

# 具有中断输出、复位和配置寄存器的 PCA9539 远程 16 位 I<sup>2</sup>C 和 SMBus 低功耗 I/O 扩展器

## 1 特性

- 1  $\mu$ A 低待机电流消耗 (最大值)
- I<sup>2</sup>C 至并行端口扩展器
- 开漏电路低电平有效中断输出
- 低电平有效复位输入
- 可耐受 5V 电压的 I/O 端口
- 兼容大多数微控制器
- 400kHz 快速 I<sup>2</sup>C 总线
- 极性反转寄存器
- 通过两个硬件地址引脚寻址, 以便使用多达 4 个器件
- 具有高电流驱动能力的锁存输出, 用于直接驱动 LED
- 闩锁性能超过 100mA, 符合 JESD 78 II 类规范的要求
- ESD 保护性能超过 JESD 22 规范要求
  - 2000V 人体放电模型 (A114-A)
  - 1000V 带电器件模型 (C101)

## 2 说明

这个用于两线双向总线 (I<sup>2</sup>C) 的 16 位扩展器设计用于在 2.3V 至 5.5V V<sub>CC</sub> 之间运行。通过 I<sup>2</sup>C 接口 [串行时钟 (SCL), 串行数据 (SDA)], 它为大多数微控制器系列产品提供通用远程 I/O 扩展。

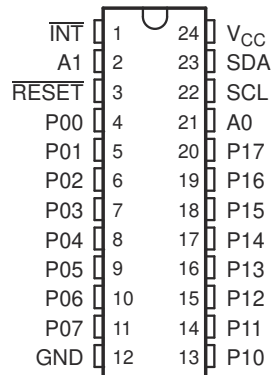
PCA9539 由两个 8 位配置 (输入或输出可选)、输入端口、输出端口和极性反转 (高电平有效或低电平有效运行) 寄存器组成。在加电时, I/O 被配置为输入。系统主控制器可以通过写入 I/O 配置位将 I/O 启用为输入或输出。每个输入或输出的数据均保存在相应的输入或输出寄存器中。输入端口寄存器的极性可借助极性反转寄存器进行转换。所有寄存器都可由系统主控制器读取。

### 器件信息

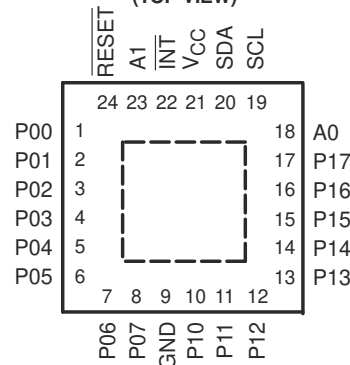
| 器件型号    | 封装 <sup>(1)</sup> | 封装尺寸 (标称值)       |
|---------|-------------------|------------------|
| PCA9539 | SSOP (24)         | 8.20mm × 5.30mm  |
|         | TVSOP (24)        | 5.00mm × 4.40mm  |
|         | SOIC (24)         | 15.40mm × 7.50mm |
|         | TSSOP (24)        | 7.80mm × 4.40mm  |
|         | VQFN (24)         | 4.00mm × 4.00mm  |

(1) 如需了解所有可用封装, 请参阅数据表末尾的可订购产品附录。

DB, DBQ, DGV, DW, OR PW PACKAGE  
(TOP VIEW)



RGE PACKAGE  
(TOP VIEW)



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## 3 Revision History

| Changes from Revision G (May 2014) to Revision H (March 2021)                                                                               | Page |
|---------------------------------------------------------------------------------------------------------------------------------------------|------|
| • Moved the "Storage temperature range" to the <i>Absolute Maximum Ratings</i> .....                                                        | 5    |
| • Moved the "Package thermal impedance" to the <i>Thermal Resistance Characteristic</i> .....                                               | 5    |
| • Changed the V <sub>CC</sub> Supply voltage Max value From: 5.5 V To: V <sub>CC</sub> in the <i>Recommended Operating Conditions</i> ..... | 5    |
| • Added the <i>Thermal Resistance Characteristics</i> .....                                                                                 | 6    |
| • Changed the V <sub>PORR</sub> Typ value From: 1.5 V To 1.2 V in the <i>Electrical Characteristics</i> .....                               | 6    |
| • Added V <sub>PORF</sub> to the <i>Electrical Characteristics</i> .....                                                                    | 6    |
| • Changed the I <sub>CC</sub> Standby mode values in the <i>Electrical Characteristics</i> .....                                            | 6    |
| • Changed the C <sub>i</sub> SCL Max value From: 7 pF To: 8 pF in the <i>Electrical Characteristics</i> .....                               | 6    |
| • Changed the C <sub>io</sub> SDA Max value From: 7 pF To: 9.5 pF in the <i>Electrical Characteristics</i> .....                            | 6    |
| • Updated the <i>Typical Characteristics</i> graphs.....                                                                                    | 8    |
| • Changed the <i>Power Supply Recommendations</i> .....                                                                                     | 27   |

| Changes from Revision F (January 2011) to Revision G (May 2014) | Page |
|-----------------------------------------------------------------|------|
| • Added RESET Errata section.....                               | 17   |
| • Added Interrupt Errata section.....                           | 18   |

## 4 Description (Continued)

The system master can reset the PCA9539 in the event of a time-out or other improper operation by asserting a low in the RESET input. The power-on reset puts the registers in their default state and initializes the I<sup>2</sup>C/SMBus state machine. Asserting RESET causes the same reset/initialization to occur without de-powering the part.

The PCA9539 open-drain interrupt (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.

INT can be connected to the interrupt input of a microcontroller. By sending an interrupt signal on this line, the remote I/O can inform the microcontroller if there is incoming data on its ports without having to communicate via the I<sup>2</sup>C bus. Thus, the PCA9539 can remain a simple slave device.

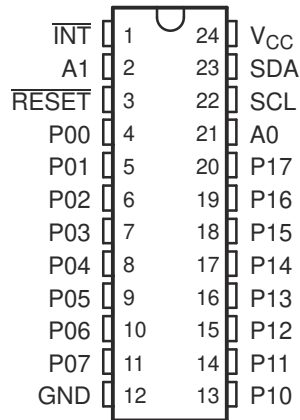
The device outputs (latched) have high-current drive capability for directly driving LEDs. The device has low current consumption.

The PCA9539 is identical to the PCA9555, except for the removal of the internal I/O pullup resistor, which greatly reduces power consumption when the I/Os are held low, replacement of A2 with RESET, and a different address range.

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

## 5 Pin Configuration and Functions

DB, DBQ, DGV, DW, OR PW PACKAGE  
(TOP VIEW)



RGE PACKAGE  
(TOP VIEW)

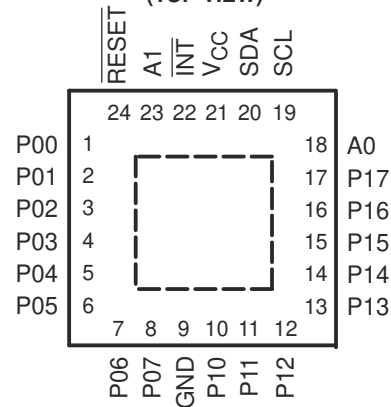


表 5-1. Pin Functions

| PIN             |                                                                           |           | DESCRIPTION                                                                                                   |
|-----------------|---------------------------------------------------------------------------|-----------|---------------------------------------------------------------------------------------------------------------|
| NAME            | NO.                                                                       |           |                                                                                                               |
|                 | SOIC (DW),<br>SSOP (DB),<br>QSOP (DBQ),<br>TSSOP (PW), AND<br>TVSOP (DGV) | QFN (RGE) |                                                                                                               |
| INT             | 1                                                                         | 22        | Interrupt output. Connect to V <sub>CC</sub> through a pullup resistor.                                       |
| A1              | 2                                                                         | 23        | Address input. Connect directly to V <sub>CC</sub> or ground.                                                 |
| RESET           | 3                                                                         | 24        | Active-low reset input. Connect to V <sub>CC</sub> through a pullup resistor if no active connection is used. |
| P00             | 4                                                                         | 1         | P-port input/output. Push-pull design structure.                                                              |
| P01             | 5                                                                         | 2         | P-port input/output. Push-pull design structure.                                                              |
| P02             | 6                                                                         | 3         | P-port input/output. Push-pull design structure.                                                              |
| P03             | 7                                                                         | 4         | P-port input/output. Push-pull design structure.                                                              |
| P04             | 8                                                                         | 5         | P-port input/output. Push-pull design structure.                                                              |
| P05             | 9                                                                         | 6         | P-port input/output. Push-pull design structure.                                                              |
| P06             | 10                                                                        | 7         | P-port input/output. Push-pull design structure.                                                              |
| P07             | 11                                                                        | 8         | P-port input/output. Push-pull design structure.                                                              |
| GND             | 12                                                                        | 9         | Ground                                                                                                        |
| P10             | 13                                                                        | 10        | P-port input/output. Push-pull design structure.                                                              |
| P11             | 14                                                                        | 11        | P-port input/output. Push-pull design structure.                                                              |
| P12             | 15                                                                        | 12        | P-port input/output. Push-pull design structure.                                                              |
| P13             | 16                                                                        | 13        | P-port input/output. Push-pull design structure.                                                              |
| P14             | 17                                                                        | 14        | P-port input/output. Push-pull design structure.                                                              |
| P15             | 18                                                                        | 15        | P-port input/output. Push-pull design structure.                                                              |
| P16             | 19                                                                        | 16        | P-port input/output. Push-pull design structure.                                                              |
| P17             | 20                                                                        | 17        | P-port input/output. Push-pull design structure.                                                              |
| A0              | 21                                                                        | 18        | Address input. Connect directly to V <sub>CC</sub> or ground.                                                 |
| SCL             | 22                                                                        | 19        | Serial clock bus. Connect to V <sub>CC</sub> through a pullup resistor.                                       |
| SDA             | 23                                                                        | 20        | Serial data bus. Connect to V <sub>CC</sub> through a pullup resistor.                                        |
| V <sub>CC</sub> | 24                                                                        | 21        | Supply voltage                                                                                                |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

|                  |                                            |                                                        | MIN   | MAX   | UNIT |
|------------------|--------------------------------------------|--------------------------------------------------------|-------|-------|------|
| V <sub>CC</sub>  | Supply voltage range                       |                                                        | - 0.5 | 6     | V    |
| V <sub>I</sub>   | Input voltage range <sup>(2)</sup>         |                                                        | - 0.5 | 6     | V    |
| V <sub>O</sub>   | Output voltage range <sup>(2)</sup>        |                                                        | - 0.5 | 6     | V    |
| I <sub>IK</sub>  | Input clamp current                        | V <sub>I</sub> < 0                                     |       | - 20  | mA   |
| I <sub>OK</sub>  | Output clamp current                       | V <sub>O</sub> < 0                                     |       | - 20  | mA   |
| I <sub>IOK</sub> | Input/output clamp current                 | V <sub>O</sub> < 0 or V <sub>O</sub> > V <sub>CC</sub> |       | ±20   | mA   |
| I <sub>OL</sub>  | Continuous output low current              | V <sub>O</sub> = 0 to V <sub>CC</sub>                  |       | 50    | mA   |
| I <sub>OH</sub>  | Continuous output high current             | V <sub>O</sub> = 0 to V <sub>CC</sub>                  |       | - 50  | mA   |
| I <sub>CC</sub>  | Continuous current through GND             |                                                        |       | - 250 | mA   |
|                  | Continuous current through V <sub>CC</sub> |                                                        |       | 160   |      |
| T <sub>stg</sub> | Storage temperature range                  |                                                        | -65   | 150   | °C   |

- (1) Stresses beyond those listed under "absolute maximum ratings" 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.
- (2) The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.

### 6.2 ESD Ratings

|                    |                         |                                                                                          | MIN | MAX  | UNIT |
|--------------------|-------------------------|------------------------------------------------------------------------------------------|-----|------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins <sup>(1)</sup>              | 0   | 2000 | V    |
|                    |                         | Charged device model (CDM), per JEDEC specification JESD22-C101, all pins <sup>(2)</sup> | 0   | 1000 |      |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

|                 |                                |                                                          | MIN                   | MAX                   | UNIT |
|-----------------|--------------------------------|----------------------------------------------------------|-----------------------|-----------------------|------|
| V <sub>CC</sub> | Supply voltage                 |                                                          | 2.3                   | V <sub>CC</sub>       | V    |
| V <sub>IH</sub> | High-level input voltage       | SCL, SDA                                                 | 0.7 × V <sub>CC</sub> | V <sub>CC</sub>       | V    |
|                 |                                | A0, A1, $\overline{\text{RESET}}$ , P07 – P00, P17 – P10 | 0.7 × V <sub>CC</sub> | 5.5                   |      |
| V <sub>IL</sub> | Low-level input voltage        | SCL, SDA                                                 | - 0.5                 | 0.3 × V <sub>CC</sub> | V    |
|                 |                                | A0, A1, $\overline{\text{RESET}}$ , P07 – P00, P17 – P10 | - 0.5                 | 0.3 × V <sub>CC</sub> |      |
| I <sub>OH</sub> | High-level output current      | P07 – P00, P17 – P10                                     |                       | - 10                  | mA   |
| I <sub>OL</sub> | Low-level output current       | P07 – P00, P17 – P00                                     |                       | 25                    | mA   |
| T <sub>A</sub>  | Operating free-air temperature |                                                          | - 40                  | 85                    | °C   |

## 6.4 Thermal Resistance Characteristics

| THERMAL METRIC <sup>(1)</sup> |                                            | PCA9539      |               |                |              |               |               | UNIT |
|-------------------------------|--------------------------------------------|--------------|---------------|----------------|--------------|---------------|---------------|------|
|                               |                                            | DB<br>(SSOP) | DBQ<br>(SSOP) | DVG<br>(TVSOP) | DW<br>(SOIC) | PW<br>(TSSOP) | RGE<br>(VQFN) |      |
|                               |                                            | 24 Pins      | 24 Pins       | 24 Pins        | 24 Pins      | 24 Pins       | 24 Pins       |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance     | 63           | 61            | 86             | 46           | 108.8         | 48.4          | °C/W |
| $\theta_{JP}$                 | Junction-to-pad characterization parameter |              |               |                |              |               | 1.5           | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC package thermal metrics](#) application report.

## 6.5 Electrical Characteristics

over recommended operating free-air temperature range (unless otherwise noted)

| PARAMETER         |                                                 | TEST CONDITIONS                                                                                       | V <sub>CC</sub> | MIN  | TYP <sup>(1)</sup> | MAX | UNIT |
|-------------------|-------------------------------------------------|-------------------------------------------------------------------------------------------------------|-----------------|------|--------------------|-----|------|
| V <sub>IK</sub>   | Input diode clamp voltage                       | I <sub>I</sub> = -18 mA                                                                               | 2.3 V to 5.5 V  | -1.2 |                    |     | V    |
| V <sub>PORR</sub> | Power-on reset voltage, V <sub>CC</sub> rising  | V <sub>I</sub> = V <sub>CC</sub> or GND, I <sub>O</sub> = 0                                           | 2.3 V to 5.5 V  |      | 1.2                | 1.5 | V    |
| V <sub>PORF</sub> | Power-on reset voltage, V <sub>CC</sub> falling | V <sub>I</sub> = V <sub>CC</sub> or GND, I <sub>O</sub> = 0                                           | 2.3 V to 5.5 V  | 0.75 | 1                  |     | V    |
| V <sub>OH</sub>   | P-port high-level output voltage <sup>(2)</sup> | I <sub>OH</sub> = -8 mA                                                                               | 2.3 V           | 1.8  |                    |     | V    |
|                   |                                                 |                                                                                                       | 3 V             | 2.6  |                    |     |      |
|                   |                                                 |                                                                                                       | 4.75 V          | 4.1  |                    |     |      |
|                   |                                                 | I <sub>OH</sub> = -10 mA                                                                              | 2.3 V           | 1.7  |                    |     |      |
|                   |                                                 |                                                                                                       | 3 V             | 2.5  |                    |     |      |
|                   |                                                 |                                                                                                       | 4.75 V          | 4    |                    |     |      |
| I <sub>OL</sub>   | SDA                                             | V <sub>OL</sub> = 0.4 V                                                                               | 2.3 V to 5.5 V  | 3    |                    |     | mA   |
|                   | P port <sup>(3)</sup>                           | V <sub>OL</sub> = 0.5 V                                                                               |                 | 8    | 20                 |     |      |
|                   |                                                 | V <sub>OL</sub> = 0.7 V                                                                               |                 | 10   | 24                 |     |      |
|                   | INT                                             | V <sub>OL</sub> = 0.4 V                                                                               |                 | 3    |                    |     |      |
| I <sub>I</sub>    | SCL, SDA                                        | V <sub>I</sub> = V <sub>CC</sub> or GND                                                               | 2.3 V to 5.5 V  |      |                    | ±1  | μA   |
|                   | A0, A1, RESET <sup>(4)</sup>                    |                                                                                                       |                 |      |                    | ±1  |      |
| I <sub>IH</sub>   | P port                                          | V <sub>I</sub> = V <sub>CC</sub>                                                                      | 2.3 V to 5.5 V  |      |                    | 1   | μA   |
| I <sub>IL</sub>   | P port                                          | V <sub>I</sub> = GND                                                                                  | 2.3 V to 5.5 V  |      |                    | -1  | μA   |
| I <sub>CC</sub>   | Operating mode                                  | V <sub>I</sub> = V <sub>CC</sub> or GND, I <sub>O</sub> = 0, I/O = inputs, f <sub>SCL</sub> = 400 kHz | 5.5 V           |      | 100                | 200 | μA   |
|                   |                                                 |                                                                                                       | 3.6 V           |      | 30                 | 75  |      |
|                   |                                                 |                                                                                                       | 2.7 V           |      | 20                 | 50  |      |
|                   | Standby mode                                    | V <sub>I</sub> = GND, I <sub>O</sub> = 0, I/O = inputs, f <sub>SCL</sub> = 0 kHz                      | 5.5 V           |      | 1.5                | 8.7 |      |
|                   |                                                 |                                                                                                       | 3.6 V           |      | 0.9                | 4   |      |
|                   |                                                 |                                                                                                       | 2.7 V           |      | 0.6                | 3   |      |
| Δ I <sub>CC</sub> | Additional current in standby mode              | One input at V <sub>CC</sub> - 0.6 V, Other inputs at V <sub>CC</sub> or GND                          | 2.3 V to 5.5 V  |      |                    | 200 | μA   |
| C <sub>i</sub>    | SCL                                             | V <sub>I</sub> = V <sub>CC</sub> or GND                                                               | 2.3 V to 5.5 V  |      | 3                  | 8   | pF   |
| C <sub>io</sub>   | SDA                                             | V <sub>IO</sub> = V <sub>CC</sub> or GND                                                              | 2.3 V to 5.5 V  |      | 3                  | 9.5 | pF   |
|                   | P port                                          |                                                                                                       |                 |      | 3.7                | 9.5 |      |

- (1) All typical values are at nominal supply voltage (2.5-V, 3.3-V, or 5-V V<sub>CC</sub>) and T<sub>A</sub> = 25°C.
- (2) Each I/O must be externally limited to a maximum of 25 mA, and each octal (P07 - P00 and P17 - P10) 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 P07 - P00 and 80 mA for P17 - P10).
- (4) RESET = V<sub>CC</sub> (held high) when all other input voltages, V<sub>I</sub> = GND.

## 6.6 I<sup>2</sup>C Interface Timing Requirements

over recommended operating free-air temperature range (unless otherwise noted) (see 图 7-1)

|                       |                                                          |                                          | MIN                                   | MAX | UNIT |
|-----------------------|----------------------------------------------------------|------------------------------------------|---------------------------------------|-----|------|
| f <sub>scl</sub>      | I <sup>2</sup> C clock frequency                         |                                          | 0                                     | 400 | kHz  |
| t <sub>sch</sub>      | I <sup>2</sup> C clock high time                         |                                          | 0.6                                   |     | μs   |
| t <sub>scl</sub>      | I <sup>2</sup> C clock low time                          |                                          | 1.3                                   |     | μs   |
| t <sub>sp</sub>       | I <sup>2</sup> C spike time                              |                                          |                                       | 50  | ns   |
| t <sub>sds</sub>      | I <sup>2</sup> C serial-data setup time                  |                                          | 100                                   |     | ns   |
| t <sub>sdh</sub>      | I <sup>2</sup> C serial-data hold time                   |                                          | 0                                     |     | ns   |
| t <sub>icr</sub>      | I <sup>2</sup> C input rise time                         |                                          | 20 + 0.1C <sub>b</sub> <sup>(1)</sup> | 300 | ns   |
| t <sub>icf</sub>      | I <sup>2</sup> C input fall time                         |                                          | 20 + 0.1C <sub>b</sub> <sup>(1)</sup> | 300 | ns   |
| t <sub>ocf</sub>      | I <sup>2</sup> C output fall time                        | 10-pF to 400-pF bus                      | 20 + 0.1C <sub>b</sub> <sup>(1)</sup> | 300 | ns   |
| t <sub>buf</sub>      | I <sup>2</sup> C bus free time between Stop and Start    |                                          | 1.3                                   |     | μs   |
| t <sub>sts</sub>      | I <sup>2</sup> C Start or repeated Start condition setup |                                          | 0.6                                   |     | μs   |
| t <sub>sth</sub>      | I <sup>2</sup> C Start or repeated Start condition hold  |                                          | 0.6                                   |     | μs   |
| t <sub>sps</sub>      | I <sup>2</sup> C Stop condition setup                    |                                          | 0.6                                   |     | μs   |
| t <sub>vd(data)</sub> | Valid-data time                                          | SCL low to SDA output valid              | 50                                    |     | ns   |
| t <sub>vd(ack)</sub>  | Valid-data time of ACK condition                         | ACK signal from SCL low to SDA (out) low | 0.1                                   | 0.9 | μs   |
| C <sub>b</sub>        | I <sup>2</sup> C bus capacitive load                     |                                          |                                       | 400 | pF   |

(1) C<sub>b</sub> = total capacitance of one bus line in pF

## 6.7 RESET Timing Requirements

over recommended operating free-air temperature range (unless otherwise noted) (see 图 7-4)

|                    |                      | MIN | MAX | UNIT |
|--------------------|----------------------|-----|-----|------|
| t <sub>W</sub>     | Reset pulse duration | 6   |     | ns   |
| t <sub>REC</sub>   | Reset recovery time  | 0   |     | ns   |
| t <sub>RESET</sub> | Time to reset        | 400 |     | ns   |

## 6.8 Switching Characteristics

over recommended operating free-air temperature range, C<sub>L</sub> ≤ 100 pF (unless otherwise noted) (see 图 7-2 and 图 7-3)

| PARAMETER       | FROM<br>(INPUT)            | TO<br>(OUTPUT) | MIN | MAX | UNIT |
|-----------------|----------------------------|----------------|-----|-----|------|
| t <sub>iv</sub> | Interrupt valid time       | P port         |     | 4   | μs   |
| t <sub>ir</sub> | Interrupt reset delay time | SCL            |     | 4   | μs   |
| t <sub>pv</sub> | Output data valid          | SCL            |     | 200 | ns   |
| t <sub>ps</sub> | Input data setup time      | P port         | 150 |     | ns   |
| t <sub>ph</sub> | Input data hold time       | P port         | 1   |     | μs   |

## 6.9 Typical Characteristics

$T_A = 25^\circ\text{C}$  (unless otherwise noted)

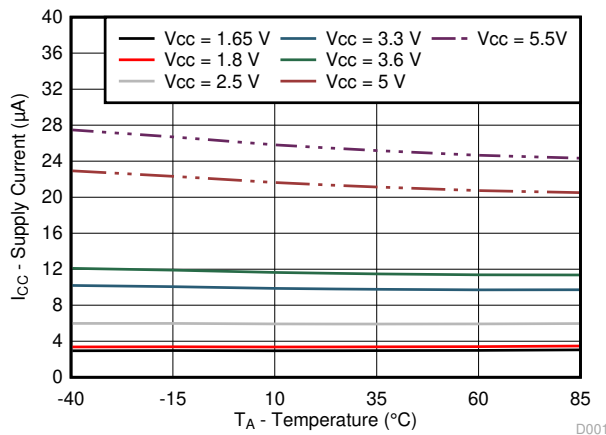


图 6-1. Supply Current vs Temperature for Different Supply Voltage ( $V_{CC}$ )

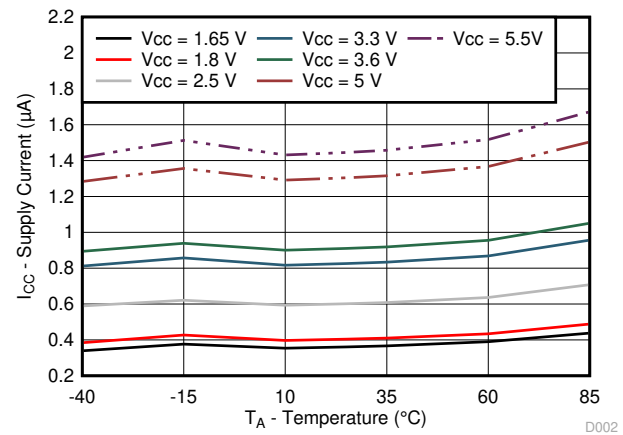


图 6-2. Standby Supply Current vs Temperature for Different Supply Voltage ( $V_{CC}$ )

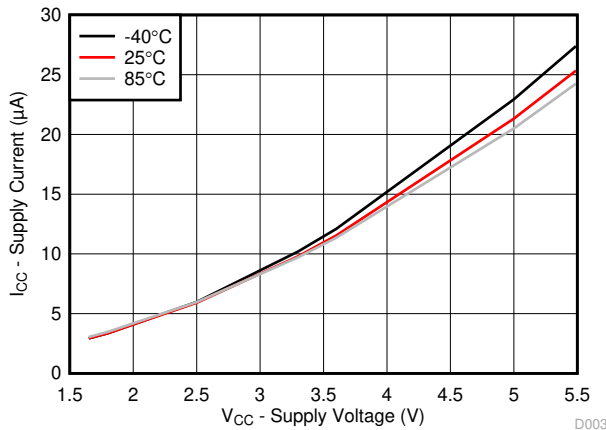


图 6-3. Supply Current vs Supply Voltage for Different Temperature ( $T_A$ )

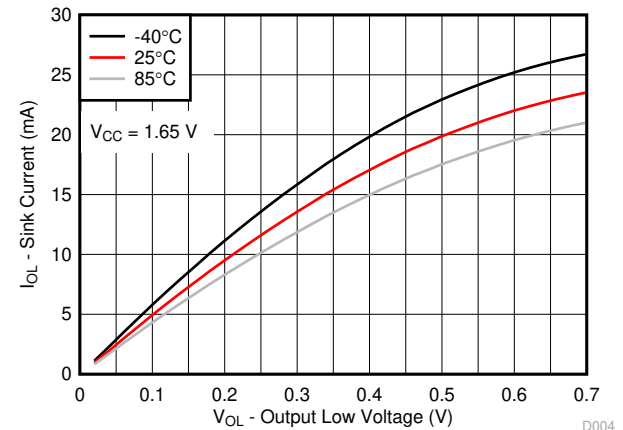


图 6-4. I/O Sink Current vs Output Low Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 1.65\text{ V}$

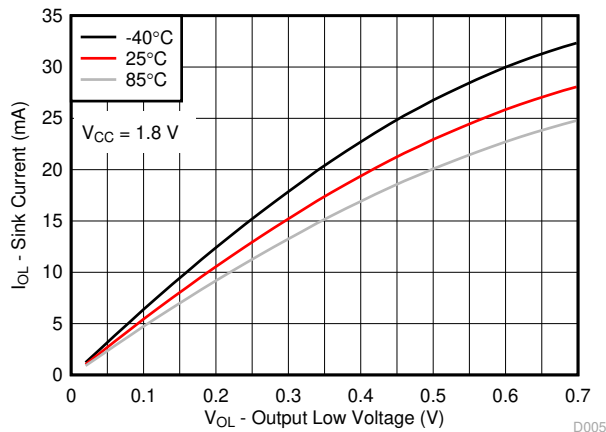


图 6-5. I/O Sink Current vs Output Low Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 1.8\text{ V}$

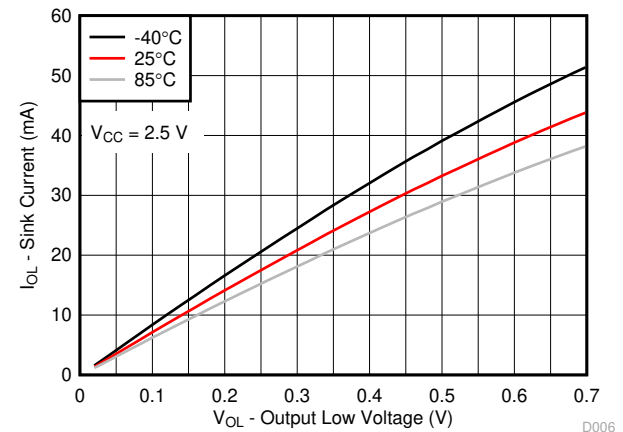


图 6-6. I/O Sink Current vs Output Low Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 2.5\text{ V}$

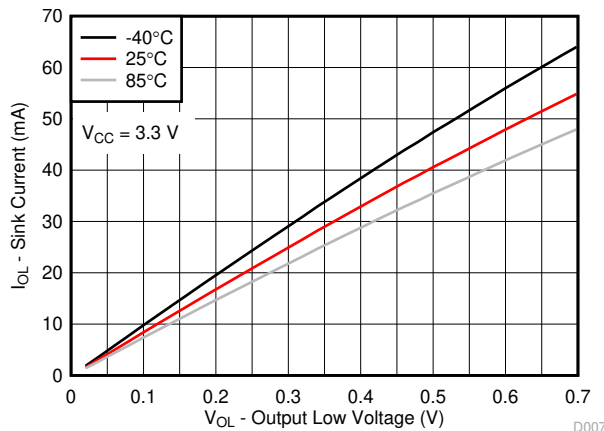


图 6-7. I/O Sink Current vs Output Low Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 3.3\text{ V}$

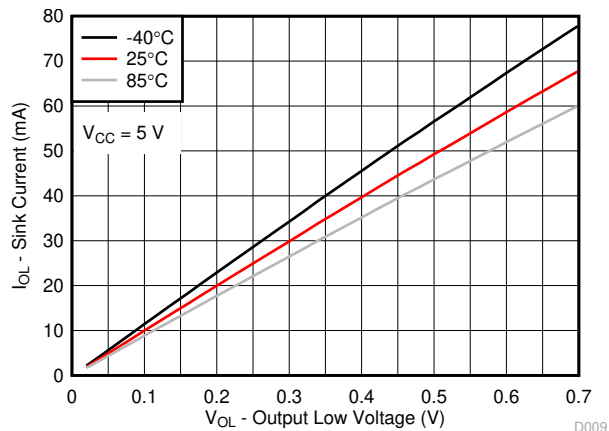


图 6-8. I/O Sink Current vs Output Low Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 5\text{ V}$

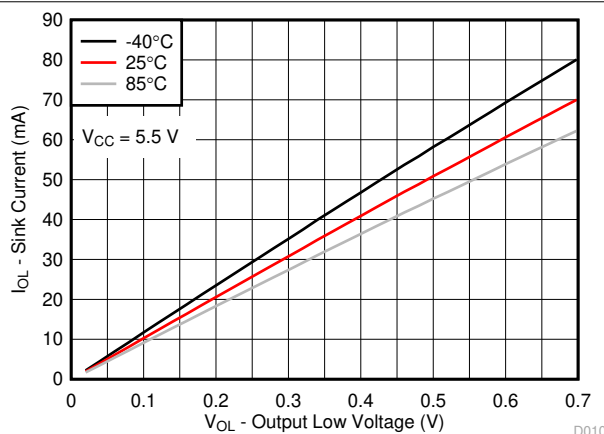


图 6-9. I/O Sink Current vs Output Low Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 5.5\text{ V}$

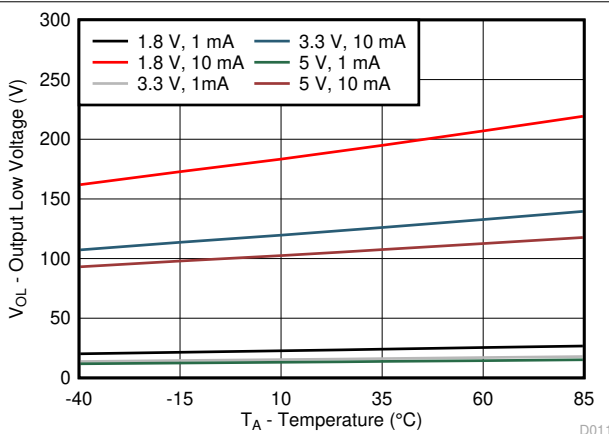


图 6-10. I/O Low Voltage vs Temperature for Different  $V_{CC}$  and  $I_{OL}$

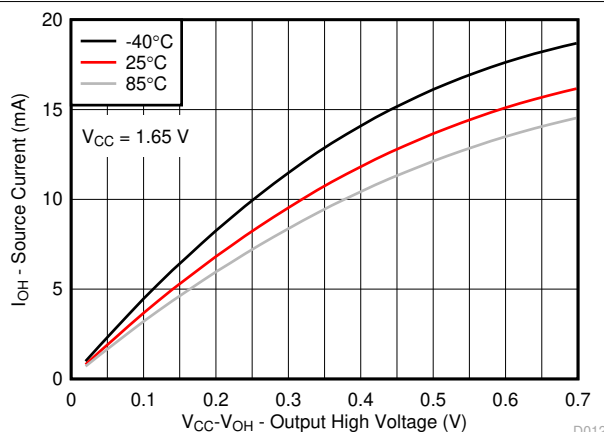


图 6-11. I/O Source Current vs Output High Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 1.65\text{ V}$

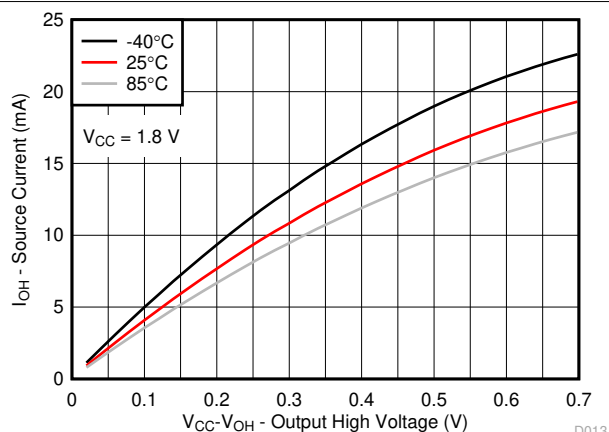


图 6-12. I/O Source Current vs Output High Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 1.8\text{ V}$

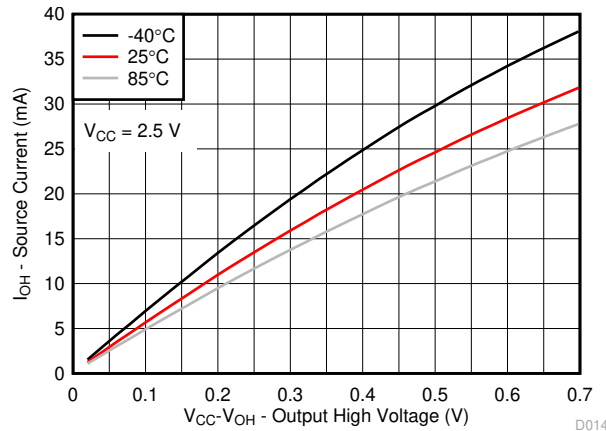


图 6-13. I/O Source Current vs Output High Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 2.5\text{ V}$

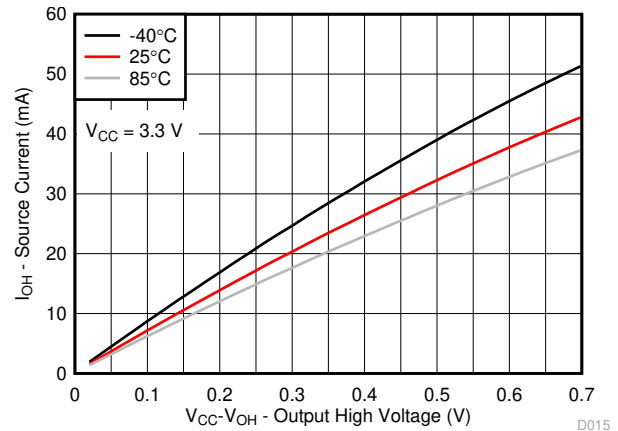


图 6-14. I/O Source Current vs Output High Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 3.3\text{ V}$

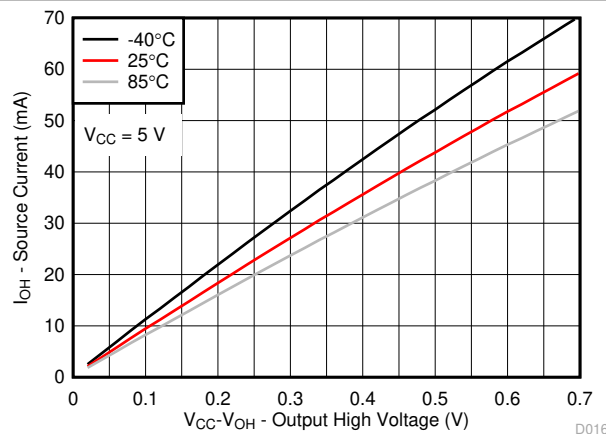


图 6-15. I/O Source Current vs Output High Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 5\text{ V}$

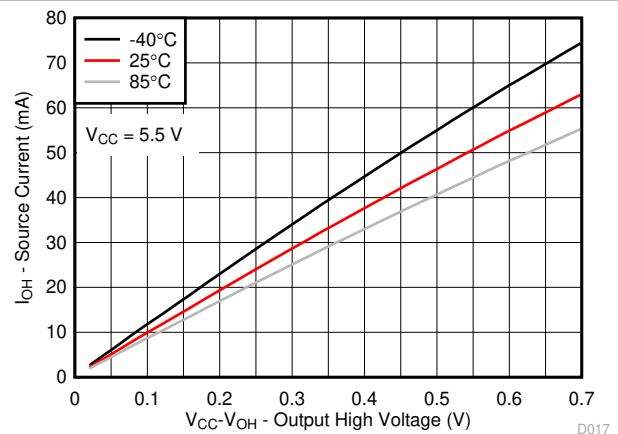


图 6-16. I/O Source Current vs Output High Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 5.5\text{ V}$

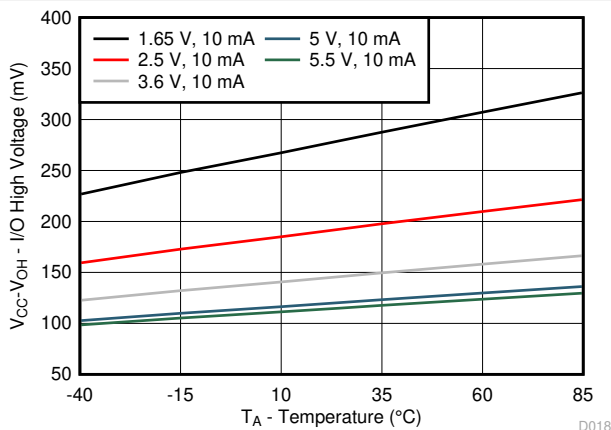


图 6-17.  $V_{CC} - V_{OH}$  Voltage vs Temperature for Different  $V_{CC}$

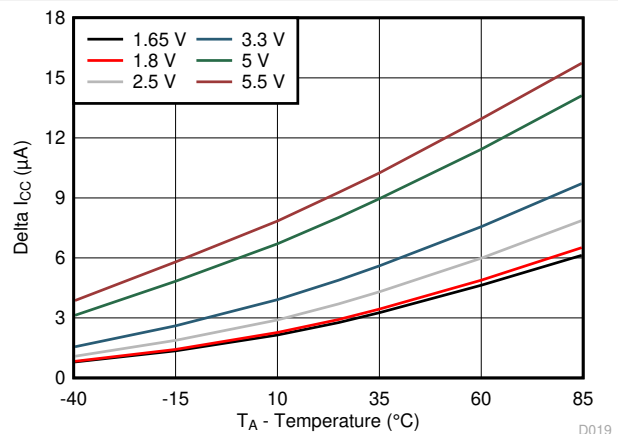
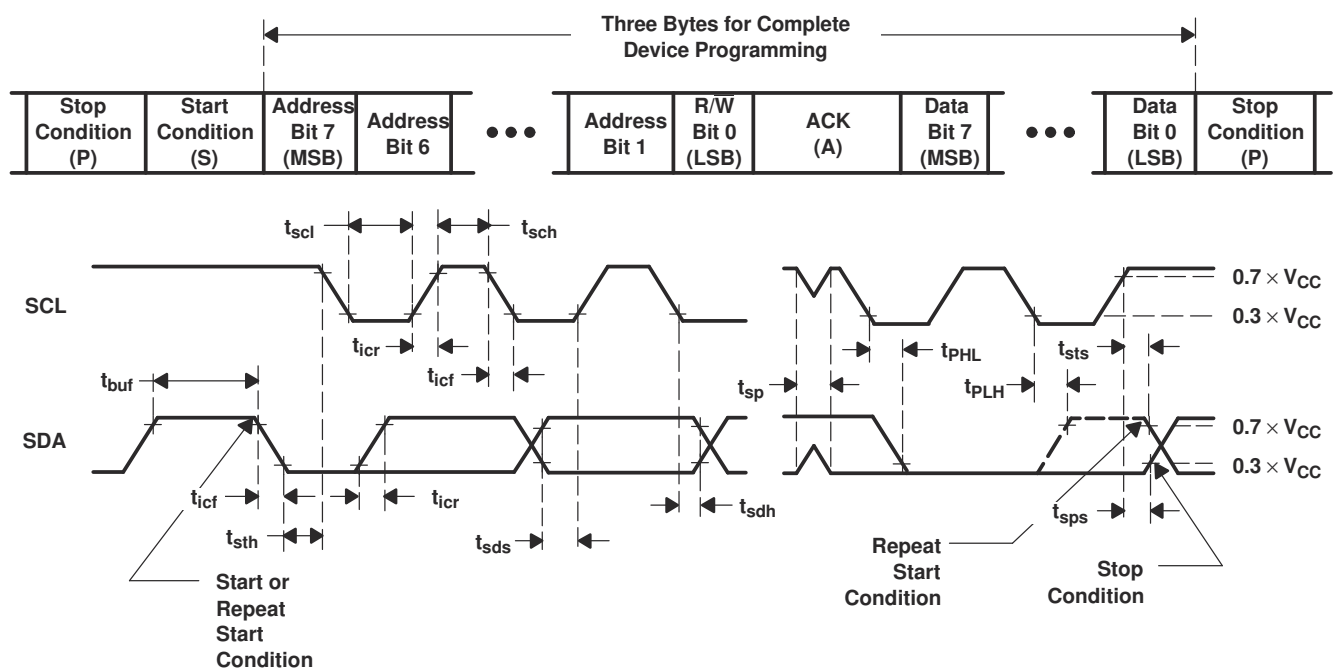
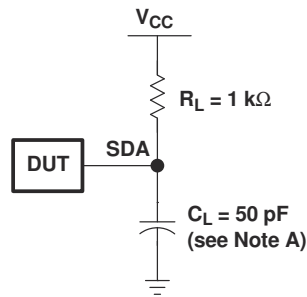


图 6-18.  $\Delta I_{CC}$  vs Temperature for Different  $V_{CC}$  ( $V_I = V_{CC} - 0.6\text{ V}$ )

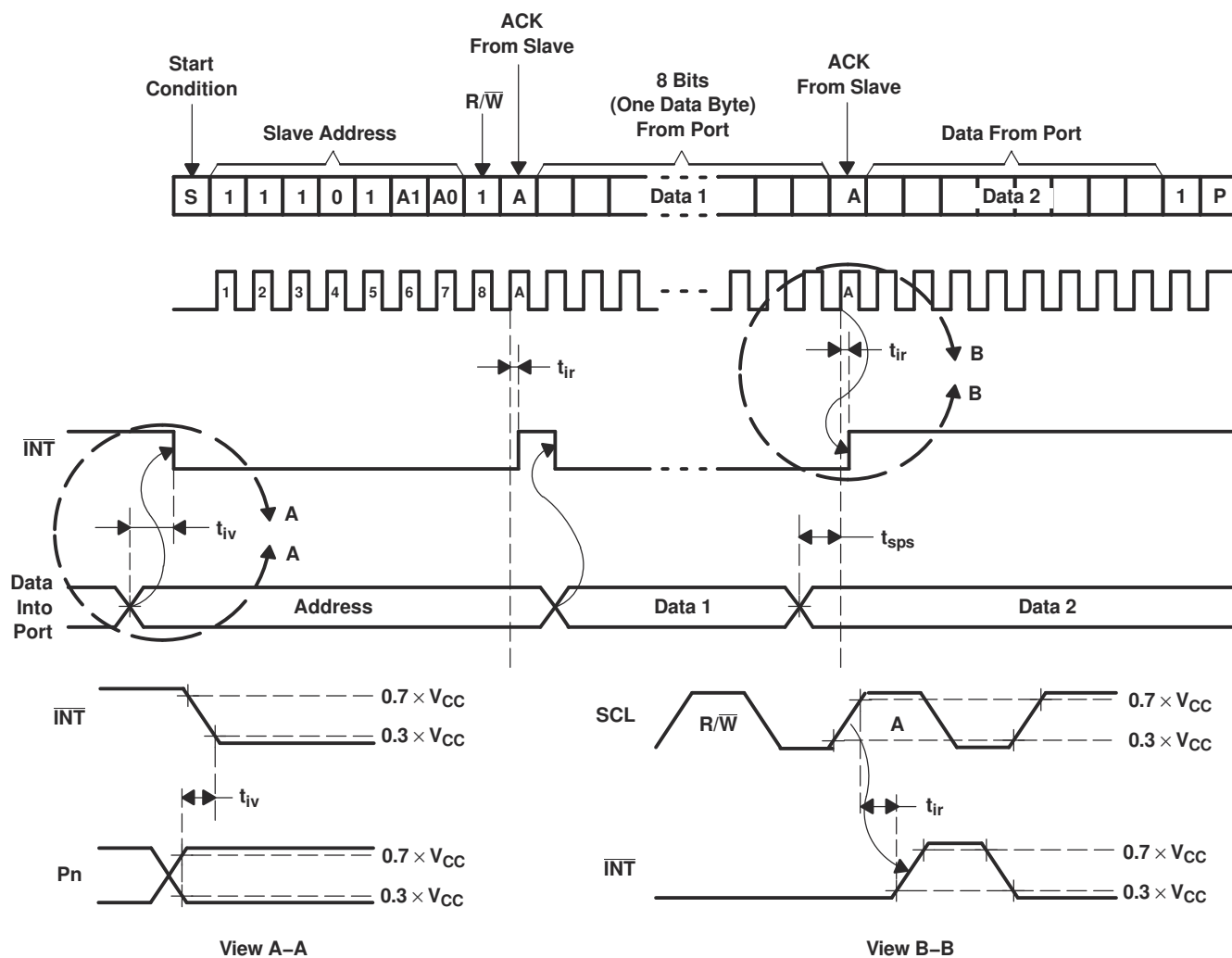
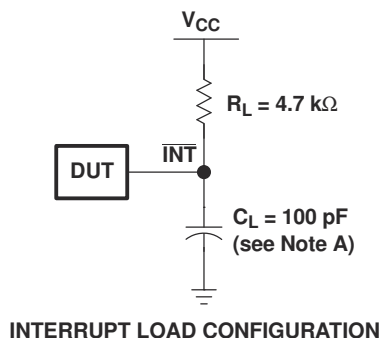
## 7 Parameter Measurement Information



| BYTE | DESCRIPTION              |
|------|--------------------------|
| 1    | I <sup>2</sup> C address |
| 2, 3 | P-port data              |

- A.  $C_L$  includes probe and jig capacitance.
- B. All inputs are supplied by generators having the following characteristics:  $PRR \leq 10 \text{ MHz}$ ,  $Z_O = 50 \Omega$ ,  $t_r/t_f \leq 30 \text{ ns}$ .
- C. All parameters and waveforms are not applicable to all devices.

**图 7-1. I<sup>2</sup>C Interface Load Circuit And Voltage Waveforms**

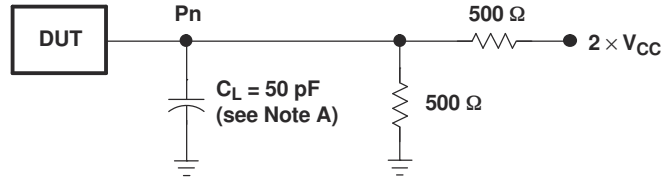


A.  $C_L$  includes probe and jig capacitance.

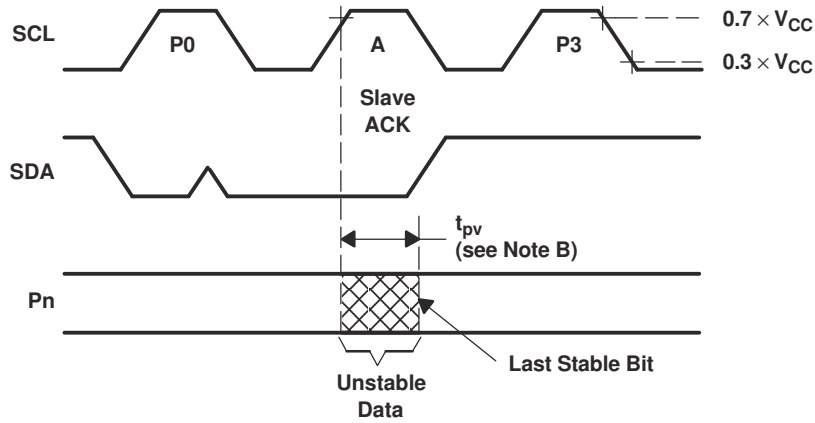
B. All inputs are supplied by generators having the following characteristics:  $PRR \leq 10 \text{ MHz}$ ,  $Z_O = 50 \Omega$ ,  $t_r/t_f \leq 30 \text{ ns}$ .

C. All parameters and waveforms are not applicable to all devices.

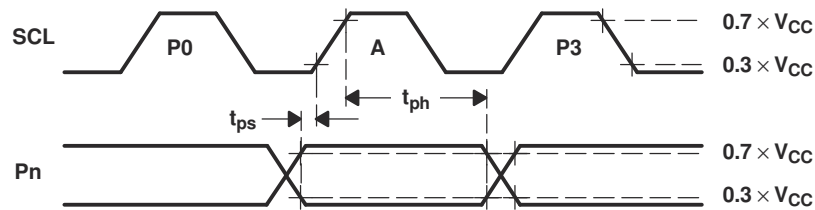
**图 7-2. Interrupt Load Circuit And Voltage Waveforms**



**P-PORT LOAD CONFIGURATION**



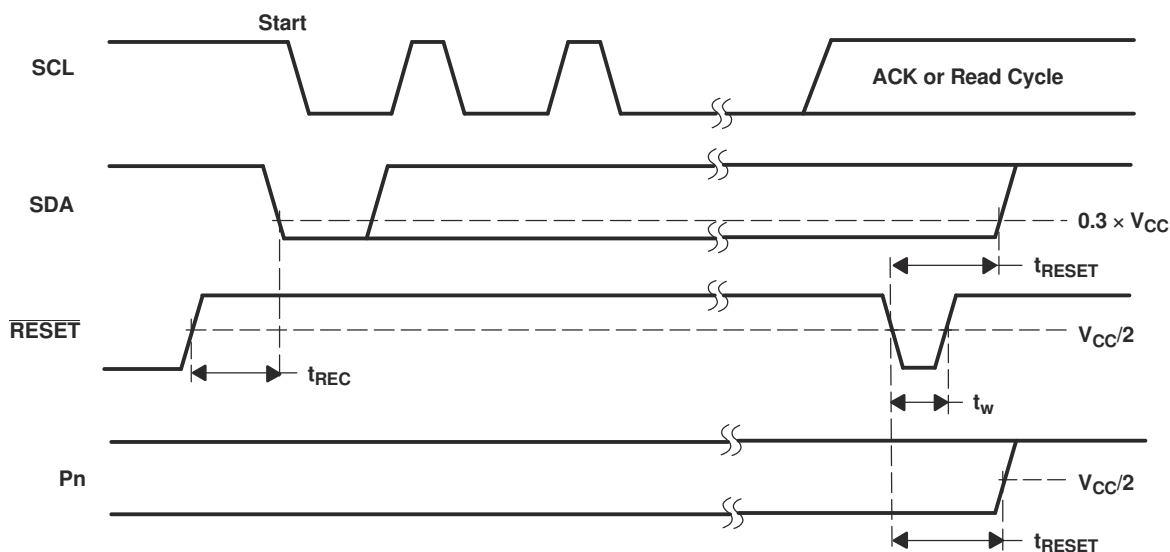
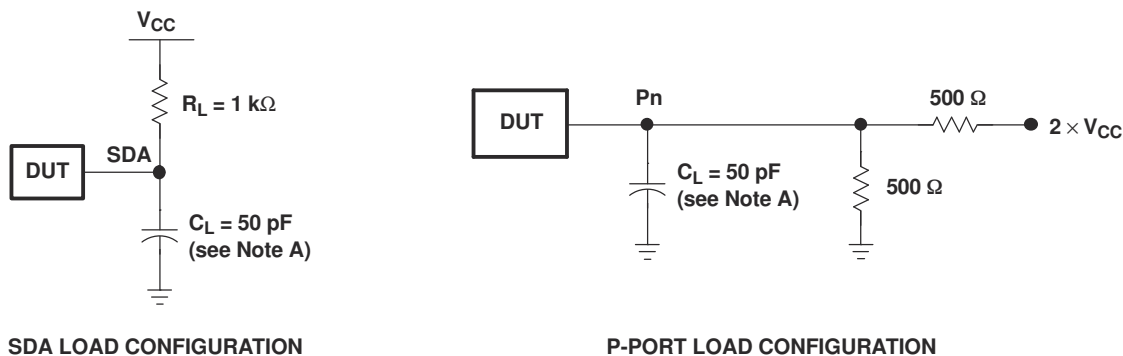
**WRITE MODE ( $R/\overline{W} = 0$ )**



**READ MODE ( $R/\overline{W} = 1$ )**

- A.  $C_L$  includes probe and jig capacitance.
- B.  $t_{pv}$  is measured from  $0.7 \times V_{CC}$  on SCL to 50% I/O ( $P_n$ ) output.
- C. All inputs are supplied by generators having the following characteristics:  $PRR \leq 10$  MHz,  $Z_O = 50 \Omega$ ,  $t_r/t_f \leq 30$  ns.
- D. The outputs are measured one at a time, with one transition per measurement.
- E. All parameters and waveforms are not applicable to all devices.

**图 7-3. P-Port Load Circuit And Voltage Waveforms**

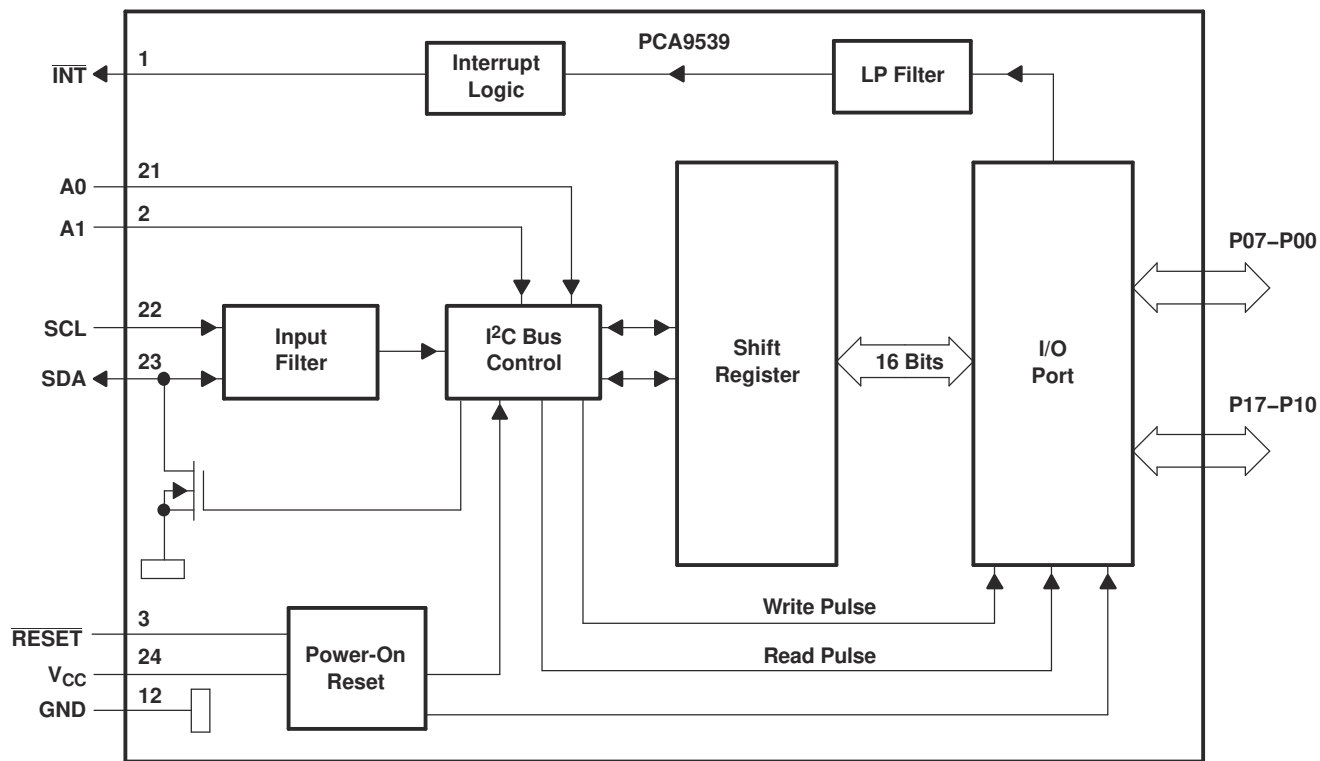


- A. C<sub>L</sub> includes probe and jig capacitance.
- B. All inputs are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z<sub>O</sub> = 50 Ω, t<sub>r</sub>/t<sub>f</sub> ≤ 30 ns.
- C. The outputs are measured one at a time, with one transition per measurement.
- D. I/Os are configured as inputs.
- E. All parameters and waveforms are not applicable to all devices.

**图 7-4. Reset Load Circuits And Voltage Waveforms**

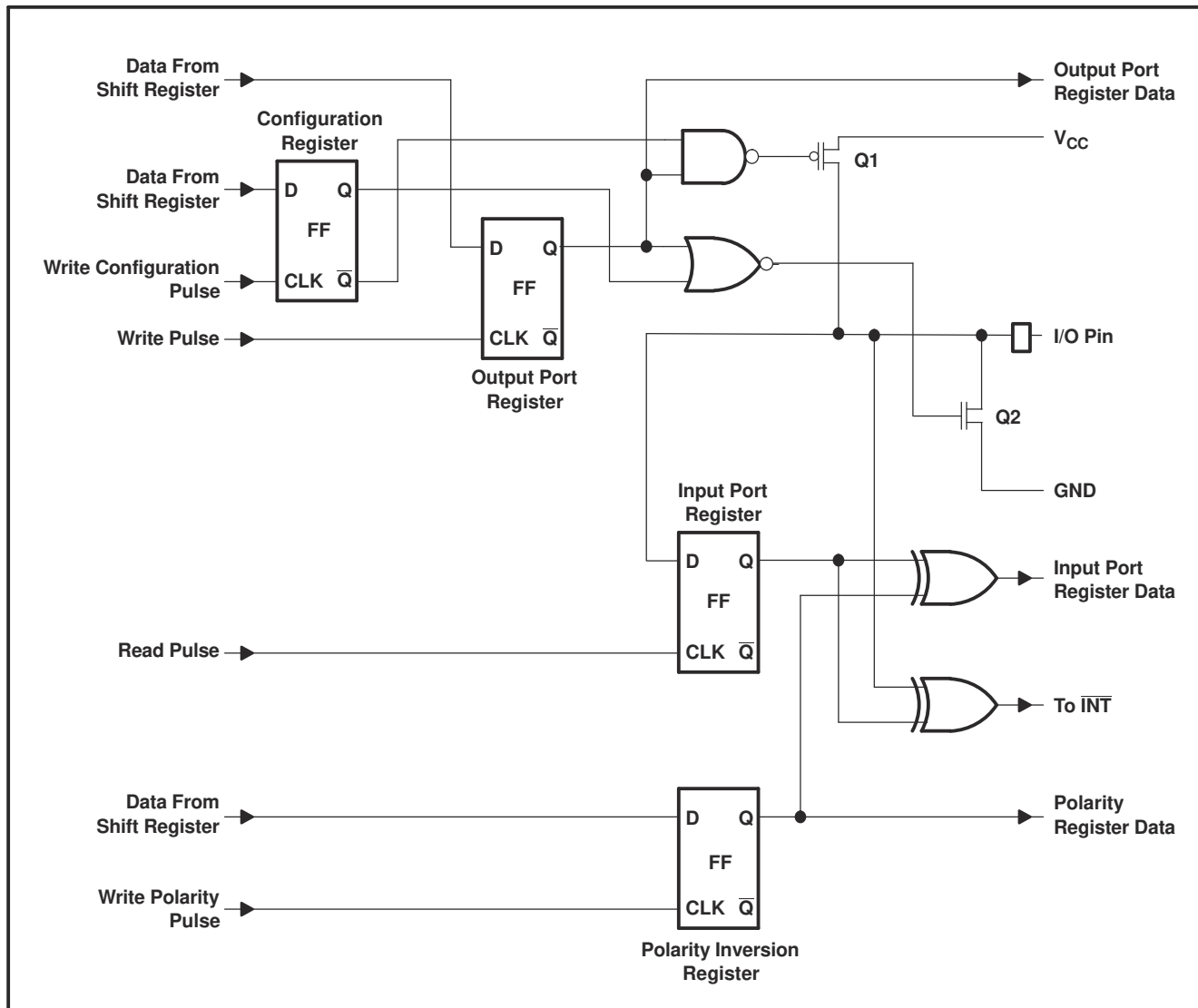
## 8 Detailed Description

### 8.1 Functional Block Diagram



- A. Pin numbers shown are for DB, DBQ, DGV, DW, and PW packages.
- B. All I/Os are set to inputs at reset.

**图 8-1. Logic Diagram (Positive Logic)**



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

**图 8-2. Simplified Schematic Of P-Port I/Os**

## 8.2 Device Functional Modes

### 8.2.1 RESET Input

A reset can be accomplished by holding the  $\overline{\text{RESET}}$  pin low for a minimum of  $t_{\text{W}}$ . The PCA9539 registers and I<sup>2</sup>C/SMBus state machine are held in their default states until  $\overline{\text{RESET}}$  is once again high. This input requires a pullup resistor to  $V_{\text{CC}}$ , if no active connection is used.

#### 8.2.1.1 RESET Errata

If  $\overline{\text{RESET}}$  voltage set higher than  $V_{\text{CC}}$ , current will flow from  $\overline{\text{RESET}}$  pin to  $V_{\text{CC}}$  pin.

##### 8.2.1.1.1 System Impact

$V_{\text{CC}}$  will be pulled above its regular voltage level

##### 8.2.1.1.2 System Workaround

Design such that  $\overline{\text{RESET}}$  voltage is same or lower than  $V_{\text{CC}}$

### 8.2.2 Power-On Reset

When power (from 0 V) is applied to  $V_{\text{CC}}$ , an internal power-on reset holds the PCA9539 in a reset condition until  $V_{\text{CC}}$  has reached  $V_{\text{POR}}$ . At that point, the reset condition is released and the PCA9539 registers and I<sup>2</sup>C/SMBus state machine initialize to their default states. After that,  $V_{\text{CC}}$  must be lowered to below 0.2 V and then back up to the operating voltage for a power-reset cycle.

### 8.2.3 I/O Port

When an I/O is configured as an input, FETs Q1 and Q2 (in [Figure 8-2](#)) are off, which creates a high-impedance input. The input voltage may be raised above  $V_{\text{CC}}$  to a maximum of 5.5 V.

If the I/O is configured as an output, Q1 or Q2 is enabled, depending on the state of the Output Port register. In this case, there are low-impedance paths between the I/O pin and either  $V_{\text{CC}}$  or GND. The external voltage applied to this I/O pin should not exceed the recommended levels for proper operation.

### 8.2.4 Interrupt (INT) Output

An interrupt is generated by any rising or falling edge of the port inputs in the input mode. After time,  $t_{\text{iv}}$ , the signal  $\overline{\text{INT}}$  is valid. Resetting the interrupt circuit is achieved when data on the port is changed to the original setting, data is read from the port that generated the interrupt. Resetting occurs in the read mode at the acknowledge (ACK) or not acknowledge (NACK) bit after the rising edge of the SCL signal.

Interrupts that occur during the ACK or NACK clock pulse can be lost (or be very short) due to the resetting of the interrupt during this pulse. Each change of the I/Os after resetting is detected and is transmitted as  $\overline{\text{INT}}$ . Writing to another device does not affect the interrupt circuit, and a pin configured as an output cannot cause an interrupt. 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. Because each 8-pin port is read independently, the interrupt caused by port 0 is not cleared by a read of port 1 or vice versa.

The  $\overline{\text{INT}}$  output has an open-drain structure and requires pullup resistor to  $V_{\text{CC}}$ .

#### 8.2.4.1 Interrupt Errata

The INT will be improperly de-asserted if the following two conditions occur:

1. The last I<sup>2</sup>C command byte (register pointer) written to the device was 00h.

---

##### Note

This generally means the last operation with the device was a Read of the input register. However, the command byte may have been written with 00h without ever going on to read the input register. After reading from the device, if no other command byte written, it will remain 00h.

2. Any other slave device on the I<sup>2</sup>C bus acknowledges an address byte with the R/W bit set high

##### 8.2.4.1.1 System Impact

Can cause improper interrupt handling as the Master will see the interrupt as being cleared.

##### 8.2.4.1.2 System Workaround

Minor software change: User must change command byte to something besides 00h after a Read operation to the PCA9539 device or before reading from another slave device.

---

##### Note

Software change will be compatible with other versions (competition and TI redesigns) of this device.

---

### 8.3 Programming

#### 8.3.1 I<sup>2</sup>C Interface

The bidirectional I<sup>2</sup>C bus consists of the serial clock (SCL) and serial data (SDA) lines. Both lines must be connected to a positive supply via a pullup resistor when connected to the output stages of a device. Data transfer may be initiated only when the bus is not busy.

I<sup>2</sup>C communication with this device is initiated by a master sending a Start condition, a high-to-low transition on the SDA input/output while the SCL input is high (see [Figure 8-3](#)). After the Start condition, the device address byte is sent, MSB first, including the data direction bit (R/  $\bar{W}$ ). This device does not respond to the general call address.

After receiving the valid address byte, this device responds with an ACK, a low on the SDA input/output during the high of the ACK-related clock pulse. The address inputs (A0 and A1) of the slave device must not be changed between the Start and Stop conditions.

On the I<sup>2</sup>C bus, only one data bit is transferred during each clock pulse. The data on the SDA line must remain stable during the high pulse of the clock period, as changes in the data line at this time are interpreted as control commands (Start or Stop) (see [Figure 8-4](#)).

A Stop condition, a low-to-high transition on the SDA input/output while the SCL input is high, is sent by the master (see [Figure 8-3](#)).

Any number of data bytes can be transferred from the transmitter to the receiver between the Start and the Stop conditions. Each byte of eight bits is followed by one ACK bit. The transmitter must release the SDA line before the receiver can send an ACK bit. The device that acknowledges must pull down the SDA line during the ACK clock pulse so that the SDA line is stable low during the high pulse of the ACK-related clock period (see [Figure 8-5](#)). When a slave receiver is addressed, it must generate an ACK after each byte is received. Similarly, the master must generate an ACK after each byte that it receives from the slave transmitter. Setup and hold times must be met to ensure proper operation.

A master receiver signals an end of data to the slave transmitter by not generating an acknowledge (NACK) after the last byte has been clocked out of the slave. This is done by the master receiver by holding the SDA line high. In this event, the transmitter must release the data line to enable the master to generate a Stop condition.

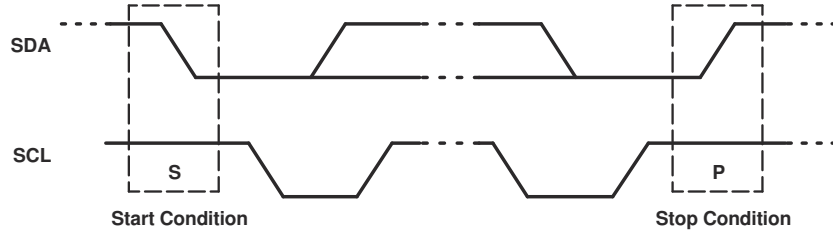


图 8-3. Definition Of Start And Stop Conditions

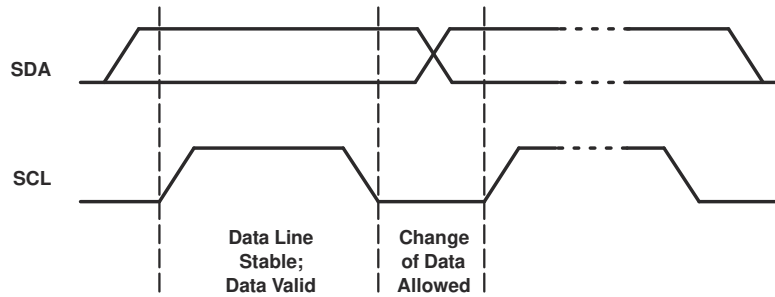


图 8-4. Bit Transfer

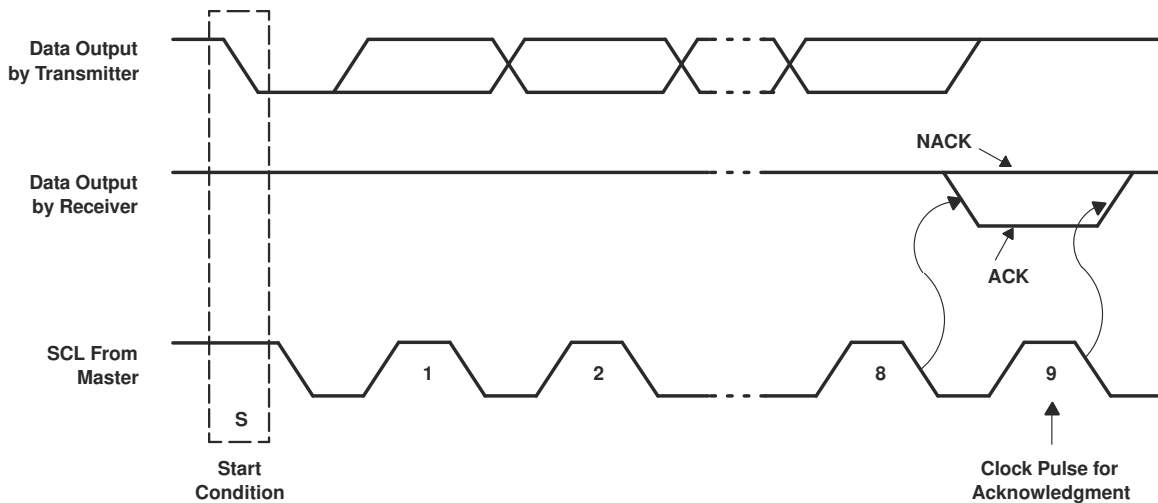


图 8-5. Acknowledgment On I²C Bus

### 8.3.2 Register Map

表 8-1. Interface Definition

| BYTE              | BIT     |     |     |     |     |     |     |         |
|-------------------|---------|-----|-----|-----|-----|-----|-----|---------|
|                   | 7 (MSB) | 6   | 5   | 4   | 3   | 2   | 1   | 0 (LSB) |
| I²C slave address | H       | H   | H   | L   | H   | A1  | A0  | R/W     |
| P0x I/O data bus  | P07     | P06 | P05 | P04 | P03 | P02 | P01 | P00     |
| P1x I/O data bus  | P17     | P16 | P15 | P14 | P13 | P12 | P11 | P10     |

### 8.3.2.1 Device Address

图 8-6 shows the address byte of the PCA9539.

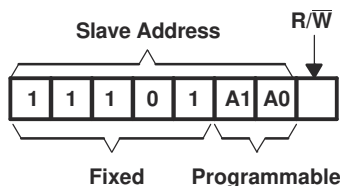


图 8-6. Pca9539 Address

表 8-2. Address Reference

| INPUTS |    | I <sup>2</sup> C BUS SLAVE ADDRESS |
|--------|----|------------------------------------|
| A1     | A0 |                                    |
| L      | L  | 116 (decimal), 74 (hexadecimal)    |
| L      | H  | 117 (decimal), 75 (hexadecimal)    |
| H      | L  | 118 (decimal), 76 (hexadecimal)    |
| H      | H  | 119 (decimal), 77 (hexadecimal)    |

The last bit of the slave address defines the operation (read or write) to be performed. A high (1) selects a read operation, while a low (0) selects a write operation.

### 8.3.2.2 Control Register And Command Byte

Following the successful acknowledgment of the address byte, the bus master sends a command byte that is stored in the control register in the PCA9539. Three bits of this data byte state the operation (read or write) and the internal register (input, output, Polarity Inversion or Configuration) that will be affected. This register can be written or read through the I<sup>2</sup>C bus. The command byte is sent only during a write transmission.

Once a command byte has been sent, the register that was addressed continues to be accessed by reads until a new command byte has been sent.

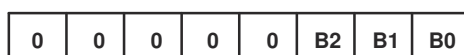


图 8-7. Control Register Bits

表 8-3. Command Byte

| CONTROL REGISTER BITS |    |    | COMMAND<br>BYTE (HEX) | REGISTER                  | PROTOCOL        | POWER-UP<br>DEFAULT |
|-----------------------|----|----|-----------------------|---------------------------|-----------------|---------------------|
| B2                    | B1 | B0 |                       |                           |                 |                     |
| 0                     | 0  | 0  | 0x00                  | Input Port 0              | Read byte       | xxxx xxxx           |
| 0                     | 0  | 1  | 0x01                  | Input Port 1              | Read byte       | xxxx xxxx           |
| 0                     | 1  | 0  | 0x02                  | Output Port 0             | Read/write byte | 1111 1111           |
| 0                     | 1  | 1  | 0x03                  | Output Port 1             | Read/write byte | 1111 1111           |
| 1                     | 0  | 0  | 0x04                  | Polarity Inversion Port 0 | Read/write byte | 0000 0000           |
| 1                     | 0  | 1  | 0x05                  | Polarity Inversion Port 1 | Read/write byte | 0000 0000           |
| 1                     | 1  | 0  | 0x06                  | Configuration Port 0      | Read/write byte | 1111 1111           |
| 1                     | 1  | 1  | 0x07                  | Configuration Port 1      | Read/write byte | 1111 1111           |

### 8.3.2.3 Register Descriptions

The Input Port registers (registers 0 and 1) reflect the incoming logic levels of the pins, regardless of whether the pin is defined as an input or an output by the Configuration register. It only acts on read operation. Writes to these registers have no effect. The default value, X, is determined by the externally applied logic level.

Before a read operation, a write transmission is sent with the command byte to indicate to the I<sup>2</sup>C device that the Input Port register will be accessed next.

**表 8-4. Registers 0 And 1 (Input Port Registers)**

| Bit     | 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    |
| Bit     | 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    |

The Output Port registers (registers 2 and 3) show the outgoing logic levels of the pins defined as outputs by the Configuration register. 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.

**表 8-5. Registers 2 And 3 (Output Port Registers)**

| Bit     | 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    |
| Bit     | 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    |

The Polarity Inversion registers (registers 4 and 5) allow Polarity Inversion of pins defined as inputs by the Configuration register. If a bit in this register is set (written with 1), the corresponding port pin's polarity is inverted. If a bit in this register is cleared (written with a 0), the corresponding port pin's original polarity is retained.

**表 8-6. Registers 4 And 5 (Polarity Inversion Registers)**

| Bit     | 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    |
| Bit     | 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    |

The Configuration registers (registers 6 and 7) configure the directions of the I/O pins. If a bit in this register is set to 1, the corresponding port pin is enabled as an input with a high-impedance output driver. If a bit in this register is cleared to 0, the corresponding port pin is enabled as an output.

**表 8-7. Registers 6 And 7 (Configuration Registers)**

| Bit     | 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    |
| Bit     | 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    |

### 8.3.2.4 Bus Transactions

Data is exchanged between the master and PCA9539 through write and read commands.

#### 8.3.2.4.1 Writes

Data is transmitted to the PCA9539 by sending the device address and setting the least-significant bit to a logic 0 (see [图 8-6](#) for device address). The command byte is sent after the address and determines which register receives the data that follows the command byte.

The eight registers within the PCA9539 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 is sent to the other register in the pair (see 图 8-8 and 图 8-9). For example, if the first byte is sent to Output Port 1 (register 3), the next byte is 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.

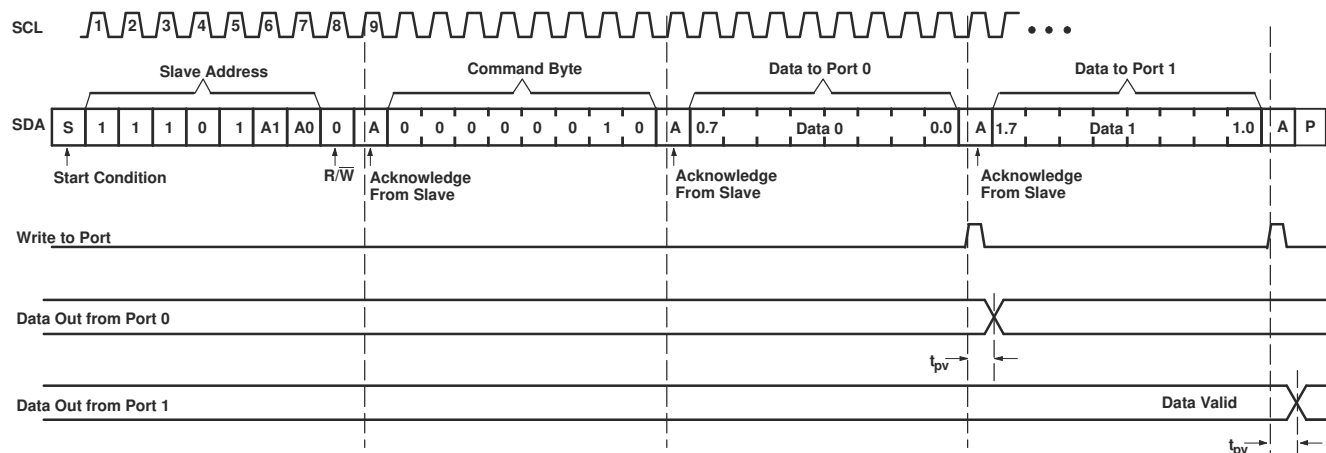


图 8-8. Write To Output Port Registers

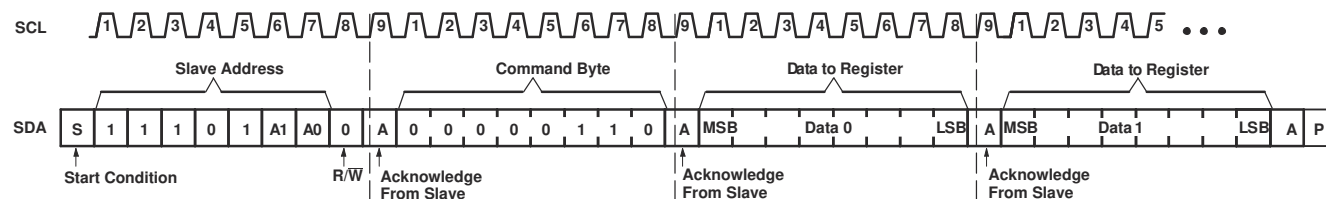


图 8-9. Write To Configuration Registers

#### 8.3.2.4.2 Reads

The bus master first must send the PCA9539 address with the least-significant bit set to a logic 0 (see 图 8-6 for device address). The command byte is sent after the address and determines which register is 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 then is sent by the PCA9539 (see 图 8-10 through 图 8-12).

After a restart, the value of the register defined by the command byte matches the register being accessed when the restart occurred. For example, if the command byte references Input Port 1 before the restart, and the restart occurs when Input Port 0 is being read, the stored command byte changes to reference Input Port 0. The original command byte is forgotten. If a subsequent restart occurs, Input Port 0 is read first. Data is clocked into the register on the rising edge of the ACK clock pulse. After the first byte is read, additional bytes may be read, but the data now reflect the information in the other register in the pair. For example, if Input Port 1 is read, the next byte read is Input Port 0.

Data is clocked into the register on the rising edge of the ACK clock pulse. There is no limitation on the number of data bytes received in one read transmission, but when the final byte is received, the bus master must not acknowledge the data.

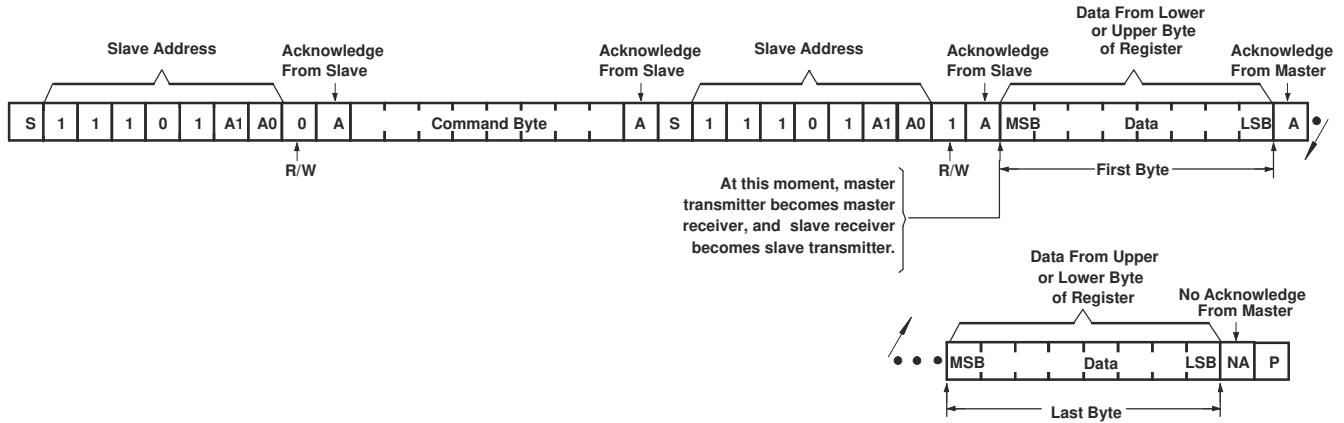
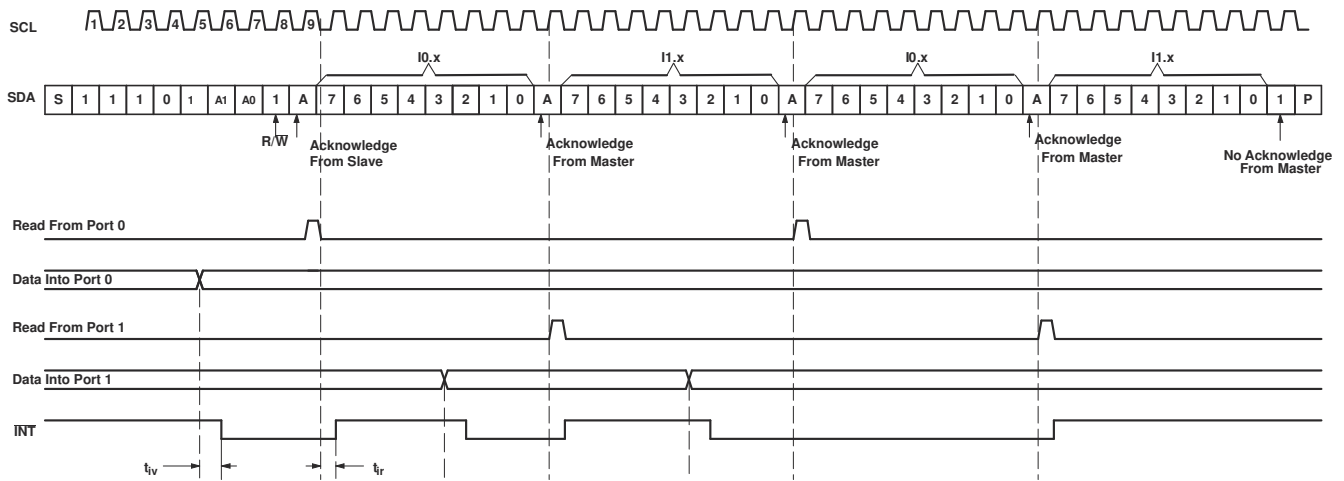
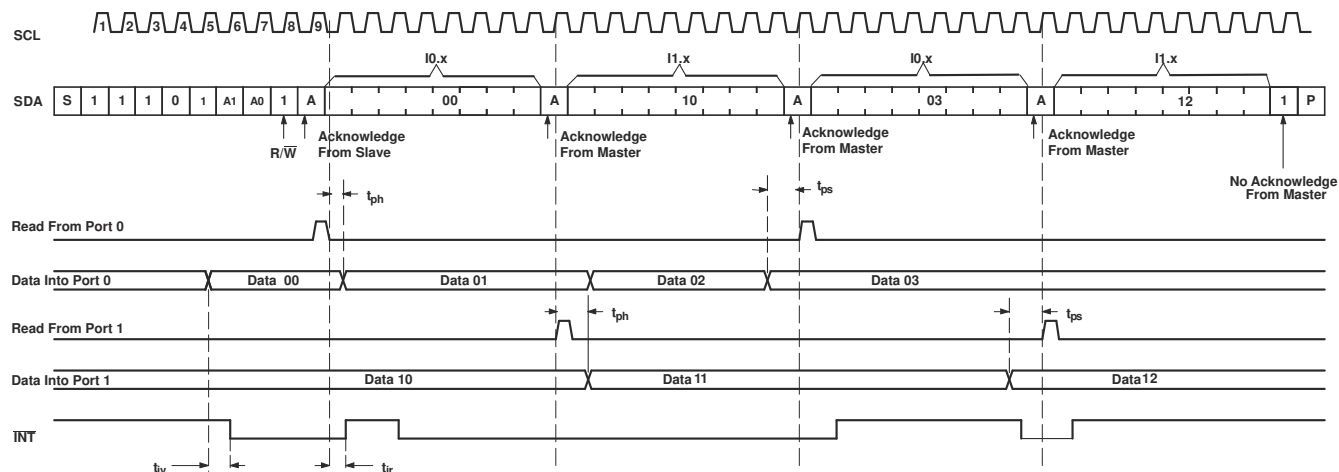


图 8-10. Read From Register



- Transfer of data can be stopped at any time 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 previously has been set to 00 (Read Input Port register).
- This figure eliminates the command byte transfer, a restart, and slave address call between the initial slave address call and actual data transfer from the P port (see 图 8-10 for these details).

图 8-11. Read Input Port Register, Scenario 1



- A. Transfer of data can be stopped at any time 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 previously has been set to 00 (Read Input Port register).
- B. This figure eliminates the command byte transfer, a restart, and slave address call between the initial slave address call and actual data transfer from the P port (see [Figure 8-10](#) for these details).

**图 8-12. Read Input Port Register, Scenario 2**

## 9 Application Information Disclaimer

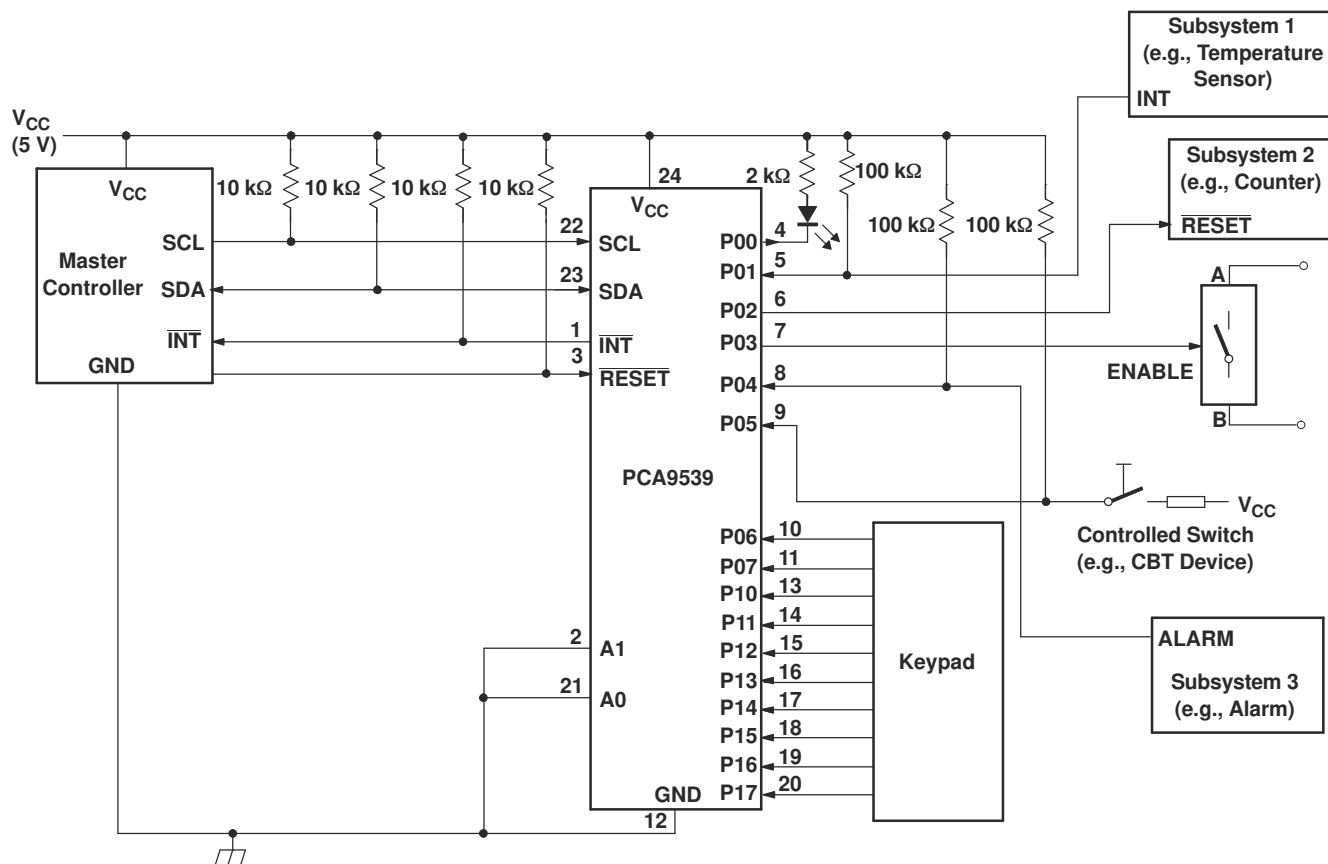
### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

### 9.1 Application Information

图 9-1 shows an application in which the PCA9539 can be used.

### 9.2 Typical Application



- A. Device address is configured as 1110100 for this example.
- B. P00, P02, and P03 are configured as outputs.
- C. P01 and P04 to P17 are configured as inputs.
- D. Pin numbers shown are for DB, DBQ, DGV, DW, and PW packages.

图 9-1. Typical Application

## 9.2.1 Detailed Design Procedure

### 9.2.1.1 Minimizing $I_{CC}$ When I/O Is Used To Control Led

When an I/O is used to control an LED, normally it is connected to  $V_{CC}$  through a resistor (see 图 9-1). Because the LED acts as a diode, when the LED is off, the I/O  $V_{IN}$  is about 1.2 V less than  $V_{CC}$ . The  $\Delta I_{CC}$  parameter in Electrical Characteristics shows how  $I_{CC}$  increases as  $V_{IN}$  becomes lower than  $V_{CC}$ . For battery-powered applications, it is essential that the voltage of I/O pins is greater than or equal to  $V_{CC}$ , when the LED is off, to minimize current consumption.

图 9-2 shows a high-value resistor in parallel with the LED. 图 9-3 shows  $V_{CC}$  less than the LED supply voltage by at least 1.2 V. Both of these methods maintain the I/O  $V_{CC}$  at or above  $V_{CC}$  and prevent additional supply-current consumption when the LED is off.

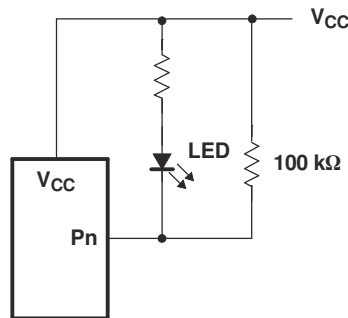


图 9-2. High-Value Resistor In Parallel With Led

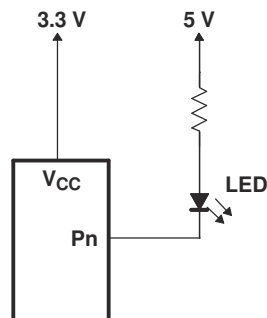


图 9-3. Device Supplied By Lower Voltage

## 10 Power Supply Recommendations

### 10.1 Power-On Reset Requirements

In the event of a glitch or data corruption, PCA9539 can be reset to its default conditions by using the power-on reset feature. Power-on reset requires that the device go through a power cycle to be completely reset. This reset also happens when the device is powered on for the first time in an application.

The two types of power-on reset are shown in 图 10-1 and 图 10-2.

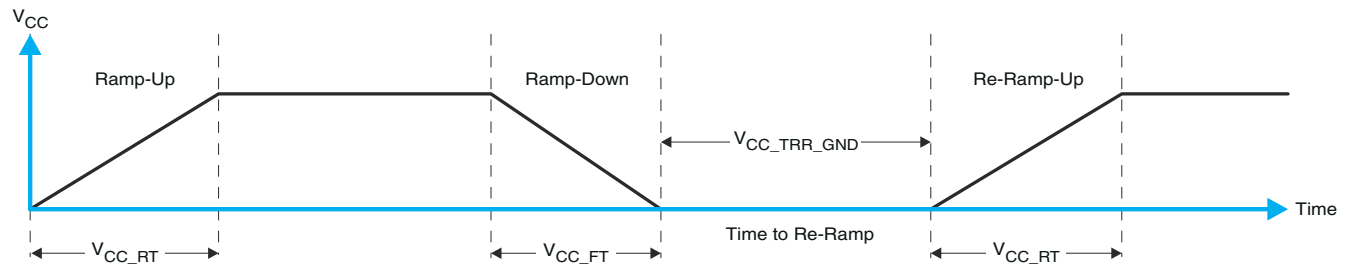


图 10-1.  $V_{CC}$  Is Lowered Below 0.2 V Or 0 V And Then Ramped Up To  $V_{CC}$

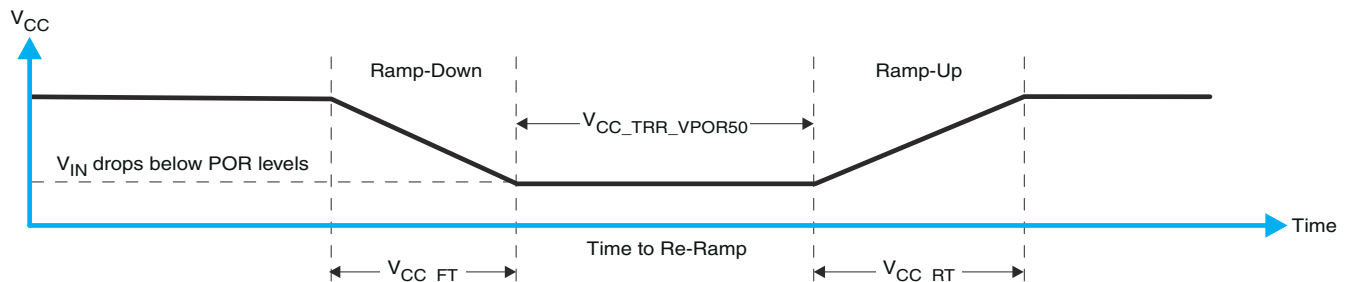


图 10-2.  $V_{CC}$  Is Lowered Below The Por Threshold, Then Ramped Back Up To  $V_{CC}$

表 10-1 specifies the performance of the power-on reset feature for PCA9539 for both types of power-on reset.

表 10-1. Recommended Supply Sequencing And Ramp Rates<sup>(1)</sup>

| PARAMETER            |                                                                                                               |            | MIN   | TYP | MAX   | UNIT    |
|----------------------|---------------------------------------------------------------------------------------------------------------|------------|-------|-----|-------|---------|
| $V_{CC\_FT}$         | Fall rate                                                                                                     | See 图 10-1 | 1     |     | 100   | ms      |
| $V_{CC\_RT}$         | Rise rate                                                                                                     | See 图 10-1 | 0.01  |     | 100   | ms      |
| $V_{CC\_TRR\_GND}$   | Time to re-ramp (when $V_{CC}$ drops to GND)                                                                  | See 图 10-1 | 0.001 |     |       | ms      |
| $V_{CC\_TRR\_POR50}$ | Time to re-ramp (when $V_{CC}$ drops to $V_{POR\_MIN} - 50$ mV)                                               | See 图 10-2 | 0.001 |     |       | ms      |
| $V_{CC\_GH}$         | Level that $V_{CCP}$ can glitch down to, but not cause a functional disruption when $V_{CCX\_GW} = 1$ $\mu$ s | See 图 10-3 |       |     | 1.2   | V       |
| $V_{CC\_GW}$         | Glitch width that will not cause a functional disruption when $V_{CCX\_GH} = 0.5 \times V_{CCX}$              | See 图 10-3 |       |     |       | $\mu$ s |
| $V_{PORF}$           | Voltage trip point of POR on falling $V_{CC}$                                                                 |            | 0.767 |     | 1.144 | V       |
| $V_{PORR}$           | Voltage trip point of POR on rising $V_{CC}$                                                                  |            | 1.033 |     | 1.428 | V       |

(1)  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$  (unless otherwise noted)

Glitches in the power supply can also affect the power-on reset performance of this device. The glitch width ( $V_{CC\_GW}$ ) and height ( $V_{CC\_GH}$ ) are dependent on each other. The bypass capacitance, source impedance, and the device impedance are factors that affect power-on reset performance. 图 10-3 and 表 10-1 provide more information on how to measure these specifications.

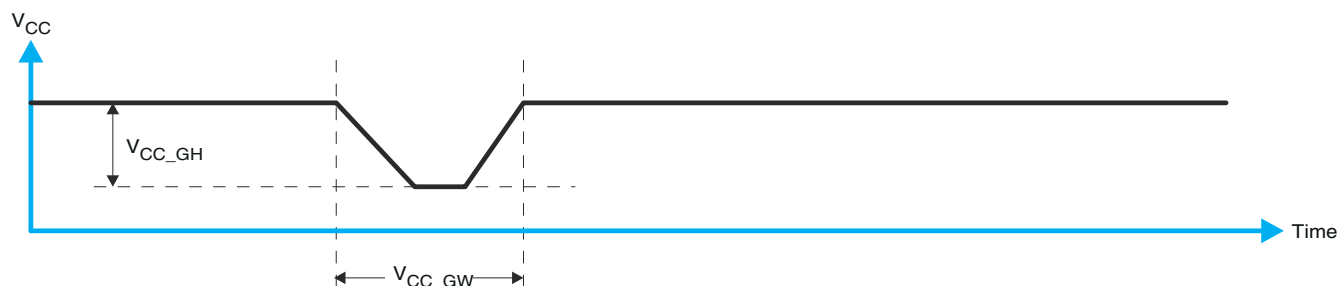
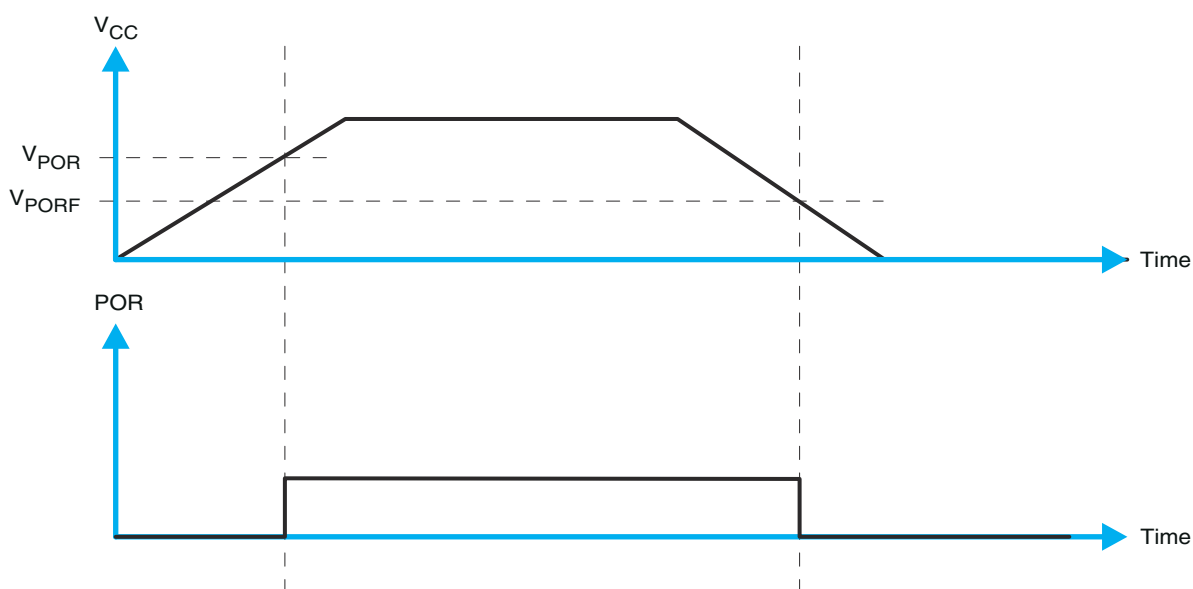


图 10-3. Glitch Width And Glitch Height

$V_{POR}$  is critical to the power-on reset.  $V_{POR}$  is the voltage level at which the reset condition is released and all the registers and the I<sup>2</sup>C/SMBus state machine are initialized to their default states. The value of  $V_{POR}$  differs based on the  $V_{CC}$  being lowered to or from 0. 图 10-4 and 表 10-1 provide more details on this specification.

图 10-4.  $V_{POR}$

## 11 Device and Documentation Support

### 11.1 Trademarks

所有商标均为其各自所有者的财产。

### 11.2 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 11.3 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## PACKAGING INFORMATION

| Orderable part number       | Status<br>(1) | Material type<br>(2) | Package   Pins   | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|-----------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">PCA9539DB</a>   | Active        | Production           | SSOP (DB)   24   | 60   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| PCA9539DB.A                 | Active        | Production           | SSOP (DB)   24   | 60   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| <a href="#">PCA9539DBQR</a> | Active        | Production           | SSOP (DBQ)   24  | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 85    | PCA9539             |
| PCA9539DBQR.A               | Active        | Production           | SSOP (DBQ)   24  | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-2-260C-1 YEAR               | -40 to 85    | PCA9539             |
| <a href="#">PCA9539DBR</a>  | Active        | Production           | SSOP (DB)   24   | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| PCA9539DBR.A                | Active        | Production           | SSOP (DB)   24   | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| <a href="#">PCA9539DGVR</a> | Active        | Production           | TVSOP (DGV)   24 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| PCA9539DGVR.A               | Active        | Production           | TVSOP (DGV)   24 | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| <a href="#">PCA9539DW</a>   | Active        | Production           | SOIC (DW)   24   | 25   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PCA9539             |
| PCA9539DW.A                 | Active        | Production           | SOIC (DW)   24   | 25   TUBE             | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PCA9539             |
| <a href="#">PCA9539DWR</a>  | Active        | Production           | SOIC (DW)   24   | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PCA9539             |
| PCA9539DWR.A                | Active        | Production           | SOIC (DW)   24   | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PCA9539             |
| PCA9539PWR                  | NRND          | Production           | TSSOP (PW)   24  | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| PCA9539PWR.A                | NRND          | Production           | TSSOP (PW)   24  | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| PCA9539PWR.B                | NRND          | Production           | TSSOP (PW)   24  | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| PCA9539PWRG4                | Active        | Production           | TSSOP (PW)   24  | 2000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| <a href="#">PCA9539RGER</a> | Active        | Production           | VQFN (RGE)   24  | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| PCA9539RGER.A               | Active        | Production           | VQFN (RGE)   24  | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| PCA9539RGER.B               | Active        | Production           | VQFN (RGE)   24  | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| PCA9539RGERG4               | Active        | Production           | VQFN (RGE)   24  | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| PCA9539RGERG4.A             | Active        | Production           | VQFN (RGE)   24  | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |
| PCA9539RGERG4.B             | Active        | Production           | VQFN (RGE)   24  | 3000   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -40 to 85    | PD9539              |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| PCA9539DBQR   | SSOP         | DBQ             | 24   | 2500 | 330.0              | 16.4               | 6.5     | 9.0     | 2.1     | 8.0     | 16.0   | Q1            |
| PCA9539DBR    | SSOP         | DB              | 24   | 2000 | 330.0              | 16.4               | 8.2     | 8.8     | 2.5     | 12.0    | 16.0   | Q1            |
| PCA9539DGVR   | TVSOP        | DGV             | 24   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| PCA9539DWR    | SOIC         | DW              | 24   | 2000 | 330.0              | 24.4               | 10.75   | 15.7    | 2.7     | 12.0    | 24.0   | Q1            |
| PCA9539PWR    | TSSOP        | PW              | 24   | 2000 | 330.0              | 16.4               | 6.95    | 8.3     | 1.6     | 8.0     | 16.0   | Q1            |
| PCA9539RGER   | VQFN         | RGE             | 24   | 3000 | 330.0              | 12.4               | 4.25    | 4.25    | 1.15    | 8.0     | 12.0   | Q2            |
| PCA9539RGERG4 | VQFN         | RGE             | 24   | 3000 | 330.0              | 12.4               | 4.25    | 4.25    | 1.15    | 8.0     | 12.0   | Q2            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| PCA9539DBQR   | SSOP         | DBQ             | 24   | 2500 | 353.0       | 353.0      | 32.0        |
| PCA9539DBR    | SSOP         | DB              | 24   | 2000 | 353.0       | 353.0      | 32.0        |
| PCA9539DGVR   | TVSOP        | DGV             | 24   | 2000 | 353.0       | 353.0      | 32.0        |
| PCA9539DWR    | SOIC         | DW              | 24   | 2000 | 350.0       | 350.0      | 43.0        |
| PCA9539PWR    | TSSOP        | PW              | 24   | 2000 | 353.0       | 353.0      | 32.0        |
| PCA9539RGER   | VQFN         | RGE             | 24   | 3000 | 346.0       | 346.0      | 33.0        |
| PCA9539RGERG4 | VQFN         | RGE             | 24   | 3000 | 346.0       | 346.0      | 33.0        |

## TUBE



\*All dimensions are nominal

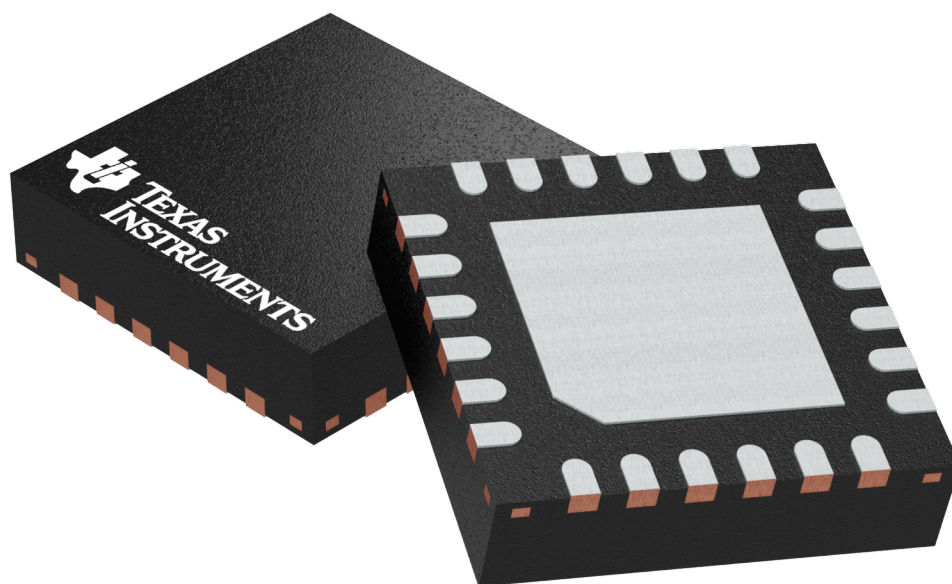
| Device      | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|-------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| PCA9539DB   | DB           | SSOP         | 24   | 60  | 530    | 10.5   | 4000   | 4.1    |
| PCA9539DB.A | DB           | SSOP         | 24   | 60  | 530    | 10.5   | 4000   | 4.1    |
| PCA9539DW   | DW           | SOIC         | 24   | 25  | 506.98 | 12.7   | 4826   | 6.6    |
| PCA9539DW.A | DW           | SOIC         | 24   | 25  | 506.98 | 12.7   | 4826   | 6.6    |

**RGE 24**

**GENERIC PACKAGE VIEW**

**VQFN - 1 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

4204104/H



### VQFN - 1 mm max height

The drawing shows a 24-pin connector with the following features and dimensions:

- Overall Dimensions:** Width is 4.1 (3.9) and height is 4.1 (3.9).
- PIN 1 INDEX AREA:** A shaded rectangular area in the top-left corner.
- DETAIL OPTIONAL TERMINAL TYPICAL:** A cross-sectional view of a terminal with dimensions 0.5, 0.3, 0.3, and 0.2.
- SEATING PLANE:** Indicated by a horizontal line and a triangle symbol.
- Terminal Dimensions:**
  - Top row: 1 MAX, 0.05, 0.00.
  - Bottom row: 0.08, C.
- Internal Features:**
  - 2X 2.5 (width of internal structure).
  - 2.45 ± 0.1 (width of internal structure).
  - 7, 12, 13, 19, 24, 25 (pin numbers and internal dimensions).
  - 6 (pin number).
  - 1 (pin number).
  - 18 (pin number).
  - 24X 0.5 (width of internal structure).
  - 24X 0.3 (width of internal structure).
  - 24X 0.2 (width of internal structure).
  - 24X 0.1 (width of internal structure).
  - 24X 0.05 (width of internal structure).
- Callouts:**
  - SEE TERMINAL DETAIL
  - EXPOSED THERMAL PAD
  - SYMM (Symmetry)
  - PIN 1 ID (OPTIONAL)
- Material and Finish:** C, A, B, M.

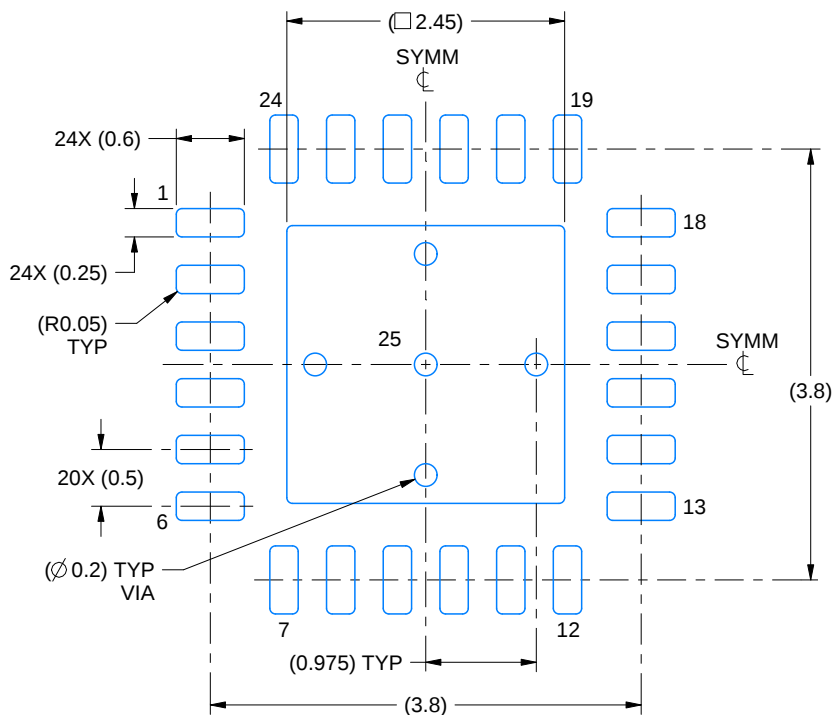
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

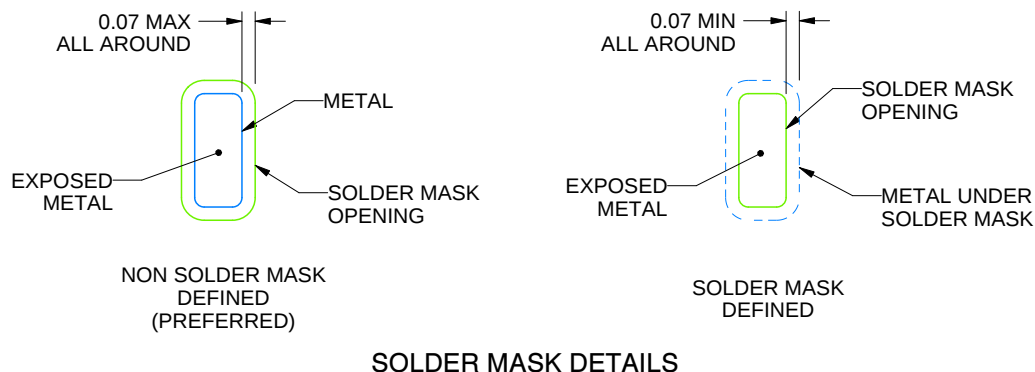
RGE0024B

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:15X



SOLDER MASK DETAILS

4219013/A 05/2017

NOTES: (continued)

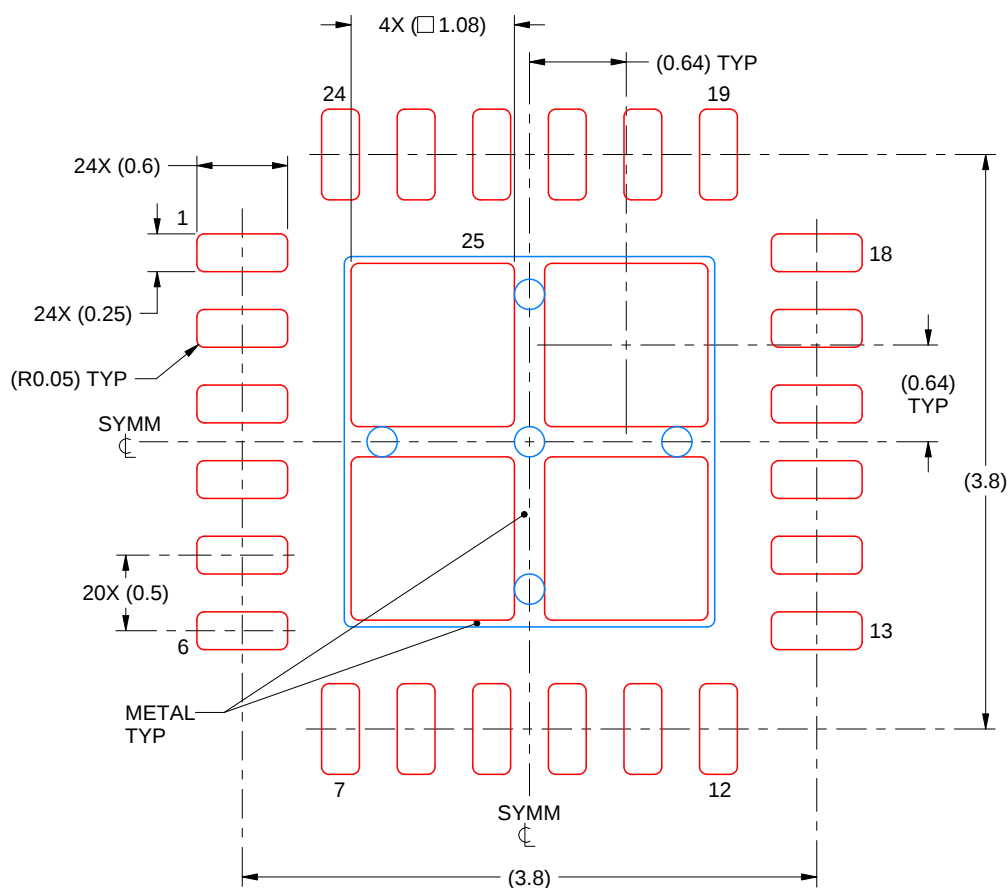
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

RGE0024B

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



**SOLDER PASTE EXAMPLE**  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 25  
78% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:20X

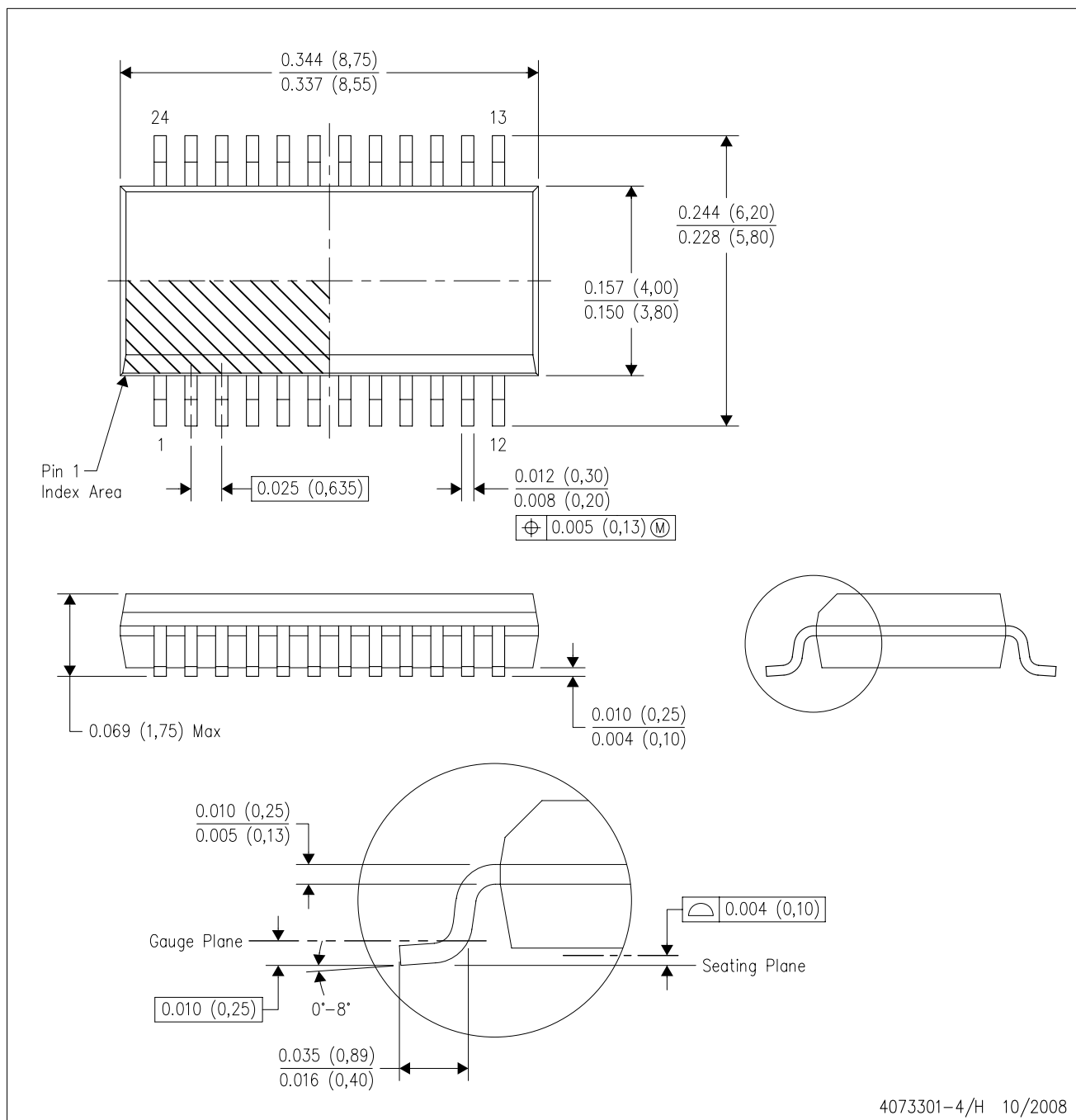
4219013/A 05/2017

NOTES: (continued)

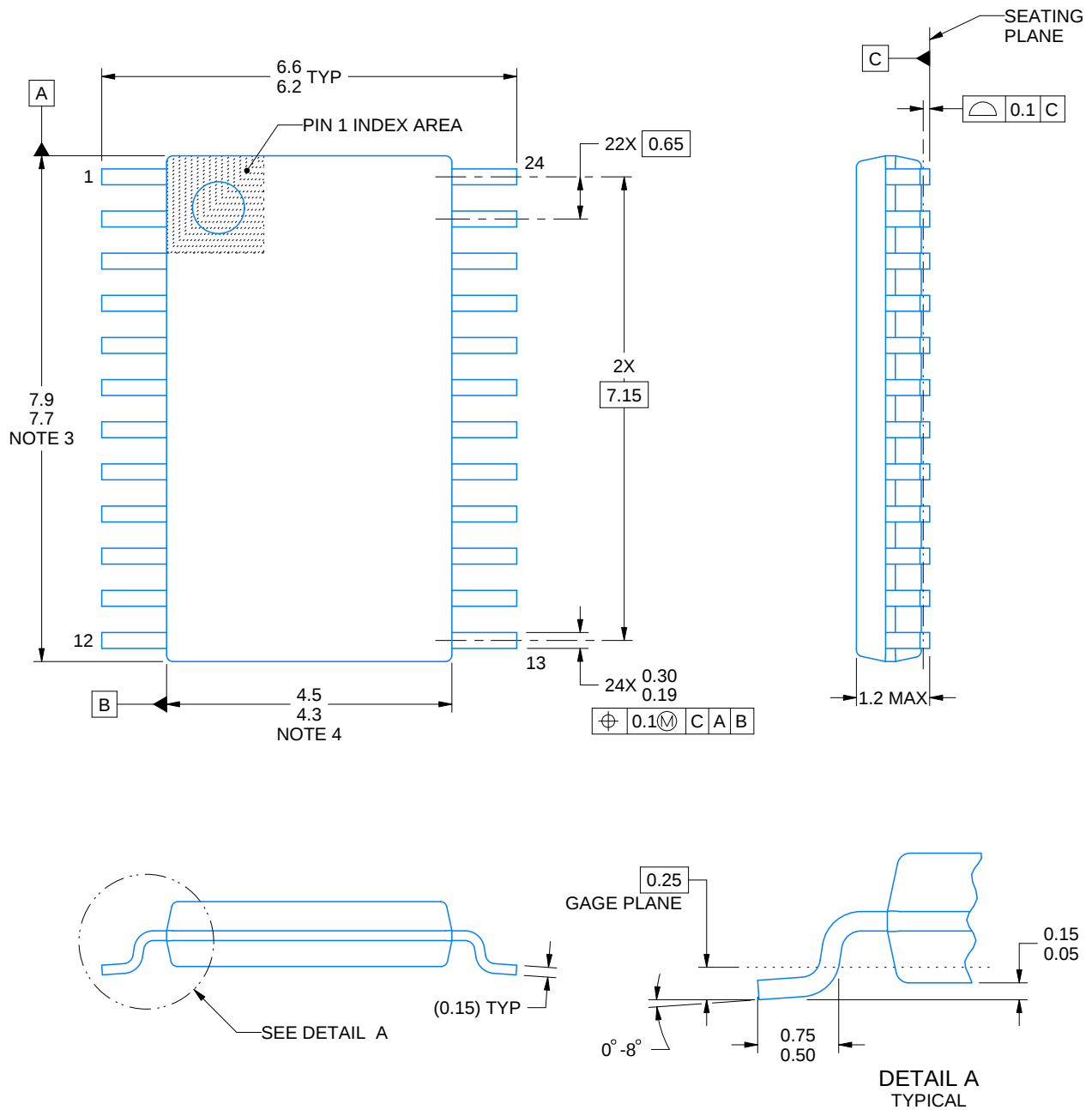
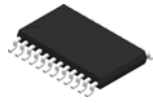
6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

DBQ (R-PDSO-G24)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15) per side.
  - D. Falls within JEDEC MO-137 variation AE.



4220208/A 02/2017

## NOTES:

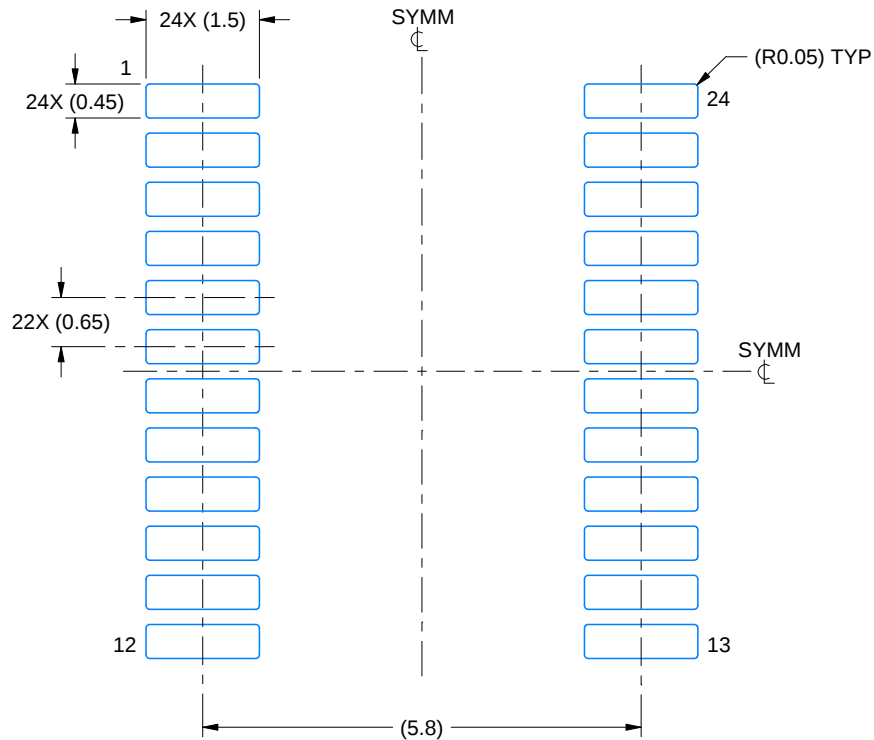
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

# EXAMPLE BOARD LAYOUT

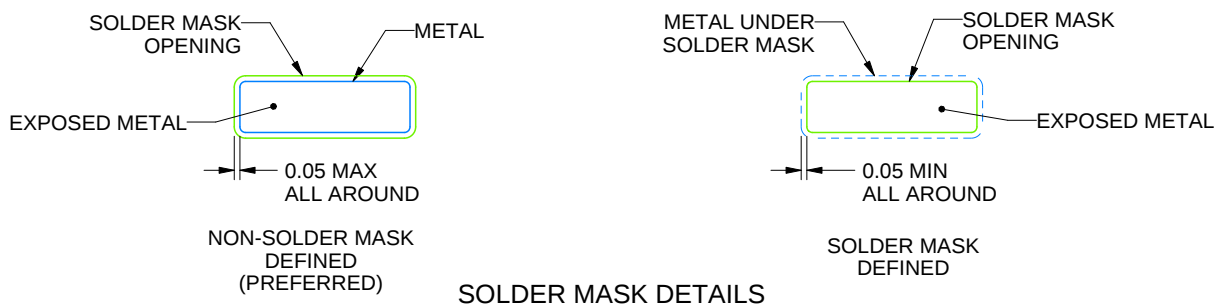
PW0024A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



4220208/A 02/2017

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

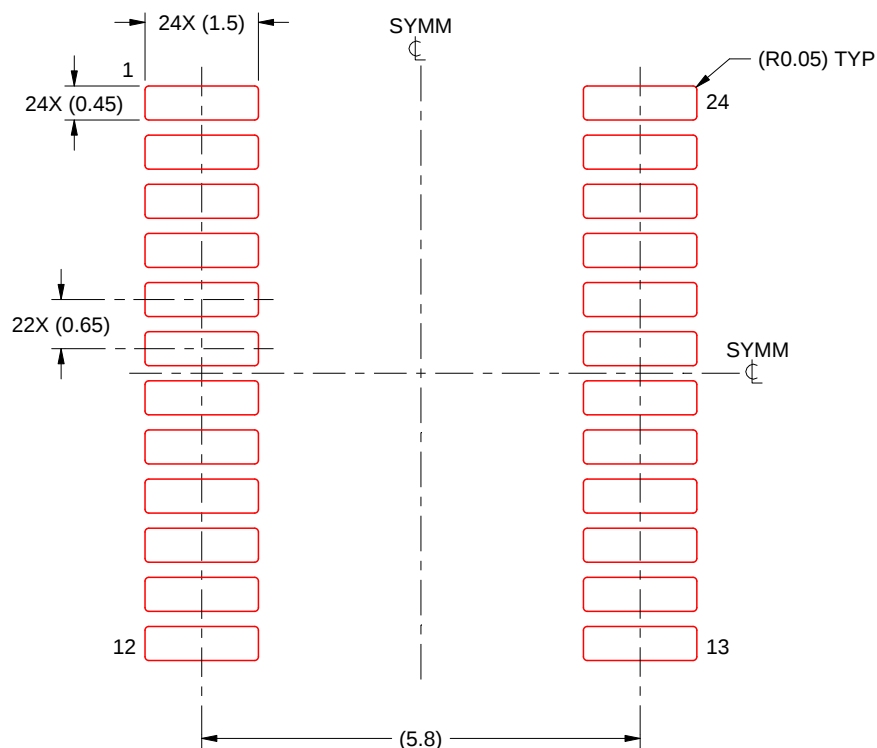
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

PW0024A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 10X

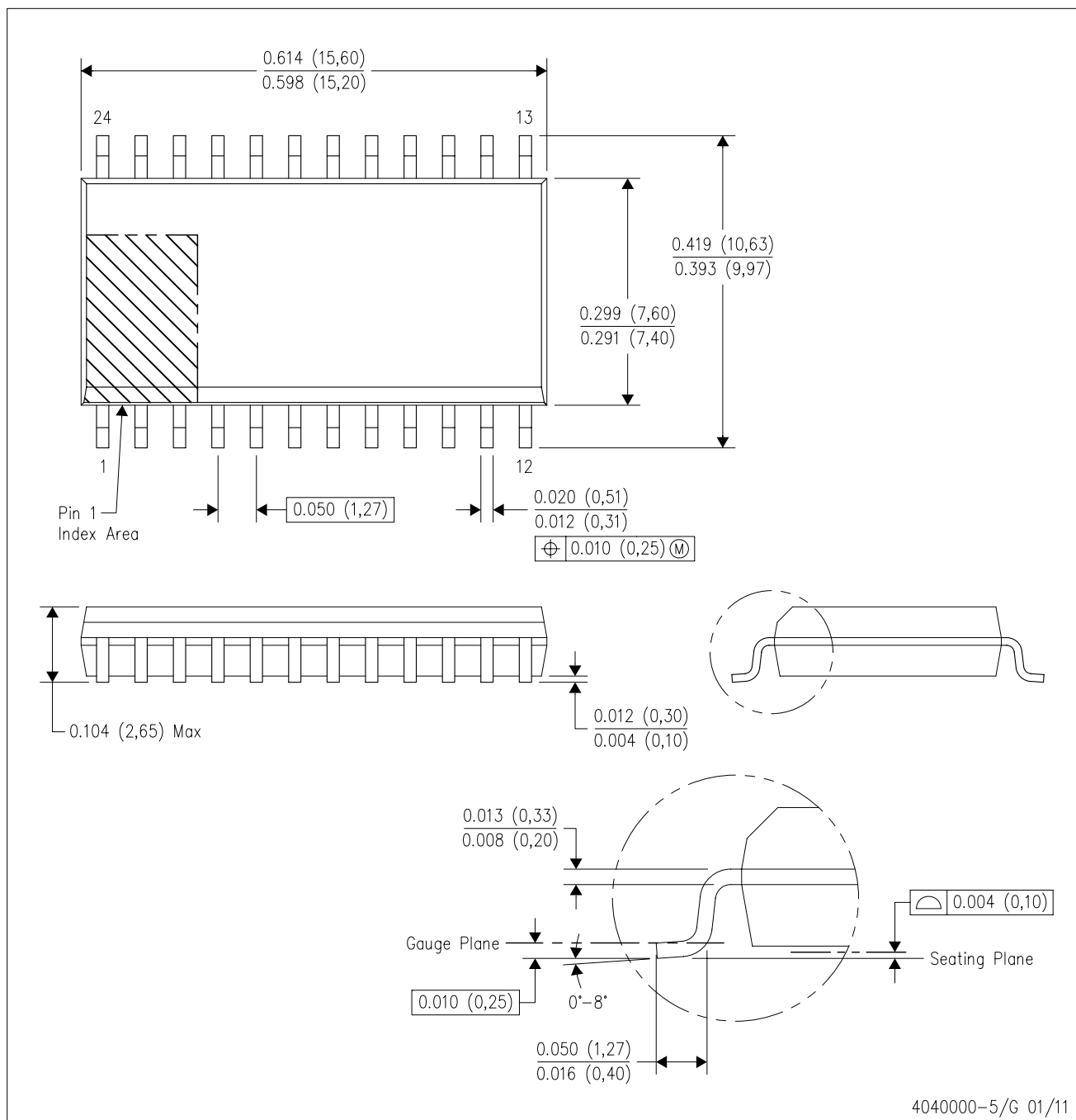
4220208/A 02/2017

NOTES: (continued)

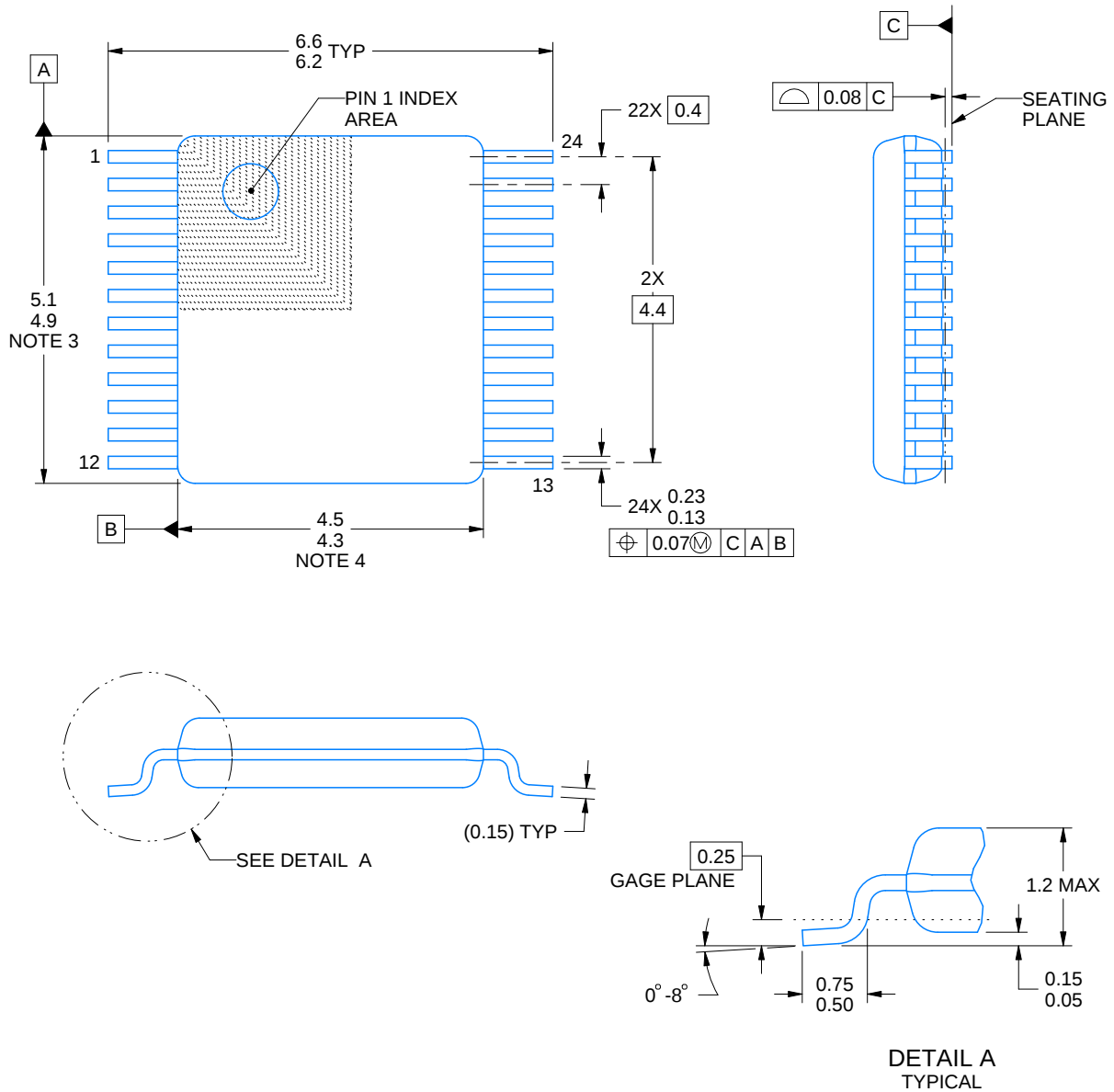
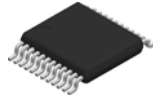
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

DW (R-PDSO-G24)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters). Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - D. Falls within JEDEC MS-013 variation AD.



4229221/A 12/2022

**NOTES:**

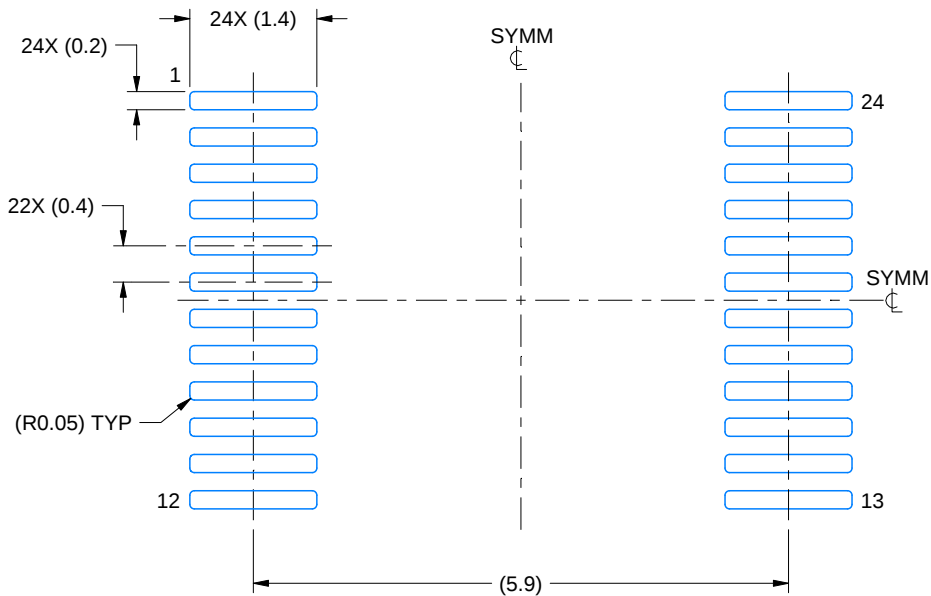
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

# EXAMPLE BOARD LAYOUT

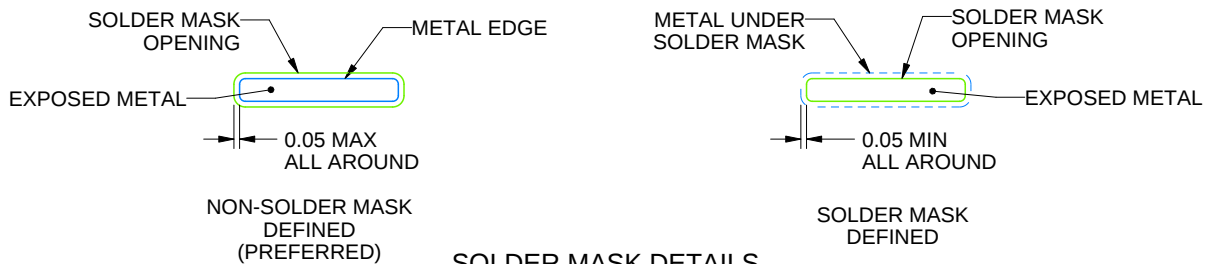
DGV0024A

TVSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 12X



SOLDER MASK DETAILS

4229221/A 12/2022

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

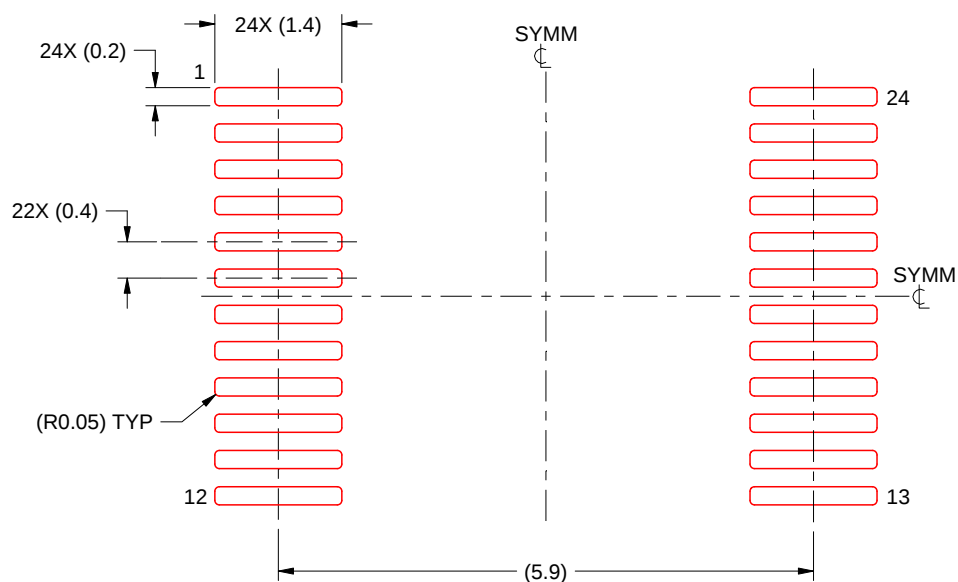
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

DGV0024A

TVSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 12X

4229221/A 12/2022

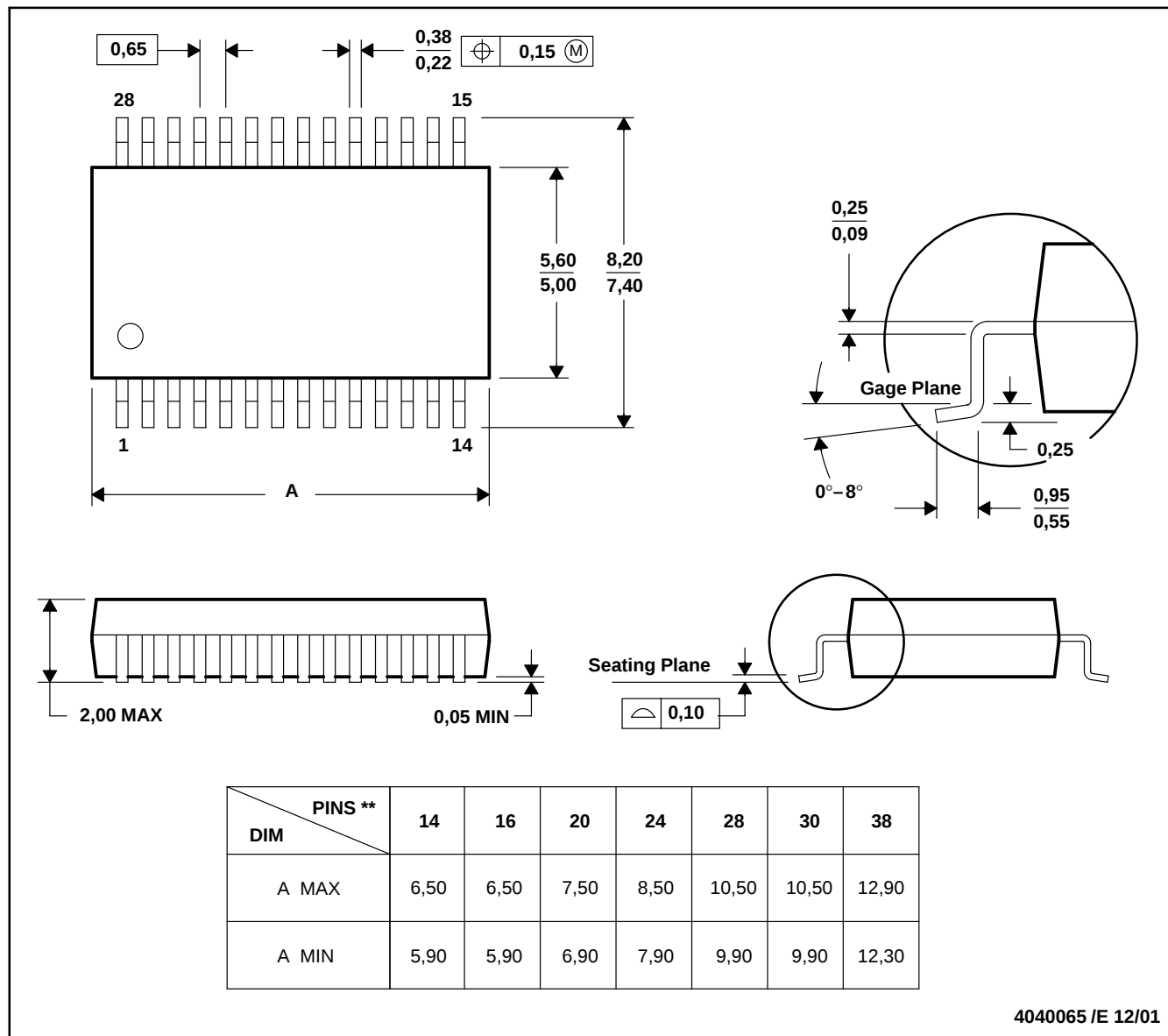
NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

## DB (R-PDSO-G\*\*)

## PLASTIC SMALL-OUTLINE

28 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.  
 D. Falls within JEDEC MO-150

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