

# PCA9654E, PCA9654EA

## 8-bit I/O Expander for I<sup>2</sup>C Bus and SMBus with Interrupt

The PCA9654E/PCA9654EA provides 8 bits of General Purpose parallel Input/Output (GPIO) expansion for I<sup>2</sup>C-bus/SMBus applications.

The PCA9654E/PCA9654EA consists of 8-bit Configuration (Input or Output selection), Input, Output and Polarity Inversion (active HIGH or active LOW operation) registers. The system master may set 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 PCA9654E/PCA9654EA open-drain interrupt ( $\overline{\text{INT}}$ ) 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.

Three hardware pins (AD0, AD1, AD2) vary the fixed I<sup>2</sup>C bus address and allow up to 64 devices to share the same I<sup>2</sup>C-bus/SMBus. The PCA9654EA has a different address map from the PCA9654E.

### Features

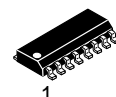
- V<sub>DD</sub> Operating Range: 1.65 V to 5.5 V
- SDA Sink Capability: 30 mA
- 5.5 V Tolerant I/Os
- Polarity Inversion Register
- Active LOW Interrupt Output
- Low Standby Current
- Noise Filter on SCL/SDA Inputs
- No Glitch on Power-up
- Internal Power-on Reset
- 64 Programmable Slave Addresses Using 3 Address Pins
- 8 I/O Pins which Default to 8 Inputs
- I<sup>2</sup>C SCL Clock Frequencies Supported:
  - Standard Mode: 100 kHz
  - Fast Mode: 400 kHz
  - Fast Mode +: 1 MHz
- ESD Performance: 4000 V Human Body Model, 400 V Machine Model
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

This document contains information on some products that are still under development. ON Semiconductor reserves the right to change or discontinue these products without notice.

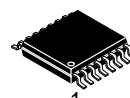
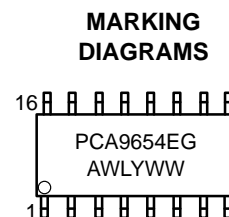


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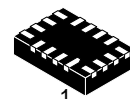
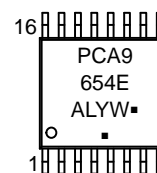
[www.onsemi.com](http://www.onsemi.com)



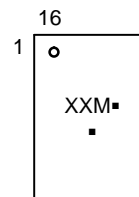
SOIC-16  
D SUFFIX  
CASE 751B



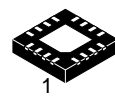
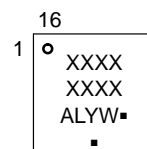
TSSOP-16  
DT SUFFIX  
CASE 948F



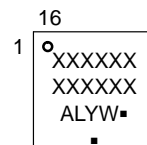
WQFN16  
MT SUFFIX  
CASE 488AP



QFN16 3x3  
MN SUFFIX  
CASE 485G



QFN16 4x4  
MN SUFFIX  
CASE 485AP



XXXX = Specific Device Code  
A = Assembly Location  
M = Date Code / Assembly Location  
WL, L = Wafer Lot  
Y = Year  
WW, W = Work Week  
G or ▪ = Pb-Free Package

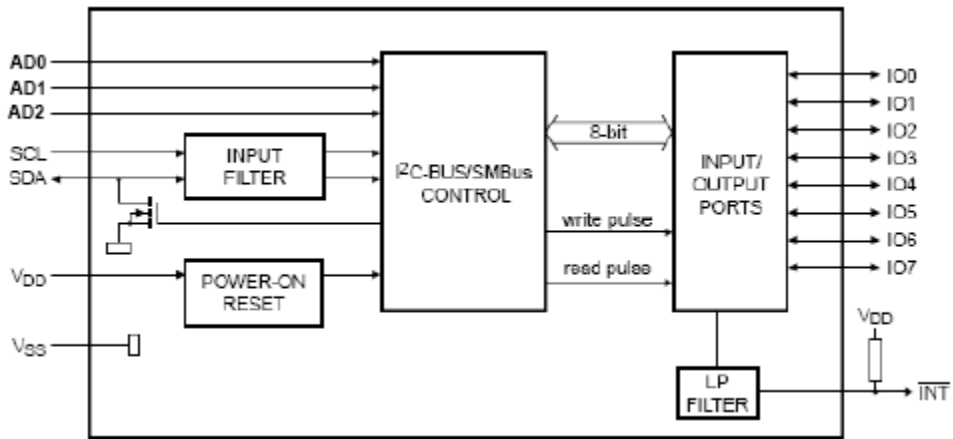
(Note: Microdot may be in either location)

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 17 of this data sheet.

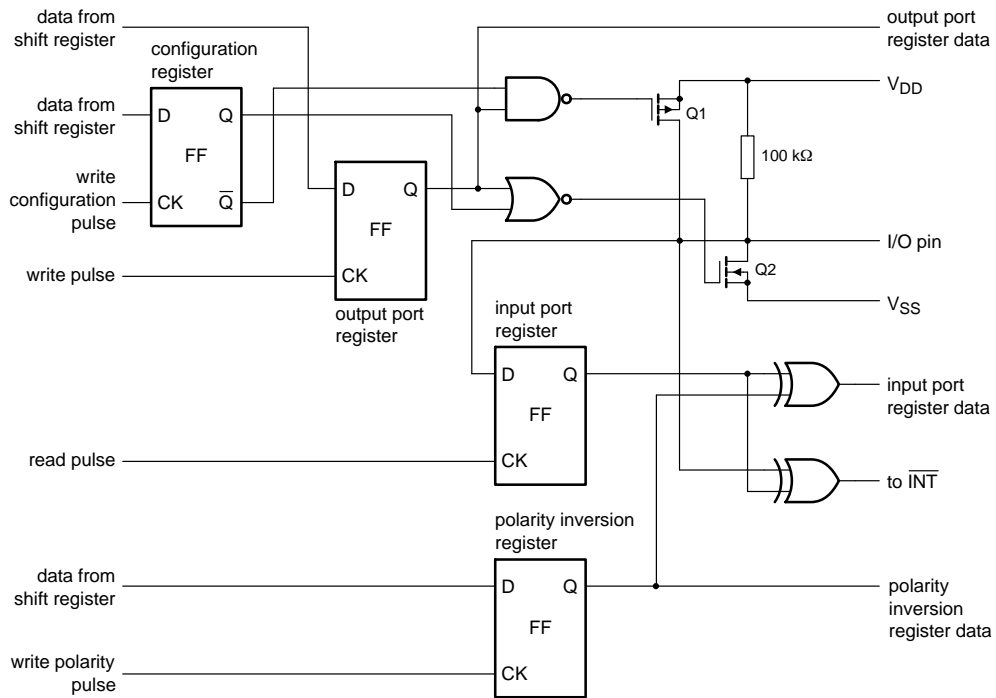
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## BLOCK DIAGRAM



Remark: All I/Os are set to inputs at reset.

Figure 1. Block Diagram



At power-on reset, all registers return to default values.

Figure 2. Simplified Schematic of I/Os

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## PIN ASSIGNMENT

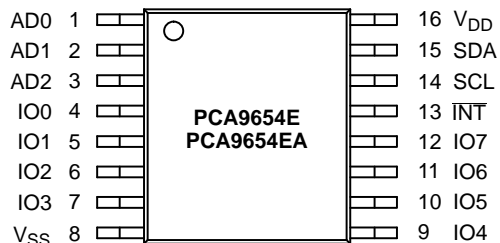
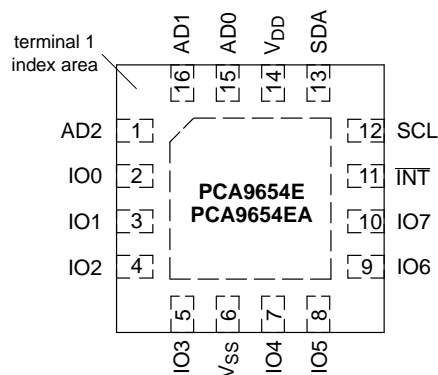


Figure 3. SOIC16 / TSSOP16



Transparent top view

Figure 4. WQFN16 / QFN16

Table 1. PIN DESCRIPTIONS

| Symbol          | Pin             |               | Description                   |
|-----------------|-----------------|---------------|-------------------------------|
|                 | SOIC16, TSSOP16 | QFN16, WQFN16 |                               |
| AD0             | 1               | 15            | Address Input 0               |
| AD1             | 2               | 16            | Address Input 1               |
| AD2             | 3               | 1             | Address Input 2               |
| IO0             | 4               | 2             | I/O 0                         |
| IO1             | 5               | 3             | I/O 1                         |
| IO2             | 6               | 4             | I/O 2                         |
| IO3             | 7               | 5             | I/O 3                         |
| V <sub>SS</sub> | 8               | 6             | Supply Ground                 |
| IO4             | 9               | 7             | I/O 4                         |
| IO5             | 10              | 8             | I/O 5                         |
| IO6             | 11              | 9             | I/O 6                         |
| IO7             | 12              | 10            | I/O 7                         |
| INT             | 13              | 11            | Interrupt Output (active-LOW) |
| SCL             | 14              | 12            | Serial Clock Line             |
| SDA             | 15              | 13            | Serial Data Line              |
| V <sub>DD</sub> | 16              | 14            | Supply Voltage                |

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**Table 2. MAXIMUM RATINGS**

| Symbol               | Parameter   | Value  | Unit                        |      |
|----------------------|---|--|-----------------------------|------|
| V <sub>DD</sub>      | DC Supply Voltage   | -0.5 to +7.0   | V                           |      |
| V <sub>I/O</sub>     | Input / Output Pin Voltage  | -0.5 to +7.0   | V                           |      |
| I <sub>I</sub>       | Input Current   | ± 20   | mA                          |      |
| I <sub>O</sub>       | Output Current  | ± 50   | mA                          |      |
| I <sub>DD</sub>      | DC Supply Current   | ± 100  | mA                          |      |
| I <sub>GND</sub>     | DC Ground Current   | ± 200  | mA                          |      |
| P <sub>TOT</sub>     | Total Power Dissipation   | 400  | mW                          |      |
| P <sub>OUT</sub>     | Power Dissipation per Output  | 100  | mW                          |      |
| T <sub>STG</sub>     | Storage Temperature Range   | -65 to +150  | °C                          |      |
| T <sub>L</sub>       | Lead Temperature, 1 mm from Case for 10 Seconds                           | 260  | °C                          |      |
| T <sub>J</sub>       | Junction Temperature Under Bias   | 150  | °C                          |      |
| θ <sub>JA</sub>      | Thermal Resistance  | SOIC-16 (Note 1)<br>TSSOP-16<br>WQFN16<br>3 x 3 QFN16<br>4 x 4 QFN16                 | 82<br>124<br>79<br>80<br>80 | °C/W |
| P <sub>D</sub>       | Power Dissipation in Still Air at 85°C                                    | 190  | mW                          |      |
| MSL                  | Moisture Sensitivity  | Level 1  |                             |      |
| F <sub>R</sub>       | Flammability Rating   | Oxygen Index: 28 to 34   | UL 94 V-0 @ 0.125 in        |      |
| V <sub>ESD</sub>     | ESD Withstand Voltage   | Human Body Model (Note 2)<br>Machine Model (Note 3)<br>Charged Device Model (Note 4) | > 4000<br>> 400<br>N/A      | V    |
| I <sub>LATCHUP</sub> | Latchup Performance Above V <sub>CC</sub> and Below GND at 125°C (Note 5) | ± 300  | mA                          |      |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Measured with minimum pad spacing on an FR4 board, using 10 mm-by-1 inch, 2 ounce copper trace no air flow.
2. Tested to EIA / JESD22-A114-A.
3. Tested to EIA / JESD22-A115-A.
4. Tested to JESD22-C101-A.
5. Tested to EIA / JESD78.

**Table 3. RECOMMENDED OPERATING CONDITIONS**

| Symbol           | Parameter                      | Min  | Max  | Unit |
|------------------|--------------------------------|------|------|------|
| V <sub>DD</sub>  | Positive DC Supply Voltage     | 1.65 | 5.5  | V    |
| V <sub>I/O</sub> | Switch Input / Output Voltage  | 0    | 5.5  | V    |
| T <sub>A</sub>   | Operating Free-Air Temperature | -55  | +125 | °C   |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

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**Table 4. DC ELECTRICAL CHARACTERISTICS**  $V_{DD} = 1.65\text{ V to }5.5\text{ V}$ , unless otherwise specified.

| Symbol | Parameter | Conditions | $T_A = -55^\circ\text{C to }+125^\circ\text{C}$ |     |     | Unit |
|--------|-----------|------------|---|-----|-----|------|
|        |           |            | Min   | Typ | Max |      |

### SUPPLIES

|           |                                 |  |  |             |            |               |
|-----------|---------------------------------|--|--|-------------|------------|---------------|
| $I_{DD}$  | Supply Current                  | Operating mode; no load;<br>$V_I = V_{DD}$ or 0 V; $f_{SCL} = 1\text{ MHz}$<br>$V_I = V_{DD}$ or 0 V; $f_{SCL} = 100\text{ kHz}$                 |  | 250<br>104  | 500<br>175 | $\mu\text{A}$ |
| $I_{STB}$ | Standby Current                 | Standby mode; no load;<br>$V_I = 0\text{ V}$ ; $f_{SCL} = 0\text{ Hz}$ ; I/O = inputs<br>$V_I = V_{DD}$ ; $f_{SCL} = 0\text{ Hz}$ ; I/O = inputs |  | 550<br>0.25 | 700<br>1   | $\mu\text{A}$ |
| $V_{POR}$ | Power-On Reset Voltage (Note 6) |  |  | 1.5         |            | V             |

### INPUT SCL; Input / Output SDA

|          |                          |  |                     |  |                     |               |
|----------|--------------------------|--|---------------------|--|---------------------|---------------|
| $V_{IH}$ | High-Level Input Voltage |  | $0.7 \times V_{DD}$ |  |                     | V             |
| $V_{IL}$ | Low-Level Input Voltage  |  |                     |  | $0.3 \times V_{DD}$ | V             |
| $I_{OL}$ | Low-Level Output Current | $V_{OL} = 0.4\text{ V}$ ; $V_{DD} < 2.3\text{ V}$    | 10                  |  |                     | mA            |
|          |                          | $V_{OL} = 0.4\text{ V}$ ; $V_{DD} \geq 2.3\text{ V}$ | 20                  |  |                     |               |
| $I_L$    | Leakage Current          | $V_I = V_{DD}$ or GND                                |                     |  | $\pm 1$             | $\mu\text{A}$ |
| $C_I$    | Input Capacitance        | $V_I = \text{GND}$                                   |                     |  | 6                   | pF            |

### I/Os

|               |  |   |                            |     |                            |               |
|---------------|--|---|----------------------------|-----|----------------------------|---------------|
| $V_{IH}$      | High-Level Input Voltage                   | $2.3\text{ V} \leq V_{CC} \leq 5.5\text{ V}$<br>$1.65\text{ V} \leq V_{CC} \leq 2.3\text{ V}$ | 2.0<br>$0.7 \times V_{DD}$ |     |                            | V             |
| $V_{IL}$      | Low-Level Input Voltage                    | $2.3\text{ V} \leq V_{CC} \leq 5.5\text{ V}$<br>$1.65\text{ V} \leq V_{CC} \leq 2.3\text{ V}$ |                            |     | 0.8<br>$0.3 \times V_{DD}$ | V             |
| $I_{OL}$      | Low-Level Output Current<br>(Note 7)       | $V_{OL} = 0.5\text{ V}$ ; $V_{DD} = 1.65\text{ V}$  | 8                          | 13  |                            | mA            |
|               |  | $V_{OL} = 0.5\text{ V}$ ; $V_{DD} = 2.3\text{ V}$   | 12                         | 22  |                            |               |
|               |  | $V_{OL} = 0.5\text{ V}$ ; $V_{DD} = 3.0\text{ V}$   | 17                         | 28  |                            |               |
|               |  | $V_{OL} = 0.5\text{ V}$ ; $V_{DD} = 4.5\text{ V}$   | 25                         | 37  |                            |               |
|               |  |   |                            |     |                            |               |
| $I_{OL(tot)}$ | Total Low-Level Output Current<br>(Note 7) | $V_{OL} = 0.5\text{ V}$ ; $V_{DD} = 4.5\text{ V}$   |                            |     | 200                        | mA            |
| $V_{OH}$      | High-Level Output Voltage                  | $I_{OH} = -3\text{ mA}$ ; $V_{DD} = 1.65\text{ V}$  | 1.2                        |     |                            | V             |
|               |  | $I_{OH} = -4\text{ mA}$ ; $V_{DD} = 1.65\text{ V}$  | 1.1                        |     |                            |               |
|               |  | $I_{OH} = -8\text{ mA}$ ; $V_{DD} = 2.3\text{ V}$   | 1.8                        |     |                            |               |
|               |  | $I_{OH} = -10\text{ mA}$ ; $V_{DD} = 2.3\text{ V}$  | 1.7                        |     |                            |               |
|               |  | $I_{OH} = -8\text{ mA}$ ; $V_{DD} = 3.0\text{ V}$   | 2.6                        |     |                            |               |
|               |  | $I_{OH} = -10\text{ mA}$ ; $V_{DD} = 3.0\text{ V}$  | 2.5                        |     |                            |               |
|               |  | $I_{OH} = -8\text{ mA}$ ; $V_{DD} = 4.5\text{ V}$   | 4.1                        |     |                            |               |
|               |  | $I_{OH} = -10\text{ mA}$ ; $V_{DD} = 4.5\text{ V}$  | 4.0                        |     |                            |               |
| $I_{LH}$      | Input Leakage Current                      | $V_{DD} = 5.5\text{ V}$ ; $V_I = V_{DD}$  |                            |     | 1                          | $\mu\text{A}$ |
| $I_{LL}$      | Input Leakage Current                      | $V_{DD} = 5.5\text{ V}$ ; $V_I = \text{GND}$  |                            |     | -100                       | $\mu\text{A}$ |
| $C_{I/O}$     | Input / Output Capacitance<br>(Note 8)     |   |                            | 3.7 | 5                          | pF            |

### INTERRUPT (INT)

|          |                          |                         |   |     |   |    |
|----------|--------------------------|-------------------------|---|-----|---|----|
| $I_{OL}$ | Low-Level Output Current | $V_{OL} = 0.4\text{ V}$ | 6 |     |   | mA |
| $C_O$    | Output Capacitance       |                         |   | 2.1 | 5 | pF |

### INPUTS AD0, AD1, AD2

|          |                          |   |                            |     |                            |               |
|----------|--------------------------|---|----------------------------|-----|----------------------------|---------------|
| $V_{IH}$ | High-Level Input Voltage | $2.3\text{ V} \leq V_{CC} \leq 5.5\text{ V}$<br>$1.65\text{ V} \leq V_{CC} \leq 2.3\text{ V}$ | 2.0<br>$0.7 \times V_{DD}$ |     |                            | V             |
| $V_{IL}$ | Low-Level Input Voltage  | $2.3\text{ V} \leq V_{CC} \leq 5.5\text{ V}$<br>$1.65\text{ V} \leq V_{CC} \leq 2.3\text{ V}$ |                            |     | 0.8<br>$0.3 \times V_{DD}$ | V             |
| $I_L$    | Leakage Current          | $V_I = V_{DD}$ or GND   |                            |     | $\pm 1$                    | $\mu\text{A}$ |
| $C_I$    | Input Capacitance        |   |                            | 2.4 | 5                          | pF            |

6. The power-on reset circuit resets the I<sup>2</sup>C bus logic with  $V_{DD} < V_{POR}$  and set all I/Os to logic 1 upon power-up. Thereafter,  $V_{DD}$  must be lower than 0.2 V to reset the part.
7. Each bit must be limited to a maximum of 25 mA and the total package limited to 200 mA due to internal bussing limits.
8. The value is not tested, but verified on sampling basis.

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**Table 5. AC ELECTRICAL CHARACTERISTICS**  $V_{DD} = 1.65\text{ V to }5.5\text{ V}$ ;  $T_A = -55^\circ\text{C to }+125^\circ\text{C}$ , unless otherwise specified.

| Symbol       | Parameter  | Standard Mode |      | Fast Mode                  |     | Fast Mode + |      | Unit          |
|--------------|--|---------------|------|----------------------------|-----|-------------|------|---------------|
|              |  | Min           | Max  | Min                        | Max | Min         | Max  |               |
| $f_{SCL}$    | SCL Clock Frequency  | 0             | 0.1  | 0                          | 0.4 | 0           | 1.0  | MHz           |
| $t_{BUF}$    | Bus-Free Time between a STOP and START Condition           | 4.7           |      | 1.3                        |     | 0.5         |      | $\mu\text{s}$ |
| $t_{HD:STA}$ | Hold Time (Repeated) START Condition                       | 4.0           |      | 0.6                        |     | 0.26        |      | $\mu\text{s}$ |
| $t_{SU:STA}$ | Setup Time for a Repeated START Condition                  | 4.7           |      | 0.6                        |     | 0.26        |      | $\mu\text{s}$ |
| $t_{SU:STO}$ | Setup Time for STOP Condition                              | 4.0           |      | 0.6                        |     | 0.26        |      | $\mu\text{s}$ |
| $t_{HD:DAT}$ | Data Hold Time   | 0             |      | 0                          |     | 0           |      | ns            |
| $t_{VD:ACK}$ | Data Valid Acknowledge Time (Note 9)                       | 0.3           | 3.45 | 0.1                        | 0.9 | 0.05        | 0.45 | $\mu\text{s}$ |
| $t_{VD:DAT}$ | Data Valid Time (Note 10)                                  | 300           |      | 50                         |     | 50          | 450  | ns            |
| $t_{SU:DAT}$ | Data Setup Time  | 250           |      | 100                        |     | 50          |      | ns            |
| $t_{LOW}$    | LOW Period of SCL  | 4.7           |      | 1.3                        |     | 0.5         |      | $\mu\text{s}$ |
| $t_{HIGH}$   | HIGH Period of SCL   | 4.0           |      | 0.6                        |     | 0.26        |      | $\mu\text{s}$ |
| $t_f$        | Fall Time of SDA and SCL (Notes 12 and 13)                 |               | 300  | $20 + 0.1C_b$<br>(Note 11) | 300 |             | 120  | ns            |
| $t_r$        | Rise Time of SDA and SCL                                   |               | 1000 | $20 + 0.1C_b$<br>(Note 11) | 300 |             | 120  | ns            |
| $t_{SP}$     | Pulse Width of Spikes Suppressed by Input Filter (Note 14) |               | 50   |                            | 50  |             | 50   | ns            |

**PORT TIMING:  $C_L \leq 100\text{ pF}$**  (See Figures 7 and 10)

|             |                        |     |     |     |     |     |     |               |
|-------------|------------------------|-----|-----|-----|-----|-----|-----|---------------|
| $t_{V(Q)}$  | Data Output Valid Time |     | 350 |     | 350 |     | 350 | ns            |
| $t_{SU(D)}$ | Data Input Setup Time  | 100 |     | 100 |     | 100 |     | ns            |
| $t_{H(D)}$  | Data Input Hold Time   | 1   |     | 1   |     | 1   |     | $\mu\text{s}$ |

**INTERRUPT TIMING:  $C_L \leq 100\text{ pF}$**  (See Figure 10)

|                   |                  |  |   |  |   |  |   |               |
|-------------------|------------------|--|---|--|---|--|---|---------------|
| $t_{V(INT\_N)}$   | Data Valid Time  |  | 4 |  | 4 |  | 4 | $\mu\text{s}$ |
| $t_{RST(INT\_N)}$ | Reset Delay Time |  | 4 |  | 4 |  | 4 | $\mu\text{s}$ |

9.  $t_{VD:ACK}$  = time for Acknowledgment signal from SCL LOW to SDA (out) LOW.

10.  $t_{VD:DAT}$  = minimum time for SDA data out to be valid following SCL LOW.

11.  $C_b$  = total capacitance of one bus line in pF.

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

13. 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  $t_f$ .

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

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

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## 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 of the PCA9654E/PCA9654EA is shown in Figure 5. Slave address pins AD2, AD1, and AD0 choose 1 of 64 slave addresses. To conserve power, no internal pull-up resistors are incorporated on AD2, AD1, and AD0. Address values can be found on Table 6 “PCA9654E Address Map” and Table 7 “PCA9654EA Address Map”.

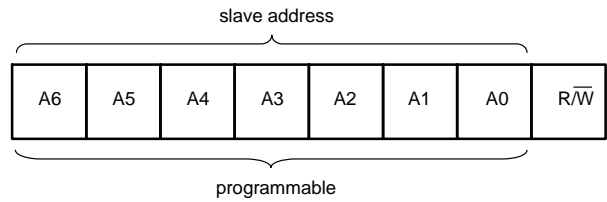


Figure 5. PCA9654E / PCA9654EA Device Address

A logic 1 on the last bit of the first byte selects a read operation while a logic 0 selects a write operation.

Table 6. PCA9654E ADDRESS MAP

| Address Input |     |     | Slave Address |    |    |    |    |    |    | HEX |
|---------------|-----|-----|---------------|----|----|----|----|----|----|-----|
| AD2           | AD1 | AD0 | A6            | A5 | A4 | A3 | A2 | A1 | A0 | HEX |
| GND           | SCL | GND | 0             | 0  | 1  | 0  | 0  | 0  | 0  | 20h |
| GND           | SCL | VDD | 0             | 0  | 1  | 0  | 0  | 0  | 1  | 22h |
| GND           | SDA | GND | 0             | 0  | 1  | 0  | 0  | 1  | 0  | 24h |
| GND           | SDA | VDD | 0             | 0  | 1  | 0  | 0  | 1  | 1  | 26h |
| VDD           | SCL | GND | 0             | 0  | 1  | 0  | 1  | 0  | 0  | 28h |
| VDD           | SCL | VDD | 0             | 0  | 1  | 0  | 1  | 0  | 1  | 2Ah |
| VDD           | SDA | GND | 0             | 0  | 1  | 0  | 1  | 1  | 0  | 2Ch |
| VDD           | SDA | VDD | 0             | 0  | 1  | 0  | 1  | 1  | 1  | 2Eh |
| GND           | SCL | SCL | 0             | 0  | 1  | 1  | 0  | 0  | 0  | 30h |
| GND           | SCL | SDA | 0             | 0  | 1  | 1  | 0  | 0  | 1  | 32h |
| GND           | SDA | SCL | 0             | 0  | 1  | 1  | 0  | 1  | 0  | 34h |
| GND           | SDA | SDA | 0             | 0  | 1  | 1  | 0  | 1  | 1  | 36h |
| VDD           | SCL | SCL | 0             | 0  | 1  | 1  | 1  | 0  | 0  | 38h |
| VDD           | SCL | SDA | 0             | 0  | 1  | 1  | 1  | 0  | 1  | 3Ah |
| VDD           | SDA | SCL | 0             | 0  | 1  | 1  | 1  | 1  | 0  | 3Ch |
| VDD           | SDA | SDA | 0             | 0  | 1  | 1  | 1  | 1  | 1  | 3Eh |
| GND           | GND | GND | 0             | 1  | 0  | 0  | 0  | 0  | 0  | 40h |
| GND           | GND | VDD | 0             | 1  | 0  | 0  | 0  | 0  | 1  | 42h |
| GND           | VDD | GND | 0             | 1  | 0  | 0  | 0  | 1  | 0  | 44h |
| GND           | VDD | VDD | 0             | 1  | 0  | 0  | 0  | 1  | 1  | 46h |
| VDD           | GND | GND | 0             | 1  | 0  | 0  | 1  | 0  | 0  | 48h |
| VDD           | GND | VDD | 0             | 1  | 0  | 0  | 1  | 0  | 1  | 4Ah |
| VDD           | VDD | GND | 0             | 1  | 0  | 0  | 1  | 1  | 0  | 4Ch |
| VDD           | VDD | VDD | 0             | 1  | 0  | 0  | 1  | 1  | 1  | 4Eh |
| GND           | GND | SCL | 0             | 1  | 0  | 1  | 0  | 0  | 0  | 50h |
| GND           | GND | SDA | 0             | 1  | 0  | 1  | 0  | 0  | 1  | 52h |
| GND           | VDD | SCL | 0             | 1  | 0  | 1  | 0  | 1  | 0  | 54h |
| GND           | VDD | SDA | 0             | 1  | 0  | 1  | 0  | 1  | 1  | 56h |
| VDD           | GND | SCL | 0             | 1  | 0  | 1  | 1  | 0  | 0  | 58h |
| VDD           | GND | SDA | 0             | 1  | 0  | 1  | 1  | 0  | 1  | 5Ah |
| VDD           | VDD | SCL | 0             | 1  | 0  | 1  | 1  | 1  | 0  | 5Ch |

# PCA9654E, PCA9654EA

**Table 6. PCA9654E ADDRESS MAP**

| Address Input |     |     | Slave Address |    |    |    |    |    |    |      |
|---------------|-----|-----|---------------|----|----|----|----|----|----|------|
| AD2           | AD1 | AD0 | A6            | A5 | A4 | A3 | A2 | A1 | A0 | HEX  |
| VDD           | VDD | SDA | 0             | 1  | 0  | 1  | 1  | 1  | 1  | 5Eh  |
| SCL           | SCL | GND | 1             | 0  | 1  | 0  | 0  | 0  | 0  | A0h  |
| SCL           | SCL | VDD | 1             | 0  | 1  | 0  | 0  | 0  | 1  | A2h  |
| SCL           | SDA | GND | 1             | 0  | 1  | 0  | 0  | 1  | 0  | A4h  |
| SCL           | SDA | VDD | 1             | 0  | 1  | 0  | 0  | 1  | 1  | A6h  |
| SDA           | SCL | GND | 1             | 0  | 1  | 0  | 1  | 0  | 0  | A8h  |
| SDA           | SCL | VDD | 1             | 0  | 1  | 0  | 1  | 0  | 1  | AAh  |
| SDA           | SDA | GND | 1             | 0  | 1  | 0  | 1  | 1  | 0  | ACH  |
| SDA           | SDA | VDD | 1             | 0  | 1  | 0  | 1  | 1  | 1  | A Eh |
| SCL           | SCL | SCL | 1             | 0  | 1  | 1  | 0  | 0  | 0  | B0h  |
| SCL           | SCL | SDA | 1             | 0  | 1  | 1  | 0  | 0  | 1  | B2h  |
| SCL           | SDA | SCL | 1             | 0  | 1  | 1  | 0  | 1  | 0  | B4h  |
| SCL           | SDA | SDA | 1             | 0  | 1  | 1  | 0  | 1  | 1  | B6h  |
| SDA           | SCL | SCL | 1             | 0  | 1  | 1  | 1  | 0  | 0  | B8h  |
| SDA           | SCL | SDA | 1             | 0  | 1  | 1  | 1  | 0  | 1  | BAh  |
| SDA           | SDA | SCL | 1             | 0  | 1  | 1  | 1  | 1  | 0  | BCh  |
| SDA           | SDA | SDA | 1             | 0  | 1  | 1  | 1  | 1  | 1  | BEh  |
| SCL           | GND | GND | 1             | 1  | 0  | 0  | 0  | 0  | 0  | C0h  |
| SCL           | GND | VDD | 1             | 1  | 0  | 0  | 0  | 0  | 1  | C2h  |
| SCL           | VDD | GND | 1             | 1  | 0  | 0  | 0  | 1  | 0  | C4h  |
| SCL           | VDD | VDD | 1             | 1  | 0  | 0  | 0  | 1  | 1  | C6h  |
| SDA           | GND | GND | 1             | 1  | 0  | 0  | 1  | 0  | 0  | C8h  |
| SDA           | GND | VDD | 1             | 1  | 0  | 0  | 1  | 0  | 1  | CAh  |
| SDA           | VDD | GND | 1             | 1  | 0  | 0  | 1  | 1  | 0  | CCh  |
| SDA           | VDD | VDD | 1             | 1  | 0  | 0  | 1  | 1  | 1  | CEh  |
| SCL           | GND | SCL | 1             | 1  | 1  | 0  | 0  | 0  | 0  | E0h  |
| SCL           | GND | SDA | 1             | 1  | 1  | 0  | 0  | 0  | 1  | E2h  |
| SCL           | VDD | SCL | 1             | 1  | 1  | 0  | 0  | 1  | 0  | E4h  |
| SCL           | VDD | SDA | 1             | 1  | 1  | 0  | 0  | 1  | 1  | E6h  |
| SDA           | GND | SCL | 1             | 1  | 1  | 0  | 1  | 0  | 0  | E8h  |
| SDA           | GND | SDA | 1             | 1  | 1  | 0  | 1  | 0  | 1  | E Ah |
| SDA           | VDD | SCL | 1             | 1  | 1  | 0  | 1  | 1  | 0  | ECh  |
| SDA           | VDD | SDA | 1             | 1  | 1  | 0  | 1  | 1  | 1  | E Eh |



# PCA9654E, PCA9654EA

**Table 7. PCA9654EA ADDRESS MAP**

| Address Input |     |     | Slave Address |    |    |    |    |    |    |     |
|---------------|-----|-----|---------------|----|----|----|----|----|----|-----|
| AD2           | AD1 | AD0 | A6            | A5 | A4 | A3 | A2 | A1 | A0 | HEX |
| VSS           | SCL | VSS | 0             | 0  | 0  | 1  | 0  | 0  | 0  | 10h |
| VSS           | SCL | VDD | 0             | 0  | 0  | 1  | 0  | 0  | 1  | 12h |
| VSS           | SDA | VSS | 0             | 0  | 0  | 1  | 0  | 1  | 0  | 14h |
| VSS           | SDA | VDD | 0             | 0  | 0  | 1  | 0  | 1  | 1  | 16h |
| VDD           | SCL | VSS | 0             | 0  | 0  | 1  | 1  | 0  | 0  | 18h |
| VDD           | SCL | VDD | 0             | 0  | 0  | 1  | 1  | 0  | 1  | 1Ah |
| VDD           | SDA | VSS | 0             | 0  | 0  | 1  | 1  | 1  | 0  | 1Ch |
| VDD           | SDA | VDD | 0             | 0  | 0  | 1  | 1  | 1  | 1  | 1Eh |
| VSS           | SCL | SCL | 0             | 1  | 1  | 0  | 0  | 0  | 0  | 60h |
| VSS           | SCL | SDA | 0             | 1  | 1  | 0  | 0  | 0  | 1  | 62h |
| VSS           | SDA | SCL | 0             | 1  | 1  | 0  | 0  | 1  | 0  | 64h |
| VSS           | SDA | SDA | 0             | 1  | 1  | 0  | 0  | 1  | 1  | 66h |
| VDD           | SCL | SCL | 0             | 1  | 1  | 0  | 1  | 0  | 0  | 68h |
| VDD           | SCL | SDA | 0             | 1  | 1  | 0  | 1  | 0  | 1  | 6Ah |
| VDD           | SDA | SCL | 0             | 1  | 1  | 0  | 1  | 1  | 0  | 6Ch |
| VDD           | SDA | SDA | 0             | 1  | 1  | 0  | 1  | 1  | 1  | 6Eh |
| VSS           | VSS | VSS | 0             | 1  | 1  | 1  | 0  | 0  | 0  | 70h |
| VSS           | VSS | VDD | 0             | 1  | 1  | 1  | 0  | 0  | 1  | 72h |
| VSS           | VDD | VSS | 0             | 1  | 1  | 1  | 0  | 1  | 0  | 74h |
| VSS           | VDD | VDD | 0             | 1  | 1  | 1  | 0  | 1  | 1  | 76h |
| VDD           | VSS | VSS | 0             | 1  | 1  | 1  | 1  | 0  | 0  | 78h |
| VDD           | VSS | VDD | 0             | 1  | 1  | 1  | 1  | 0  | 1  | 7Ah |
| VDD           | VDD | VSS | 0             | 1  | 1  | 1  | 1  | 1  | 0  | 7Ch |
| VDD           | VDD | VDD | 0             | 1  | 1  | 1  | 1  | 1  | 1  | 7Eh |
| VSS           | VSS | SCL | 1             | 0  | 0  | 0  | 0  | 0  | 0  | 80h |
| VSS           | VSS | SDA | 1             | 0  | 0  | 0  | 0  | 0  | 1  | 82h |
| VSS           | VDD | SCL | 1             | 0  | 0  | 0  | 0  | 1  | 0  | 84h |
| VSS           | VDD | SDA | 1             | 0  | 0  | 0  | 0  | 1  | 1  | 86h |
| VDD           | VSS | SCL | 1             | 0  | 0  | 0  | 1  | 0  | 0  | 88h |
| VDD           | VSS | SDA | 1             | 0  | 0  | 0  | 1  | 0  | 1  | 8Ah |
| VDD           | VDD | SCL | 1             | 0  | 0  | 0  | 1  | 1  | 0  | 8Ch |
| VDD           | VDD | SDA | 1             | 0  | 0  | 0  | 1  | 1  | 1  | 8Eh |
| SCL           | SCL | VSS | 1             | 0  | 0  | 1  | 0  | 0  | 0  | 90h |
| SCL           | SCL | VDD | 1             | 0  | 0  | 1  | 0  | 0  | 1  | 92h |
| SCL           | SDA | VSS | 1             | 0  | 0  | 1  | 0  | 1  | 0  | 94h |
| SCL           | SDA | VDD | 1             | 0  | 0  | 1  | 0  | 1  | 1  | 96h |
| SDA           | SCL | VSS | 1             | 0  | 0  | 1  | 1  | 0  | 0  | 98h |
| SDA           | SCL | VDD | 1             | 0  | 0  | 1  | 1  | 0  | 1  | 9Ah |
| SDA           | SDA | VSS | 1             | 0  | 0  | 1  | 1  | 1  | 0  | 9Ch |
| SDA           | SDA | VDD | 1             | 0  | 0  | 1  | 1  | 1  | 1  | 9Eh |
| SCL           | SCL | SCL | 1             | 1  | 0  | 1  | 0  | 0  | 0  | D0h |

# PCA9654E, PCA9654EA

**Table 7. PCA9654EA ADDRESS MAP**

| Address Input |     |     | Slave Address |    |    |    |    |    |    |             |
|---------------|-----|-----|---------------|----|----|----|----|----|----|-------------|
| AD2           | AD1 | AD0 | A6            | A5 | A4 | A3 | A2 | A1 | A0 | HEX         |
| SCL           | SCL | SDA | 1             | 1  | 0  | 1  | 0  | 0  | 1  | D2h         |
| SCL           | SDA | SCL | 1             | 1  | 0  | 1  | 0  | 1  | 0  | D4h         |
| SCL           | SDA | SDA | 1             | 1  | 0  | 1  | 0  | 1  | 1  | D6h         |
| SDA           | SCL | SCL | 1             | 1  | 0  | 1  | 1  | 0  | 0  | D8h         |
| SDA           | SCL | SDA | 1             | 1  | 0  | 1  | 1  | 0  | 1  | DAh         |
| SDA           | SDA | SCL | 1             | 1  | 0  | 1  | 1  | 1  | 0  | DCh         |
| SDA           | SDA | SDA | 1             | 1  | 0  | 1  | 1  | 1  | 1  | DEh         |
| SCL           | VSS | VSS | 1             | 1  | 1  | 1  | 0  | 0  | 0  | F0h         |
| SCL           | VSS | VDD | 1             | 1  | 1  | 1  | 0  | 0  | 1  | F2h         |
| SCL           | VDD | VSS | 1             | 1  | 1  | 1  | 0  | 1  | 0  | F4h         |
| SCL           | VDD | VDD | 1             | 1  | 1  | 1  | 0  | 1  | 1  | F6h         |
| SDA           | VSS | VSS | 1             | 1  | 1  | 1  | 1  | 0  | 0  | – (Note 15) |
| SDA           | VSS | VDD | 1             | 1  | 1  | 1  | 1  | 0  | 1  | FAh         |
| SDA           | VDD | VSS | 1             | 1  | 1  | 1  | 1  | 1  | 0  | FCh         |
| SDA           | VDD | VDD | 1             | 1  | 1  | 1  | 1  | 1  | 1  | FEh         |
| SCL           | VSS | SCL | 0             | 0  | 0  | 0  | 0  | 0  | 0  | – (Note 15) |
| SCL           | VSS | SDA | 0             | 0  | 0  | 0  | 0  | 0  | 1  | 02h         |
| SCL           | VDD | SCL | 0             | 0  | 0  | 0  | 0  | 1  | 0  | 04h         |
| SCL           | VDD | SDA | 0             | 0  | 0  | 0  | 0  | 1  | 1  | 06h         |
| SDA           | VSS | SCL | 0             | 0  | 0  | 0  | 1  | 0  | 0  | 08h         |
| SDA           | VSS | SDA | 0             | 0  | 0  | 0  | 1  | 0  | 1  | 0Ah         |
| SDA           | VDD | SCL | 0             | 0  | 0  | 0  | 1  | 1  | 0  | 0Ch         |
| SDA           | VDD | SDA | 0             | 0  | 0  | 0  | 1  | 1  | 1  | 0Eh         |

15. The PCA9654EA does not acknowledge this AD2, AD1 and AD0 configuration.

# PCA9654E, PCA9654EA

## REGISTERS

### Command Byte

**Table 8. COMMAND BYTE**

| COMMAND | PROTOCOL          | REGISTER           |
|---------|-------------------|--------------------|
| 0       | Read byte         | Input Port         |
| 1       | Read / Write byte | Output Port        |
| 2       | Read / Write byte | Polarity Inversion |
| 3       | Read / Write byte | Configuration      |

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.

#### Register 0 – Input Port Register

This register is a read-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 'X' is determined by the externally applied logic level, normally '1' when no external signal externally applied because of the internal pull-up resistors.

**Table 9. INPUT PORT REGISTER**

| Bit     | 7  | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
|---------|----|----|----|----|----|----|----|----|
| Symbol  | I7 | I6 | I5 | I4 | I3 | I2 | I1 | I0 |
| Access  | R  | R  | R  | R  | R  | R  | R  | R  |
| Default | X  | X  | X  | X  | X  | X  | X  | X  |

#### Register 1 – Output Port Register

This register reflects the outgoing logic levels of the pins defined as outputs by Register 3. Bit values in this register have no effect on pins defined as inputs. Reads from this

register return the value that is in the flip-flop controlling the output selection, **not** the actual pin value.

**Table 10. OUTPUT PORT REGISTER**

| Bit     | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|
| Symbol  | O7  | O6  | O5  | O4  | O3  | O2  | O1  | O0  |
| Access  | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Default | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |

#### Register 2 – Polarity Inversion Register

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 corresponding Input Port data is inverted. If a

bit in this register is cleared (written with a '0'), the Input Port data polarity is retained.

**Table 11. POLARITY INVERSION REGISTER**

| Bit     | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|
| Symbol  | N7  | N6  | N5  | N4  | N3  | N2  | N1  | N0  |
| Access  | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Default | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   |

# PCA9654E, PCA9654EA

## Register 3 – Configuration Register

This register configures the directions of the I/O pins. If a bit in this register is set, the corresponding port pin is enabled as an input with high-impedance output driver. If a

bit in this register is cleared, the corresponding port pin is enabled as an output. At reset, the I/Os are configured as inputs with a weak pull-up to  $V_{DD}$ .

**Table 12. CONFIGURATION REGISTER**

| Bit     | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|
| Symbol  | C7  | C6  | C5  | C4  | C3  | C2  | C1  | C0  |
| Access  | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Default | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   |

### Power-on Reset

When power is applied to  $V_{DD}$ , an internal Power-On Reset (POR) holds the PCA9654E/PCA9654EA in a reset condition until  $V_{DD}$  has reached  $V_{POR}$ . At that point, the reset condition is released and the PCA9654E/PCA9654EA registers and state machine will initialize to their default states. Thereafter,  $V_{DD}$  must be lowered below 0.2 V to reset the device.

For a power reset cycle,  $V_{DD}$  must be lowered below 0.2 V and then restored to the operating voltage.

### Interrupt Output

The open-drain interrupt output is activated when one of the port pins changes 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.

Note that 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.

### I/O Port (Figure 2)

When an I/O is configured as an input, FETs Q1 and Q2 are off, creating a high-impedance input with a weak pull-up (100 k $\Omega$  typ.) to  $V_{DD}$ . The input voltage may be raised above  $V_{DD}$  to a maximum of 5.5 V.

If the I/O is configured as an output, then either Q1 or Q2 is enabled, 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 paths that exist between the pin and either  $V_{DD}$  or  $V_{SS}$ .

# PCA9654E, PCA9654EA

## BUS TRANSACTIONS

Data is transmitted to the PCA9654E/PCA9654EA registers using the Write mode as shown in Figure 6 and Figure 7. Data is read from the PCA9654E/PCA9654EA registers using the Read mode as shown in Figure 8 and

Figure 9. These devices do not implement an auto-increment function, so once a command byte has been sent, the register which was addressed will continue to be accessed by reads until a new command byte has been sent.

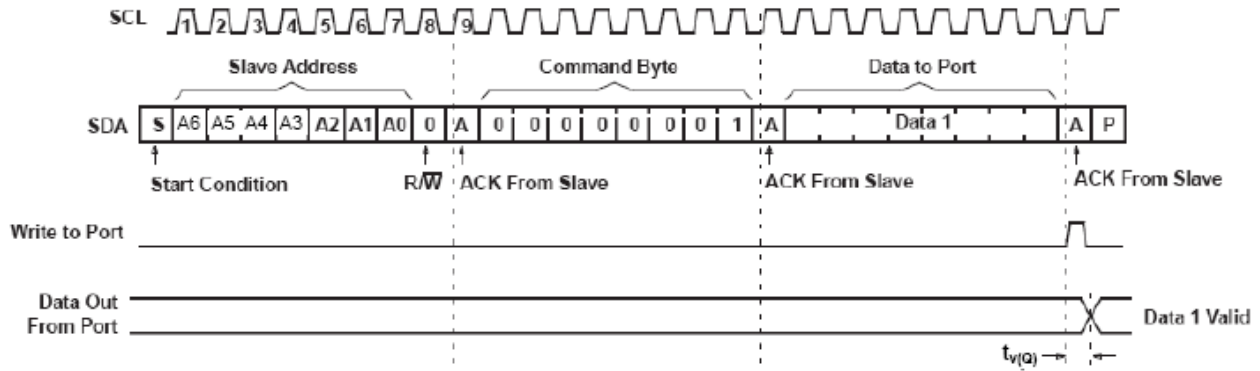


Figure 6. Write to Output Port Registers

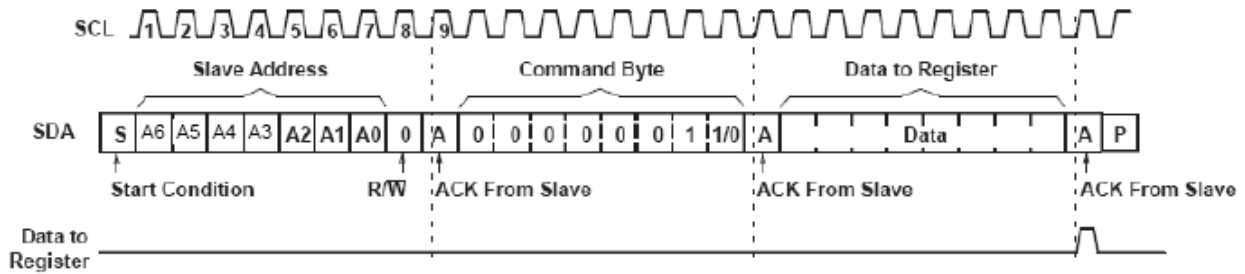


Figure 7. Write to Configuration or Polarity Inversion Register

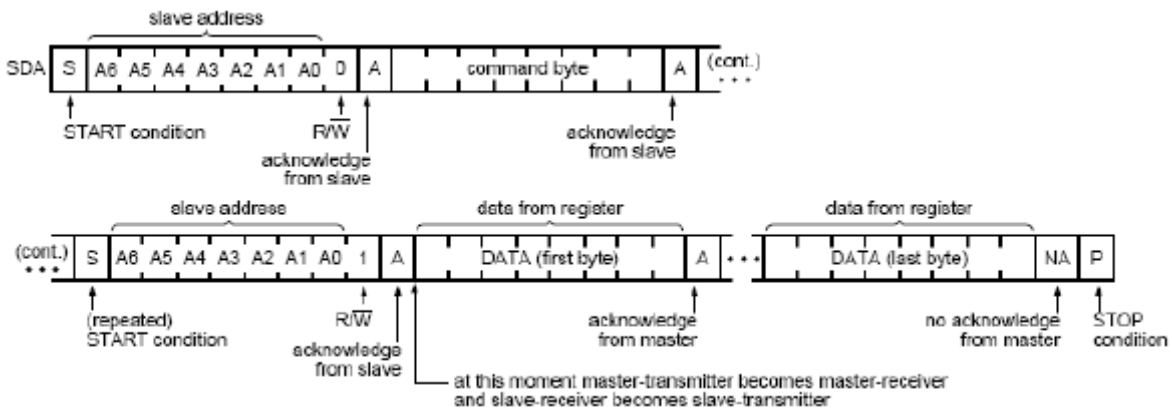
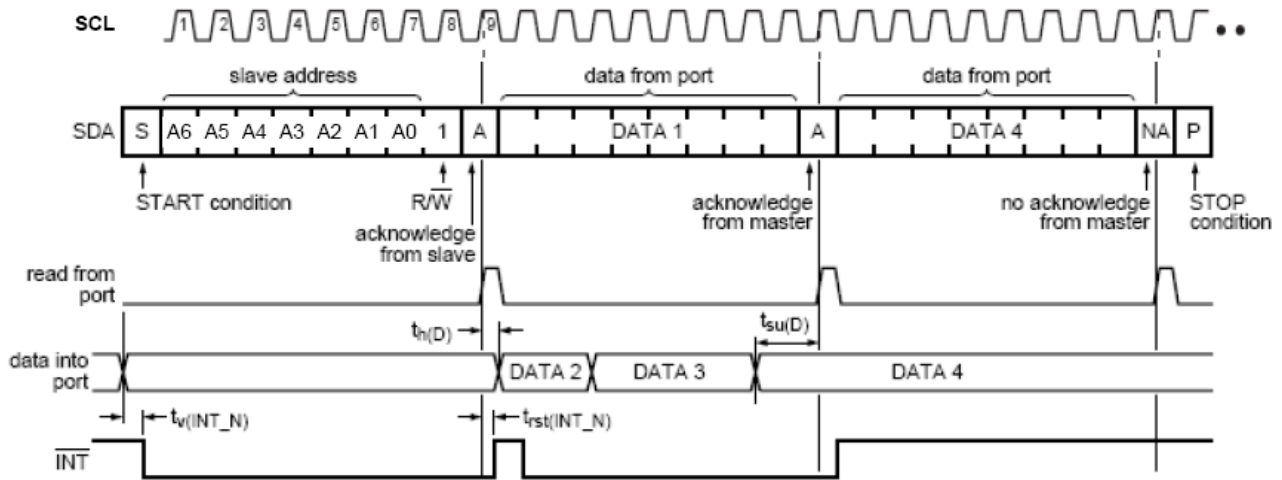


Figure 8. Read from Register

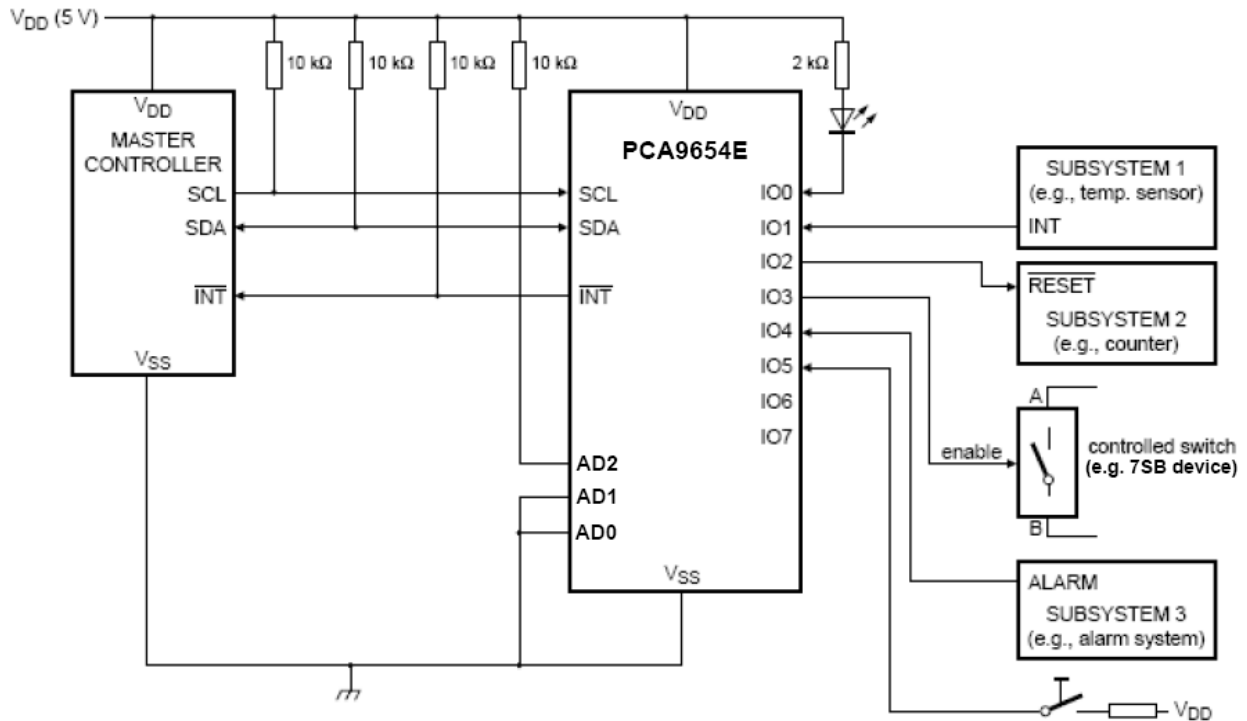
# PCA9654E, PCA9654EA



This figure assumes the command byte has previously been programmed with 00h. Transfer of data can be stopped at any moment by a STOP condition.

Figure 9. Read Input Port Register

## APPLICATION INFORMATION



Device address configured as 0100 100X for this example.  
 IO0, IO1, IO2 configured as outputs.  
 IO3, IO4, IO5 configured as inputs.  
 IO6 and IO7 are not used and must be configured as outputs.

Figure 10. Typical Application

# PCA9654E, PCA9654EA

## 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 11).

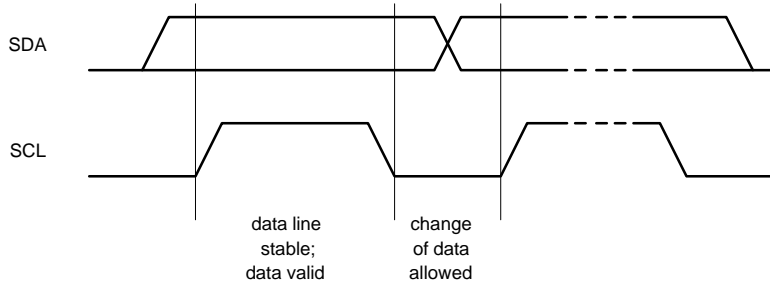


Figure 11. Bit Transfer

## 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 12).

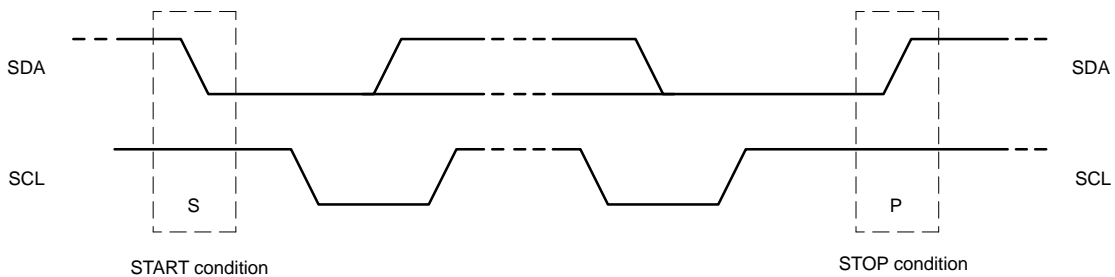


Figure 12. Definition of START and STOP Conditions

## 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 13).

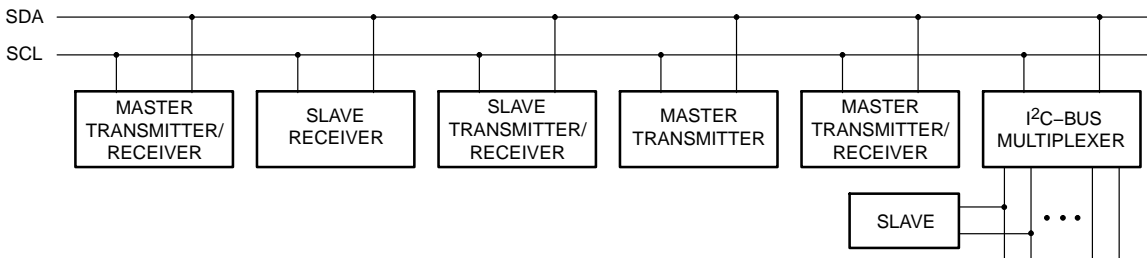


Figure 13. System Configuration

**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.

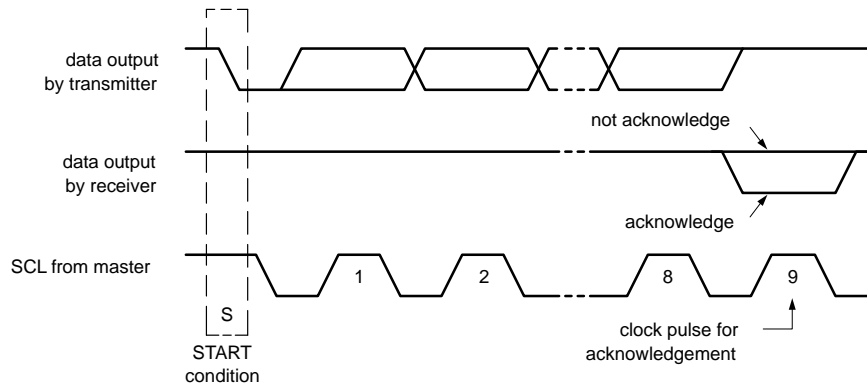


Figure 14. Acknowledgement of the I<sup>2</sup>C Bus

**TIMING AND TEST SETUP**

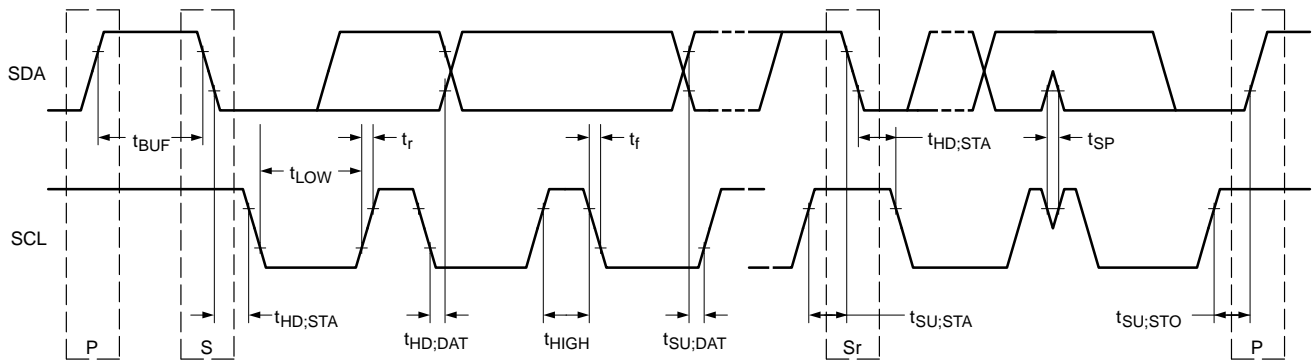
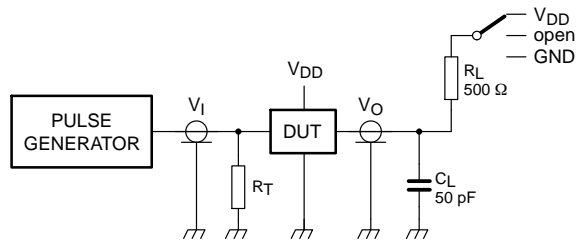


Figure 15. Definition of Timing on the I<sup>2</sup>C Bus



## PCA9654E, PCA9654EA

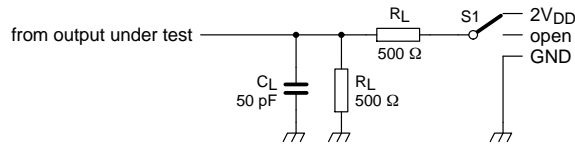


$R_L$  = load resistor.

$C_L$  = load capacitance includes jig and probe capacitance.

$R_T$  = termination resistance should be equal to the output impedance of  $Z_o$  of the pulse generators.

**Figure 16. Test Circuitry for Switching Times**



**Figure 17. Load Circuit**

### ORDERING INFORMATION

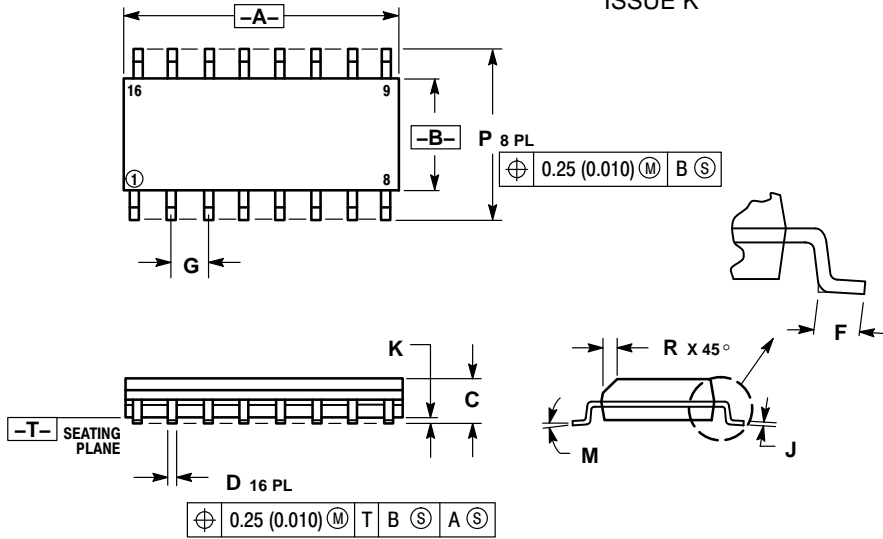
| Device                              | Package                  | Shipping†          |
|-------------------------------------|--------------------------|--------------------|
| PCA9654EDR2G                        | SOIC-16<br>(Pb-Free)     | 2500 / Tape & Reel |
| PCA9654EDTR2G                       | TSSOP-16<br>(Pb-Free)    | 2500 / Tape & Reel |
| PCA9654EMTTBG<br>(In Development)   | WQFN16<br>(Pb-Free)      | 3000 / Tape & Reel |
| PCA9654E3MNTWG<br>(In Development)  | QFN16 (3x3)<br>(Pb-Free) | 3000 / Tape & Reel |
| PCA9654E4MNTWG<br>(In Development)  | QFN16 (4x4)<br>(Pb-Free) | 2000 / Tape & Reel |
| PCA9654EADR2G<br>(In Development)   | SOIC-16<br>(Pb-Free)     | 2500 / Tape & Reel |
| PCA9654EADTR2G<br>(In Development)  | TSSOP-16<br>(Pb-Free)    | 2500 / Tape & Reel |
| PCA9654EAMTTBG<br>(In Development)  | WQFN16<br>(Pb-Free)      | 3000 / Tape & Reel |
| PCA9654EA3MNTWG<br>(In Development) | QFN16 (3x3)<br>(Pb-Free) | 3000 / Tape & Reel |
| PCA9654EA4MNTWG<br>(In Development) | QFN16 (4x4)<br>(Pb-Free) | 2000 / Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

# PCA9654E, PCA9654EA

## PACKAGE DIMENSIONS

SOIC-16  
CASE 751B-05  
ISSUE K

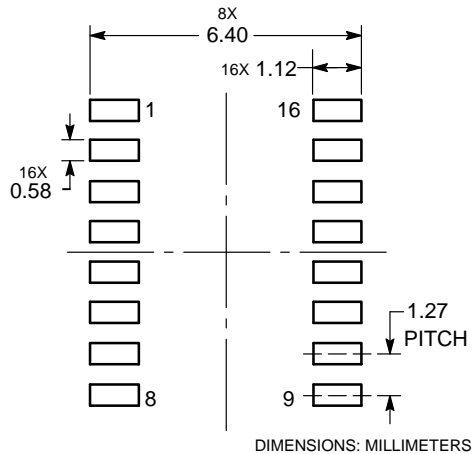


NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

| DIM | MILLIMETERS |       | INCHES    |       |
|-----|-------------|-------|-----------|-------|
|     | MIN         | MAX   | MIN       | MAX   |
| A   | 9.80        | 10.00 | 0.386     | 0.393 |
| B   | 3.80        | 4.00  | 0.150     | 0.157 |
| C   | 1.35        | 1.75  | 0.054     | 0.068 |
| D   | 0.35        | 0.49  | 0.014     | 0.019 |
| F   | 0.40        | 1.25  | 0.016     | 0.049 |
| G   | 1.27 BSC    |       | 0.050 BSC |       |
| J   | 0.19        | 0.25  | 0.008     | 0.009 |
| K   | 0.10        | 0.25  | 0.004     | 0.009 |
| M   | 0°          | 7°    | 0°        | 7°    |
| P   | 5.80        | 6.20  | 0.229     | 0.244 |
| R   | 0.25        | 0.50  | 0.010     | 0.019 |

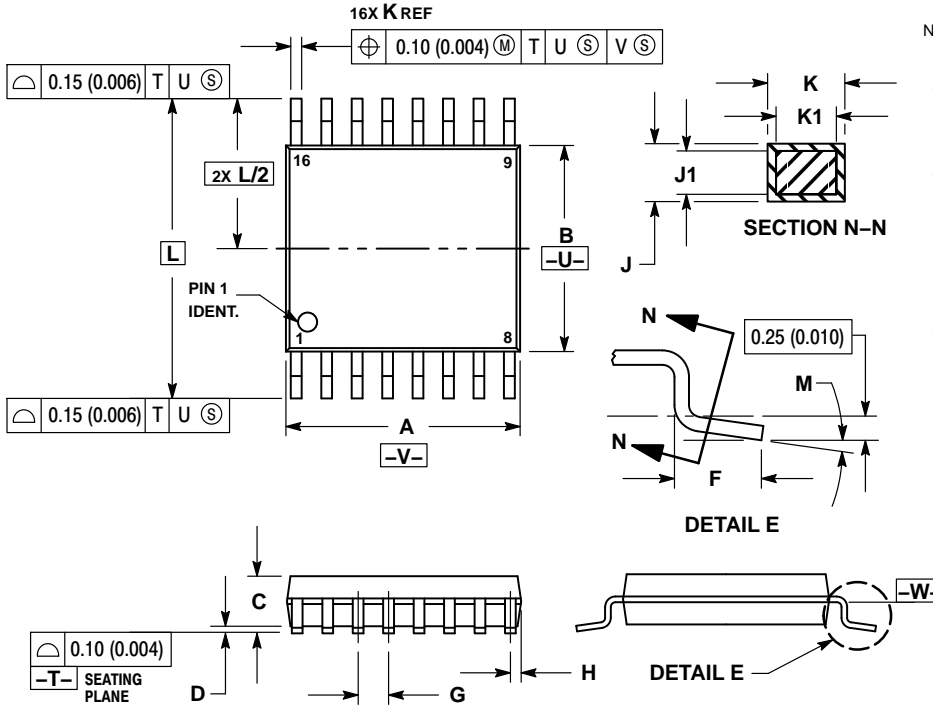
### SOLDERING FOOTPRINT



# PCA9654E, PCA9654EA

## PACKAGE DIMENSIONS

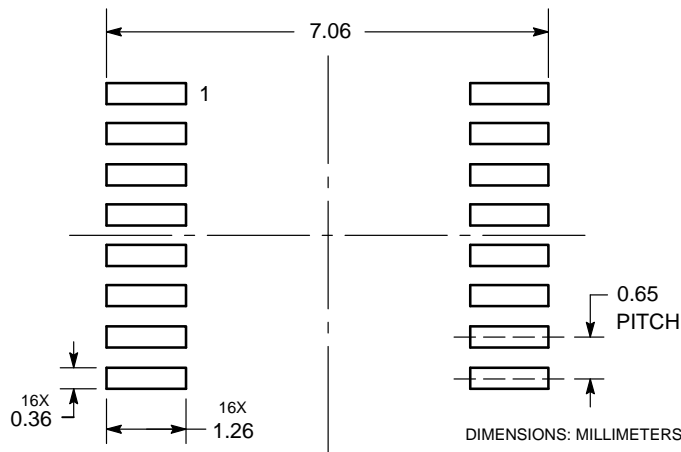
TSSOP-16  
CASE 948F  
ISSUE B



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.
  3. DIMENSION A DOES NOT INCLUDE MOLD FLASH. PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
  4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
  5. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
  6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
  7. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE -W-.

| DIM | MILLIMETERS |      | INCHES    |       |
|-----|-------------|------|-----------|-------|
|     | MIN         | MAX  | MIN       | MAX   |
| A   | 4.90        | 5.10 | 0.193     | 0.200 |
| B   | 4.30        | 4.50 | 0.169     | 0.177 |
| C   | ---         | 1.20 | ---       | 0.047 |
| D   | 0.05        | 0.15 | 0.002     | 0.006 |
| F   | 0.50        | 0.75 | 0.020     | 0.030 |
| G   | 0.65 BSC    |      | 0.026 BSC |       |
| H   | 0.18        | 0.28 | 0.007     | 0.011 |
| J   | 0.09        | 0.20 | 0.004     | 0.008 |
| J1  | 0.09        | 0.16 | 0.004     | 0.006 |
| K   | 0.19        | 0.30 | 0.007     | 0.012 |
| K1  | 0.19        | 0.25 | 0.007     | 0.010 |
| L   | 6.40 BSC    |      | 0.252 BSC |       |
| M   | 0°          | 8°   | 0°        | 8°    |

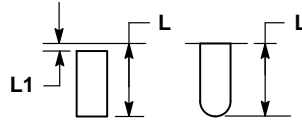
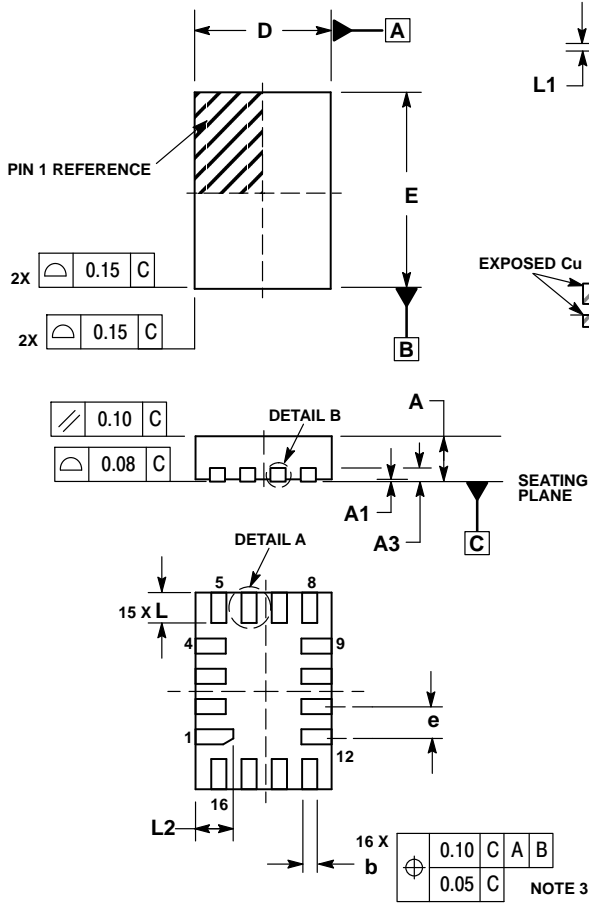
### SOLDERING FOOTPRINT



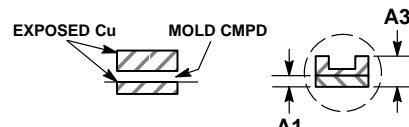
# PCA9654E, PCA9654EA

## PACKAGE DIMENSIONS

WQFN16, 1.8x2.6, 0.4P  
CASE 488AP  
ISSUE B



**DETAIL A**  
ALTERNATE TERMINAL  
CONSTRUCTIONS



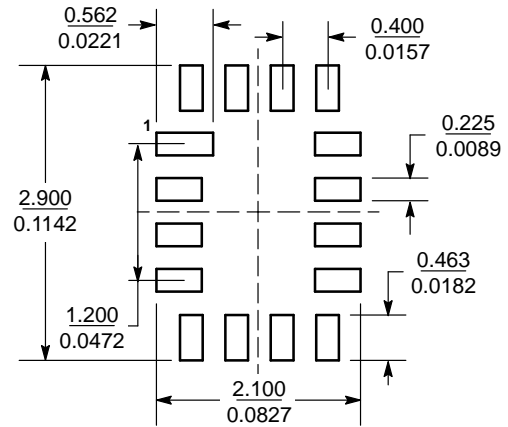
**DETAIL B**  
ALTERNATE  
CONSTRUCTIONS

**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.25 AND 0.30 MM FROM TERMINAL.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
5. EXPOSED PADS CONNECTED TO DIE FLAG. USED AS TEST CONTACTS.

| DIM | MILLIMETERS |       |
|-----|-------------|-------|
|     | MIN         | MAX   |
| A   | 0.70        | 0.80  |
| A1  | 0.00        | 0.050 |
| A3  | 0.20        | REF   |
| b   | 0.15        | 0.25  |
| D   | 1.80        | BSC   |
| E   | 2.60        | BSC   |
| e   | 0.40        | BSC   |
| L   | 0.30        | 0.50  |
| L1  | 0.00        | 0.15  |
| L2  | 0.40        | 0.60  |

### MOUNTING FOOTPRINT

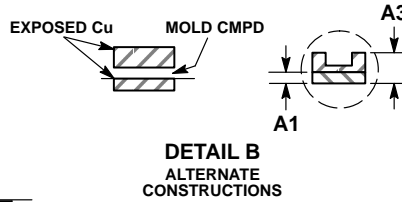
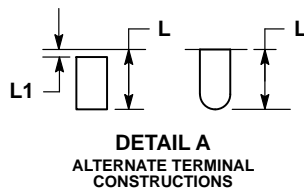
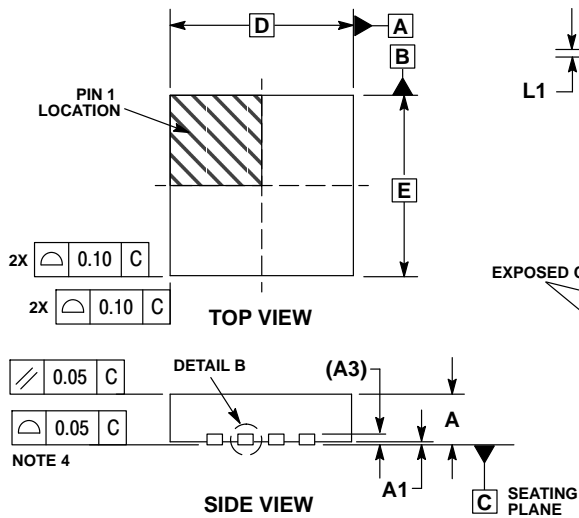


SCALE 20:1 (mm/inches)

# PCA9654E, PCA9654EA

## PACKAGE DIMENSIONS

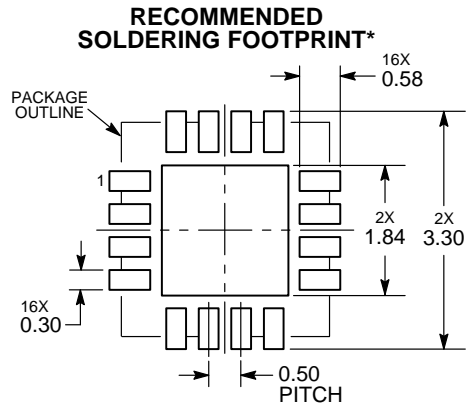
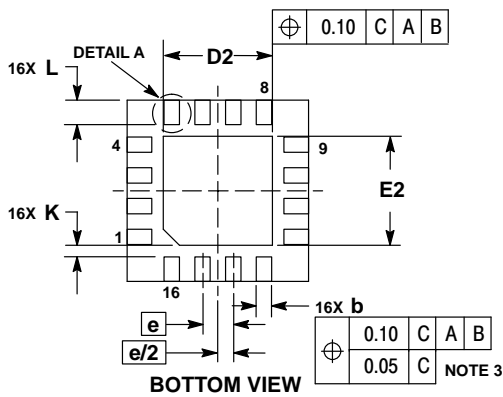
QFN16 3x3, 0.5P  
CASE 485G  
ISSUE F



**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.25 AND 0.30 MM FROM TERMINAL.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

| DIM | MILLIMETERS |      |      |
|-----|-------------|------|------|
|     | MIN         | NOM  | MAX  |
| A   | 0.80        | 0.90 | 1.00 |
| A1  | 0.00        | 0.03 | 0.05 |
| A3  | 0.20 REF    |      |      |
| b   | 0.18        | 0.24 | 0.30 |
| D   | 3.00 BSC    |      |      |
| D2  | 1.65        | 1.75 | 1.85 |
| E   | 3.00 BSC    |      |      |
| E2  | 1.65        | 1.75 | 1.85 |
| e   | 0.50 BSC    |      |      |
| K   | 0.18 TYP    |      |      |
| L   | 0.30        | 0.40 | 0.50 |
| L1  | 0.00        | 0.08 | 0.15 |



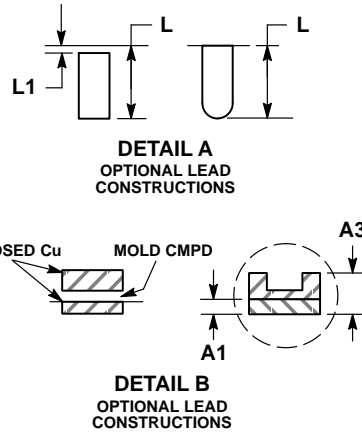
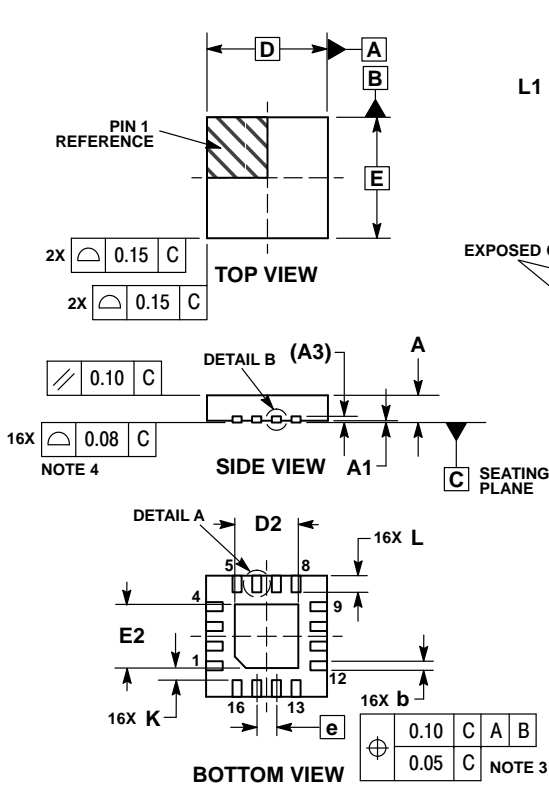
DIMENSIONS: MILLIMETERS

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

# PCA9654E, PCA9654EA

## PACKAGE DIMENSIONS

QFN16 4x4, 0.65P  
CASE 485AP  
ISSUE A

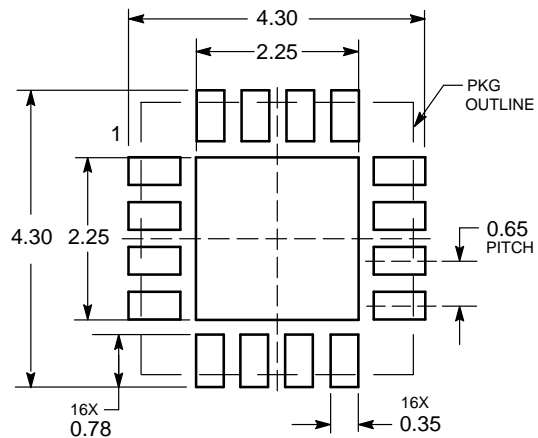


**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 MM FROM TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

| DIM | MILLIMETERS |      |
|-----|-------------|------|
|     | MIN         | MAX  |
| A   | 0.80        | 1.00 |
| A1  | 0.00        | 0.05 |
| A3  | 0.20        | REF  |
| b   | 0.25        | 0.35 |
| D   | 4.00        | BSC  |
| D2  | 2.00        | 2.20 |
| E   | 4.00        | BSC  |
| E2  | 2.00        | 2.20 |
| e   | 0.65        | BSC  |
| K   | 0.20        | ---  |
| L   | 0.45        | 0.65 |
| L1  | ---         | 0.15 |

### MOUNTING FOOTPRINT\*



DIMENSIONS: MILLIMETERS

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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