

# 具有中断输出、复位引脚和配置寄存器的 TCA9539-Q1 汽车类低压 16 位 I<sup>2</sup>C 和 SMBus 低功耗 I/O 扩展器

## 1 特性

- AEC-Q100 (等级 1) : 符合汽车应用要求
- 提供功能安全
  - 可帮助进行功能安全系统设计的文档
- 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
- 5V 耐压输入和输出端口
- 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
- 内部上电复位
- 加电时无干扰
- 通过两个硬件地址引脚寻址, 以便使用多达 4 个器件
- 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 应用

- 汽车信息娱乐系统、高级驾驶辅助系统 (ADAS)、汽车车身电子装置、混合动力汽车 (HEV)、电动车 (EV) 和动力总成
- 工业自动化、工厂自动化、楼宇自动化、测试与测量、电子销售点终端 (EPOS)
- I<sup>2</sup>C GPIO 扩展

## 3 说明

TCA9539-Q1 是一款 24 引脚器件, 可为两线双向 I<sup>2</sup>C 总线 (或 SMBus 协议) 提供 16 位通用并行输入和输出 (I/O) 扩展。该器件的工作电源电压 ( $V_{CC}$ ) 范围为 1.65V 至 3.6V, 并且支持 100kHz (I<sup>2</sup>C 标准模式) 和 400kHz (I<sup>2</sup>C 快速模式) 两种时钟频率。当开关、传感器、按钮、LED、风扇以及其他相似器件需要额外的 I/O 时, I/O 扩展器 (如 TCA9539-Q1) 可提供简单解决方案。

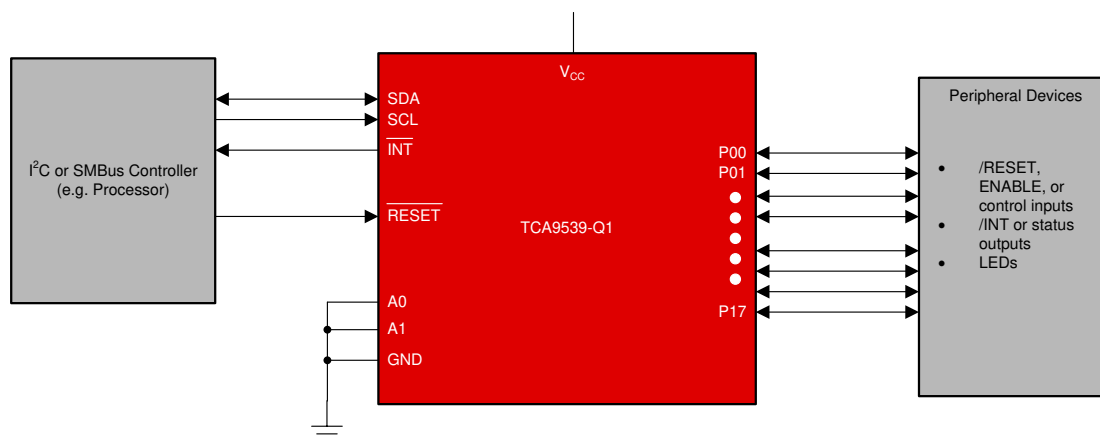
TCA9539-Q1 包括一项功能: 当输入端口状态发生变化时, 在  $\overline{INT}$  引脚上生成中断。硬件可选地址引脚 A0 和 A1 最多允许四个 TCA9539-Q1 器件位于同一 I<sup>2</sup>C 总线上。也可以通过下电上电生成上电复位, 将此器件复位为默认状态。此外, TCA9539-Q1 还具有一个硬件  $\overline{RESET}$  引脚, 可用于将器件复位为默认状态。

TCA9539-Q1 I<sup>2</sup>C I/O 扩展器符合汽车类应用的要求。

### 器件信息

器件型号	封装类型 <sup>(1)</sup>	封装尺寸 (标称值)
TCA9539-Q1	TSSOP (24)	7.80mm × 4.40mm

(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。



简化版方框图



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## 4 Revision History

### Changes from Revision C (December 2018) to Revision D (October 2021) Page

- 添加了特性：提供功能安全 ..... 1
- 将提到的旧术语实例全局更改为控制器和目标。 ..... 1
- Corrected the pin number for pins A0, SCL, SDA, and VCC in the *TCA9539-Q1 Layout* ..... 32

### Changes from Revision B (April 2016) to Revision C (December 2018) Page

- Changed the appearance of the PW pinout image ..... 3
- Removed (5 V) from the V<sub>CC</sub> label in 图 9-1 ..... 25

### Changes from Revision A (September 2015) to Revision B (April 2016) Page

- 将器件状态从产品预发布更改为量产数据 ..... 1

### Changes from Revision \* (January 2014) to Revision A (September 2015) Page

- 添加了“ESD 等级”表、“特性说明”部分、“器件功能模式”、“应用和实施”部分、“电源相关建议”部分、“布局”部分、“器件和文档支持”部分以及“机械、封装和可订购信息”部分 ..... 1

## 5 Pin Configuration and Functions

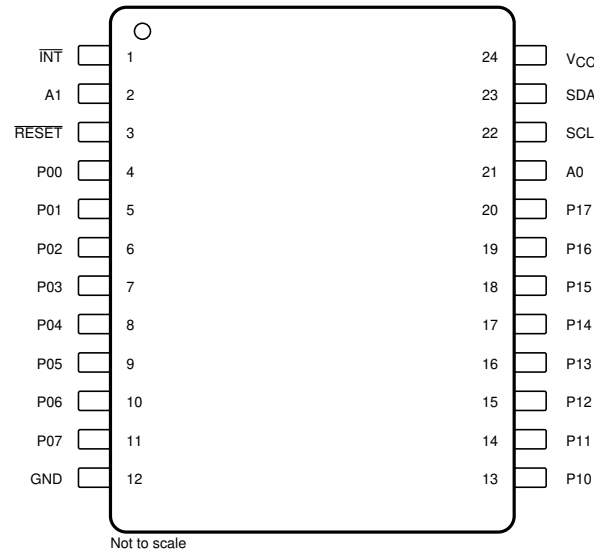


图 5-1. PW Package, 24-Pin TSSOP, Top View

表 5-1. Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
1	INT	O	Interrupt open-drain output. Connect to $V_{CC}$ through a pull-up resistor
2	A1	I	Address input. Connect directly to $V_{CC}$ or ground
3	RESET	I	Active-low reset input. Connect to $V_{CC}$ through a pull-up resistor if no active connection is used
4	P00	I/O	P-port input-output. Push-pull design structure. At power-on, P00 is configured as an input
5	P01	I/O	P-port input-output. Push-pull design structure. At power-on, P01 is configured as an input
6	P02	I/O	P-port input-output. Push-pull design structure. At power-on, P02 is configured as an input
7	P03	I/O	P-port input-output. Push-pull design structure. At power-on, P03 is configured as an input
8	P04	I/O	P-port input-output. Push-pull design structure. At power-on, P04 is configured as an input
9	P05	I/O	P-port input-output. Push-pull design structure. At power-on, P05 is configured as an input
10	P06	I/O	P-port input-output. Push-pull design structure. At power-on, P06 is configured as an input
11	P07	I/O	P-port input-output. Push-pull design structure. At power-on, P07 is configured as an input
12	GND	—	Ground
13	P10	I/O	P-port input-output. Push-pull design structure. At power-on, P10 is configured as an input
14	P11	I/O	P-port input-output. Push-pull design structure. At power-on, P11 is configured as an input
15	P12	I/O	P-port input-output. Push-pull design structure. At power-on, P12 is configured as an input
16	P13	I/O	P-port input-output. Push-pull design structure. At power-on, P13 is configured as an input
17	P14	I/O	P-port input-output. Push-pull design structure. At power-on, P14 is configured as an input
18	P15	I/O	P-port input-output. Push-pull design structure. At power-on, P15 is configured as an input
19	P16	I/O	P-port input-output. Push-pull design structure. At power-on, P16 is configured as an input
20	P17	I/O	P-port input-output. Push-pull design structure. At power-on, P17 is configured as an input
21	A0	I	Address input. Connect directly to $V_{CC}$ or ground
22	SCL	I	Serial clock bus. Connect to $V_{CC}$ through a pull-up resistor
23	SDA	I/O	Serial data bus. Connect to $V_{CC}$ through a pull-up resistor
24	$V_{CC}$	—	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	- 0.5	3.6	V
V <sub>I</sub>	Input voltage <sup>(2)</sup>	- 0.5	6	V
V <sub>O</sub>	Output voltage <sup>(2)</sup>	- 0.5	6	V
I <sub>IK</sub>	Input clamp current		- 20	mA
I <sub>OK</sub>	Output clamp current		- 20	mA
I <sub>IOK</sub>	Input-output clamp current		±20	mA
I <sub>OL</sub>	Continuous output low current		50	mA
I <sub>OH</sub>	Continuous output high current		- 50	mA
I <sub>CC</sub>	Continuous current through GND		- 250	mA
	Continuous current through V <sub>CC</sub>		160	
T <sub>J(MAX)</sub>	Maximum junction temperature		135	°C
T <sub>stg</sub>	Storage temperature	- 65	150	°C

- (1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. *Absolute Maximum Ratings* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
- (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

		VALUE	UNIT
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002 <sup>(1)</sup>	±2000
		Charged-device model (CDM), per AEC Q100-011	±1000

- (1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

### 6.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT	
V <sub>CC</sub>	Supply voltage	1.65	3.6	V	
V <sub>I/O</sub>	I/O ports voltage	SCL, SDA, A0, A1, RESET, INT <sup>(1)</sup>	- 0.5	5.5	V
		For P00 - P07, P10 - P17 configured as outputs	- 0.5	3.6	V
		For P00 - P07, P10 - P17 configured as inputs <sup>(1)</sup>	- 0.5	5.5	V
V <sub>IH</sub>	High-level input voltage	SCL, SDA, A0, A1, $\overline{\text{RESET}}$ , P07 - P00, P10 - P17		0.7 × V <sub>CC</sub>	V
V <sub>IL</sub>	Low-level input voltage	SCL, SDA, A0, A1, $\overline{\text{RESET}}$ , P07 - P00, P10 - P17		0.3 × V <sub>CC</sub>	V
I <sub>OH</sub>	High-level output current	P00 - P07, P10 - P17		- 10	mA
I <sub>OL</sub> <sup>(2)</sup>	Low-level output current	P00 - P07, P10 - P17	T <sub>J</sub> ≤ 65°C	25	mA
			T <sub>J</sub> = 85°C	18	
			T <sub>J</sub> = 105°C	9	
			T <sub>J</sub> = 125°C	4.5	
			T <sub>J</sub> = 135°C	3.5	

### 6.3 Recommended Operating Conditions (continued)

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

			MIN	MAX	UNIT
$I_{OL}^{(2)}$ Low-level output current	INT, SDA	$T_j \leq 85^\circ\text{C}$		6	mA
		$T_j = 105^\circ\text{C}$		3	
		$T_j = 125^\circ\text{C}$		1.8	
		$T_j = 135^\circ\text{C}$		1.5	
$T_A$ Operating free-air temperature			- 40	125	$^\circ\text{C}$

- (1) For voltages applied above  $V_{CC}$ , an increase in  $I_{CC}$  results.  
(2) The values shown apply to specific junction temperatures. See the [§ 9.2.1.1](#) section on how to calculate the junction temperature.

### 6.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		TCA9539-Q1	
		PW (TSSOP)	
		24 PINS	
			UNIT
$R_{\theta JA}$ Junction-to-ambient thermal resistance		108.8	$^\circ\text{C/W}$
$R_{\theta JC(\text{top})}$ Junction-to-case (top) thermal resistance		54	$^\circ\text{C/W}$
$R_{\theta JB}$ Junction-to-board thermal resistance		62.8	$^\circ\text{C/W}$
$\psi_{JT}$ Junction-to-top characterization parameter		11.1	$^\circ\text{C/W}$
$\psi_{JB}$ Junction-to-board characterization parameter		62.3	$^\circ\text{C/W}$

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

### 6.5 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	$V_{CC}$	MIN	TYP <sup>(1)</sup>	MAX	UNIT
$V_{IK}$	Input diode clamp voltage	$I_I = -18\text{ mA}$	1.65 V to 3.6 V	- 1.2			V
$V_{PORR}$	Power-on reset voltage, $V_{CC}$ rising	$V_I = V_{CC}$ or GND	1.65 V to 3.6 V		1.2	1.5	V
$V_{PORF}$	Power-on reset voltage, $V_{CC}$ falling	$V_I = V_{CC}$ or GND	1.65 V to 3.6 V	0.75	1		V
$V_{OH}$	P-port high-level output voltage <sup>(2)</sup>	$I_{OH} = -8\text{ mA}$	1.65 V	1.2			V
			2.3 V	1.8			
			3 V	2.6			
			3.6 V	3.3			
		$I_{OH} = -10\text{ mA}$	1.65 V	1			
			2.3 V	1.7			
			3 V	2.5			
			3.6 V	3.2			
$I_{OL}$	SDA	$V_{OL} = 0.4\text{ V}$	1.65 V to 3.6 V			3	mA
	P port <sup>(3)</sup>	$V_{OL} = 0.5\text{ V}$				8	
		$V_{OL} = 0.7\text{ V}$				10	
	INT	$V_{OL} = 0.4\text{ V}$				3	
$I_I$	SCL, SDA	$V_I = V_{CC}$ or GND	1.65 V to 3.6 V			$\pm 1$	$\mu\text{A}$
	A0, A1, RESET					$\pm 1$	
$I_{IH}$	P port	$V_I = V_{CC}$	1.65 V to 3.6 V			1	$\mu\text{A}$
$I_{IL}$	P port	$V_I = \text{GND}$	1.65 V to 3.6 V			- 1	$\mu\text{A}$

## 6.5 Electrical Characteristics (continued)

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

PARAMETER		TEST CONDITIONS		V <sub>CC</sub>	MIN	TYP <sup>(1)</sup>	MAX	UNIT
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, no load		3.6 V		10	30	μA
				2.7 V		5	19	
				1.95 V		4	11	
	Standby mode	I <sub>O</sub> = 0, I/O = inputs, f <sub>SCL</sub> = 0 kHz, no load	V <sub>I</sub> = V <sub>CC</sub>	3.6 V		1.1	5	
				2.7 V		1	4.5	
			1.95 V		0.4	3.5		
			V <sub>I</sub> = GND	3.6 V		1.1	13	
				2.7 V		1	9.5	
1.95 V		0.4	6.5					
C <sub>i</sub>	SCL	V <sub>I</sub> = V <sub>CC</sub> or GND		1.65 V to 3.6 V		3	8	pF
C <sub>io</sub>	SDA	V <sub>IO</sub> = V <sub>CC</sub> or GND		1.65 V to 3.6 V		3	9.5	pF
	P port					3.7	9.5	

- (1) All typical values are at nominal supply voltage (1.8 V, 2.5 V, or 3.3 V, V<sub>CC</sub>) and T<sub>A</sub> = 25°C.
- (2) Each I/O must be externally limited to the maximum allowed I<sub>OL</sub>, 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 at T<sub>j</sub> ≤ 85°C. See the # 6.3 table for more information.
- (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) for T<sub>j</sub> ≤ 85°C. See the # 6.3 table for more information.

## 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
<b>I<sup>2</sup>C BUS—STANDARD MODE</b>					
f <sub>scl</sub>	I <sup>2</sup> C clock frequency		0	100	kHz
t <sub>sch</sub>	I <sup>2</sup> C clock high time		4		μs
t <sub>scl</sub>	I <sup>2</sup> C clock low time		4.7		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		250		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			1000	ns
t <sub>icf</sub>	I <sup>2</sup> C input fall time			300	ns
t <sub>ocf</sub>	I <sup>2</sup> C output fall time	10 pF to 400 pF bus		300	ns
t <sub>buf</sub>	I <sup>2</sup> C bus free time between stop and start		4.7		μs
t <sub>sts</sub>	I <sup>2</sup> C start or repeated start condition setup		4.7		μs
t <sub>sth</sub>	I <sup>2</sup> C start or repeated start condition hold		4		μs
t <sub>sps</sub>	I <sup>2</sup> C stop condition setup		4		μs
t <sub>vd(data)</sub>	Valid data time	SCL low to SDA output valid		3.45	μs
t <sub>vd(ack)</sub>	Valid data time of ACK condition	ACK signal from SCL low to SDA (out) low		3.45	μs
C <sub>b</sub>	I <sup>2</sup> C bus capacitive load			400	pF

			MIN	MAX	UNIT
<b>I<sup>2</sup>C BUS—FAST MODE</b>					
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

		MIN	MAX	UNIT
$t_{sds}$	I <sup>2</sup> C serial-data setup time	100		ns
$t_{sdh}$	I <sup>2</sup> C serial-data hold time	0		ns
$t_{icr}$	I <sup>2</sup> C input rise time	20	300	ns
$t_{icf}$	I <sup>2</sup> C input fall time	$20 \times (V_{CC} / 5.5 \text{ V})$	300	ns
$t_{ocf}$	I <sup>2</sup> C output fall time	10 pF to 400 pF bus	$20 \times (V_{CC} / 5.5 \text{ V})$	300 ns
$t_{buf}$	I <sup>2</sup> C bus free time between stop and start	1.3		$\mu\text{s}$
$t_{sts}$	I <sup>2</sup> C start or repeated start condition setup	0.6		$\mu\text{s}$
$t_{sth}$	I <sup>2</sup> C start or repeated start condition hold	0.6		$\mu\text{s}$
$t_{sps}$	I <sup>2</sup> C stop condition setup	0.6		$\mu\text{s}$
$t_{vd(\text{data})}$	Valid data time	SCL low to SDA output valid	0.9	$\mu\text{s}$
$t_{vd(\text{ack})}$	Valid data time of ACK condition	ACK signal from SCL low to SDA (out) low	0.9	$\mu\text{s}$
$C_b$	I <sup>2</sup> C bus capacitive load		400	pF

## 6.7 RESET Timing Requirements

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

		MIN	MAX	UNIT
$t_W$	Reset pulse duration	6		ns
$t_{REC}$	Reset recovery time	0		ns
$t_{RESET}$	Time to reset; For $V_{CC} = 2.3 \text{ V} - 3.6 \text{ V}$	400		ns
	Time to reset; For $V_{CC} = 1.65 \text{ V} - 2.3 \text{ V}$	550		ns

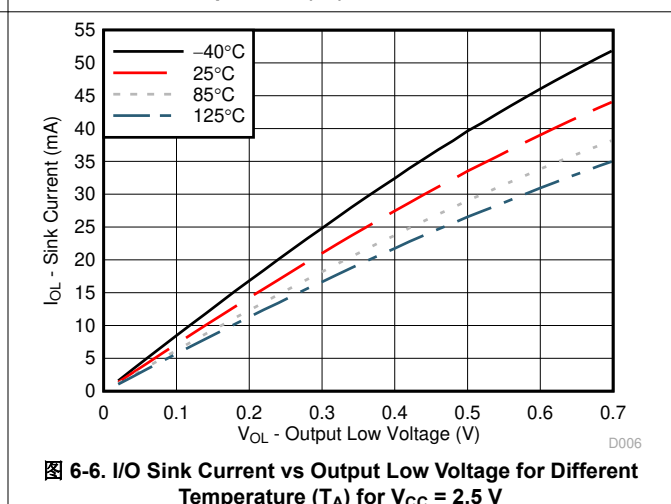
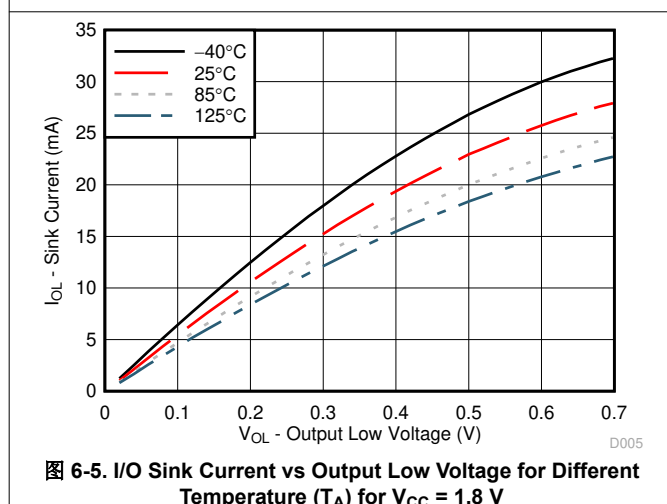
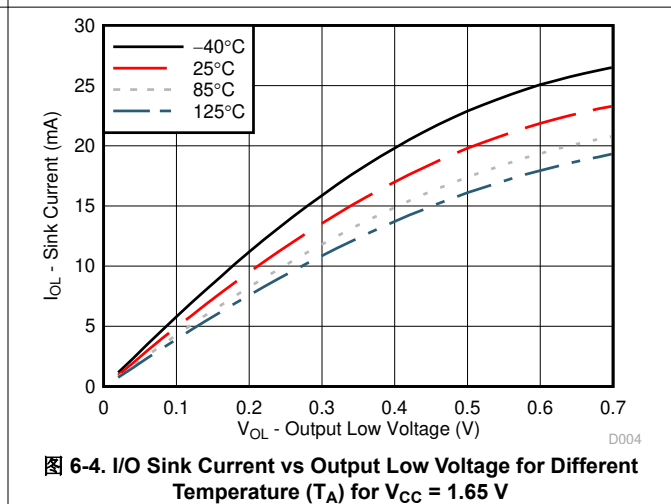
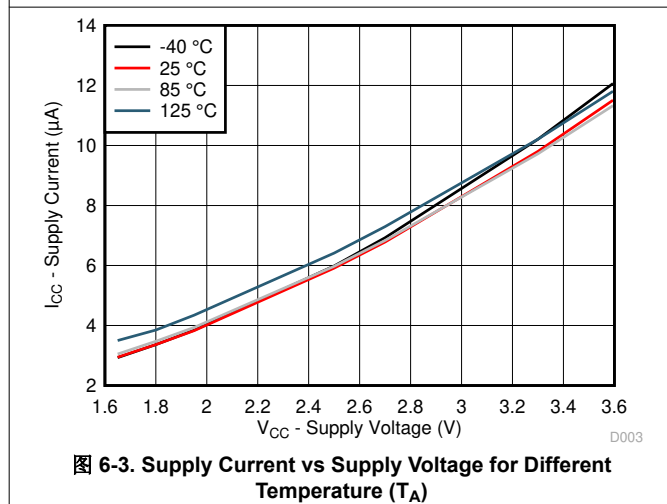
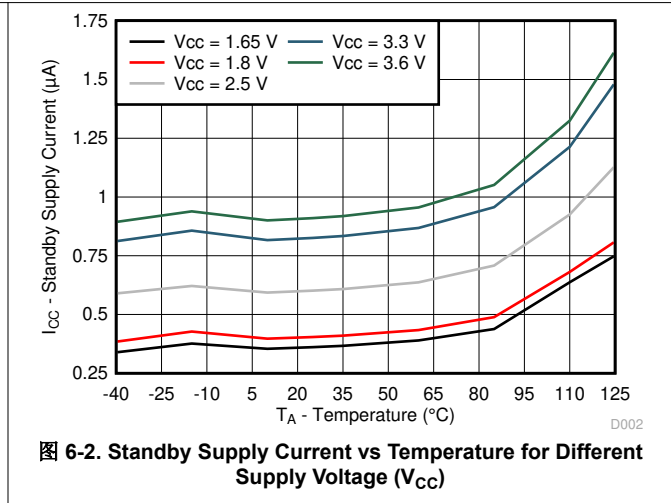
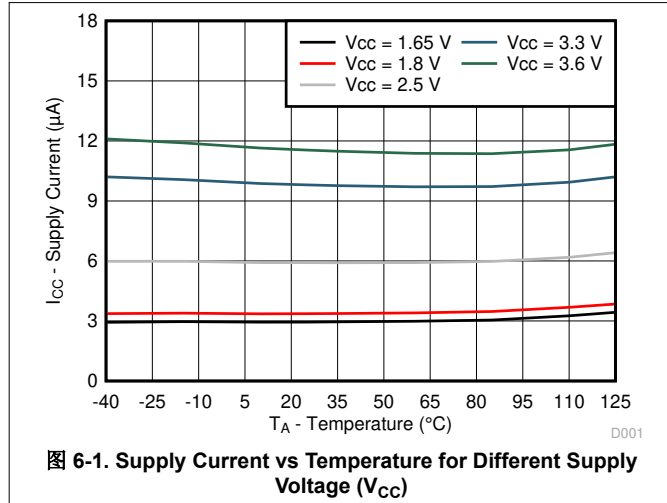
## 6.8 Switching Characteristics

over recommended operating free-air temperature range,  $C_L \leq 100 \text{ pF}$  (unless otherwise noted) (see [图 7-2](#) and [图 7-3](#))

PARAMETER		FROM (INPUT)	TO (OUTPUT)	MIN	MAX	UNIT
$t_{iv}$	Interrupt valid time	P port	INT		4	$\mu\text{s}$
$t_{ir}$	Interrupt reset delay time	SCL	INT		4	$\mu\text{s}$
$t_{pv}$	Output data valid; For $V_{CC} = 2.3 \text{ V} - 3.6 \text{ V}$	SCL	P port		200	ns
	Output data valid; For $V_{CC} = 1.65 \text{ V} - 2.3 \text{ V}$				300	ns
$t_{ps}$	Input data setup time	P port	SCL	150		ns
$t_{ph}$	Input data hold time	P port	SCL	1		$\mu\text{s}$

## 6.9 Typical Characteristics

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





## 6.9 Typical Characteristics (continued)

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

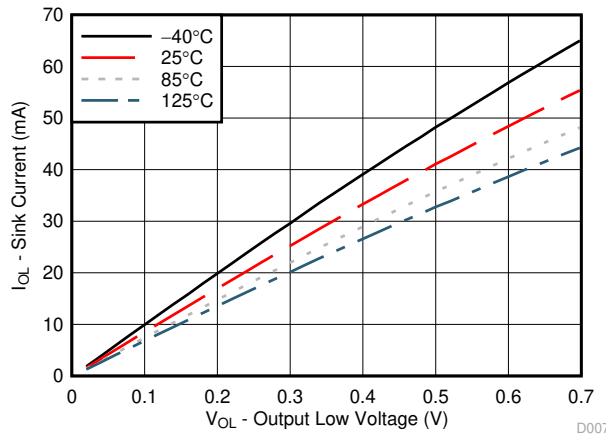


图 6-7. I/O Sink Current vs Output Low Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 3.3\text{ V}$

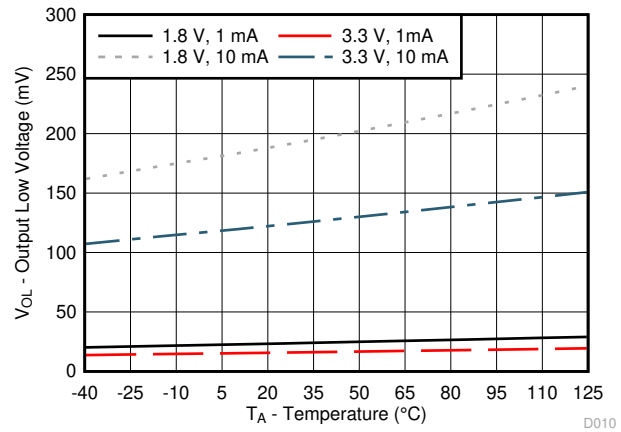


图 6-8. I/O Low Voltage vs Temperature for Different  $V_{CC}$  and  $I_{OL}$

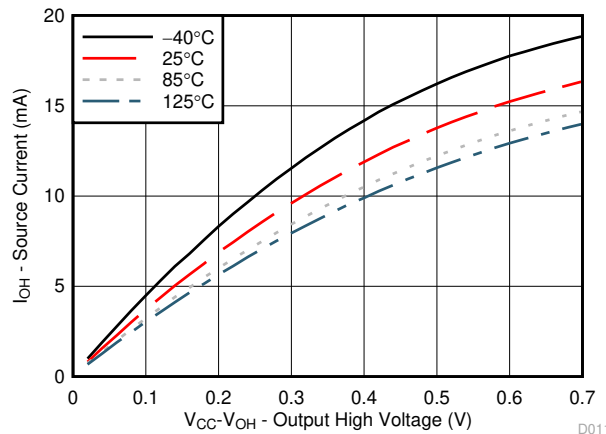


图 6-9. I/O Source Current vs Output High Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 1.65\text{ V}$

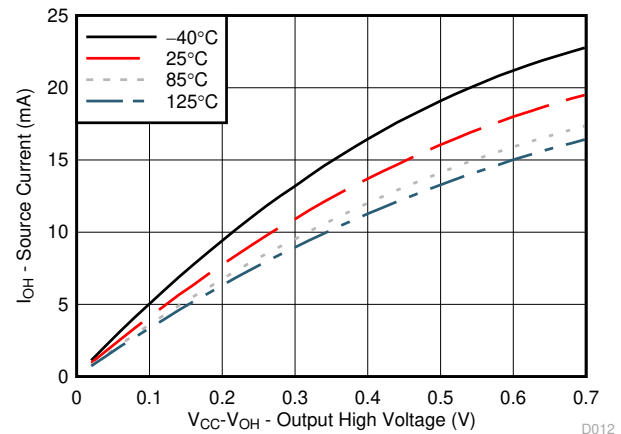


图 6-10. I/O Source Current vs Output High Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 1.8\text{ V}$

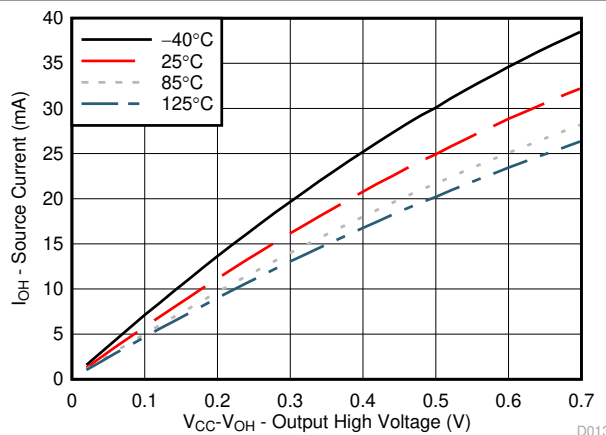


图 6-11. I/O Source Current vs Output High Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 2.5\text{ V}$

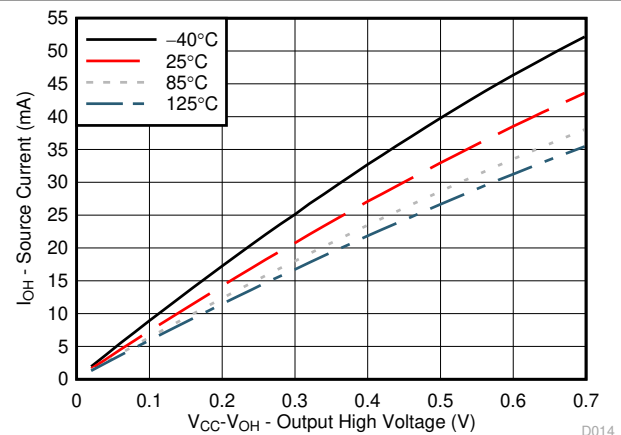


图 6-12. I/O Source Current vs Output High Voltage for Different Temperature ( $T_A$ ) for  $V_{CC} = 3.3\text{ V}$

### 6.9 Typical Characteristics (continued)

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

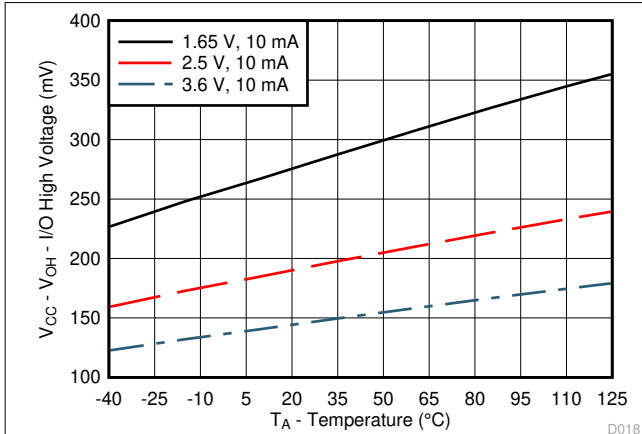


图 6-13.  $V_{CC} - V_{OH}$  Voltage vs Temperature for Different  $V_{CC}$  D018

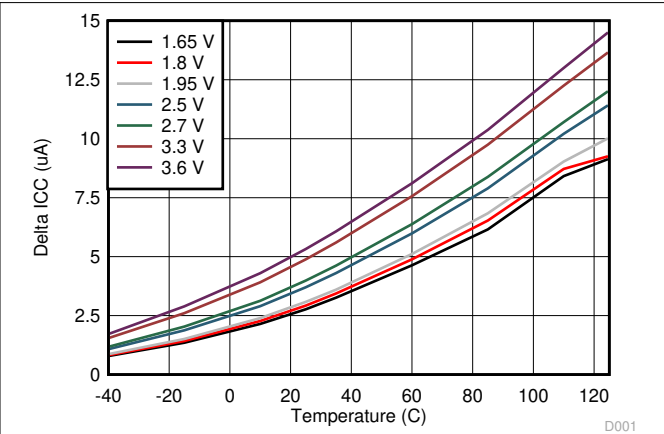
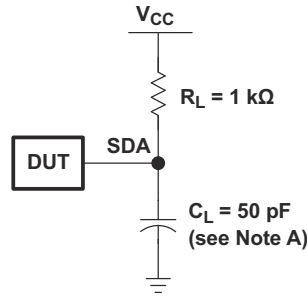
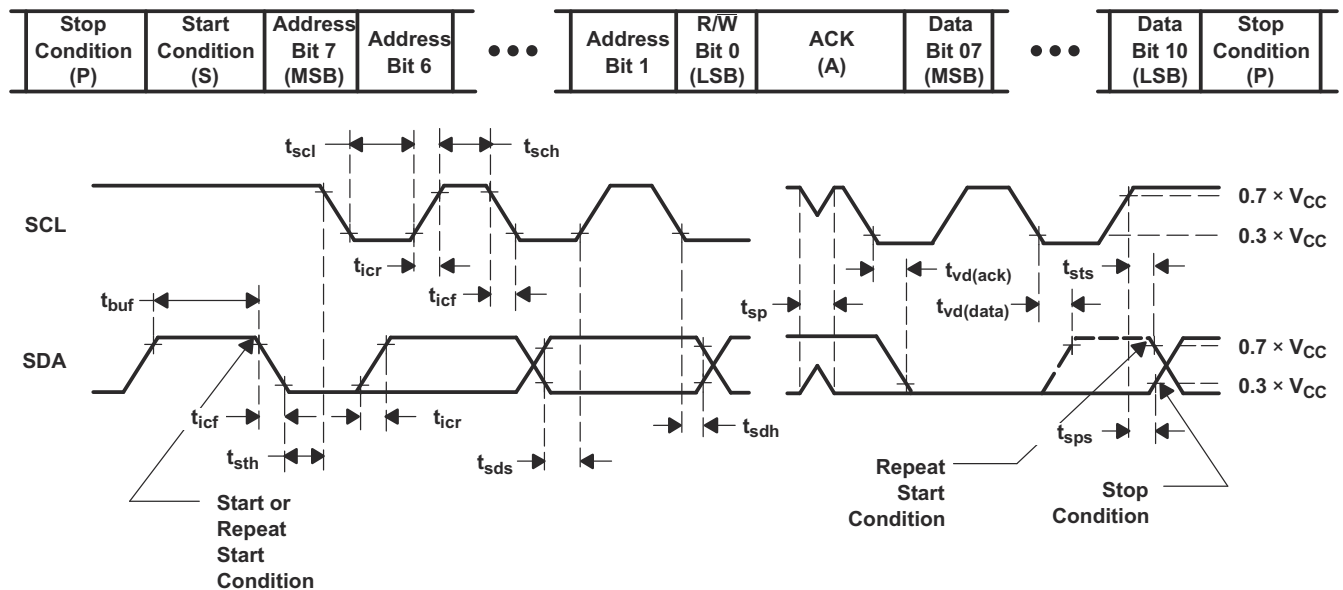


图 6-14.  $\Delta I_{CC}$  vs Temperature for Different  $V_{CC}$  ( $V_I = V_{CC} - 0.6$  V) D001

## 7 Parameter Measurement Information



SDA Load Configuration

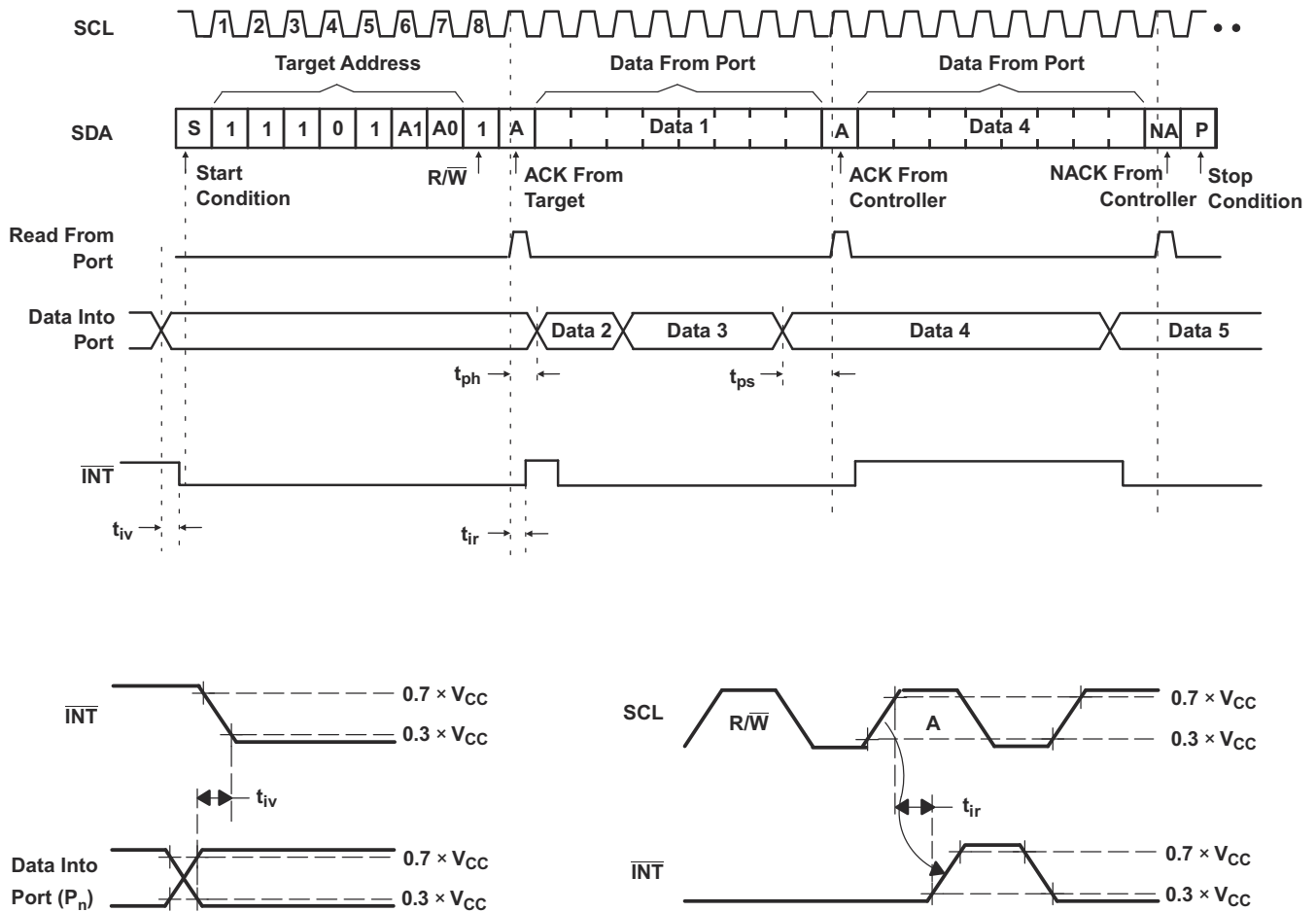
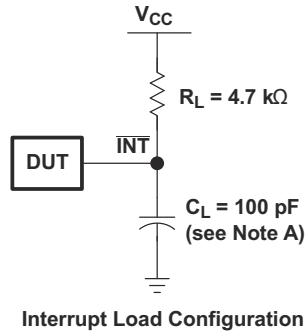


Voltage Waveforms

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

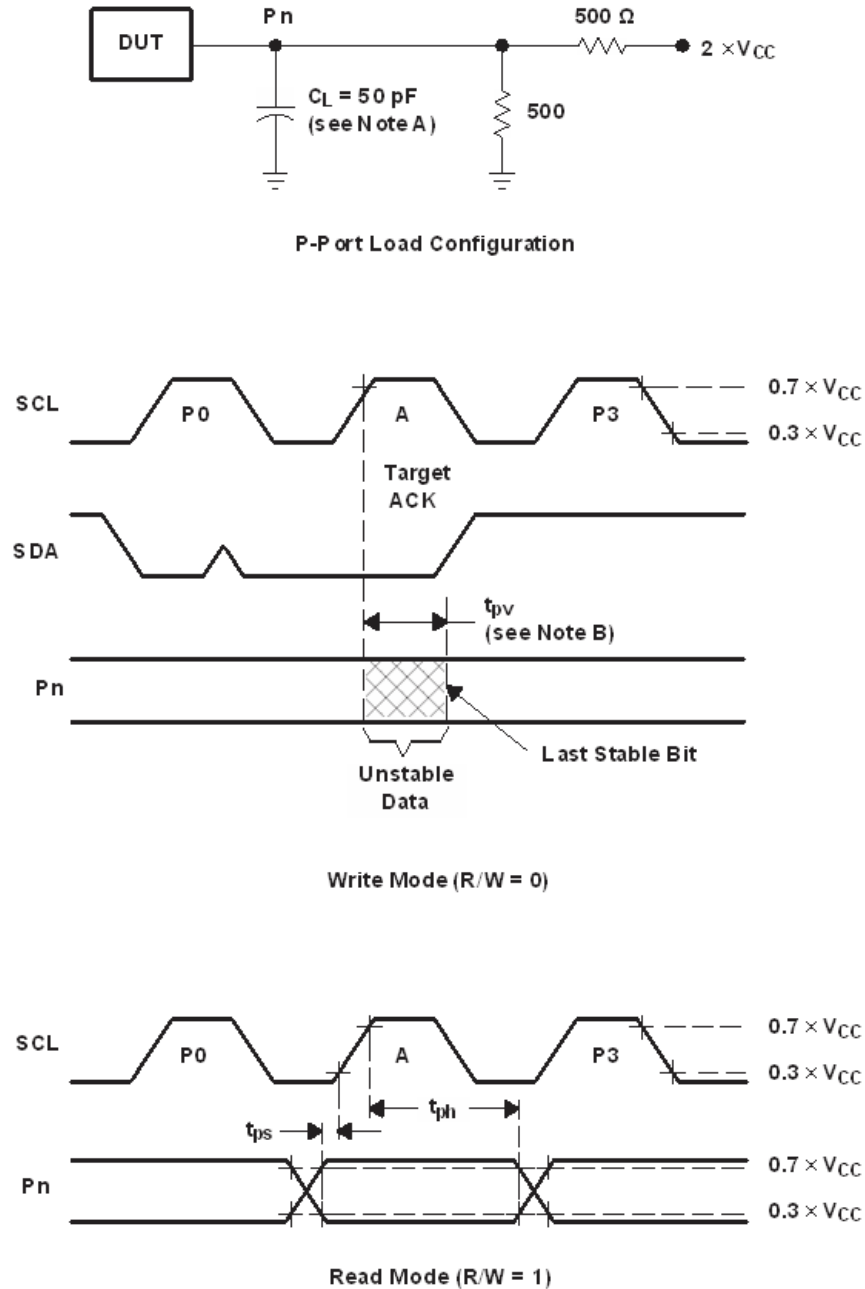
- A.  $C_L$  includes probe and jig capacitance.
- B. All inputs are supplied by generators having the following characteristics:  $PRR \leq 10\text{ MHz}$ ,  $Z_O = 50\ \Omega$ ,  $t_r/t_f \leq 30\text{ ns}$ .
- C. All parameters and waveforms are not applicable to all devices.

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



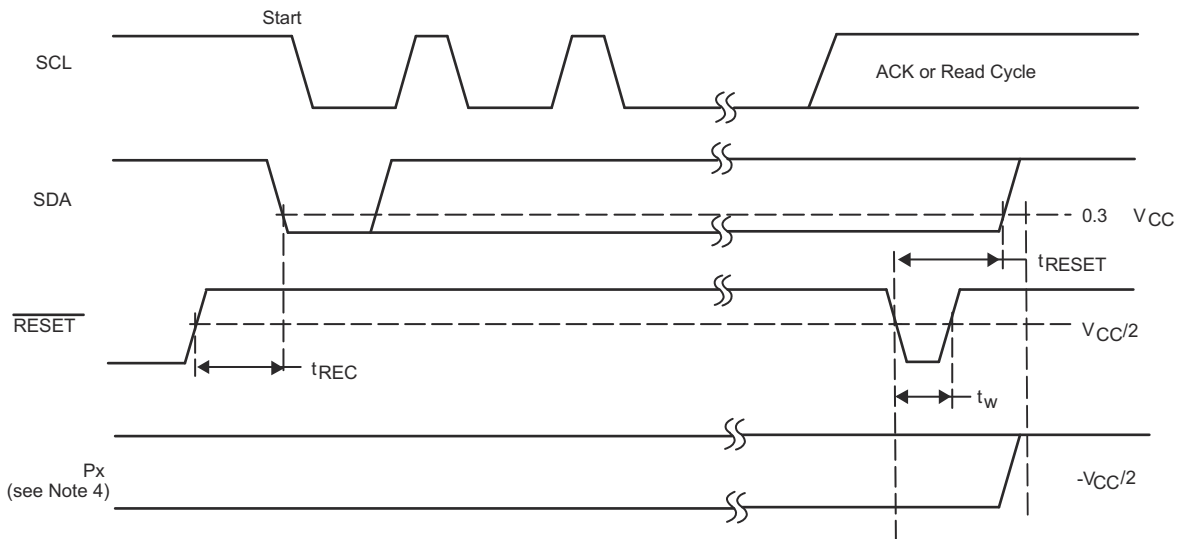
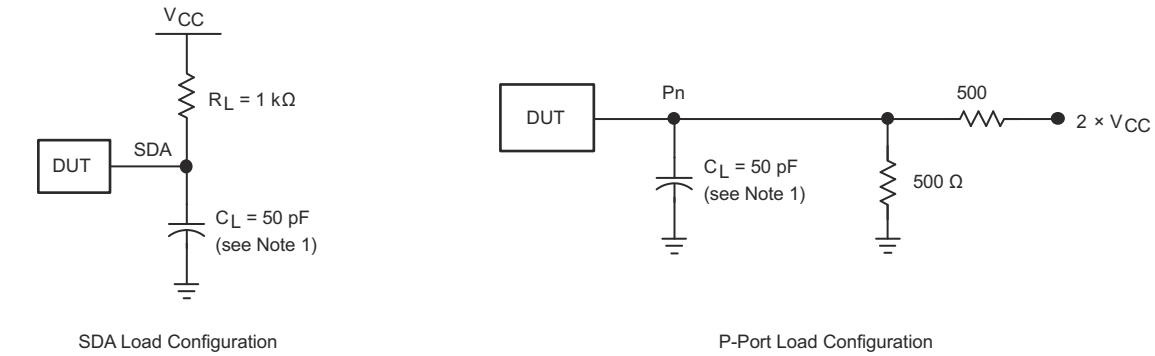
- A.  $C_L$  includes probe and jig capacitance.
- B. All inputs are supplied by generators having the following characteristics:  $PRR \leq 10$  Hz,  $Z_O = 50 \Omega$ ,  $t_r/t_f \leq 30$  ns.
- C. All parameters and waveforms are not applicable to all devices.

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



- A. C<sub>L</sub> includes probe and jig capacitance.
- B. t<sub>pv</sub> is measured from 0.7 × V<sub>CC</sub> on SCL to 50% I/O (P<sub>n</sub>) output.
- C. 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.
- 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



- C<sub>L</sub> includes probe and jig capacitance.
- 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.
- The outputs are measured one at a time, with one transition per measurement.
- I/Os are configured as inputs.
- All parameters and waveforms are not applicable to all devices.

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

## 8 Detailed Description

### 8.1 Overview

The TCA9539-Q1 is a 16-bit I/O expander for the two-line bidirectional bus (I<sup>2</sup>C) designed for 1.65 V to 3.6 V, V<sub>CC</sub> operation. It provides general-purpose remote I/O expansion for most microcontroller families via the I<sup>2</sup>C interface, serial clock (SCL) and serial data (SDA).

The TCA9539-Q1 consists of two 8-bit Configuration (input or output selection), Input Port, Output Port, and Polarity Inversion (active-high or active-low operation) registers. At power-on, the I/Os are configured as inputs. The system controller can enable the I/Os as either inputs or outputs by writing to the configuration register bits. The data for each input or output is kept in the corresponding Input or output register. The polarity of the Input Port register can be inverted with the Polarity Inversion register. All registers can be read by the system controller.

The system controller can reset the TCA9539-Q1 in the event of a time-out or other improper operation by asserting a low in the  $\overline{\text{RESET}}$  input. The power-on reset puts the registers in their default state and initializes the I<sup>2</sup>C-SMBus state machine. Asserting  $\overline{\text{RESET}}$  causes the same reset-initialization to occur without depowering the part.

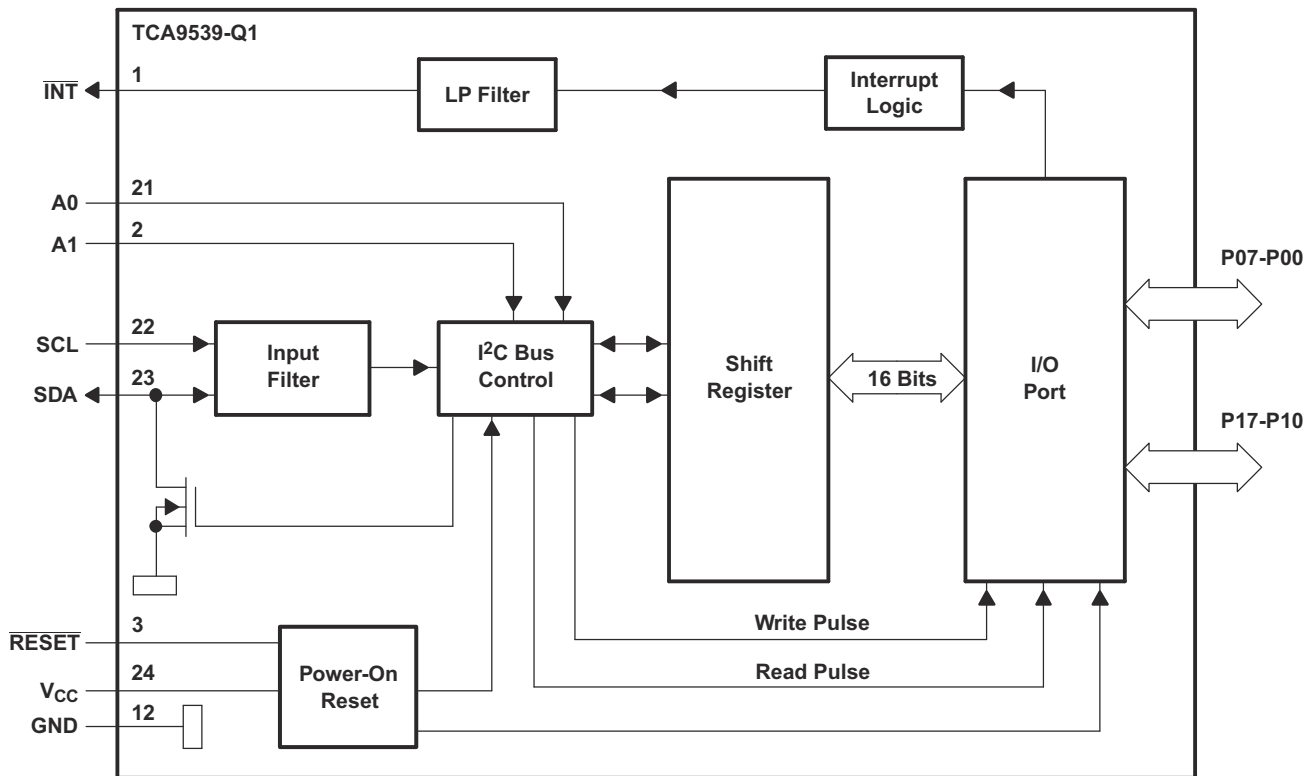
The TCA9539-Q1 open-drain interrupt ( $\overline{\text{INT}}$ ) output is activated when any input state differs from its corresponding Input Port register state and is used to indicate to the system controller that an input state has changed.

$\overline{\text{INT}}$  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 TCA9539-Q1 can remain a simple target device.

The TCA9539-Q1 is similar to the TCA9555, except for the removal of the internal I/O pull-up resistor, which greatly reduces power consumption when the I/Os are held low, replacement of A2 with  $\overline{\text{RESET}}$ , and a different address range. The TCA9539-Q1 is similar to the PCA9539 with lower voltage support (down to V<sub>CC</sub> = 1.65 V), and also improved power-on reset circuitry for different application scenarios.

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.

## 8.2 Functional Block Diagram

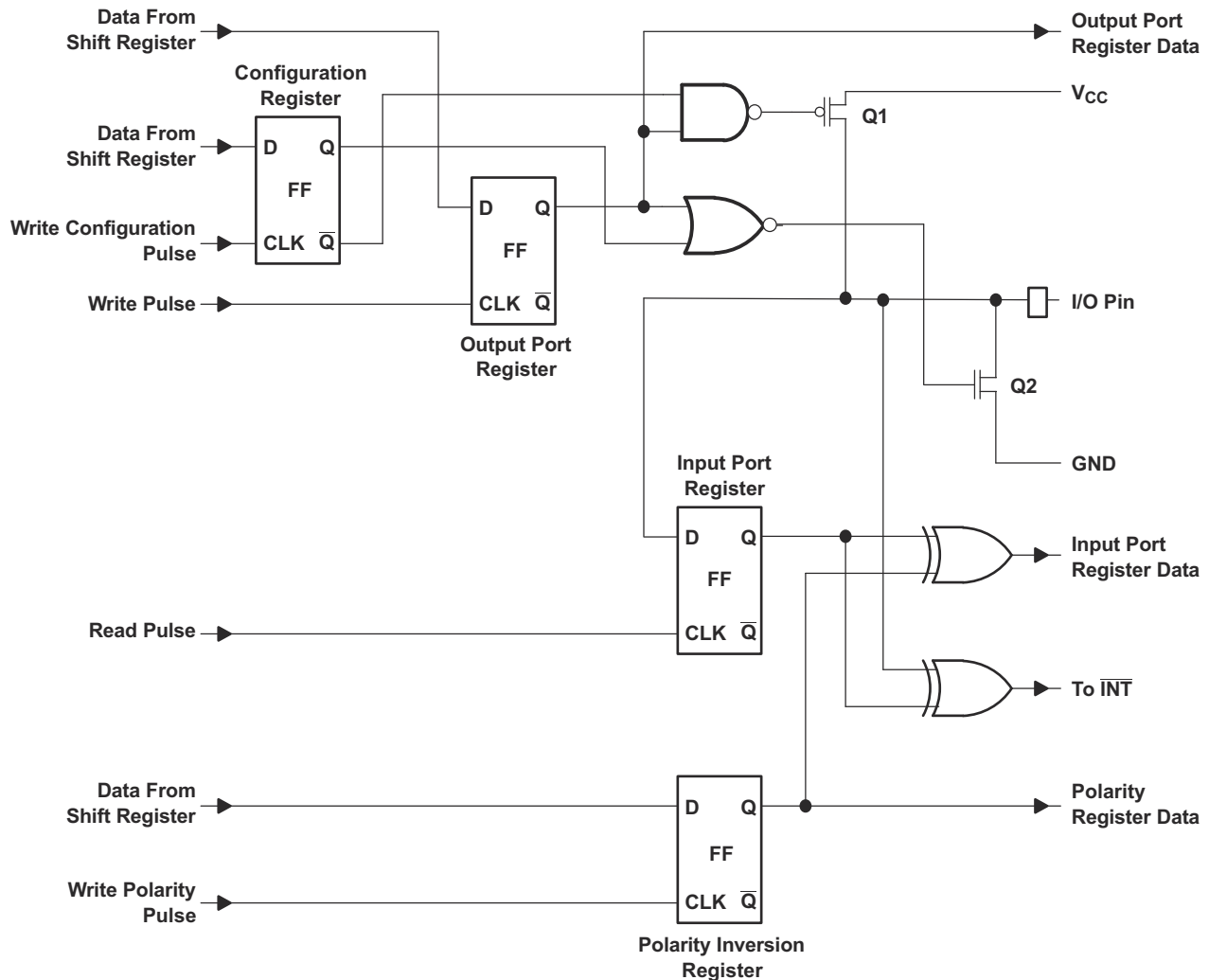


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Pin numbers shown are for PW package.  
All I/Os are set to inputs at reset.

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





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

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

## 8.3 Feature Description

### 8.3.1 I/O Port

When an I/O is configured as an input, FETs Q1 and Q2 are off, which creates a high-impedance input. The input voltage may be raised above  $V_{CC}$  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  $V_{CC}$  or GND. The external voltage applied to this I/O pin must not exceed the recommended levels for proper operation.

### 8.3.2 RESET Input

A reset can be accomplished by holding the  $\overline{\text{RESET}}$  pin low for a minimum of  $t_{W}$ . The TCA9539-Q1 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 pull-up resistor to  $V_{CC}$ , if no active connection is used.

### 8.3.3 Interrupt ( $\overline{\text{INT}}$ ) Output

An interrupt is generated by any rising or falling edge of the port inputs in the input mode. After time,  $t_{iv}$ , the signal  $\overline{\text{INT}}$  is valid. Resetting the interrupt circuit is achieved when data on the port is changed to the original setting or data is read from the port that generated the interrupt. Resetting occurs in the read mode at the

acknowledge (ACK) bit after the rising edge of the SCL signal. Note that the  $\overline{\text{INT}}$  is reset at the ACK just before the byte of changed data is sent. Interrupts that occur during the ACK clock pulse can be lost (or be very short) because of the resetting of the interrupt during this pulse. Each change of the I/Os after resetting is detected and is transmitted as  $\overline{\text{INT}}$ .

Reading from or 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-bit port is read independently, the interrupt caused by port 0 is not cleared by a read of port 1, or vice versa.

$\overline{\text{INT}}$  has an open-drain structure and requires a pull-up resistor to  $V_{\text{CC}}$ .

## 8.4 Device Functional Modes

### 8.4.1 Power-On Reset

When power (from 0 V) is applied to  $V_{\text{CC}}$ , an internal power-on reset holds the TCA9539-Q1 in a reset condition until  $V_{\text{CC}}$  has reached  $V_{\text{PORR}}$ . At that point, the reset condition is released and the TCA9539-Q1 registers and I<sup>2</sup>C-SMBus state machine initialize to their default states. After that,  $V_{\text{CC}}$  must be lowered to  $V_{\text{PORF}}$  and then back up to the operating voltage for a power-reset cycle. See [Figure 8-3](#).

## 8.5 Programming

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

The TCA9539-Q1 has a standard bidirectional I<sup>2</sup>C interface that is controlled by a controller device in order to be configured or read the status of this device. Each target on the I<sup>2</sup>C bus has a specific device address to differentiate between other target devices that are on the same I<sup>2</sup>C bus. Many target devices require configuration upon startup to set the behavior of the device. This is typically done when the controller accesses internal register maps of the target, which have unique register addresses. A device can have one or multiple registers where data is stored, written, or read. For more information see *Understanding the I<sup>2</sup>C Bus*, [SLVA704](#).

The physical I<sup>2</sup>C interface consists of the serial clock (SCL) and serial data (SDA) lines. Both SDA and SCL lines must be connected to  $V_{\text{CC}}$  through a pull-up resistor. The size of the pull-up resistor is determined by the amount of capacitance on the I<sup>2</sup>C lines. For further details, see *I<sup>2</sup>C Pull-up Resistor Calculation*, [SLVA689](#). Data transfer may be initiated only when the bus is idle. A bus is considered idle if both SDA and SCL lines are high after a STOP condition. See [Table 8-1](#).

[Figure 8-3](#) and [Figure 8-4](#) show the general procedure for a controller to access a target device:

1. If a controller wants to send data to a target:
  - Controller-transmitter sends a START condition and addresses the target-receiver.
  - Controller-transmitter sends data to target-receiver.
  - Controller-transmitter terminates the transfer with a STOP condition.
2. If a controller wants to receive or read data from a target:
  - Controller-receiver sends a START condition and addresses the target-transmitter.
  - Controller-receiver sends the requested register to read to target-transmitter.
  - Controller-receiver receives data from the target-transmitter.

- Controller-receiver terminates the transfer with a STOP condition.

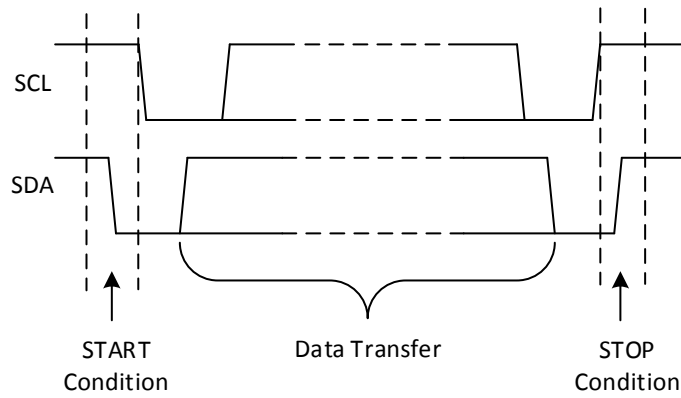


图 8-3. Definition of Start and Stop Conditions

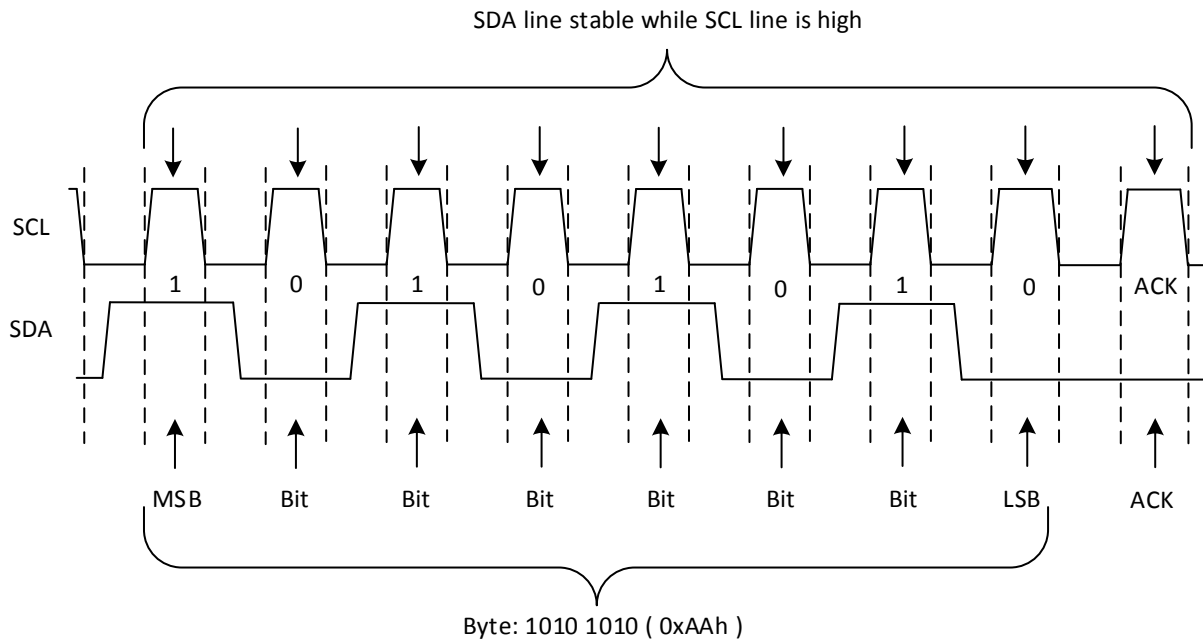


图 8-4. Bit Transfer

表 8-1 shows the interface definition.

表 8-1. Interface Definition

BYTE	BIT							
	7 (MSB)	6	5	4	3	2	1	0 (LSB)
I <sup>2</sup> C target address	H	H	H	L	H	A1	A0	R/ $\bar{W}$
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

## 8.6 Register Maps

### 8.6.1 Device Address

图 8-5 shows the address byte of the TCA9539-Q1.

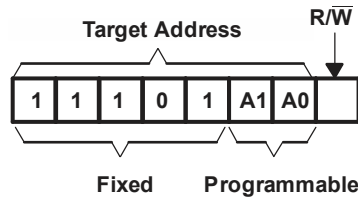


图 8-5. TCA9539-Q1 Address

表 8-2 shows the address reference of the TCA9539-Q1.

表 8-2. Address Reference

INPUTS		I <sup>2</sup> C BUS TARGET 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 target 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.

### 8.6.2 Control Register And Command Byte

Following the successful acknowledgment of the address byte, the bus controller sends a command byte shown in 表 8-3 that is stored in the control register in the TCA9539-Q1. Three bits of this data byte state the operation (read or write) and the internal register (input, output, Polarity Inversion or Configuration) that is 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.

When a command byte has been sent, the register pair that was addressed continues to be accessed by reads until a new command byte has been sent. 图 8-6 shows the control register bits.

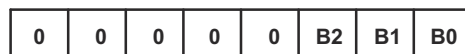


图 8-6. Control Register Bits

表 8-3. Command Byte

CONTROL REGISTER BITS			COMMAND BYTE (HEX)	REGISTER	PROTOCOL	POWER-UP 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

### 8.6.3 Register Descriptions

The Input Port registers (registers 0 and 1) shown in 表 8-4 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 is accessed next.

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

<b>Bit</b>	<b>I0.7</b>	<b>I0.6</b>	<b>I0.5</b>	<b>I0.4</b>	<b>I0.3</b>	<b>I0.2</b>	<b>I0.1</b>	<b>I0.0</b>
<b>Default</b>	X	X	X	X	X	X	X	X
<b>Bit</b>	<b>I1.7</b>	<b>I1.6</b>	<b>I1.5</b>	<b>I1.4</b>	<b>I1.3</b>	<b>I1.2</b>	<b>I1.1</b>	<b>I1.0</b>
<b>Default</b>	X	X	X	X	X	X	X	X

The Output Port registers (registers 2 and 3) shown in 表 8-5 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)**

<b>Bit</b>	<b>O0.7</b>	<b>O0.6</b>	<b>O0.5</b>	<b>O0.4</b>	<b>O0.3</b>	<b>O0.2</b>	<b>O0.1</b>	<b>O0.0</b>
<b>Default</b>	1	1	1	1	1	1	1	1
<b>Bit</b>	<b>O1.7</b>	<b>O1.6</b>	<b>O1.5</b>	<b>O1.4</b>	<b>O1.3</b>	<b>O1.2</b>	<b>O1.1</b>	<b>O1.0</b>
<b>Default</b>	1	1	1	1	1	1	1	1

The Polarity Inversion registers (registers 4 and 5) shown in 表 8-6 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)**

<b>Bit</b>	<b>N0.7</b>	<b>N0.6</b>	<b>N0.5</b>	<b>N0.4</b>	<b>N0.3</b>	<b>N0.2</b>	<b>N0.1</b>	<b>N0.0</b>
<b>Default</b>	0	0	0	0	0	0	0	0
<b>Bit</b>	<b>N1.7</b>	<b>N1.6</b>	<b>N1.5</b>	<b>N1.4</b>	<b>N1.3</b>	<b>N1.2</b>	<b>N1.1</b>	<b>N1.0</b>
<b>Default</b>	0	0	0	0	0	0	0	0

The Configuration registers (registers 6 and 7) shown in 表 8-7 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)**

<b>Bit</b>	<b>C0.7</b>	<b>C0.6</b>	<b>C0.5</b>	<b>C0.4</b>	<b>C0.3</b>	<b>C0.2</b>	<b>C0.1</b>	<b>C0.0</b>
<b>Default</b>	1	1	1	1	1	1	1	1
<b>Bit</b>	<b>C1.7</b>	<b>C1.6</b>	<b>C1.5</b>	<b>C1.4</b>	<b>C1.3</b>	<b>C1.2</b>	<b>C1.1</b>	<b>C1.0</b>
<b>Default</b>	1	1	1	1	1	1	1	1

#### 8.6.3.1 Bus Transactions

Data is exchanged between the controller and the TCA9539-Q1 through write and read commands, and this is accomplished by reading from or writing to registers in the target device.

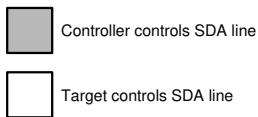
Registers are locations in the memory of the target which contain information, whether it be the configuration information or some sampled data to send back to the controller. The controller must write information to these registers in order to instruct the target device to perform a task.

### 8.6.3.1.1 Writes

To write on the I<sup>2</sup>C bus, the controller sends a START condition on the bus with the address of the target, as well as the last bit (the R/  $\bar{W}$  bit) set to 0, which signifies a write. After the target sends the acknowledge bit, the controller then sends the register address of the register to which it wishes to write. The target acknowledges again, letting the controller know it is ready. After this, the controller starts sending the register data to the target until the controller has sent all the data necessary (which is sometimes only a single byte), and the controller terminates the transmission with a STOP condition.

See the [§ 8.6.2](#) section to see list of the TCA9539-Q1s internal registers and a description of each one.

图 8-7 shows an example of writing a single byte to a target register.



Write to one register in a device

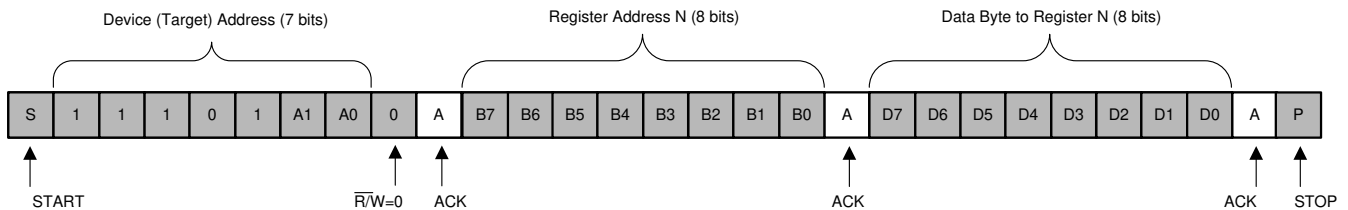


图 8-7. Write to Register

图 8-9 shows the Write to the Polarity Inversion Register.

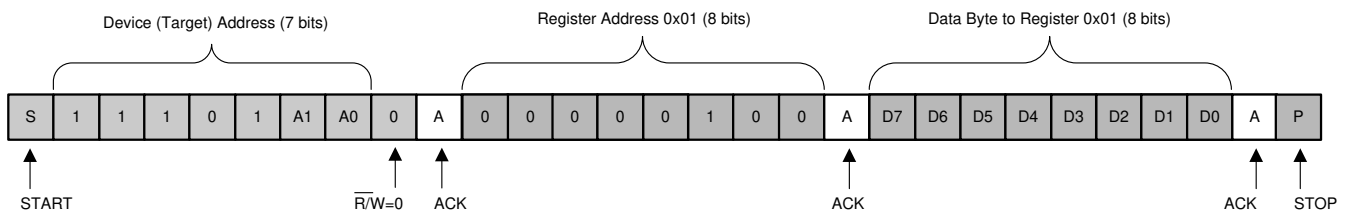
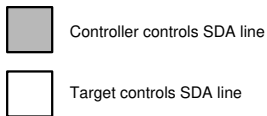


图 8-8. Write to the Polarity Inversion Register

图 8-9 shows the Write to Output Port Registers

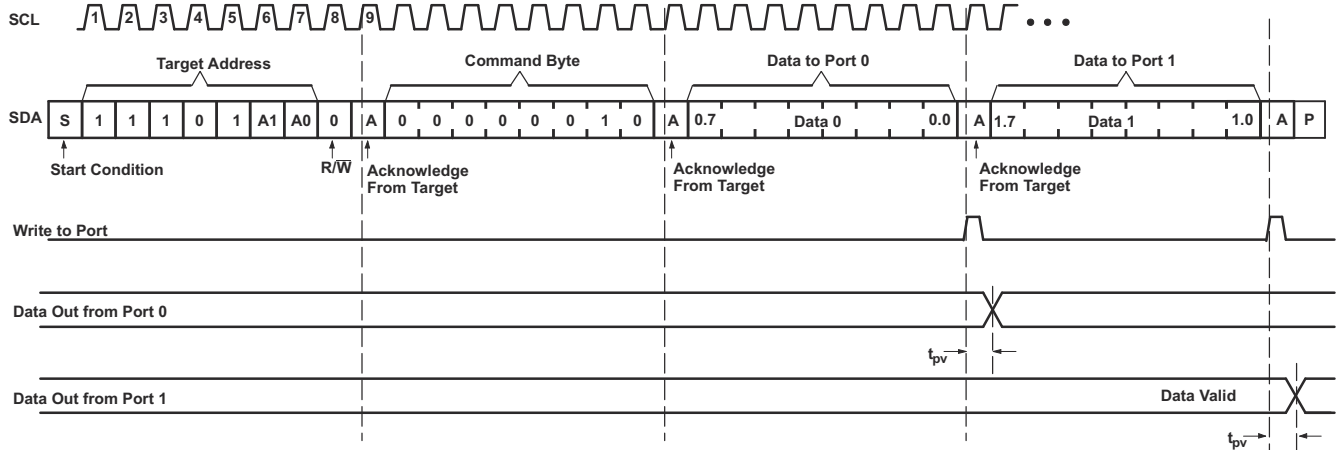


图 8-9. Write to Output Port Registers

8.6.3.1.2 Reads

Reading from a target is very similar to writing, but requires some additional steps. In order to read from a target, the controller must first instruct the target which register it wishes to read from. This is done by the controller starting off the transmission in a similar fashion as the write, by sending the address with the R/  $\bar{W}$  bit equal to 0 (signifying a write), followed by the register address it wishes to read from. When the target acknowledges this register address, the controller sends a START condition again, followed by the target address with the R/  $\bar{W}$  bit set to 1 (signifying a read). This time, the target acknowledges the read request, and the controller releases the SDA bus but continues supplying the clock to the target. During this part of the transaction, the controller becomes the controller-receiver, and the target becomes the target-transmitter.

The controller continues to send out the clock pulses, but releases the SDA line so that the target can transmit data. At the end of every byte of data, the controller sends an ACK to the target, letting the target know that it is ready for more data. When the controller has received the number of bytes it is expecting, it sends a NACK, signaling to the target to halt communications and release the bus. The controller follows this up with a STOP condition.

If a read is requested by the controller after a POR without first setting the command byte via a write, the device NACKs until a command byte-register address is set as described above.

See the 8.6.2 section to see list of the TCA9539-Q1s internal registers and a description of each one.

图 8-10 shows an example of reading a single byte from a target register.

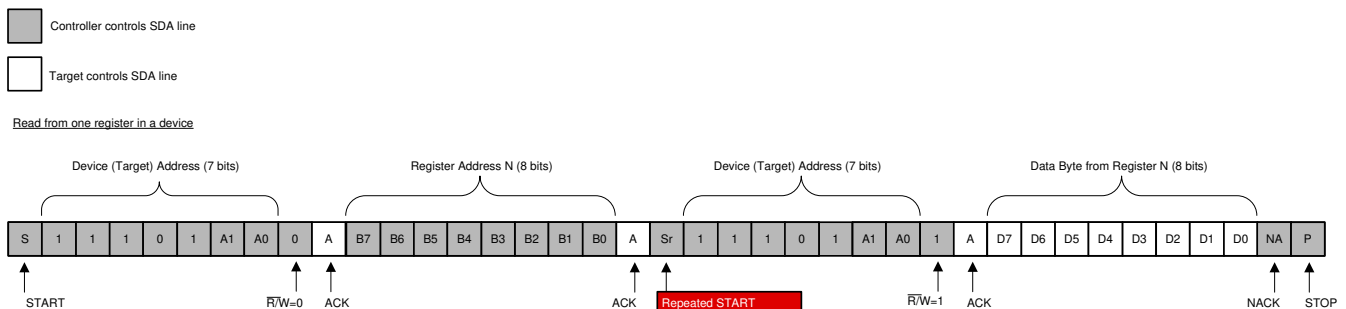


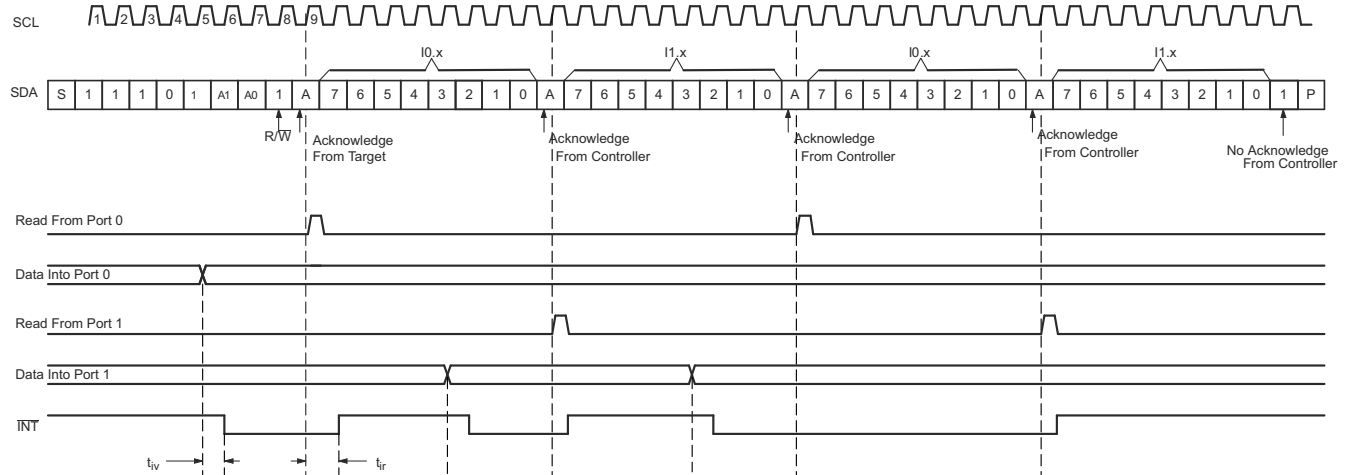


图 8-10. Read from Register

When a restart occurs after a single write request to a register, the requested register is used for the read request. Note that when reading multiple bytes of data. Data is clocked into the register on the rising edge of the ACK clock pulse before data is sent. The internal register value is also changed to the other register of the pair on the rising edge of the ACK clock pulse before data is sent. 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. If a restart occurs during a read, the data is lost because the internal register already has been changed to the next register in the pair.

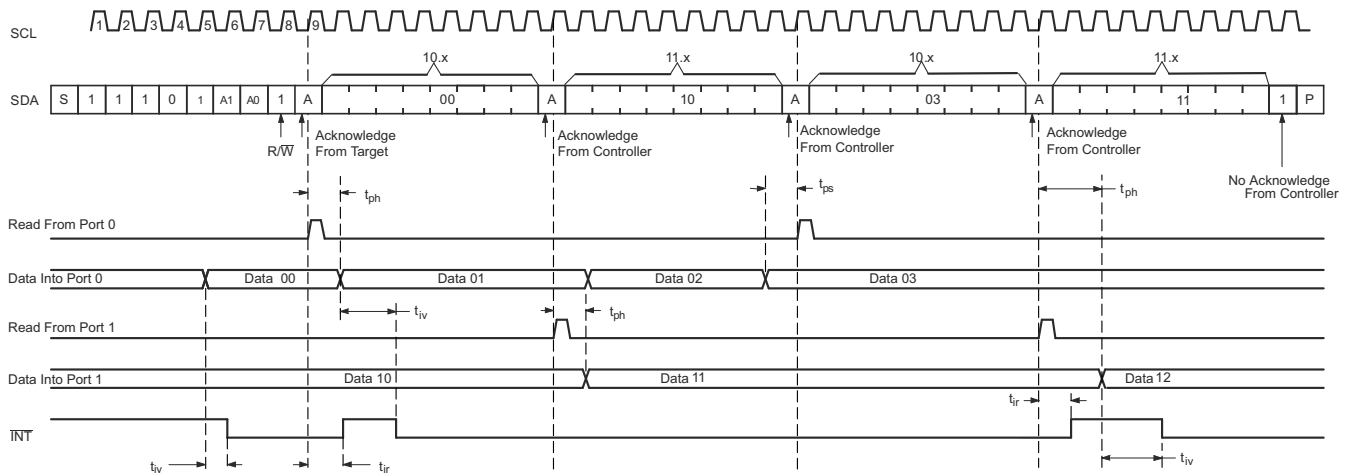
There is no limitation on the number of data bytes received in one read transmission, but when the final byte is received, the bus controller must not acknowledge the data.  and  show two different scenarios of Read Input Port Register.



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 target address call between the initial target address call and actual data transfer from the P port (see the [§ 8.6.3.1.2](#) section for these details).

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



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 target address call between the initial target address call and actual data transfer from the P port (see the [§ 8.6.3.1.2](#) section for these details).

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



## Application and Implementation

### 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. Customers should validate and test their design implementation to confirm system functionality.

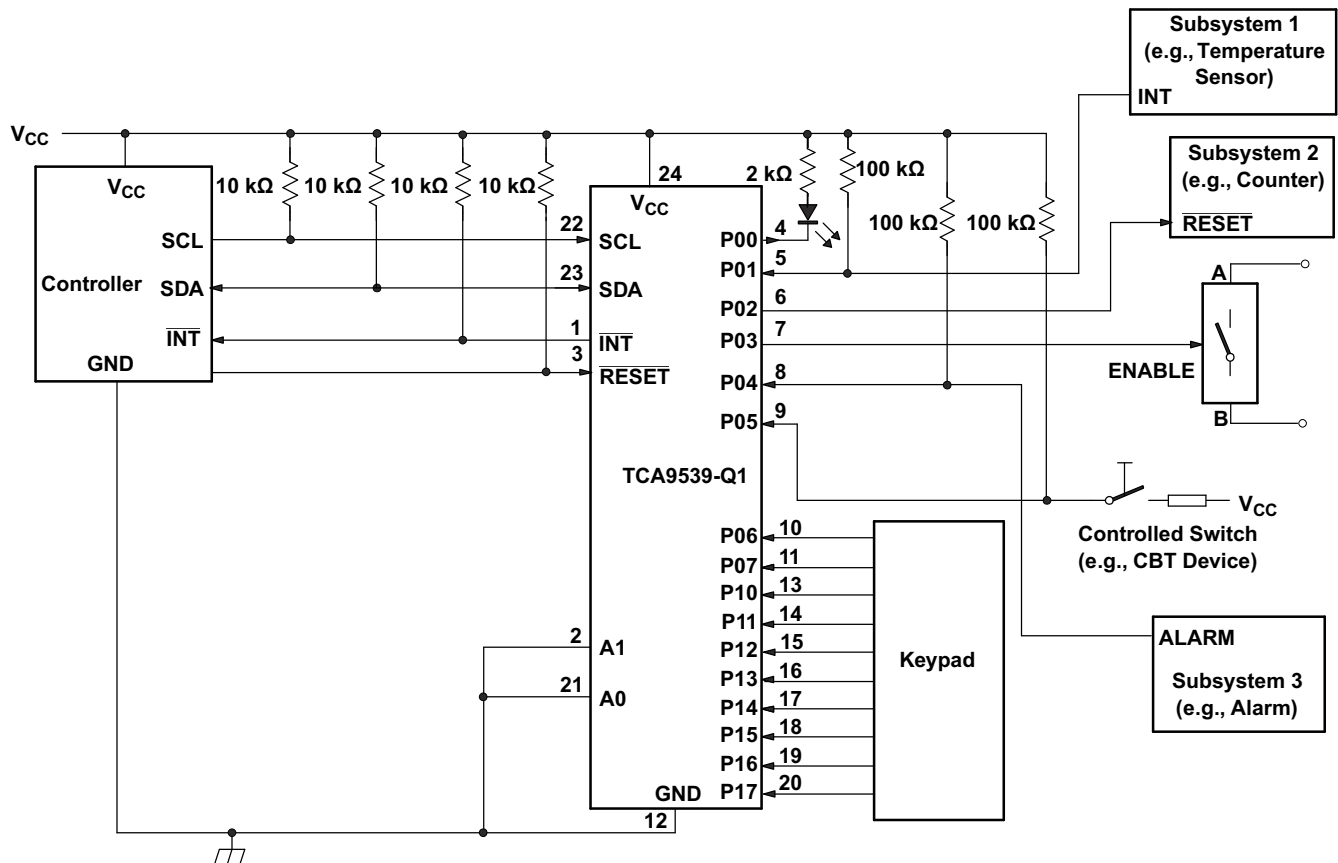
### 9.1 Application Information

Applications of the TCA9539-Q1 has this device connected as a target to an I<sup>2</sup>C controller (processor), and the I<sup>2</sup>C bus may contain any number of other target devices. The TCA9539-Q1 is typically in a remote location from the controller, placed close to the GPIOs to which the controller needs to monitor or control.

IO Expanders such as the TCA9539-Q1 are typically used for controlling LEDs (for feedback or status lights), controlling enable or reset signals of other devices, and even reading the outputs of other devices or buttons.

### 9.2 Typical Application

Figure 9-1 shows an application in which the TCA9539-Q1 can be used.



Device address is configured as 1110100 for this example.

P00, P02, and P03 are configured as outputs.

P01 and P04 to P17 are configured as inputs.

Pin numbers shown are for the PW package.

图 9-1. Application Schematic

## 9.2.1 Design Requirements

### 9.2.1.1 Calculating Junction Temperature and Power Dissipation

When designing with the TCA9539-Q1, it is important that the [§ 6.3](#) not be violated. Many of the parameters of this device are rated based on junction temperature, so junction temperature must be calculated in order to verify that safe operation of the device is met. The basic equation for junction temperature is shown in [方程式 1](#).

$$T_j = T_A + (\theta_{JA} \times P_d) \quad (1)$$

$\theta_{JA}$  is the standard junction to ambient thermal resistance measurement of the package, as seen in [§ 6.4](#) table.  $P_d$  is the total power dissipation of the device, and the approximation is shown in [方程式 2](#).

$$P_d \approx (I_{CC\_STATIC} \times V_{CC}) + \sum P_{d\_PORT\_L} + \sum P_{d\_PORT\_H} \quad (2)$$

[方程式 2](#) is the approximation of power dissipation in the device. The equation is the static power plus the summation of power dissipated by each port (with a different equation based on if the port is outputting high, or outputting low. If the port is set as an input, then power dissipation is the input leakage of the pin multiplied by the voltage on the pin). Note that this ignores power dissipation in the  $\overline{INT}$  and SDA pins, assuming these transients to be small. They can easily be included in the power dissipation calculation by using [方程式 3](#) to calculate the power dissipation in  $\overline{INT}$  or SDA while they are pulling low, and this gives maximum power dissipation.

$$P_{d\_PORT\_L} = (I_{OL} \times V_{OL}) \quad (3)$$

[方程式 3](#) shows the power dissipation for a single port which is set to output low. The power dissipated by the port is the  $V_{OL}$  of the port multiplied by the current it is sinking.

$$P_{d\_PORT\_H} = (I_{OH} \times (V_{CC} - V_{OH})) \quad (4)$$

[方程式 4](#) shows the power dissipation for a single port which is set to output high. The power dissipated by the port is the current sourced by the port multiplied by the voltage drop across the device (difference between  $V_{CC}$  and the output voltage).

### 9.2.1.2 Minimizing $I_{CC}$ When I/Os Control LEDs

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 the [§ 6.5](#) table show 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.

Take care to make sure that the recommended maximum  $I_{OL}$  through the ports not be violated based upon junction temperature. See the [§ 6.3](#) for more information.

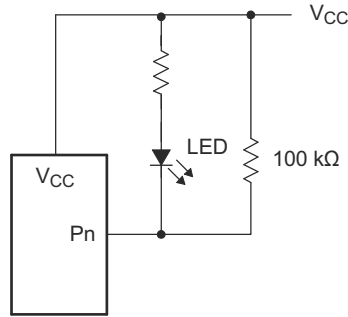


图 9-2. High-Value Resistor In Parallel With LED

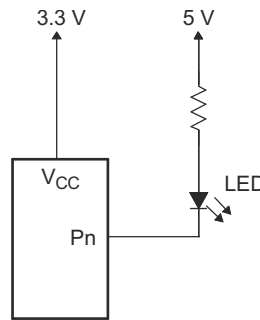


图 9-3. Device Supplied By Lower Voltage

### 9.2.2 Detailed Design Procedure

The pull-up resistors,  $R_p$ , for the SCL and SDA lines need to be selected appropriately and take into consideration the total capacitance of all targets on the I<sup>2</sup>C bus. The minimum pull-up resistance is a function of  $V_{CC}$ ,  $V_{OL(max)}$ , and  $I_{OL}$  as shown in 方程式 5.

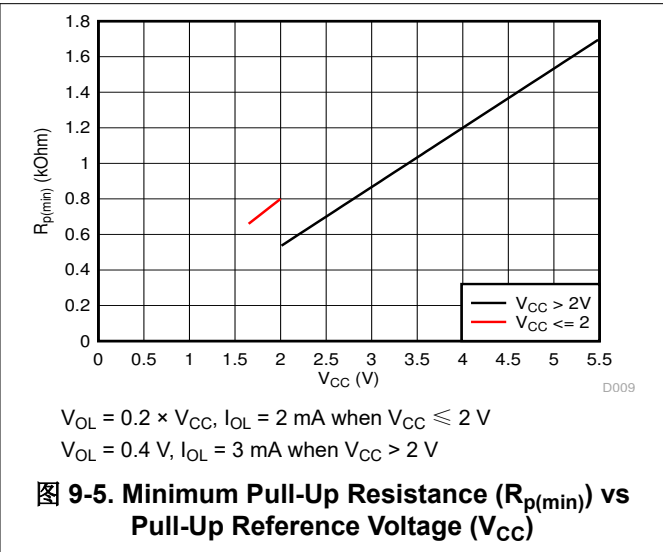
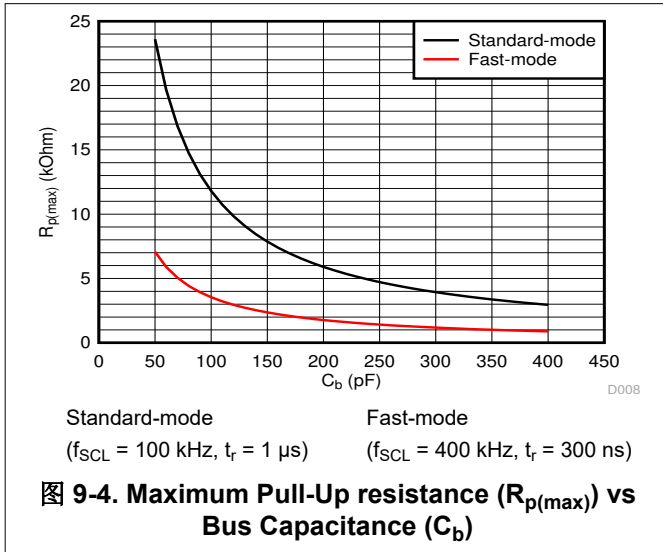
$$R_{p(min)} = \frac{V_{CC} - V_{OL(max)}}{I_{OL}} \quad (5)$$

The maximum pull-up resistance is a function of the maximum rise time,  $t_r$  (300 ns for fast-mode operation,  $f_{SCL} = 400$  kHz) and bus capacitance,  $C_b$  as shown in 方程式 6.

$$R_{p(max)} = \frac{t_r}{0.8473 \times C_b} \quad (6)$$

The maximum bus capacitance for an I<sup>2</sup>C bus must not exceed 400 pF for standard-mode or fast-mode operation. The bus capacitance can be approximated by adding the capacitance of the TCA9539-Q1,  $C_i$  for SCL or  $C_{io}$  for SDA, the capacitance of wires, connections, traces, and the capacitance of additional targets on the bus.

### 9.2.3 Application Curves



## 9 Power Supply Recommendations

### 9.1 Power-On Reset Requirements

In the event of a glitch or data corruption, TCA9539-Q1 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 voltage waveform for a power-on reset is shown in 图 9-1.

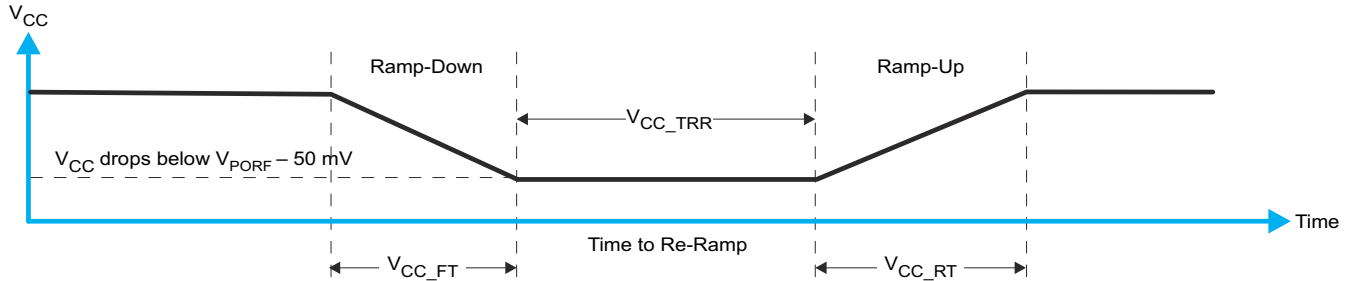


图 9-1.  $V_{CC}$  is Lowered Below the POR Threshold, then Ramped Back Up to  $V_{CC}$

表 9-1 specifies the performance of the power-on reset feature for TCA9539-Q1.

表 9-1. Recommended Supply Sequencing And Ramp Rates <sup>(1)</sup>

PARAMETER		MIN	TYP	MAX	UNIT
$V_{CC\_FT}$	Fall rate	See 图 9-1	0.1		ms
$V_{CC\_RT}$	Rise rate	See 图 9-1	0.1		ms
$V_{CC\_TRR}$	Time to re-ramp (when $V_{CC}$ drops to $V_{POR\_MIN} - 50$ mV or when $V_{CC}$ drops to GND)	See 图 9-1	2		$\mu$ s
$V_{CC\_GH}$	The level (referenced to $V_{CC}$ ) that $V_{CC}$ can glitch down to, but not cause a functional disruption when $V_{CC\_GW}$	See 图 9-2		1.2	V
$V_{CC\_MV}$	The minimum voltage that $V_{CC}$ can glitch down to without causing a reset ( $V_{CC\_GH}$ must not be violated)	See 图 9-2	1.5		V
$V_{CC\_GW}$	Glitch width that does not cause a functional disruption	See 图 9-2		10	$\mu$ s
$V_{PORF}$	Voltage trip point of POR on falling $V_{CC}$		0.75	1	V
$V_{PORR}$	Voltage trip point of POR on rising $V_{CC}$		1.2	1.5	V

(1)  $T_A = -40^\circ\text{C}$  to  $+125^\circ\text{C}$  (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 device impedance are factors that affect power-on reset performance. 图 9-2 and 表 9-1 provide more information on how to measure these specifications.

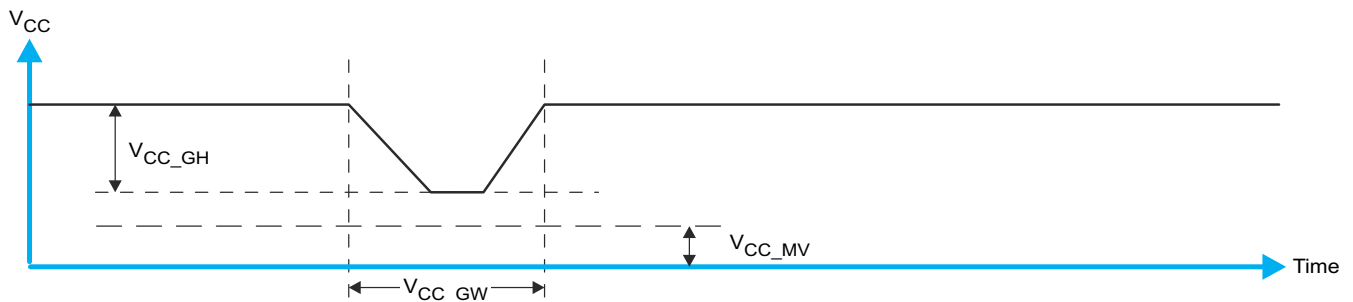


图 9-2. Glitch Width, Glitch Height, and Minimum Glitch Voltage

$V_{POR}$  is critical to the power-on reset.  $V_{PORR}$  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 9-3 和 表 9-1 provide more details on this specification.

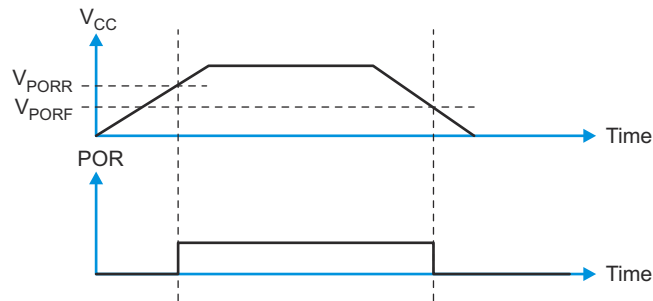


图 9-3.  $V_{POR}$

## 10 Layout

### 10.1 Layout Guidelines

For printed circuit board (PCB) layout of the TCA9539-Q1, common PCB layout practices must be followed but additional concerns related to high-speed data transfer such as matched impedances and differential pairs are not a concern for I<sup>2</sup>C signal speeds.

In all PCB layouts, it is a best practice to avoid right angles in signal traces, to fan out signal traces away from each other upon leaving the vicinity of an integrated circuit (IC), and to use thicker trace widths to carry higher amounts of current that commonly pass through power and ground traces. By-pass and de-coupling capacitors are commonly used to control the voltage on the V<sub>CC</sub> pin, using a larger capacitor to provide additional power in the event of a short power supply glitch and a smaller capacitor to filter out high-frequency ripple. These capacitors must be placed as close to the TCA9539-Q1 as possible. These best practices are shown in [Figure 10-1](#).

For the layout example provided in [Figure 10-1](#), it would be possible to fabricate a PCB with only 2 layers by using the top layer for signal routing and the bottom layer as a split plane for power (V<sub>CC</sub>) and ground (GND). However, a 4 layer board is preferable for boards with higher density signal routing. On a 4 layer PCB, it is common to route signals on the top and bottom layer, dedicate one internal layer to a ground plane, and dedicate the other internal layer to a power plane. In a board layout using planes or split planes for power and ground, vias are placed directly next to the surface mount component pad which must attach to V<sub>CC</sub> or GND and the via is connected electrically to the internal layer or the other side of the board. Vias are also used when a signal trace needs to be routed to the opposite side of the board, but this technique is not demonstrated in [Figure 10-1](#).

## 10.2 Layout Example

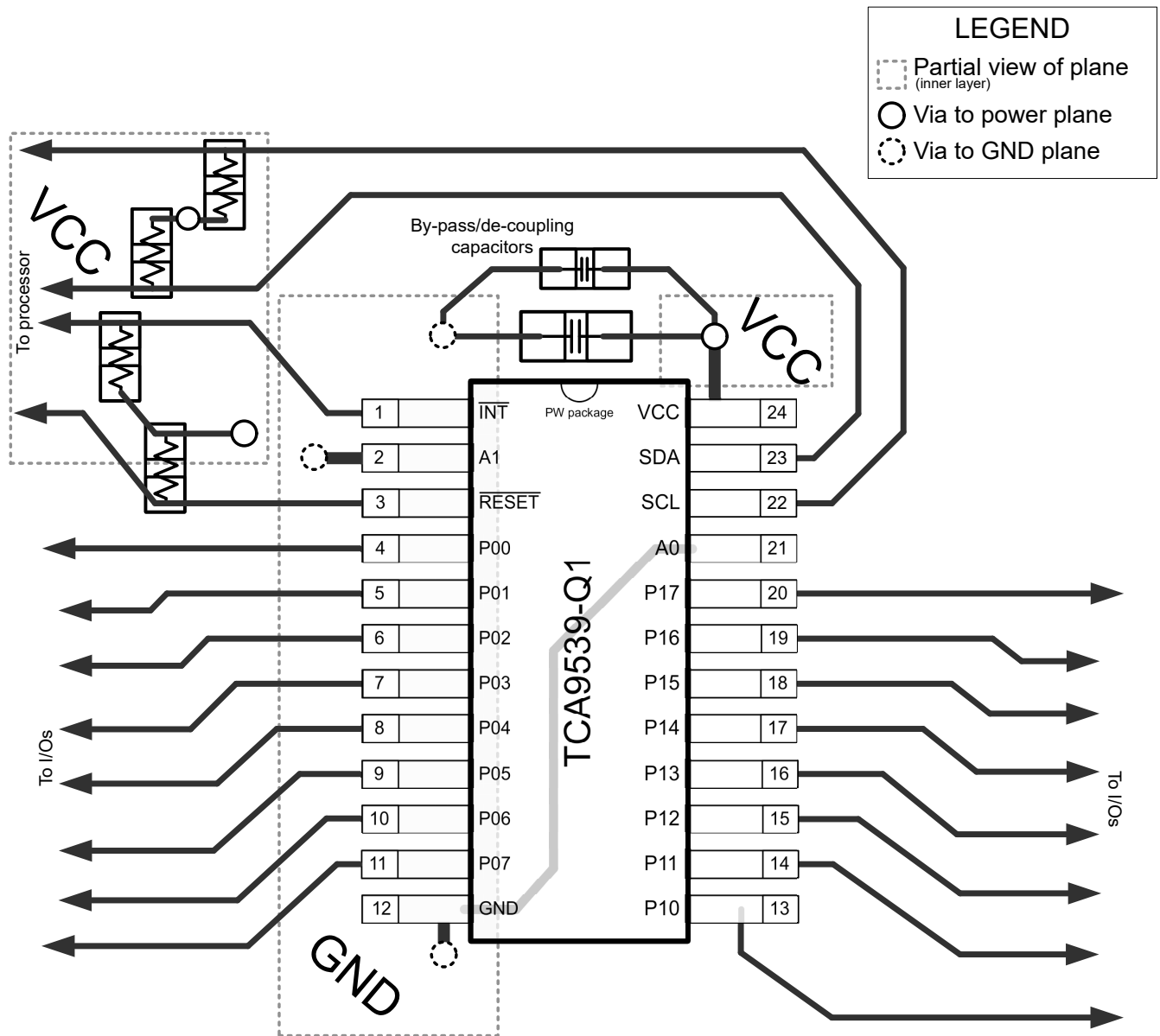


图 10-1. TCA9539-Q1 Layout



## 11 Device and Documentation Support

### 11.1 Documentation Support

#### 11.1.1 Related Documentation

For related documentation see the following:

- *Understanding the I2C Bus*, [SLVA704](#)
- *I2C Pull-up Resistor Calculation*, [SLVA689](#)
- *Introduction to Logic*, [SLVA700](#)
- *Maximum Clock Frequency of I2C Bus Using Repeaters*, [SLVA695](#)
- *I2C Bus Pull-Up Resistor Calculation*, [SLVA689](#)

#### 11.2 接收文档更新通知

要接收文档更新通知，请导航至 [ti.com](#) 上的器件产品文件夹。点击 [订阅更新](#) 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

#### 11.3 支持资源

[TI E2E™ 支持论坛](#) 是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

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#### 11.4 Trademarks

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#### 11.5 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.

#### 11.6 术语表

[TI 术语表](#) 本术语表列出并解释了术语、首字母缩略词和定义。

### 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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TCA9539QPWRQ1	ACTIVE	TSSOP	PW	24	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TCA539Q	Samples

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

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**OTHER QUALIFIED VERSIONS OF TCA9539-Q1 :**

- Catalog : [TCA9539](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*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
TCA9539QPWRQ1	TSSOP	PW	24	2000	330.0	16.4	6.95	8.3	1.6	8.0	16.0	Q1

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TCA9539QPWRQ1	TSSOP	PW	24	2000	356.0	356.0	35.0

PW0024A



# PACKAGE OUTLINE

## TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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

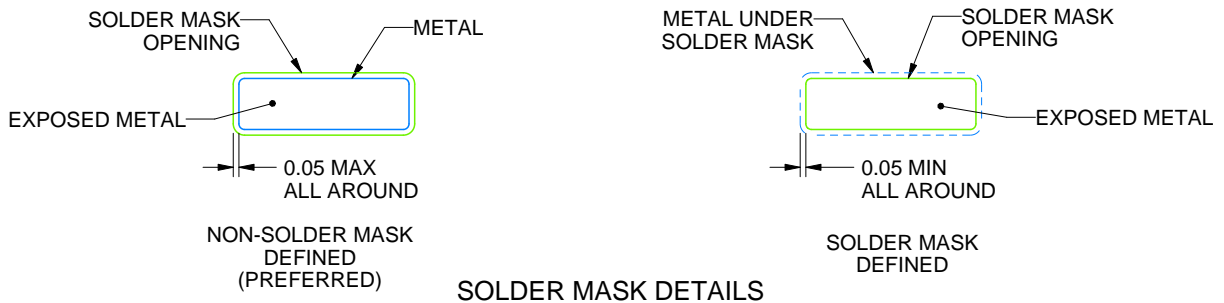
PW0024A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



SOLDER MASK DETAILS

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



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.



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