sub>SS</sub>  | Supply current                |            | ±100         | mA   |
| P <sub>tot</sub> | total power dissipation       |            | 400          | mW   |
| T <sub>stg</sub> | Storage temperature range     |            | -60 to +150  | °C   |
| T <sub>amb</sub> | Operating ambient temperature |            | 0 to +70     | °C   |

**NOTES:**

- Stresses beyond those listed may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- The performance capability of a high-performance integrated circuit in conjunction with its thermal environment can create junction temperatures which are detrimental to reliability. The maximum junction temperature of this integrated circuit should not exceed 150°C.

**DC CHARACTERISTICS**V<sub>DD</sub> = 2.5 to 3.6 V; V<sub>SS</sub> = 0 V; T<sub>amb</sub> = 0°C to +70°C; unless otherwise specified.

| SYMBOL                                       | PARAMETER                | TEST CONDITIONS  | LIMITS              |     |                       | UNIT |
|--|--------------------------|--|---------------------|-----|-----------------------|------|
|  |                          |  | MIN                 | TYP | MAX                   |      |
| <b>Supply</b>                                |                          |  |                     |     |                       |      |
| V <sub>DDQn</sub> ≤ V <sub>DD</sub>          | Supply voltage           |  | 2.5                 |     | 3.6                   | V    |
| I <sub>DD</sub>                              | Supply current           | Operating mode; V <sub>DD</sub> = 3.6 V;<br>no load; V <sub>I</sub> = V <sub>DD</sub> or V <sub>SS</sub> ;<br>f <sub>SCL</sub> = 100 kHz | -                   | 20  | 100                   | μA   |
| I <sub>DP</sub>                              | Power on current         | Power on mode with no channels selected  | -                   | 140 | 200                   | μA   |
| I <sub>stb</sub>                             | Standby current          | Standby mode; V <sub>DD</sub> = 3.6 V;<br>no load; V <sub>I</sub> = V <sub>DD</sub> or V <sub>SS</sub>                                   | -                   | 2.5 | 100                   | μA   |
| V <sub>POR</sub>                             | Power-on reset voltage   | V <sub>DD</sub> = 3.6 V; no load;<br>V <sub>I</sub> = V <sub>DD</sub> or V <sub>SS</sub>   | -                   | 1.3 | 2.1                   | V    |
| <b>Input SCL; input/output SDA</b>           |                          |  |                     |     |                       |      |
| V <sub>IL</sub>                              | LOW level input voltage  |  | -0.5                | -   | 0.3 V <sub>DD</sub>   | V    |
| V <sub>IH</sub>                              | HIGH level input voltage |  | 0.3 V <sub>DD</sub> | -   | 6                     | V    |
| I <sub>OL</sub>                              | LOW level output current | V <sub>OL</sub> = 0.4 V  | 3                   | -   | -                     | mA   |
|  |                          | V <sub>OL</sub> = 0.6 V  | 6                   | -   | -                     | mA   |
| I <sub>L</sub>                               | Leakage current          | V <sub>I</sub> = V <sub>DD</sub> or V <sub>SS</sub>  | -1                  | -   | +1                    | μA   |
| C <sub>i</sub>                               | Input capacitance        | V <sub>I</sub> = V <sub>SS</sub>   | -                   | -   | 10                    | pF   |
| <b>Select inputs A0 to A2 / INT0 to INT3</b> |                          |  |                     |     |                       |      |
| V <sub>IL</sub>                              | LOW level input voltage  |  | -0.5                | -   | +0.3 V <sub>DD</sub>  | V    |
| V <sub>IH</sub>                              | HIGH level input voltage |  | 0.7 V <sub>DD</sub> | -   | V <sub>DD</sub> + 0.5 | V    |
| I <sub>LI</sub>                              | Input leakage current    | pin at V <sub>DD</sub> or V <sub>SS</sub>  | -1                  | -   | +1                    | μA   |
| <b>Pass Gate</b>                             |                          |  |                     |     |                       |      |
| R <sub>ON</sub>                              | Switch resistance        | V <sub>CC</sub> = 3.67 V, V <sub>O</sub> = 0.4 V, I <sub>O</sub> = 15 mA   | 5                   | 20  | 21                    | Ω    |
|  |                          | V <sub>CC</sub> = 2.3 to 2.7 V, V <sub>O</sub> = 0.4 V, I <sub>O</sub> = 10 mA   | 7                   | 26  | 55                    |      |
| V <sub>Pass</sub>                            | Switch output voltage    | V <sub>swin</sub> = V <sub>DD</sub> = 3.3 V; I <sub>swout</sub> = -100 μA  |                     | 2.2 |                       | V    |
|  |                          | V <sub>swin</sub> = V <sub>DD</sub> = 3.0 to 3.6 V; I <sub>swout</sub> = -100 μA   | 1.6                 |     | 2.8                   |      |
|  |                          | V <sub>swin</sub> = V <sub>DD</sub> = 2.5 V; I <sub>swout</sub> = -100 μA  |                     | 1.5 |                       |      |
|  |                          | V <sub>swin</sub> = V <sub>DD</sub> = 2.3 to 2.7 V; I <sub>swout</sub> = -100 μA   | 1.1                 |     | 2.0                   |      |

# 2-channel I<sup>2</sup>C multiplexer

PCA9540

## AC CHARACTERISTICS

| SYMBOL              | PARAMETER   | STANDARD-MODE I <sup>2</sup> C-BUS |                  | FAST-MODE I <sup>2</sup> C-BUS      |                  | UNIT |
|---------------------|---|------------------------------------|------------------|-------------------------------------|------------------|------|
|                     |   | MIN                                | MAX              | MIN                                 | MAX              |      |
| t <sub>pd</sub>     | Propagation delay from SDA to SD <sub>n</sub> or SCL to SC <sub>n</sub>                       |                                    | 0.3 <sup>1</sup> |                                     | 0.3 <sup>1</sup> | ns   |
| 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<br>After this period, the first clock pulse is generated | 4.0                                | –                | 0.6                                 | –                | μs   |
| 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>SU:STA</sub> | Set-up time for a repeated START condition  | 4.7                                | –                | 0.6                                 |                  | μs   |
| t <sub>HD:DAT</sub> | Data hold time:<br>for CBUS compatible masters<br>for I <sup>2</sup> C-bus devices            | 5.0                                | –                | –                                   | –                | μs   |
|                     |   | 0 <sup>2</sup>                     | –                | 0 <sup>2</sup>                      | 0.9 <sup>3</sup> | μs   |
| t <sub>SU:DAT</sub> | Data set-up time  | 250                                | –                | 100 <sup>4</sup>                    | –                | ns   |
| t <sub>SU:STO</sub> | Set-up time for STOP condition  | –                                  | 1000             | 20 + 0.1C <sub>b</sub> <sup>5</sup> | 300              | ns   |
| t <sub>r</sub>      | Rise time of both SDA and SCL signals   | –                                  | 300              | 20 + 0.1C <sub>b</sub> <sup>5</sup> | 300              | ns   |
| t <sub>f</sub>      | Fall time of both SDA and SCL signals   | 4.0                                | –                | 0.6                                 | –                | μs   |
| C <sub>b</sub>      | Capacitive load for each bus line   |                                    | 400              | –                                   | 400              | pF   |

**NOTES:**

1. Pass gate propagation delay is calculated from the 20 Ω typical R<sub>ON</sub> and and the 15 pF load capacitance.
2. A device must internally provide a hold time of at least 300 ns for the SDA signal (referred to the V<sub>IHmin</sub> of the SCL signal) in order to bridge the undefined region of the falling edge of SCL.
3. The maximum t<sub>HD:DAT</sub> has only to be met if the device does not stretch the LOW period (t<sub>LOW</sub>) of the SCL signal.
4. A fast-mode I<sup>2</sup>C bus device can be used in a standard-mode I<sup>2</sup>C-bus system, but the requirement t<sub>SU:DAT</sub> ≥ 250 ns must then be met. This will automatically be the case if the device does not stretch the LOW period of the SCL signal. If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line t<sub>rmax</sub> + t<sub>SU:DAT</sub> = 1000 + 250 = 1250 ns (according to the standard-mode I<sup>2</sup>C-bus specification) before the SCL line is released.
5. C<sub>b</sub> = total capacitance of one bus line in pF.

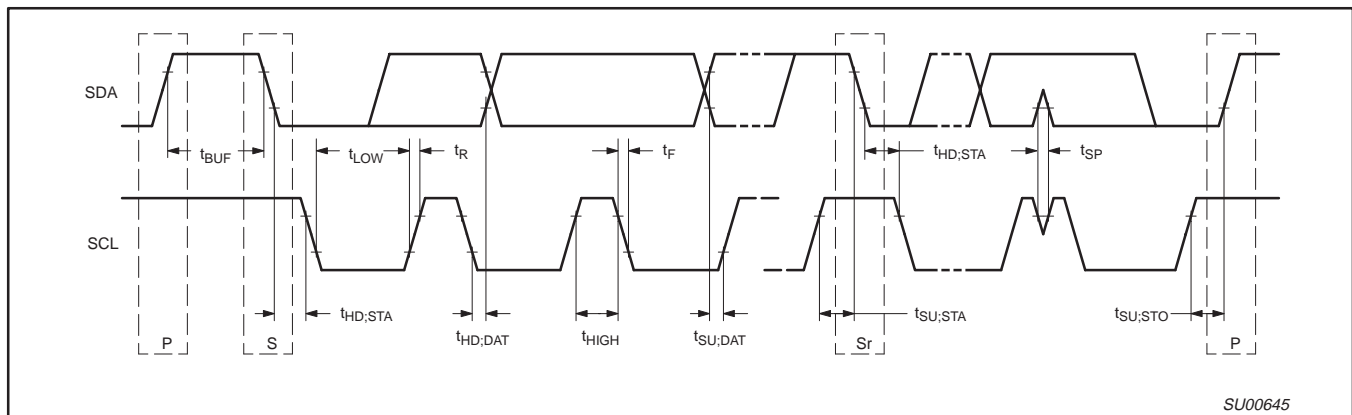


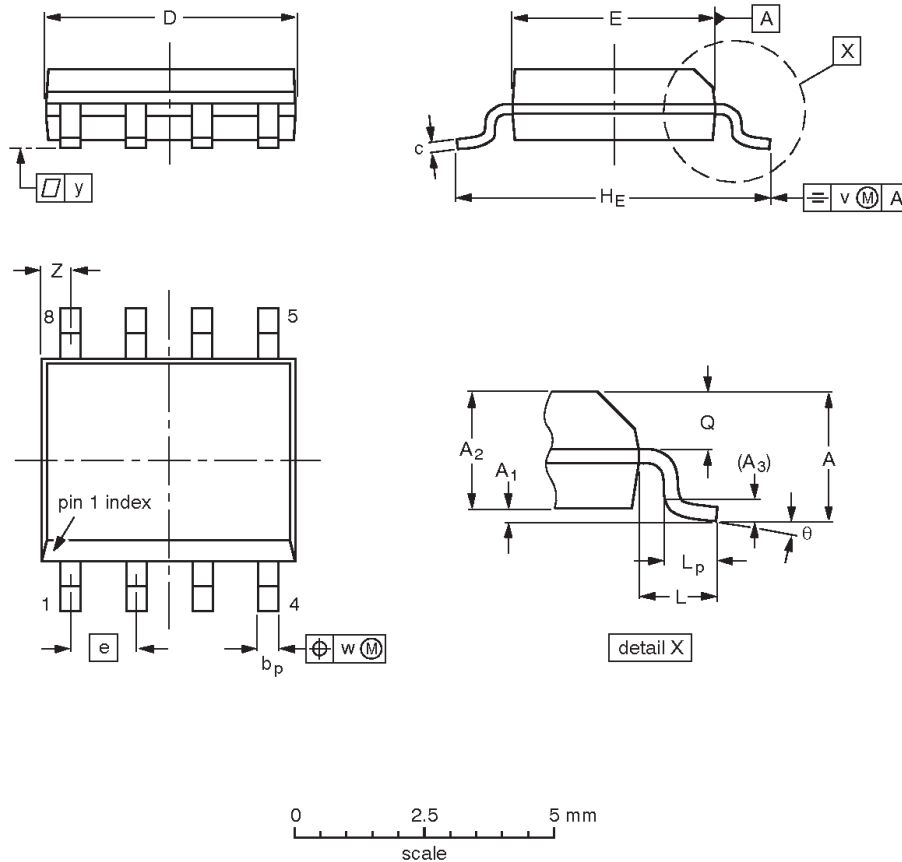
Figure 8. Definition of timing on the I<sup>2</sup>C-bus

# 2-channel I<sup>2</sup>C multiplexer

# PCA9540

**S08: plastic small outline package; 8 leads; body width 3.9mm**

**SOT96-1**



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

| UNIT   | A max. | A <sub>1</sub> | A <sub>2</sub> | A <sub>3</sub> | b <sub>p</sub> | c                | D <sup>(1)</sup> | E <sup>(2)</sup> | e     | H <sub>E</sub> | L     | L <sub>p</sub> | Q              | v    | w    | y     | Z <sup>(1)</sup> | θ        |
|--------|--------|----------------|----------------|----------------|----------------|------------------|------------------|------------------|-------|----------------|-------|----------------|----------------|------|------|-------|------------------|----------|
| mm     | 1.75   | 0.25<br>0.10   | 1.45<br>1.25   | 0.25           | 0.49<br>0.36   | 0.25<br>0.19     | 5.0<br>4.8       | 4.0<br>3.8       | 1.27  | 6.2<br>5.8     | 1.05  | 1.0<br>0.4     | 0.7<br>0.6     | 0.25 | 0.25 | 0.1   | 0.7<br>0.3       | 8°<br>0° |
| inches | 0.069  | 0.010<br>0.004 | 0.057<br>0.049 | 0.01           | 0.019<br>0.014 | 0.0100<br>0.0075 | 0.20<br>0.19     | 0.16<br>0.15     | 0.050 | 0.244<br>0.228 | 0.041 | 0.039<br>0.016 | 0.028<br>0.024 | 0.01 | 0.01 | 0.004 | 0.028<br>0.012   |          |

**Notes**

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

| OUTLINE VERSION | REFERENCES |          |      |  | EUROPEAN PROJECTION | ISSUE DATE           |
|-----------------|------------|----------|------|--|---------------------|----------------------|
|                 | IEC        | JEDEC    | EIAJ |  |                     |                      |
| SOT96-1         | 076E03S    | MS-012AA |      |  |                     | 95-02-04<br>97-05-22 |

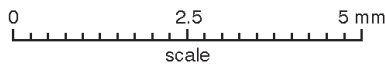
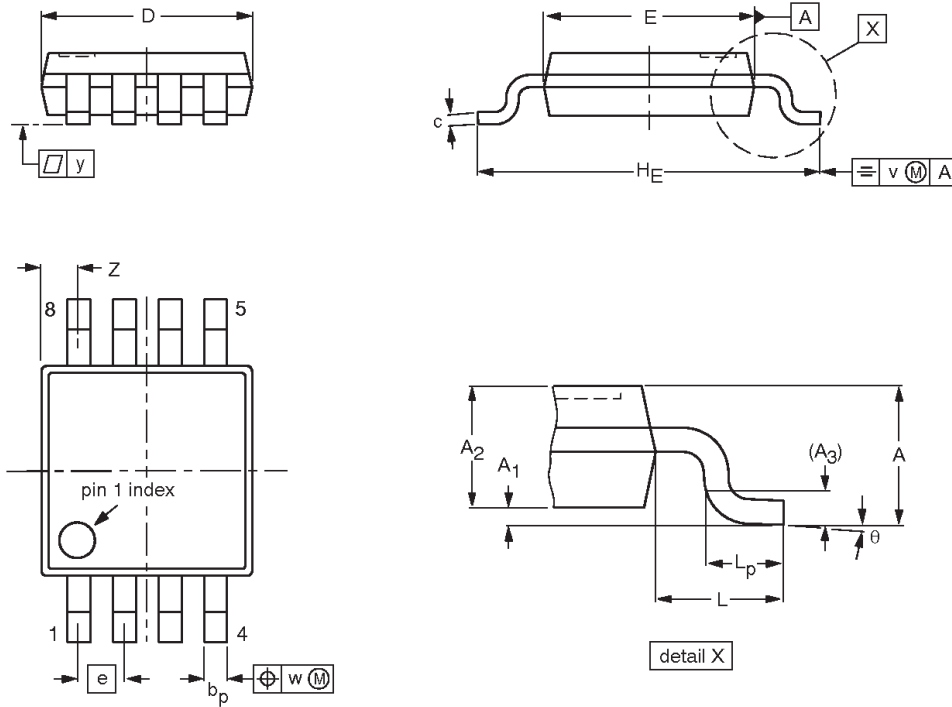


# 2-channel I<sup>2</sup>C multiplexer

# PCA9540

**TSSOP8: plastic thin shrink small outline package; 8 leads; body width 3 mm**

**SOT505-1**



**DIMENSIONS (mm are the original dimensions)**

| UNIT | A max. | A <sub>1</sub> | A <sub>2</sub> | A <sub>3</sub> | b <sub>p</sub> | c            | D <sup>(1)</sup> | E <sup>(2)</sup> | e    | H <sub>E</sub> | L    | L <sub>p</sub> | v   | w   | y   | Z <sup>(1)</sup> | θ        |
|------|--------|----------------|----------------|----------------|----------------|--------------|------------------|------------------|------|----------------|------|----------------|-----|-----|-----|------------------|----------|
| mm   | 1.10   | 0.15<br>0.05   | 0.95<br>0.80   | 0.25           | 0.45<br>0.25   | 0.28<br>0.15 | 3.10<br>2.90     | 3.10<br>2.90     | 0.65 | 5.10<br>4.70   | 0.94 | 0.70<br>0.40   | 0.1 | 0.1 | 0.1 | 0.70<br>0.35     | 6°<br>0° |

**Notes**

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

| OUTLINE VERSION | REFERENCES |       |      |  | EUROPEAN PROJECTION | ISSUE DATE |
|-----------------|------------|-------|------|--|---------------------|------------|
|                 | IEC        | JEDEC | EIAJ |  |                     |            |
| SOT505-1        |            |       |      |  |                     | 99-04-09   |

2-channel I<sup>2</sup>C multiplexer

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Purchase of Philips I<sup>2</sup>C components conveys a license under the Philips' I<sup>2</sup>C patent to use the components in the I<sup>2</sup>C system provided the system conforms to the I<sup>2</sup>C specifications defined by Philips. This specification can be ordered using the code 9398 393 40011.

## Data sheet status

| Data sheet status         | Product status | Definition [1]   |
|---------------------------|----------------|--|
| Objective specification   | Development    | This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice.  |
| Preliminary specification | Qualification  | This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product. |
| Product specification     | Production     | This data sheet contains final specifications. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.   |

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

## Definitions

**Short-form specification** — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

**Limiting values definition** — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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