TEXAS INSTRUMENTS
TCA6408A
JAJSPM2E – APRIL 2009 – REVISED JANUARY 2023

TCA6408A 割り込み出力、リセット、構成レジスタ内蔵の低電圧 8 ビット I²C/SMBus I/O エクスパンダ

1 特長

- I²C からパラレル・ポートへのエクスパンダ
- 1.65V～5.5V の動作電源電圧範囲
- 双方向電圧レベル変換と、1.8V、2.5V、3.3V、5V の I²C バスおよび P ポート間での GPIO 拡張が可能
- 低いスタンバイ消費電流：1µA
- 5V 許容の I/O ポート
- 400kHz の高速 I²C バス
- ハードウェア・アドレス・ピンにより、同じ I²C/SMBus バス上に 2 つの TCA6408A デバイスを接続可能
- アクティブ LOW のリセット (RESET) 入力
- オープンドレインのアクティブ LOW 割り込み (INT) 出力
- 入力 / 出力構成レジスタ
- 極性反転レジスタ
- パワーオン・リセット内蔵
- 電源投入時はすべてのチャネルが入力に構成された状態
- 電源オン時のグリッチなし
- SCL/SDA 入力のノイズ・フィルタ
- 大電流の最大駆動能力を持つラッチ付き出力により LED を直接駆動
- JESD 78、Class II 準拠で 100mA 超のラッチアップ性能
- シュミット・トリガ動作により低速入力遷移が実現され、SCL および SDA 入力でのスイッチング・ノイズ耐性が向上
- JESD 22 を超える ESD 保護
  - 2000V、人体モデル (A114-A)
  - 1000V、デバイス帯電モデル (C101)

2 アプリケーション

- サーバー
- ルーター (テレコム・スイッチング機器)
- パーソナル・コンピュータ
- パーソナル・エレクトロニクス (ゲーム機)
- 産業用オートメーション
- GPIO が制限されたプロセッサを使用する製品

3 概要

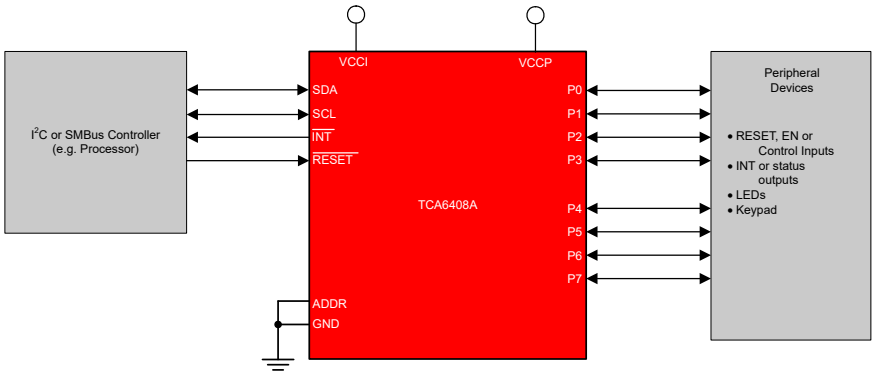
TCA6408A は 16 ピン・デバイスで、2 ライン双方向 I²C バス (または SMBus) プロトコル用に 8 ビットの汎用パラレル入出力 (I/O) 拡張機能を提供します。このデバイスは、I²C バス側 (V_{CCI}) と P ポート側 (V_{CCP}) の両方とも 1.65V～5.5V の電源電圧で動作できます。このため、TCA6408A は SDA/SCL 側で、消費電力削減のため電源電圧レベルが引き下げられる次世代のマイクロプロセッサおよびマイクロコントローラと接続できます。マイクロプロセッサおよびマイクロコントローラの電源供給は低下しますが、LED など PCB の部品には引き続き 5V の電源が供給されます。

このデバイスは、100kHz (標準モード) と 400kHz (高速モード) の両方のクロック周波数をサポートしています。TCA6408A をはじめとする I/O エクスパンダは、スイッチ、センサ、押しボタン、LED、ファンなどに I/O を追加する必要がある場合の簡単なソリューションとなります。

パッケージ情報

部品番号	パッケージ (1)	本体サイズ (公称)
TCA6408A	TSSOP (16)	5.00mm × 4.40mm
	VQFN (16)	3.00mm × 3.00mm
	UQFN (16)	2.60mm × 1.80mm

(1) 利用可能なパッケージについては、このデータシートの末尾にある注文情報を参照してください。



簡略回路図

英語版の TI 製品についての情報を翻訳したこの資料は、製品の概要を確認する目的で便宜的に提供しているものです。該当する正式な英語版の最新情報は、www.ti.com で閲覧でき、その内容が常に優先されます。TI では翻訳の正確性および妥当性につきましては一切保証いたしません。実際の設計などの前には、必ず最新版の英語版をご参照くださいますようお願いいたします。

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4 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

Changes from Revision D (July 2015) to Revision E (January 2023) **Page**

- I²C に言及している場合、すべての旧式の用語をコントローラおよびターゲットに変更 ... 1
- Added paragraph: "Ramping up the device V_{CCP}" to *Power-On Reset Requirements* ... 31

Changes from Revision C (July 2009) to Revision D (July 2015) **Page**

- 「ピン構成および機能」セクション、「ESD 定格」表、「機能説明」セクション、「デバイスの機能モード」セクション、「アプリケーションと実装」セクション、「電源に関する推奨事項」セクション、「レイアウト」セクション、「デバイスおよびドキュメントのサポート」セクション、「メカニカル、パッケージ、および注文情報」セクションを追加 ... 1
- V_{IH} - Split SCL, SDA and RESET to different rows in the *Recommended Operating Conditions* table. Max value of SCL, SDA changed From: 5.5 V To: V_{CCI} ... 5

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5 Pin Configuration and Functions

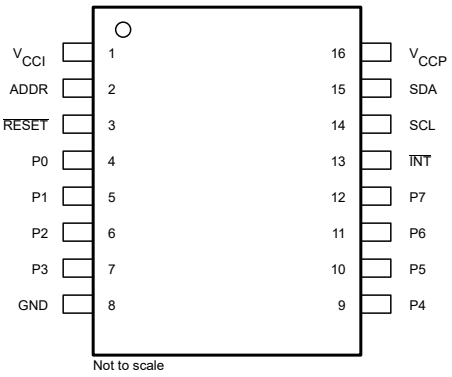


図 5-1. PW Package, 16-Pin TSSOP (Top View)

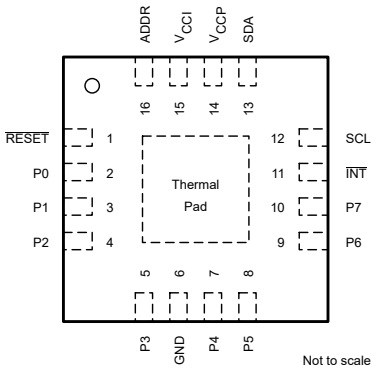


図 5-2. RGT Package, 16-Pin VQFN (Top View)

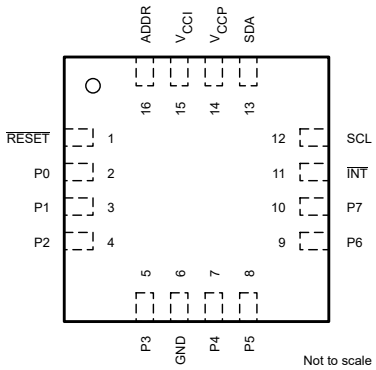


図 5-3. RSV Package, 16-Pin UQFN (Top View)

表 5-1. Pin Functions

PIN			DESCRIPTION
NAME	TSSOP	UQFN, VQFN	
ADDR	2	16	Address input. Connect directly to V_{CCP} or ground.
GND	8	6	Ground
$\overline{INT}$	13	11	Interrupt output. Connect to V_{CCI} through a pull-up resistor.
P0	4	2	P-port input/output (push-pull design structure). At power on, P0 is configured as an input.
P1	5	3	P-port input/output (push-pull design structure). At power on, P1 is configured as an input.
P2	6	4	P-port input/output (push-pull design structure). At power on, P2 is configured as an input.
P3	7	5	P-port input/output (push-pull design structure). At power on, P3 is configured as an input.
P4	9	7	P-port input/output (push-pull design structure). At power on, P4 is configured as an input.

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表 5-1. Pin Functions (continued)

PIN			DESCRIPTION
NAME	TSSOP	UQFN, VQFN	
P5	10	8	P-port input/output (push-pull design structure). At power on, P5 is configured as an input.
P6	11	9	P-port input/output (push-pull design structure). At power on, P6 is configured as an input.
P7	12	10	P-port input/output (push-pull design structure). At power on, P7 is configured as an input.
$\overline{\text{RESET}}$	3	1	Active-low reset input. Connect to V_{CCI} through a pull-up resistor, if no active connection is used.
SCL	14	12	Serial clock bus. Connect to V_{CCI} through a pull-up resistor.
SDA	15	13	Serial data bus. Connect to V_{CCI} through a pull-up resistor.
V_{CCI}	1	15	Supply voltage of I^2C bus. Connect directly to the V_{CC} of the external I^2C controller. Provides voltage level translation.
V_{CCP}	16	14	Supply voltage of TCA6408A for P-ports

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6 Specifications

6.1 Absolute Maximum Ratings

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

				MIN	MAX	UNIT
V_{CCI}	Supply voltage for I^2C pins			–0.5	6.5	V
V_{CCP}	Supply voltage for P-ports			–0.5	6.5	V
V_I	Input voltage(2)			–0.5	6.5	V
V_O	Output voltage(2)			–0.5	6.5	V
I_{IK}	Input clamp current	ADDR, $\overline{RESET}$, SCL	$V_I < 0$		±20	mA
I_{OK}	Output clamp current	$\overline{INT}$	$V_O < 0$		±20	mA
I_{IOK}	Input/output clamp current	P-port	$V_O < 0$ or $V_O > V_{CCP}$		±20	mA
		SDA	$V_O < 0$ or $V_O > V_{CCI}$		±20	
I_{OL}	Continuous output low current	P-port	V_O = 0 to V_{CCP}		50	mA
	Continuous output low current	SDA, $\overline{INT}$	V_O = 0 to V_{CCI}		25	
I_{OH}	Continuous output high current	P-port	V_O = 0 to V_{CCP}		50	mA
I_{CC}	Continuous current through GND				200	mA
	Continuous current through V_{CCP}				160	
	Continuous current through V_{CCI}				10	
T_{stg}	Storage temperature			–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under セクション 6.3. 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

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±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_{CCI}	Supply voltage for I^2C pins		1.65	5.5	V
V_{CCP}	Supply voltage for P-ports		1.65	5.5	
V_{IH}	High-level input voltage	SCL, SDA	0.7 × V_{CCI}	V_{CCI}	V
		$\overline{RESET}$	0.7 × V_{CCI}	5.5	
		ADDR, P7–P0	0.7 × V_{CCP}	5.5	
V_{IL}	Low-level input voltage	SCL, SDA, $\overline{RESET}$	–0.5	0.3 × V_{CCI}	V
		ADDR, P7–P0	–0.5	0.3 × V_{CCP}	
I_{OH}	High-level output current	P7–P0		10	mA
I_{OL}	Low-level output current	P7–P0		25	mA
T_A	Operating free-air temperature		–40	85	°C

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6.4 Thermal Information

THERMAL METRIC(1)		TCA6408A			UNIT
		PW (TSSOP)	RGT (VQFN)	RSV (UQFN)	
		16 PINS	16 PINS	16 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	122	65.5	127.7	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	56.4	92.1	62.3	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	67.1	40.0	48.4	°C/W
ψ_{JT}	Junction-to-top characterization parameter	10.8	6.9	2.5	°C/W
ψ_{JB}	Junction-to-board characterization parameter	66.5	21.3	48.6	°C/W

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

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6.5 Electrical Characteristics

over recommended operating free-air temperature range, V_{CCI} = 1.65 V to 5.5 V (unless otherwise noted)

PARAMETER			TEST CONDITIONS	V_{CCP}	MIN	TYP(1)	MAX	UNIT
V_{IK}	Input diode clamp voltage		I_I = –18 mA	1.65 V to 5.5 V	–1.2			V
V_{POR}	Power-on reset voltage(2)		V_I = V_{CCP} or GND, I_O = 0	1.65 V to 5.5 V		1	1.4	V
V_{OH}	P-port high-level output voltage		I_{OH} = –8 mA	1.65 V	1.2			V
				2.3 V	1.8			
				3 V	2.6			
				4.5 V	4.1			
			I_{OH} = –10 mA	1.65 V	1.1			
				2.3 V	1.7			
				3 V	2.5			
				4.5 V	4.0			
V_{OL}	P-port low-level output voltage		I_{OL} = 8 mA	1.65 V			0.45	V
				2.3 V			0.25	
				3 V			0.25	
				4.5 V			0.2	
			I_{OL} = 10 mA	1.65 V			0.6	
				2.3 V			0.3	
				3 V			0.25	
				4.5 V			0.2	
I_{OL}	SDA		V_{OL} = 0.4 V	1.65 V to 5.5 V	3			mA
	$\overline{INT}$				3	15		
I_I	SCL, SDA, $\overline{RESET}$		V_I = V_{CCI} or GND	1.65 V to 5.5 V			±0.1	µA
	ADDR		V_I = V_{CCP} or GND				±0.1	
I_{IH}	P-port		V_I = V_{CCP}	1.65 V to 5.5 V			1	µA
I_{IL}	P-port		V_I = GND				1	µA
I_{CC} (I_{CCI} + I_{CCP})	Operating mode	SDA, P-port, ADDR, $\overline{RESET}$	V_I on SDA and $\overline{RESET}$= V_{CCI} or GND, V_I on P-port and ADDR = V_{CCP} or GND, I_O = 0, I/O = inputs, f_{SCL} = 400 kHz	3.6 V to 5.5 V		10	20	µA
				2.3 V to 3.6 V		6.5	15	
				1.65 V to 2.3 V		4	9	
	Standby mode	SCL, SDA, P-port, ADDR, $\overline{RESET}$	V_I on SCL, SDA and $\overline{RESET}$ = V_{CCI} or GND, V_I on P-Port and ADDR = V_{CCP} or GND, I_O = 0, I/O = inputs, f_{SCL} = 0	3.6 V to 5.5 V		1.5	7	
				2.3 V to 3.6 V		1	3.2	
				1.65 V to 2.3 V		0.5	1.7	
ΔI_{CCI}	Additional current in standby mode	SCL, SDA, $\overline{RESET}$	One input at V_{CCI} – 0.6 V, Other inputs at V_{CCI} or GND	1.65 V to 5.5 V			25	µA
ΔI_{CCP}		P-port, ADDR	One input at V_{CCP} – 0.6 V, Other inputs at V_{CCP} or GND	1.65 V to 5.5 V			80	µA
C_i	SCL		V_I = V_{CCI} or GND	1.65 V to 5.5 V		6	7	pF
C_{io}	SDA		V_{IO} = V_{CCI} or GND	1.65 V to 5.5 V		7	8	pF
	P-port		V_{IO} = V_{CCP} or GND			7.5	8.5	

(1) All typical values are at nominal supply voltage (1.8-V, 2.5-V, 3.3-V, or 5-V V_{CC}) and T_A = 25°C.
(2) When power (from 0 V) is applied to V_{CCP}, an internal power-on reset holds the TCA6408A in a reset condition until V_{CCP} has reached V_{POR}. At that time, the reset condition is released, and the TCA6408A registers and I^2C/SMBus state machine initialize to their default states. After that, V_{CCP} must be lowered to below 0.2 V and back up to the operating voltage for a power-reset cycle.

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6.6 I²C Interface Timing Requirements

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

		STANDARD MODE I²C BUS		FAST MODE I²C BUS		UNIT
		MIN	MAX	MIN	MAX	
f_{scl}	I²C clock frequency	0	100	0	400	kHz
t_{sch}	I²C clock high time	4		0.6		µs
t_{scl}	I²C clock low time	4.7		1.3		µs
t_{sp}	I²C spike time	0	50	0	50	ns
t_{sds}	I²C serial data setup time	250		100		ns
t_{sdh}	I²C serial data hold time	0		0		ns
t_{icr}	I²C input rise time		1000	20 + 0.1C_b	300	ns
t_{icf}	I²C input fall time		300	20 + 0.1C_b	300	ns
t_{ocf}	I²C output fall time, 10-pF to 400-pF bus		300	20 + 0.1C_b	300	µs
t_{buf}	I²C bus free time between Stop and Start	4.7		1.3		µs
t_{sts}	I²C Start or repeater Start condition setup time	4.7		0.6		µs
t_{sth}	I²C Start or repeater Start condition hold time	4		0.6		µs
t_{sps}	I²C Stop condition setup time	4		0.6		µs
$t_{vd(data)}$	Valid data time, SCL low to SDA output valid		1		1	µs
$t_{vd(ack)}$	Valid data time of ACK condition, ACK signal from SCL low to SDA (out) low		1		1	µs

6.7 Reset Timing Requirements

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

		STANDARD MODE I²C BUS		FAST MODE I²C BUS		UNIT
		MIN	MAX	MIN	MAX	
t_W	Reset pulse duration	4		4		ns
t_{REC}	Reset recovery time	0		0		ns
t_{RESET}	Time to reset	600		600		ns

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6.8 Switching Characteristics

over recommended operating free-air temperature range, C_L ≤ 100 pF (unless otherwise noted) (see 図 7-1)

PARAMETER		FROM (INPUT)	TO (OUTPUT)	STANDARD MODE I²C BUS		FAST MODE I²C BUS		UNIT
				MIN	MAX	MIN	MAX	
t_{iv}	Interrupt valid time	P-Port	$\overline{INT}$		4		4	µs
t_{ir}	Interrupt reset delay time	SCL	$\overline{INT}$		4		4	µs
t_{pv}	Output data valid	SCL	P7–P0		400		400	ns
t_{ps}	Input data setup time	P-Port	SCL	0		0		ns
t_{ph}	Input data hold time	P-Port	SCL	300		300		ns

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6.9 Typical Characteristics

T_A = 25°C (unless otherwise noted)

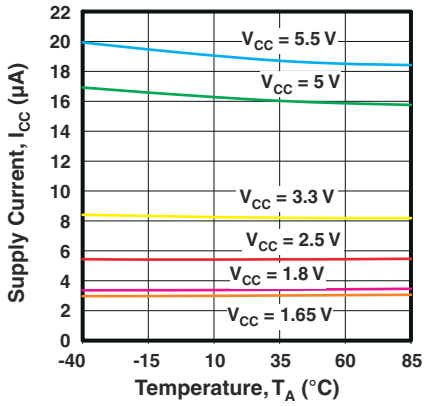


図 6-1. Supply Current vs Temperature

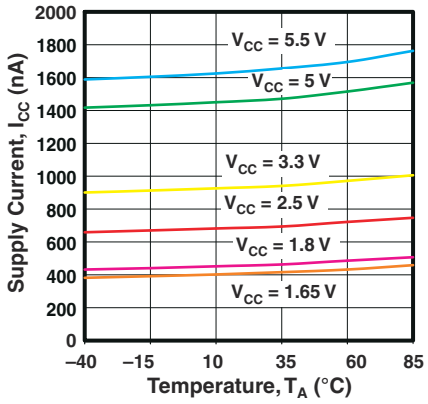


図 6-2. Standby Supply Current vs Temperature

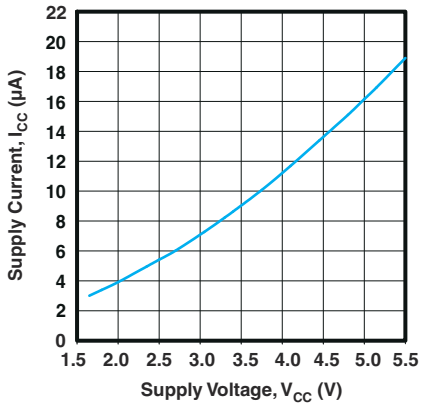


図 6-3. Supply Current vs Supply Voltage

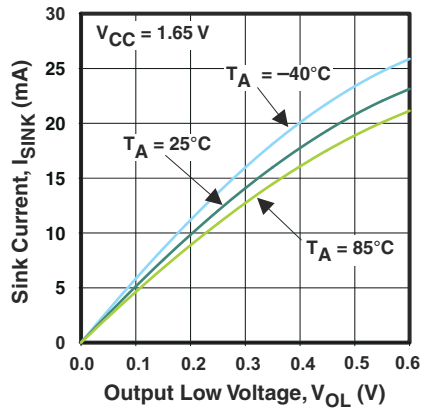


図 6-4. I/O Sink Current vs Output Low Voltage

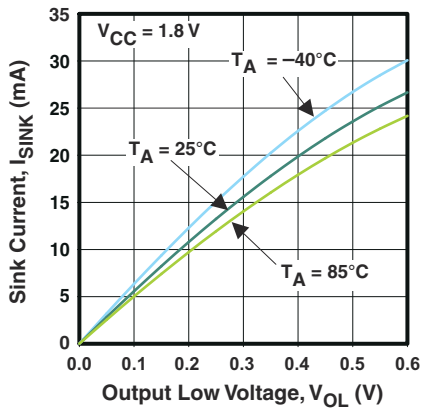


図 6-5. I/O Sink Current vs Output Low Voltage

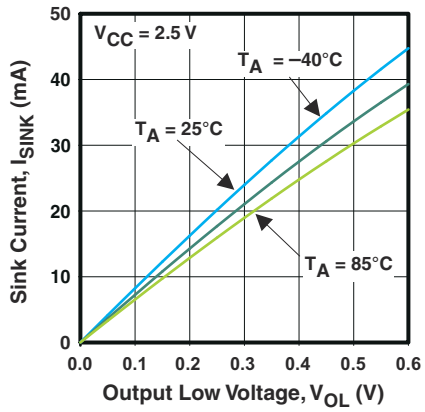


図 6-6. I/O Sink Current vs Output Low Voltage

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6.9 Typical Characteristics (continued)

T_A = 25°C (unless otherwise noted)

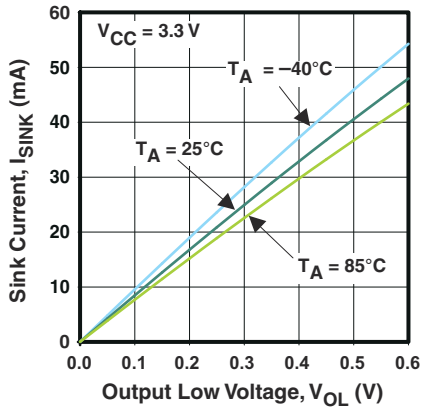


図 6-7. I/O Sink Current vs Output Low Voltage

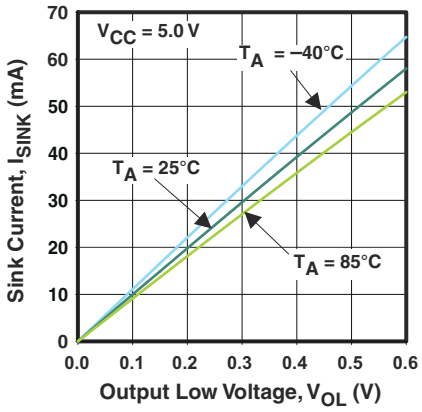


図 6-8. I/O Sink Current vs Output Low Voltage

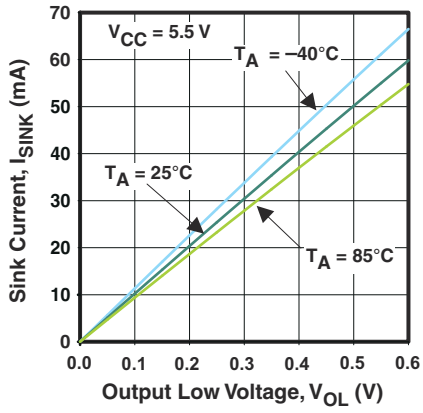


図 6-9. I/O Sink Current vs Output Low Voltage

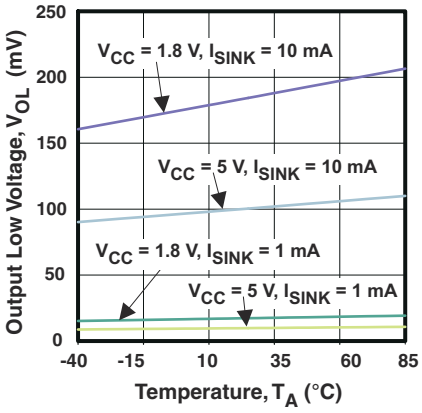


図 6-10. I/O Low Voltage vs Temperature

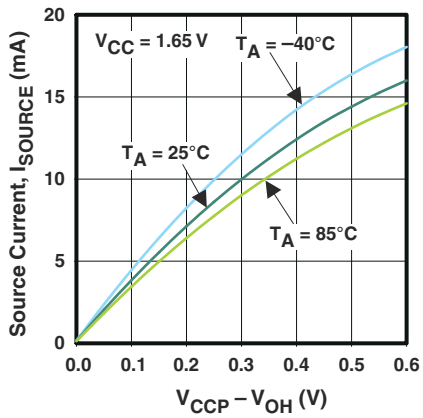


図 6-11. I/O Source Current vs Output High Voltage

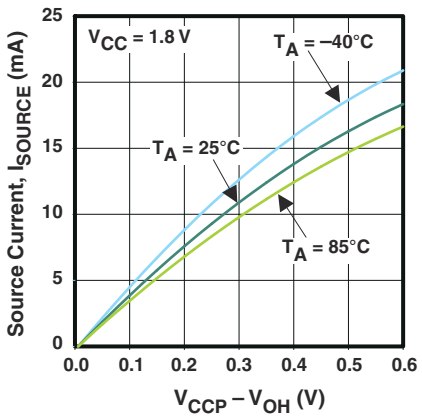


図 6-12. I/O Source Current vs Output High Voltage

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6.9 Typical Characteristics (continued)

T_A = 25°C (unless otherwise noted)

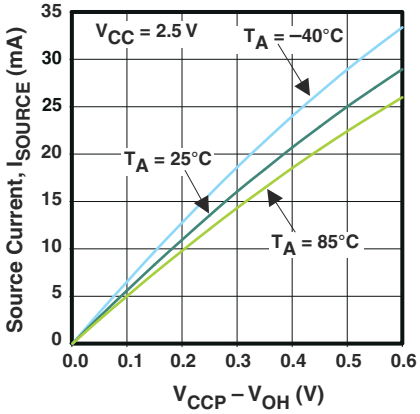


図 6-13. I/O Source Current vs Output High Voltage

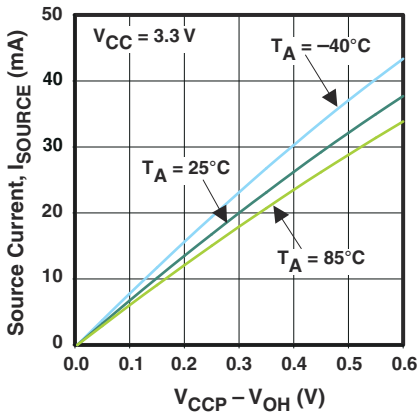


図 6-14. I/O Source Current vs Output High Voltage

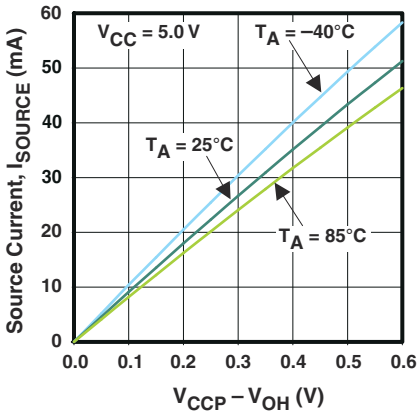


図 6-15. I/O Source Current vs Output High Voltage

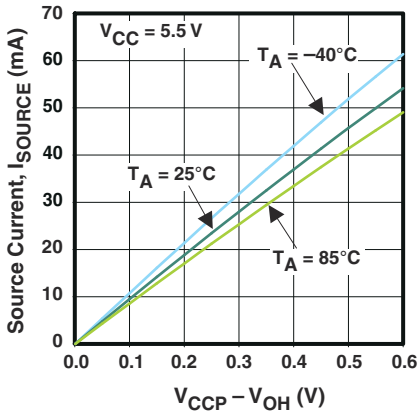


図 6-16. I/O Source Current vs Output High Voltage

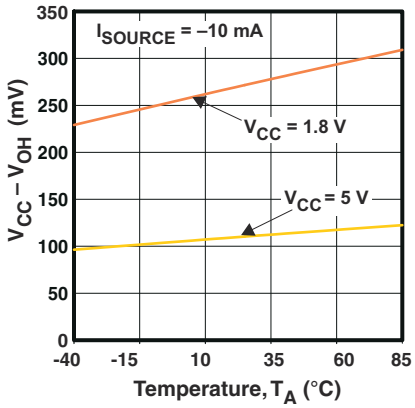
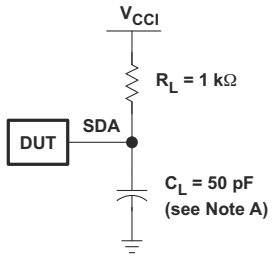


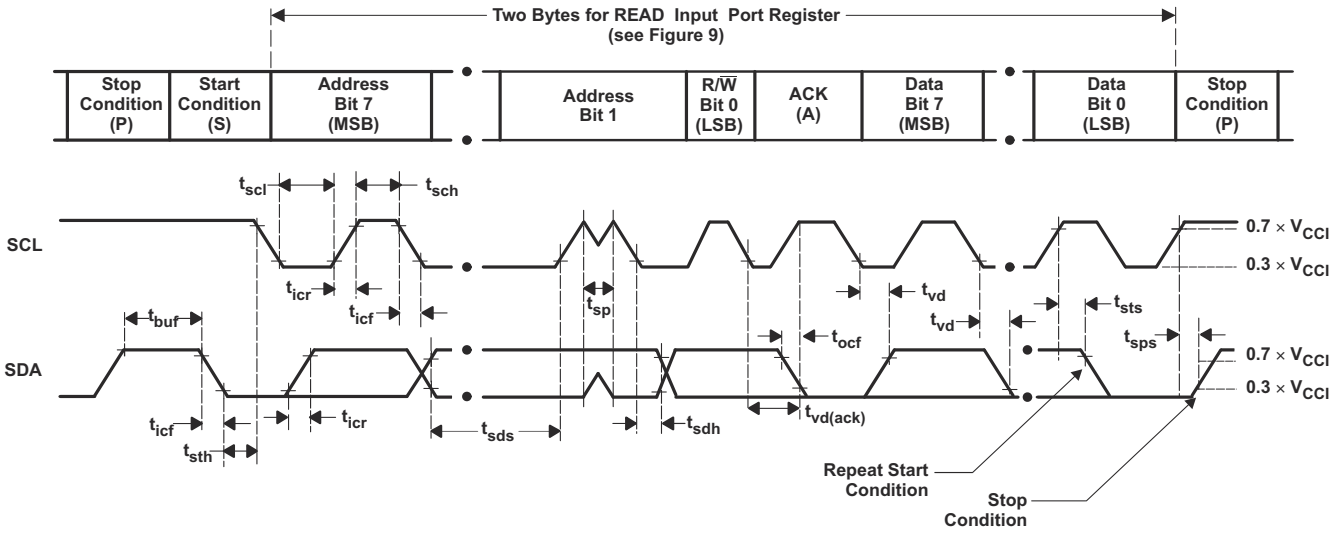
図 6-17. I/O High Voltage vs Temperature

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7 Parameter Measurement Information



SDA LOAD CONFIGURATION



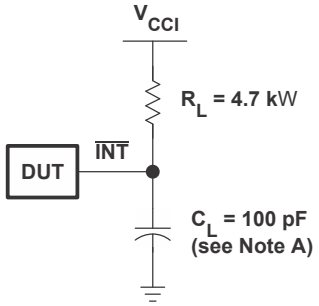
VOLTAGE WAVEFORMS

BYTE	DESCRIPTION
1	I^2C address
2	Input register port data

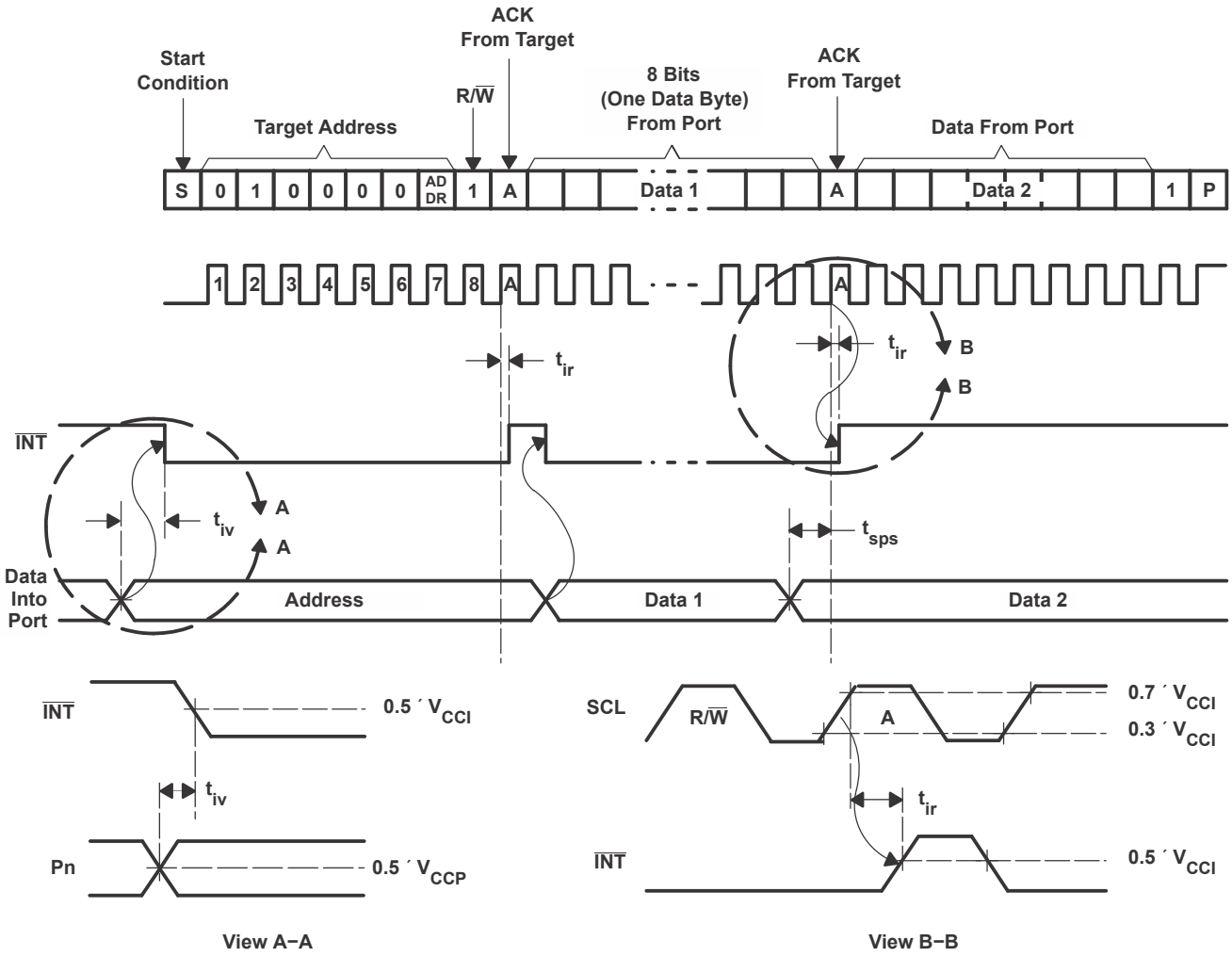
A. C_L includes probe and jig capacitance. tocf is measured with C_L of 10 pF or 400 pF.
B. All inputs are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r/t_f ≤ 30 ns.
C. All parameters and waveforms are not applicable to all devices.

図 7-1. I^2C Interface Load Circuit and Voltage Waveforms

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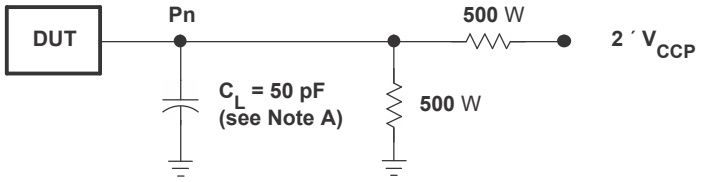
INTERRUPT LOAD CONFIGURATION



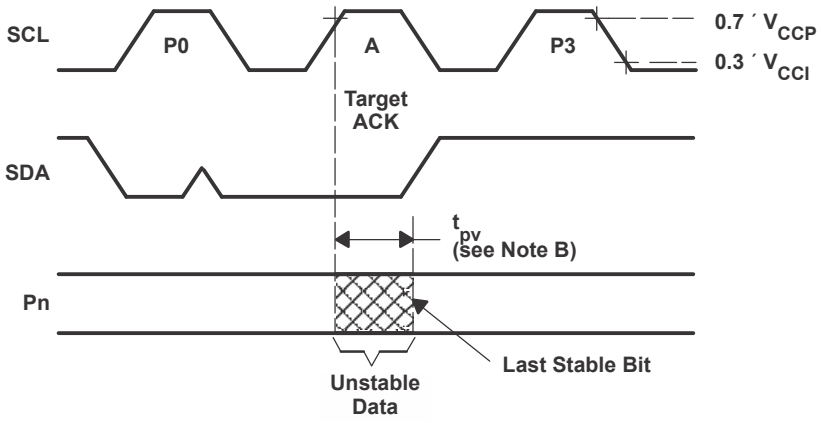
A. C_L includes probe and jig capacitance.
B. All inputs are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r/t_f ≤ 30 ns.
C. All parameters and waveforms are not applicable to all devices.

図 7-2. Interrupt Load Circuit And Voltage Waveforms

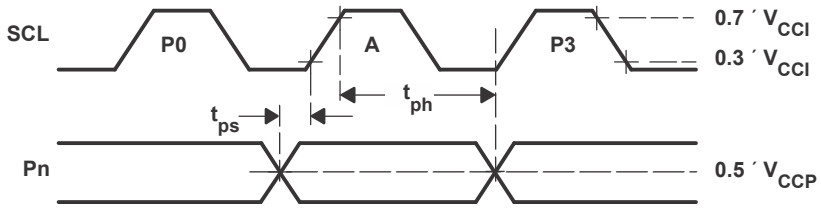
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P-PORT LOAD CONFIGURATION



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

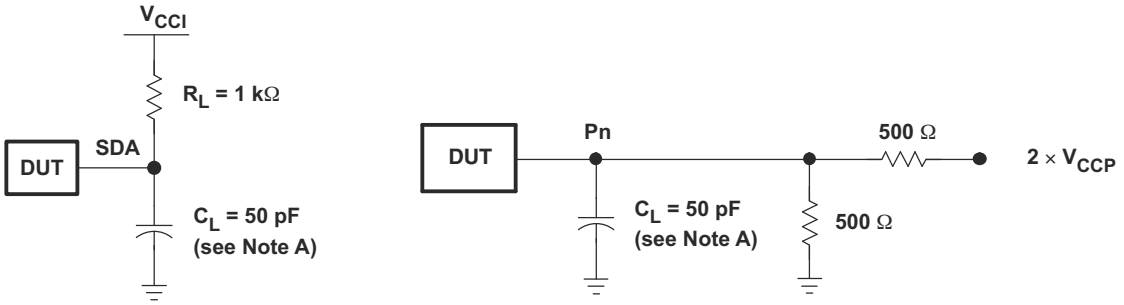


READ MODE (R/$\overline{W}$ = 1)

A. C_L includes probe and jig capacitance.
B. t_{pv} is measured from 0.7 × V_{CC} on SCL to 50% I/O (Pn) output.
C. All inputs are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r/t_f ≤ 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.

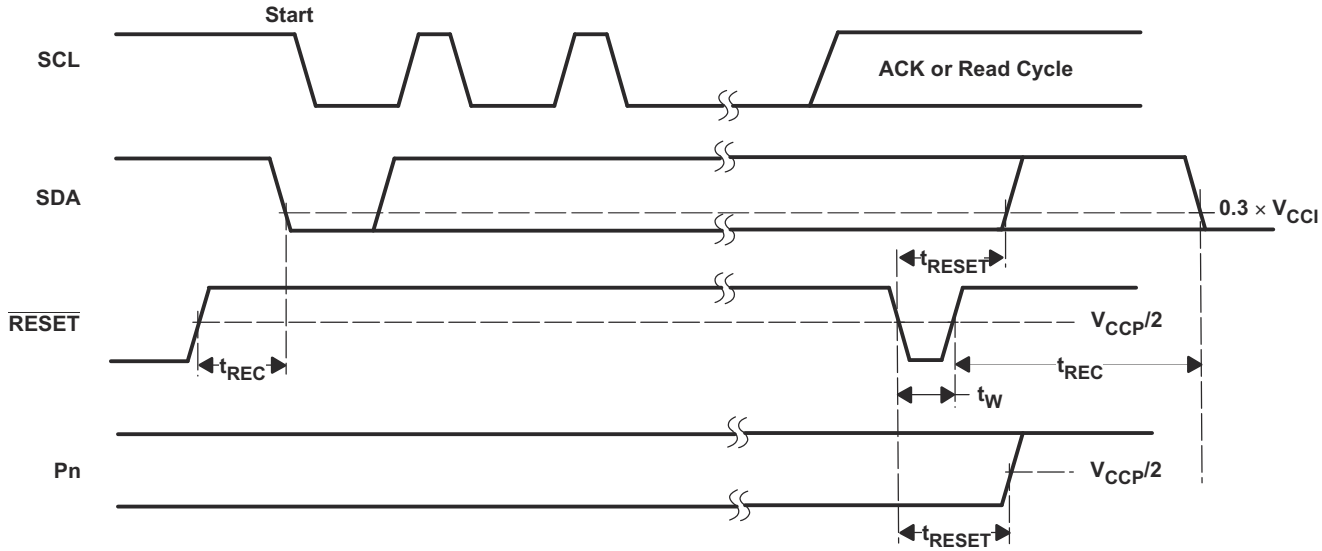
図 7-3. P-Port Load Circuit And Timing Waveforms

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SDA LOAD CONFIGURATION

P-PORT LOAD CONFIGURATION



A. C_L includes probe and jig capacitance.
B. All inputs are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r/t_f ≤ 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.

図 7-4. Reset Load Circuits And Voltage Waveforms

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8 Detailed Description

8.1 Overview

The bidirectional voltage-level translation in the TCA6408A is provided through V_{CCI}. V_{CCI} should be connected to the V_{CC} of the external SCL/SDA lines. This indicates the V_{CC} level of the I^2C bus to the TCA6408A. The voltage level on the P-port of the TCA6408A is determined by V_{CCP}.

The TCA6408A consists of one 8-bit Configuration (input or output selection), Input, Output, and Polarity Inversion (active high) Register. At power on, the I/Os are configured as inputs. However, the system controller can enable the I/Os as either inputs or outputs by writing to the I/O configuration bits. The data for each input or output is kept in the corresponding Input or Output Register. The polarity of the 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 TCA6408A in the event of a timeout 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^2C/SMBus state machine. The $\overline{\text{RESET}}$ pin causes the same reset/initialization to occur without depowering the part.

The TCA6408A 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.

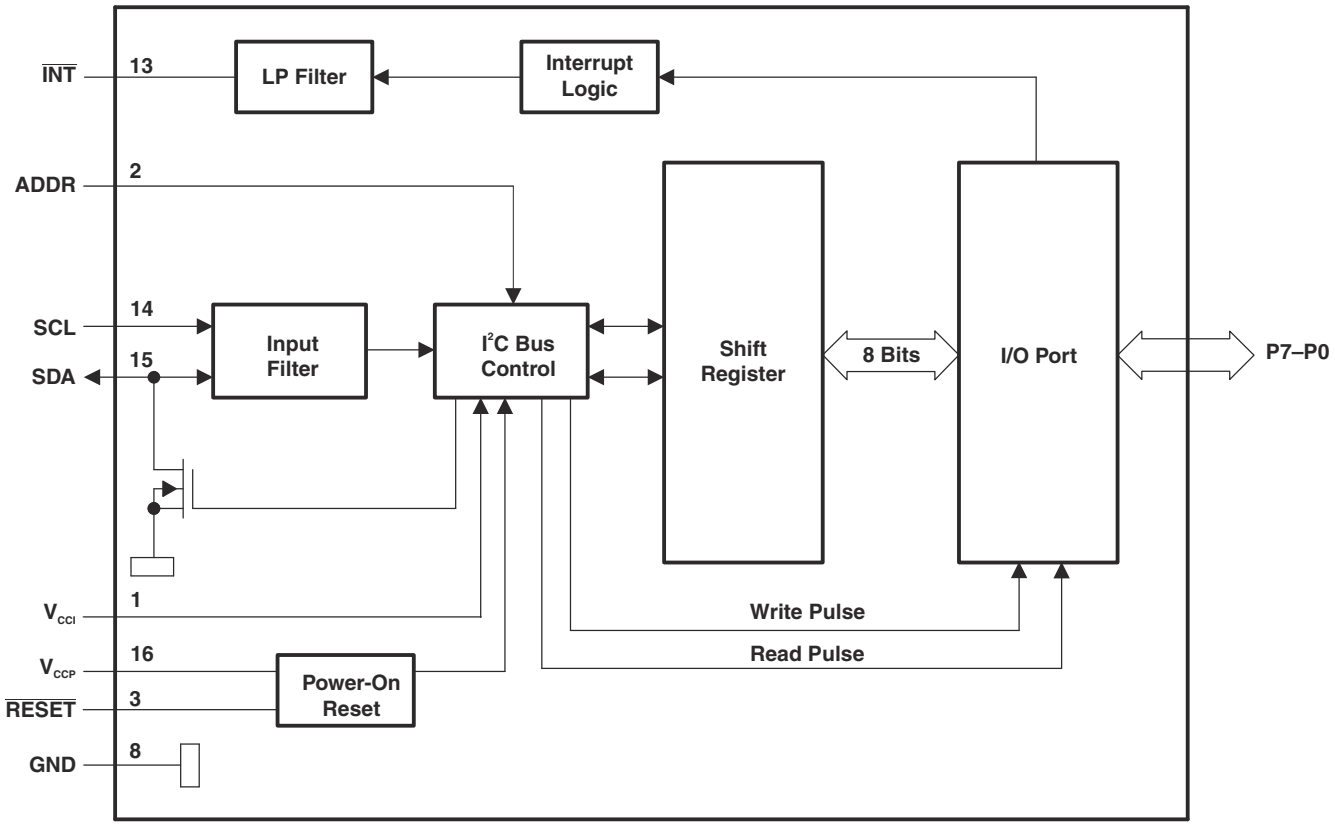
$\overline{\text{INT}}$ can be connected to the interrupt input of a microcontroller. By sending an interrupt signal on this line, the remote I/O can inform the microcontroller if there is incoming data on its ports without having to communicate via the I^2C bus. Thus, the TCA6408A can remain a simple target device.

The device P-port outputs have high-current sink capabilities for directly driving LEDs while consuming low device current.

One hardware pin (ADDR) can be used to program and vary the fixed I^2C address and allow up to two devices to share the same I^2C bus or SMBus.

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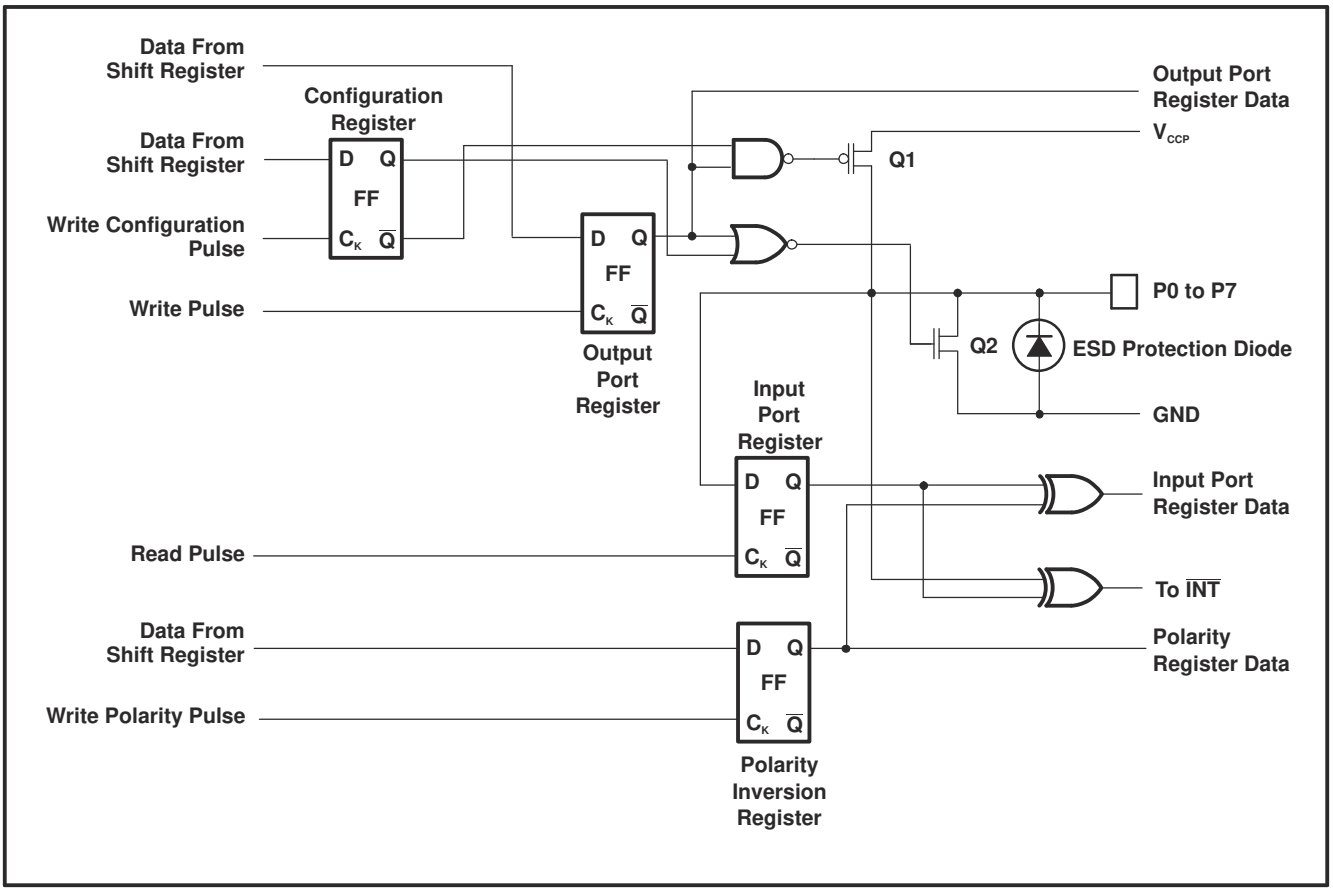
8.2 Functional Block Diagrams



A. All pin numbers shown are for the PW package.
B. All I/Os are set to inputs at reset.

図 8-1. Logic Diagram (Positive Logic)

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A. On power up or reset, all registers return to default values.

図 8-2. Simplified Schematic of P0 to P7

8.3 Feature Description

8.3.1 Voltage Translation

表 8-1 shows some common supply voltage options for voltage translation between the I^2C bus and the P-ports of the TCA6408A.

表 8-1. Voltage Translation

V_{CCI} (SCL AND SDA OF I^2C CONTROLLER) (V)	V_{CCP} (P-PORT) (V)
1.8	1.8
1.8	2.5
1.8	3.3
1.8	5
2.5	1.8
2.5	2.5
2.5	3.3
2.5	5
3.3	1.8
3.3	2.5
3.3	3.3
3.3	5
5	1.8
5	2.5
5	3.3
5	5

8.3.2 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 should not exceed the recommended levels for proper operation.

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

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

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.

The $\overline{INT}$ output has an open-drain structure and requires pull-up resistor to V_{CCP} or V_{CCI}, depending on the application. $\overline{INT}$ should be connected to the voltage source of the device that requires the interrupt information.

8.3.4 Reset Input ($\overline{RESET}$)

The $\overline{RESET}$ input can be asserted to initialize the system while keeping the V_{CCP} at its operating level. A reset can be accomplished by holding the $\overline{RESET}$ pin low for a minimum of t_W. The TCA6408A registers and I^2C/

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SMBus state machine are changed to their default state once $\overline{\text{RESET}}$ is low (0). When $\overline{\text{RESET}}$ is high (1), the I/O levels at the P-port can be changed externally or through the controller. This input requires a pull-up resistor to V_{CCI}, if no active connection is used.

8.4 Device Functional Modes

8.4.1 Power-On Reset (POR)

When power (from 0 V) is applied to V_{CCP}, an internal power-on reset holds the TCA6408A in a reset condition until V_{CCP} has reached V_{POR}. At that time, the reset condition is released, and the TCA6408A registers and I^2C/SMBus state machine initialize to their default states. After that, V_{CCP} must be lowered to below V_{PORF} and back up to the operating voltage for a power-reset cycle.

8.4.2 Powered-Up

When power has been applied to both V_{CCP} and V_{CCI} and a POR has taken place, the device is in a functioning mode. The device will always be ready to receive new requests via the I^2C bus.

8.5 Programming

8.5.1 I^2C Interface

The TCA6408A has a standard bidirectional I^2C 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^2C bus has a specific device address to differentiate between other target devices that are on the same I^2C bus. Many target devices will 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.

The physical I^2C interface consists of the serial clock (SCL) and serial data (SDA) lines. Both SDA and SCL lines must be connected to V_{CC} through a pull-up resistor. The size of the pull-up resistor is determined by the amount of capacitance on the I^2C lines. (For further details, refer to *I^2C 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.

The following is 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.

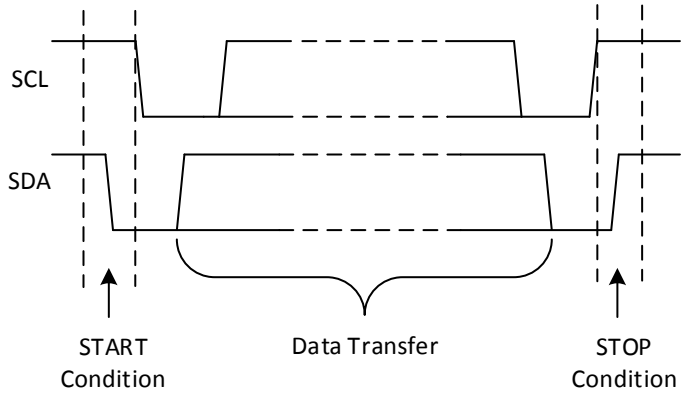


図 8-3. Definition of Start and Stop Conditions

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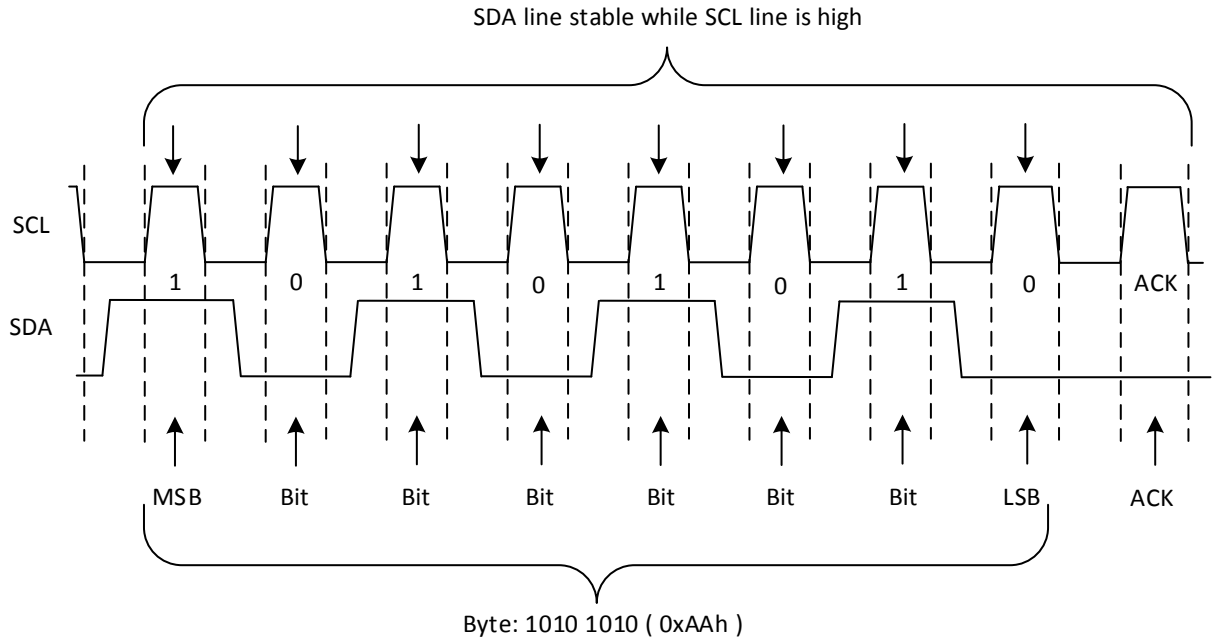


図 8-4. Bit Transfer

表 8-2. Interface Definition

BYTE	BIT							
	7 (MSB)	6	5	4	3	2	1	0 (LSB)
I^2C target address	L	H	L	L	L	L	ADDR	R/ $\overline{W}$
I/O data bus	P7	P6	P5	P4	P3	P2	P1	P0

8.5.2 Bus Transactions

Data must be sent to and received from the target devices, 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.

While it is common to have registers in I^2C targets, note that not all target devices will have registers. Some devices are simple and contain only 1 register, which may be written to directly by sending the register data immediately after the target address, instead of addressing a register. An example of a single-register device would be an 8-bit I^2C switch, which is controlled via I^2C commands. Since it has 1 bit to enable or disable a channel, there is only 1 register needed, and the controller merely writes the register data after the target address, skipping the register number.

8.5.2.1 Writes

To write on the I^2C bus, the controller will send a START condition on the bus with the address of the target, as well as the last bit (the R/ $\overline{W}$ bit) set to 0, which signifies a write. After the target sends the acknowledge bit, the controller will then send the register address of the register to which it wishes to write. The target will acknowledge again, letting the controller know it is ready. After this, the controller will start 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 will terminate the transmission with a STOP condition.

図 8-5 shows an example of writing a single byte to a target register.

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Controller controls SDA line

Target controls SDA line

Write to one register in a device

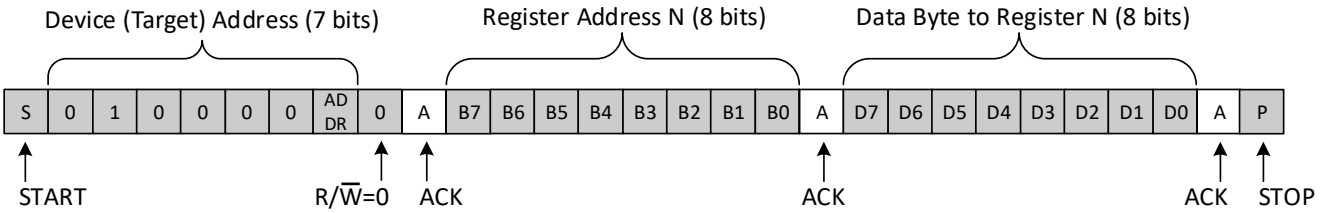


図 8-5. Write to Register

Controller controls SDA line

Target controls SDA line

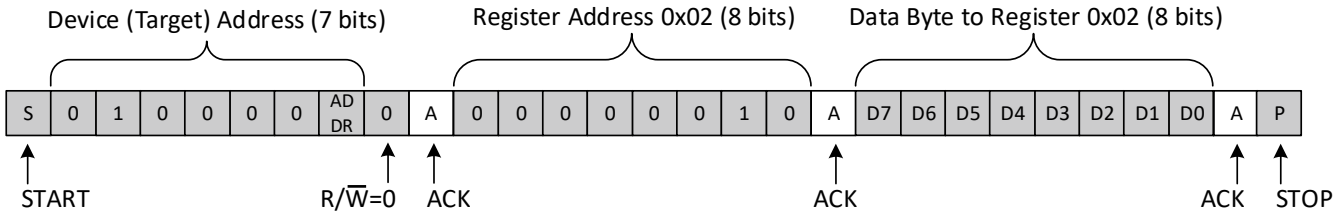


図 8-6. Write to the Polarity Inversion Register

8.5.2.2 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/ $\overline{W}$ bit equal to 0 (signifying a write), followed by the register address it wishes to read from. Once the target acknowledges this register address, the controller will send a START condition again, followed by the target address with the R/ $\overline{W}$ bit set to 1 (signifying a read). This time, the target will acknowledge the read request, and the controller will release the SDA bus but will continue supplying the clock to the target. During this part of the transaction, the controller will become the controller-receiver, and the target will become the target-transmitter.

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

図 8-7 shows an example of reading a single byte from a target register.

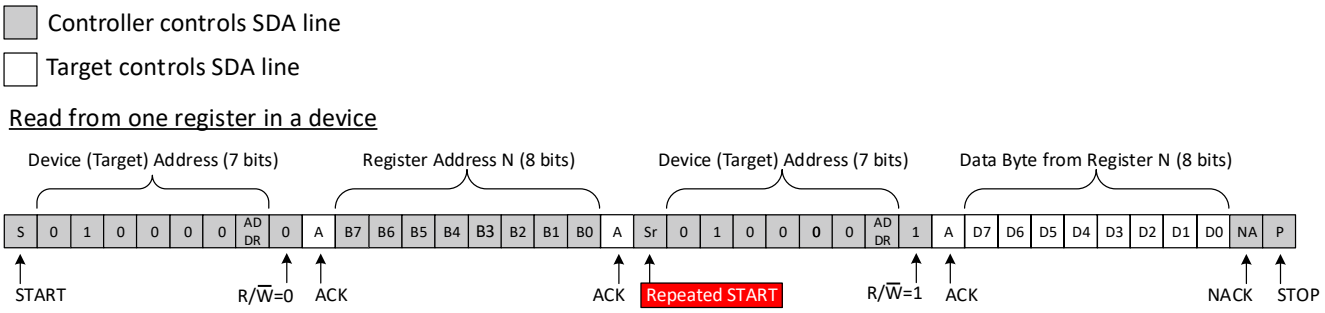
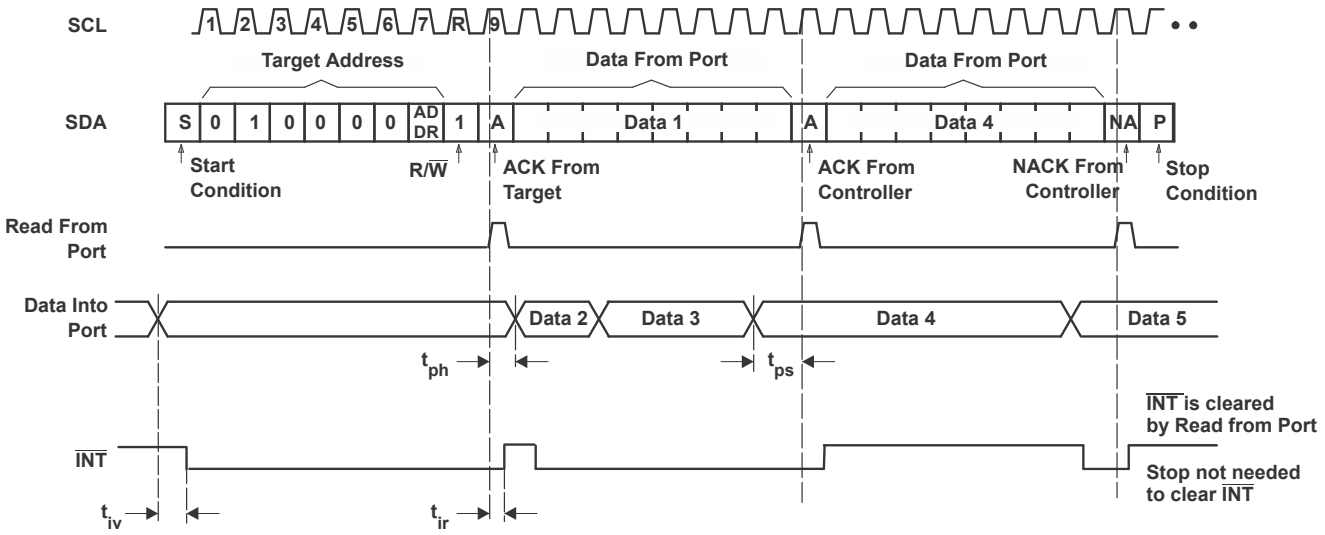


図 8-7. Read from Register



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 target address call between the initial target address call and actual data transfer from P-port (see 図 8-7).

図 8-8. Read from Input Port Register

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8.6 Register Map

8.6.1 Device Address

The address of the TCA6408A is shown in 図 8-9.

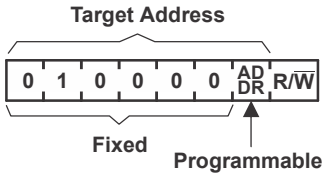


図 8-9. TCA6408A Address

表 8-3. Address Reference

ADDR	I²C BUS TARGET ADDRESS
L	32 (decimal), 20 (hexadecimal)
H	33 (decimal), 21 (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, which is stored in the Control Register in the TCA6408A. Two bits of this data byte will state both the operation (read or write) and the internal registers (Input, Output, Polarity Inversion, or Configuration) that will be affected. This register can be written or read through the I²C bus. The command byte is sent only during a write transmission.

B7	B6	B5	B4	B3	B2	B1	B0

図 8-10. Control Register Bits

表 8-4. Command Byte

CONTROL REGISTER BITS								COMMAND BYTE (HEX)	REGISTER	PROTOCOL	POWER-UP DEFAULT
B7	B6	B5	B4	B3	B2	B1	B0				
0	0	0	0	0	0	0	0	00	Input Port	Read byte	xxxx xxxx
0	0	0	0	0	0	0	1	01	Output Port	Read/write byte	1111 1111
0	0	0	0	0	0	1	0	02	Polarity Inversion	Read/write byte	0000 0000
0	0	0	0	0	0	1	1	03	Configuration	Read/write byte	1111 1111

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8.6.3 Register Descriptions

The Input Port Register (register 0) reflects the incoming logic levels of the pins, regardless of whether the pin is defined as an input or an output by the Configuration Register. They act only on read operation. Writes to this register 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^2C device that the Input Port Register will be accessed next.

表 8-5. Register 0 (Input Port Register)

BIT	I-7	I-6	I-5	I-4	I-3	I-2	I-1	I-0
DEFAULT	X	X	X	X	X	X	X	X

The Output Port Register (register 1) shows 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 8-6. Register 1 (Output Port Register)

BIT	O-7	O-6	O-5	O-4	O-3	O-2	O-1	O-0
DEFAULT	1	1	1	1	1	1	1	1

The Polarity Inversion Register (register 2) allows polarity inversion of pins defined as inputs by the Configuration Register. If a bit in this register is set (written with 1), the polarity of the corresponding port pin is inverted. If a bit in this register is cleared (written with a 0), the original polarity of the corresponding port pin is retained.

表 8-7. Register 2 (Polarity Inversion Register)

BIT	N-7	N-6	N-5	N-4	N-3	N-2	N-1	N-0
DEFAULT	0	0	0	0	0	0	0	0

The Configuration Register (register 3) configures the direction 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 8-8. Register 3 (Configuration Register)

BIT	C-7	C-6	C-5	C-4	C-3	C-2	C-1	C-0
DEFAULT	1	1	1	1	1	1	1	1

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9 Application and Implementation

注

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

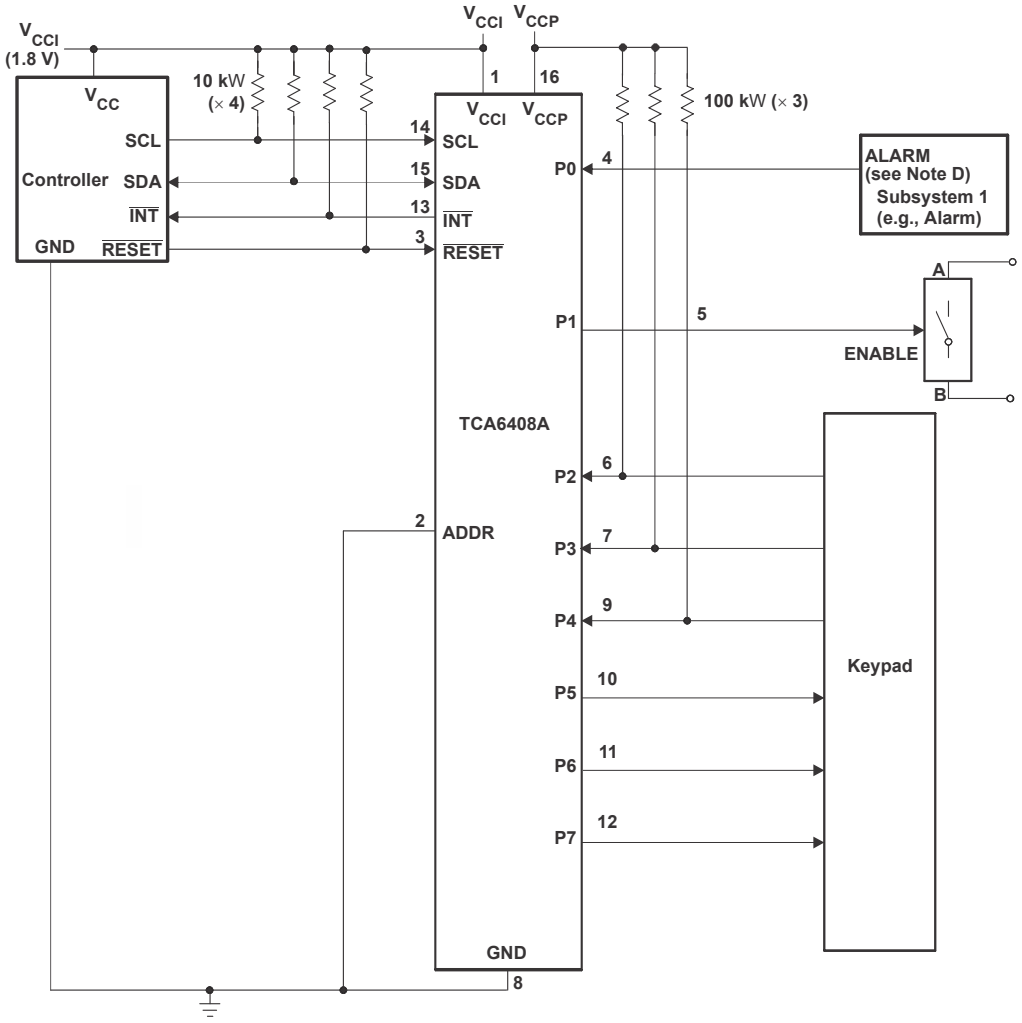
Applications of the TCA6408A will have this device connected as a target to an I^2C controller (processor), and the I^2C bus may contain any number of other target devices. The TCA6408A will be in a remote location from the controller, placed close to the GPIOs to which the controller needs to monitor or control.

A typical application of the TCA6408A will operate with a lower voltage on the controller side (V_{CCI}), and a higher voltage on the P-port side (V_{CCP}). The P-ports can be configured as outputs connected to inputs of devices such as enable, reset, power select, the gate of a switch, and LEDs. The P-ports can also be configured as inputs to receive data from interrupts, alarms, status outputs, or push buttons.

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9.2 Typical Application

図 9-1 shows an application in which the TCA6408A can be used.



A. Device address configured as 0100000 for this example.
B. P0 and P2–P4 are configured as inputs.
C. P1 and P5–P7 are configured as outputs.
D. Resistors are required for inputs (on P-port) that may float. If a driver to an input will never let the input float, a resistor is not needed. Outputs (in the P-port) do not need pull-up resistors.

図 9-1. Typical Application Schematic

9.2.1 Design Requirements

表 9-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
I^2C input voltage (V_{CCI})	1.8 V
P-port input/output voltage (V_{CCP})	5 V
Output current rating, P-port sinking (I_{OL})	25 mA
Output current rating, P-port sourcing (I_{OH})	10 mA
I^2C bus clock (SCL) speed	400 kHz

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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^2C bus. The minimum pull-up resistance is a function of V_{CC}, $V_{OL,(max)}$, and I_{OL}:

$$R_{p(min)} = \frac{V_{CC} - V_{OL(max)}}{I_{OL}} \quad (1)$$

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:

$$R_{p(max)} = \frac{t_r}{0.8473 \times C_b} \quad (2)$$

The maximum bus capacitance for an I^2C 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 TCA9538, C_i for SCL or C_{IO} for SDA, the capacitance of wires, connections, and traces, and the capacitance of additional targets on the bus.

9.2.2.1 Minimizing I_{CC} When I/O is Used to Control LEDs

When the I/Os are used to control LEDs, normally they are connected to V_{CC} through a resistor as shown in 図 9-1. The LED acts as a diode, so when the LED is off, the I/O V_{IN} is about 1.2 V less than V_{CC}. The ΔI_{CC} parameter in *セクション 6.5* shows how I_{CC} increases as V_{IN} becomes lower than V_{CC}. Designs that must minimize current consumption, such as battery power applications, should consider maintaining the I/O pins greater than or equal to V_{CC} when the LED is off.

図 9-2 shows a high-value resistor in parallel with the LED. 図 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_{IN} at or above V_{CC} and prevent additional supply current consumption when the LED is off.

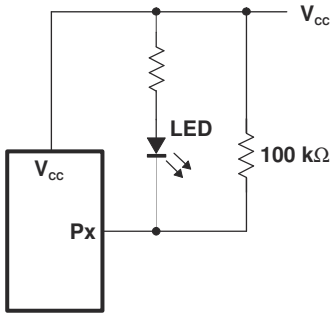


図 9-2. High-Value Resistor in Parallel With LED

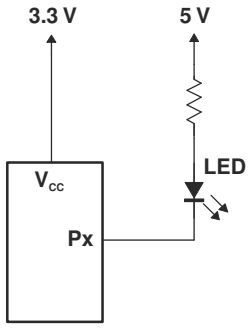
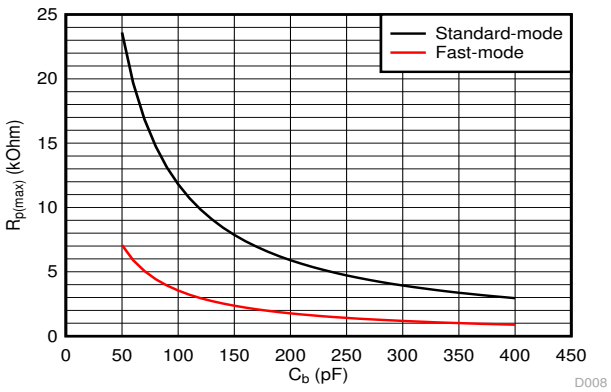


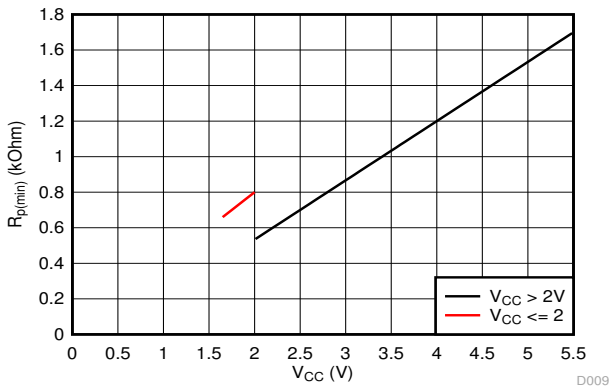
図 9-3. Device Supplied by a Low Voltage

9.2.3 Application Curves



Standard-mode: f_{SCL}= 100 kHz, t_r = 1 µs
Fast-mode: f_{SCL}= 400 kHz, t_r= 300 ns

図 9-4. Maximum Pullup Resistance ($R_{p(max)}$) vs Bus Capacitance (C_b)



V_{OL} = 0.2 × V_{CC}, I_{OL} = 2 mA when V_{CC} ≤ 2 V
V_{OL} = 0.4 V, I_{OL} = 3 mA when V_{CC} > 2 V

図 9-5. Minimum Pullup Resistance ($R_{p(min)}$) vs Pullup Reference Voltage (V_{CC})

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10 Power Supply Recommendations

10.1 Power-On Reset Requirements

In the event of a glitch or data corruption, TCA6408A 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.

Ramping up the device V_{CCP} before V_{CCI} is recommended to prevent SDA from potentially being stuck LOW.

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

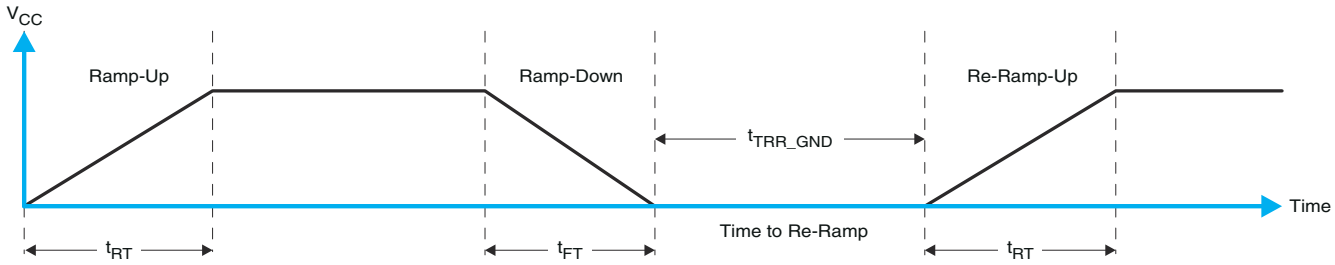


図 10-1. V_{CC} is Lowered Below 0.2 V Or 0 V and then Ramped Up to V_{CC}

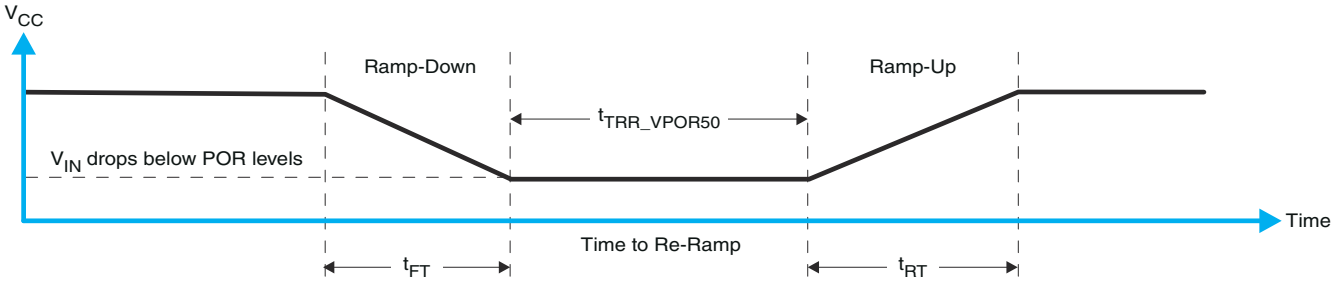


図 10-2. V_{CC} is Lowered Below the POR Threshold, then Ramped Back Up to V_{CC}

表 10-1 specifies the performance of the power-on reset feature for TCA6408A for both types of power-on reset.

表 10-1. Recommended Supply Sequencing and Ramp Rates at T_A = 25°C(1)

PARAMETER			MIN	TYP	MAX	UNIT
t_{FT}	Fall rate	See 図 10-1	0.1		2000	ms
t_{RT}	Rise rate	See 図 10-1	0.1		2000	ms
t_{RR_GND}	Time to re-ramp (when V_{CC} drops to GND)	See 図 10-1	1			µs
t_{RR_POR50}	Time to re-ramp (when V_{CC} drops to V_{POR_MIN} – 50 mV)	See 図 10-2	1			µs
V_{CC_GH}	Level that V_{CCP} can glitch down to, but not cause a functional disruption when V_{CCX_GW} = 1 µs	See 図 10-3			1.2	V
t_{GW}	Glitch width that will not cause a functional disruption when V_{CCX_GH} = 0.5 × V_{CCx}	See 図 10-3			10	µs
V_{PORF}	Voltage trip point of POR on falling V_{CC}		0.7			V
V_{PORR}	Voltage trip point of POR on rising V_{CC}				1.4	V

(1) Not tested. Specified by design.

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

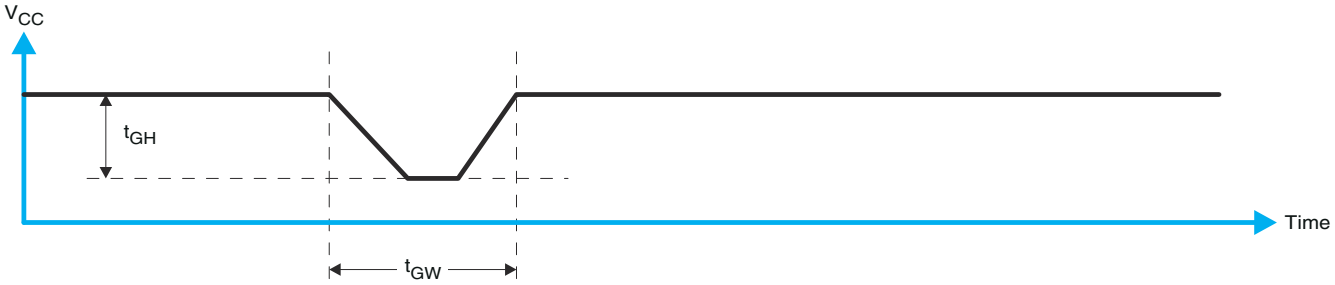


図 10-3. Glitch Width And Glitch Height

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^2C/SMBus state machine are initialized to the default states. The value of V_{POR} differs based on the V_{CC} being lowered to or from 0. 図 10-4 and 表 10-1 provide more details on this specification.

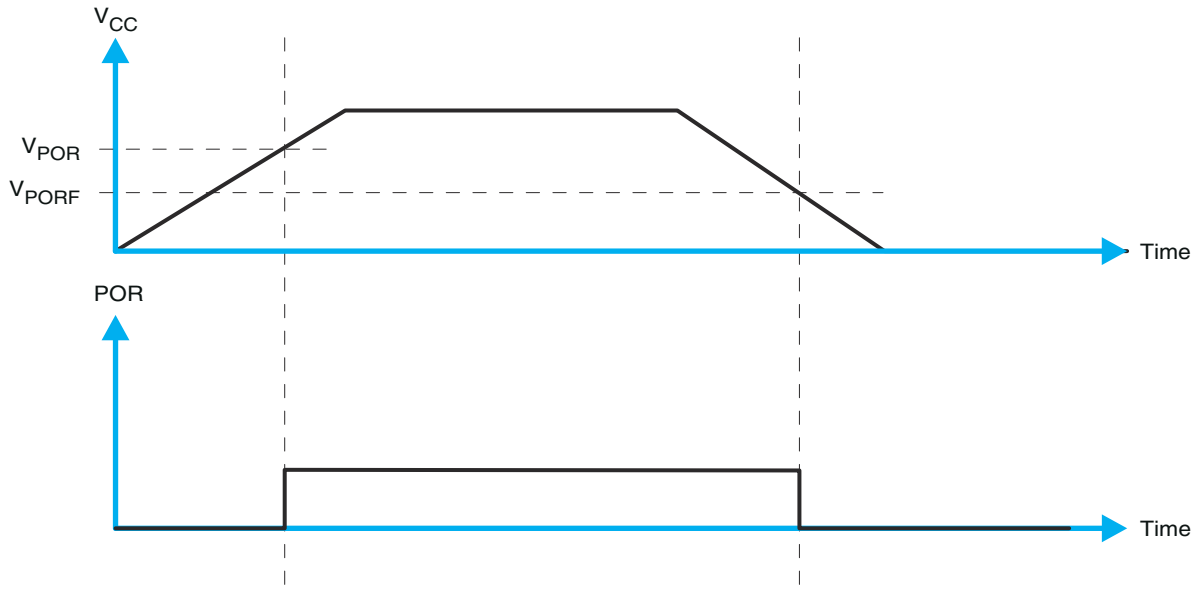


図 10-4. V_{POR}

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11 Layout

11.1 Layout Guidelines

For printed circuit board (PCB) layout of the TCA6408A, common PCB layout practices should be followed, but additional concerns related to high-speed data transfer such as matched impedances and differential pairs are not a concern for I^2C 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_{CCP} 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 should be placed as close to the TCA6408A as possible. These best practices are shown in *セクション 11.2*.

For the layout example provided in *セクション 11.2*, 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_{CCI} and V_{CCP}) 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 needs to attach to V_{CCI}, V_{CCP}, 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 *セクション 11.2*.

11.2 Layout Example

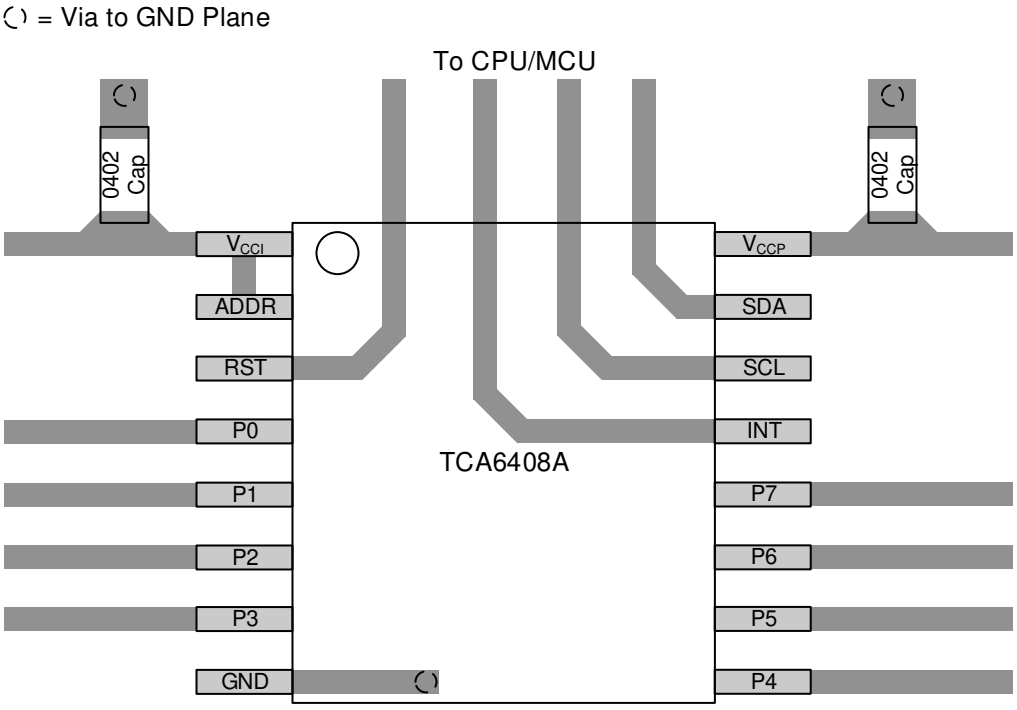


図 11-1. Example Layout (PW Package)

12 Device and Documentation Support

12.1 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、ti.com のデバイス製品フォルダを開いてください。「更新の通知を受け取る」をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取れます。変更の詳細については、修正されたドキュメントに含まれている改訂履歴をご覧ください。

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12.4 静電気放電に関する注意事項



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ESD による破損は、わずかな性能低下からデバイスの完全な故障まで多岐にわたります。精密な IC の場合、パラメータがわずかに変化するだけで公表されている仕様から外れる可能性があるため、破損が発生しやすくなっています。

12.5 用語集

テキサス・インスツルメンツ用語集　　この用語集には、用語や略語の一覧および定義が記載されています。

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.

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PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TCA6408APWR	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 85	PH408A
TCA6408APWR.A	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PH408A
TCA6408APWR.B	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PH408A
TCA6408APWRG4	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PH408A
TCA6408APWRG4.A	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PH408A
TCA6408APWRG4.B	Active	Production	TSSOP (PW) | 16	2000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PH408A
TCA6408ARGTR	Active	Production	VQFN (RGT) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ZVU
TCA6408ARGTR.A	Active	Production	VQFN (RGT) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ZVU
TCA6408ARGTR.B	Active	Production	VQFN (RGT) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ZVU
TCA6408ARGTRG4	Active	Production	VQFN (RGT) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ZVU
TCA6408ARGTRG4.A	Active	Production	VQFN (RGT) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ZVU
TCA6408ARGTRG4.B	Active	Production	VQFN (RGT) | 16	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ZVU
TCA6408ARSVR	Active	Production	UQFN (RSV) | 16	3000 | LARGE T&R	Yes	NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	ZVU
TCA6408ARSVR.A	Active	Production	UQFN (RSV) | 16	3000 | LARGE T&R	Yes	NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	ZVU
TCA6408ARSVR.B	Active	Production	UQFN (RSV) | 16	3000 | LARGE T&R	Yes	NIPDAUAG	Level-1-260C-UNLIM	-40 to 85	ZVU

(1) **Status:** For more details on status, see our product life cycle.

(2) **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.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **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.

(5) **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.

(6) **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.

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OTHER QUALIFIED VERSIONS OF TCA6408A :

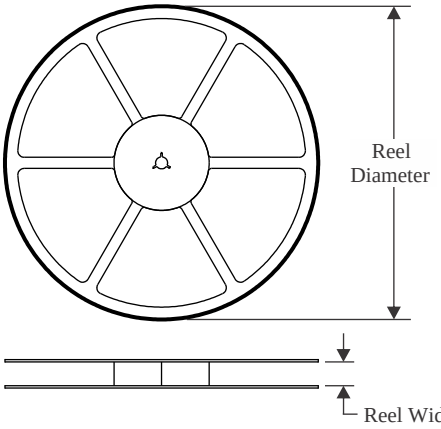
- Automotive : TCA6408A-Q1

NOTE: Qualified Version Definitions:

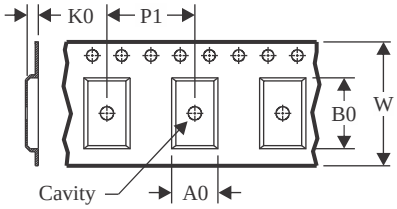
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

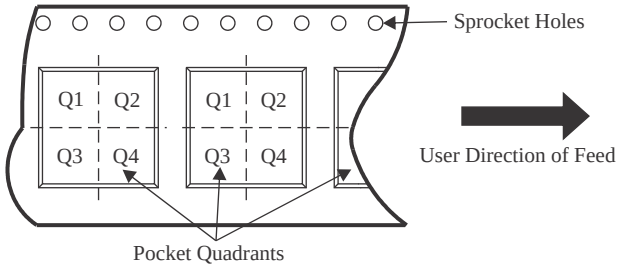


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

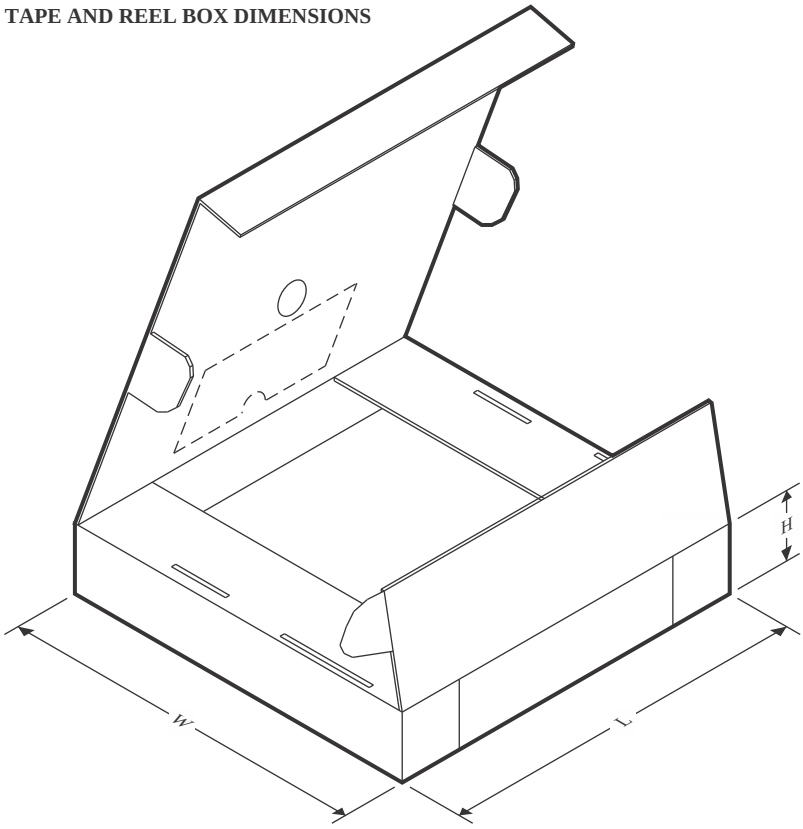
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TCA6408APWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TCA6408APWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.3	1.6	8.0	12.0	Q1
TCA6408APWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TCA6408APWRG4	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TCA6408ARGTR	VQFN	RGT	16	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
TCA6408ARGTRG4	VQFN	RGT	16	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
TCA6408ARSVR	UQFN	RSV	16	3000	177.8	12.4	2.0	2.8	0.7	4.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS

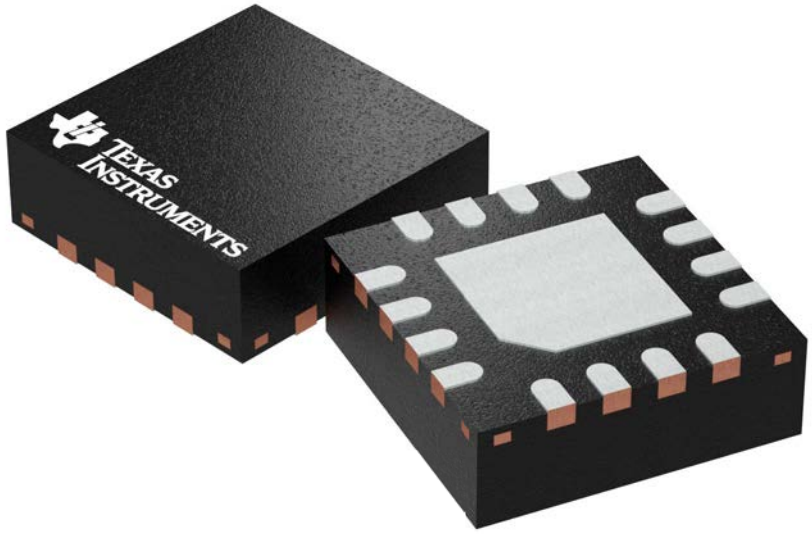


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TCA6408APWR	TSSOP	PW	16	2000	356.0	356.0	35.0
TCA6408APWR	TSSOP	PW	16	2000	367.0	367.0	35.0
TCA6408APWR	TSSOP	PW	16	2000	353.0	353.0	32.0
TCA6408APWRG4	TSSOP	PW	16	2000	353.0	353.0	32.0
TCA6408ARGTR	VQFN	RGT	16	3000	353.0	353.0	32.0
TCA6408ARGTRG4	VQFN	RGT	16	3000	353.0	353.0	32.0
TCA6408ARSVR	UQFN	RSV	16	3000	202.0	201.0	28.0

RGT 16 VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



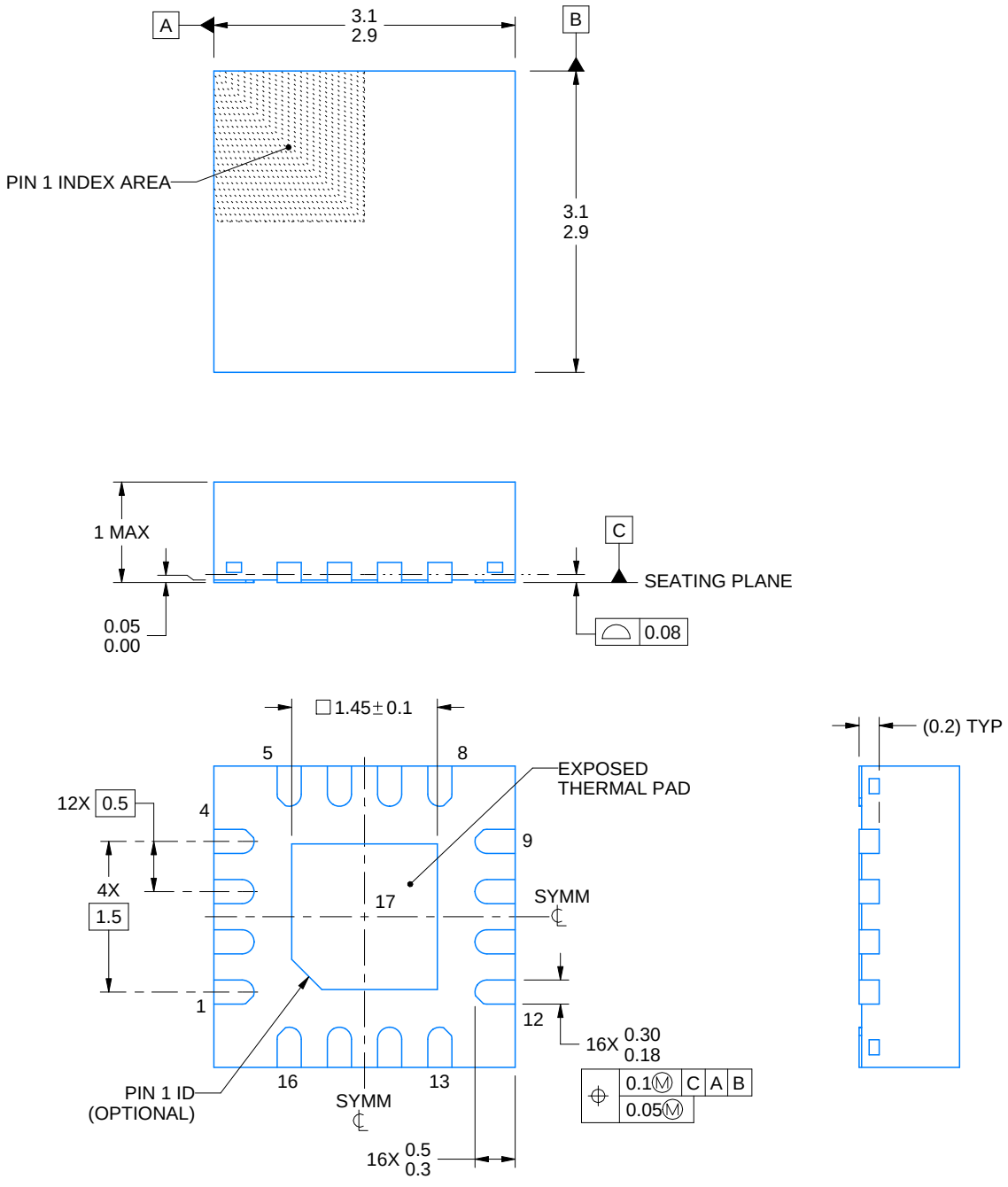
Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

RGT0016A

PACKAGE OUTLINE

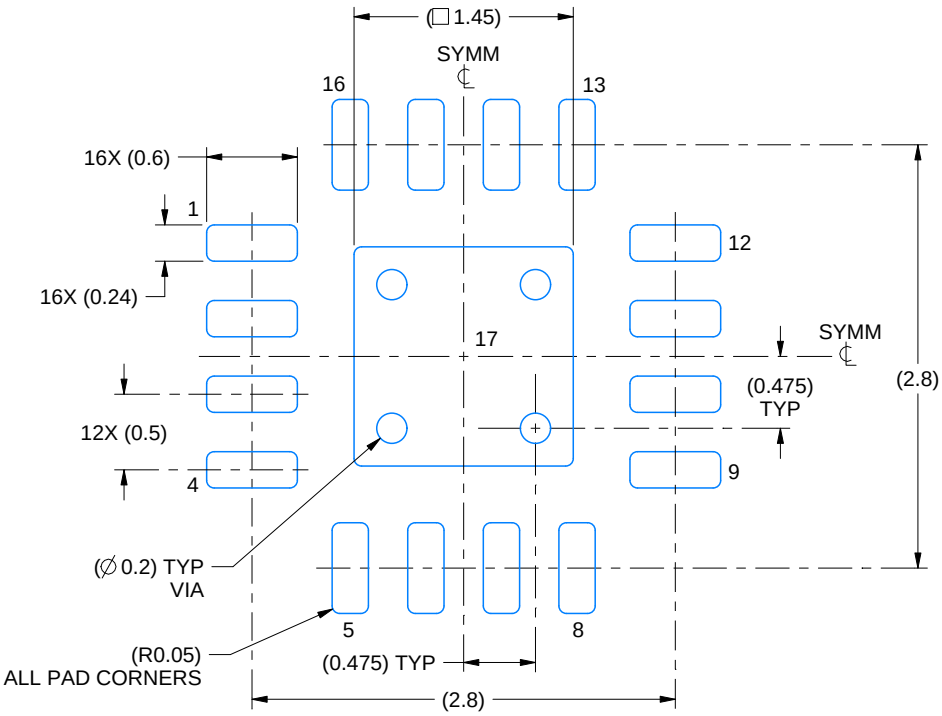
VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD

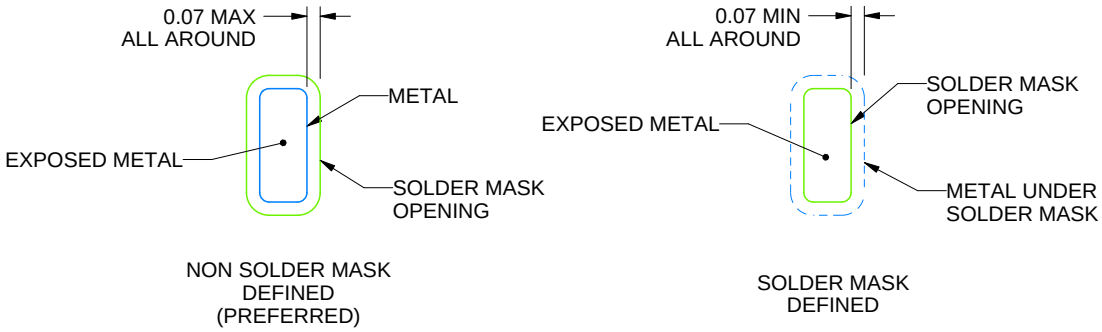


NOTES:

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. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.
4. Reference JEDEC registration MO-220



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:20X

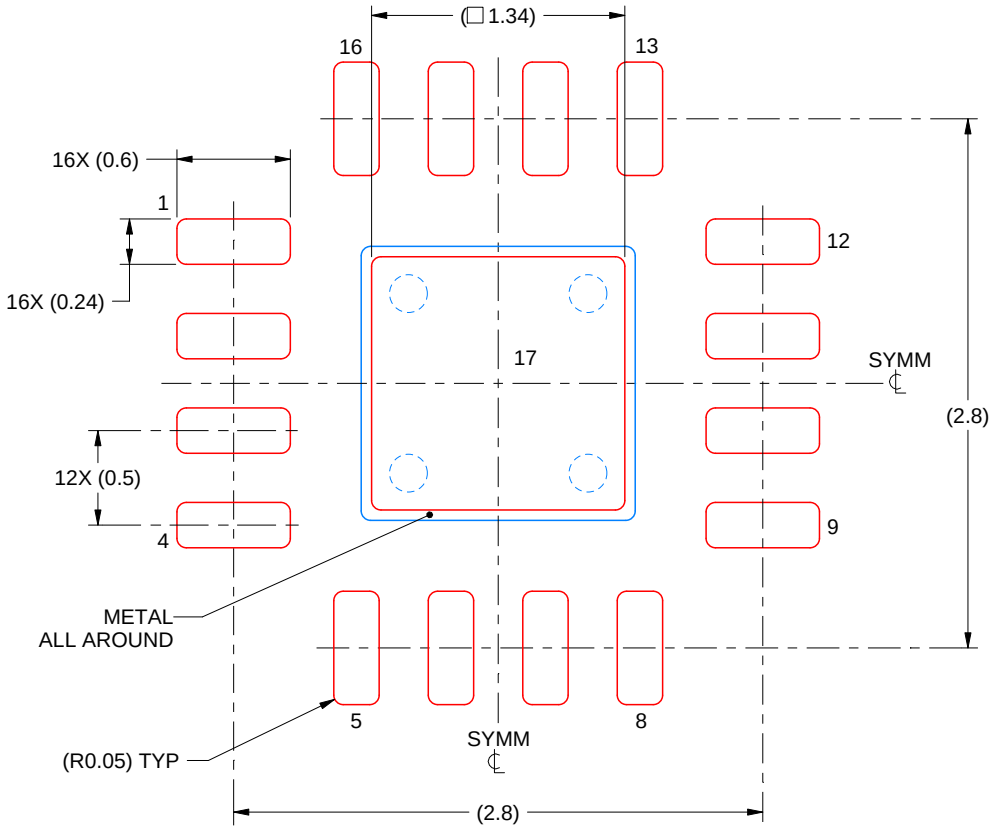


SOLDER MASK DETAILS

4219032/A 02/2017

NOTES: (continued)

5. 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/slua271).
6. 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.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 17:
86% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:25X

4219032/A 02/2017

NOTES: (continued)

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

GENERIC PACKAGE VIEW

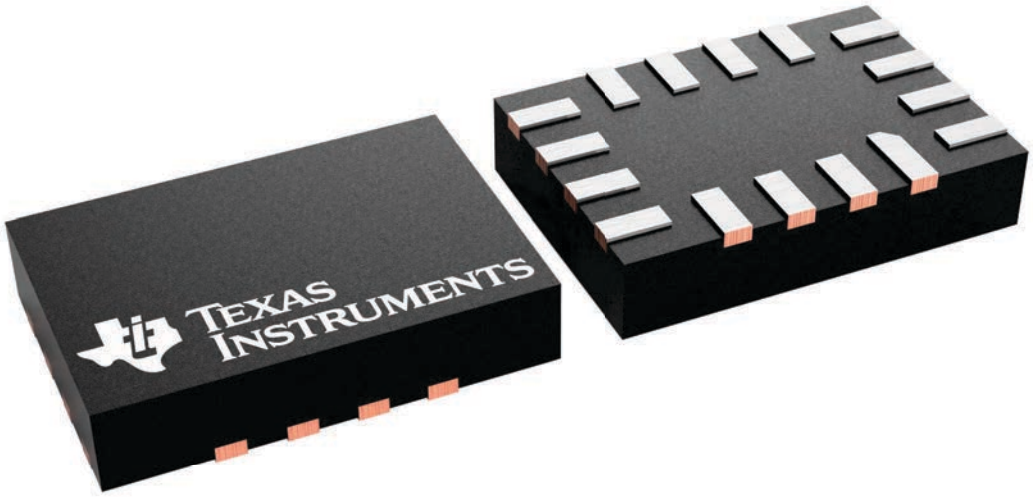
RSV 16

UQFN - 0.55 mm max height

1.8 x 2.6, 0.4 mm pitch

ULTRA THIN QUAD FLATPACK - NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



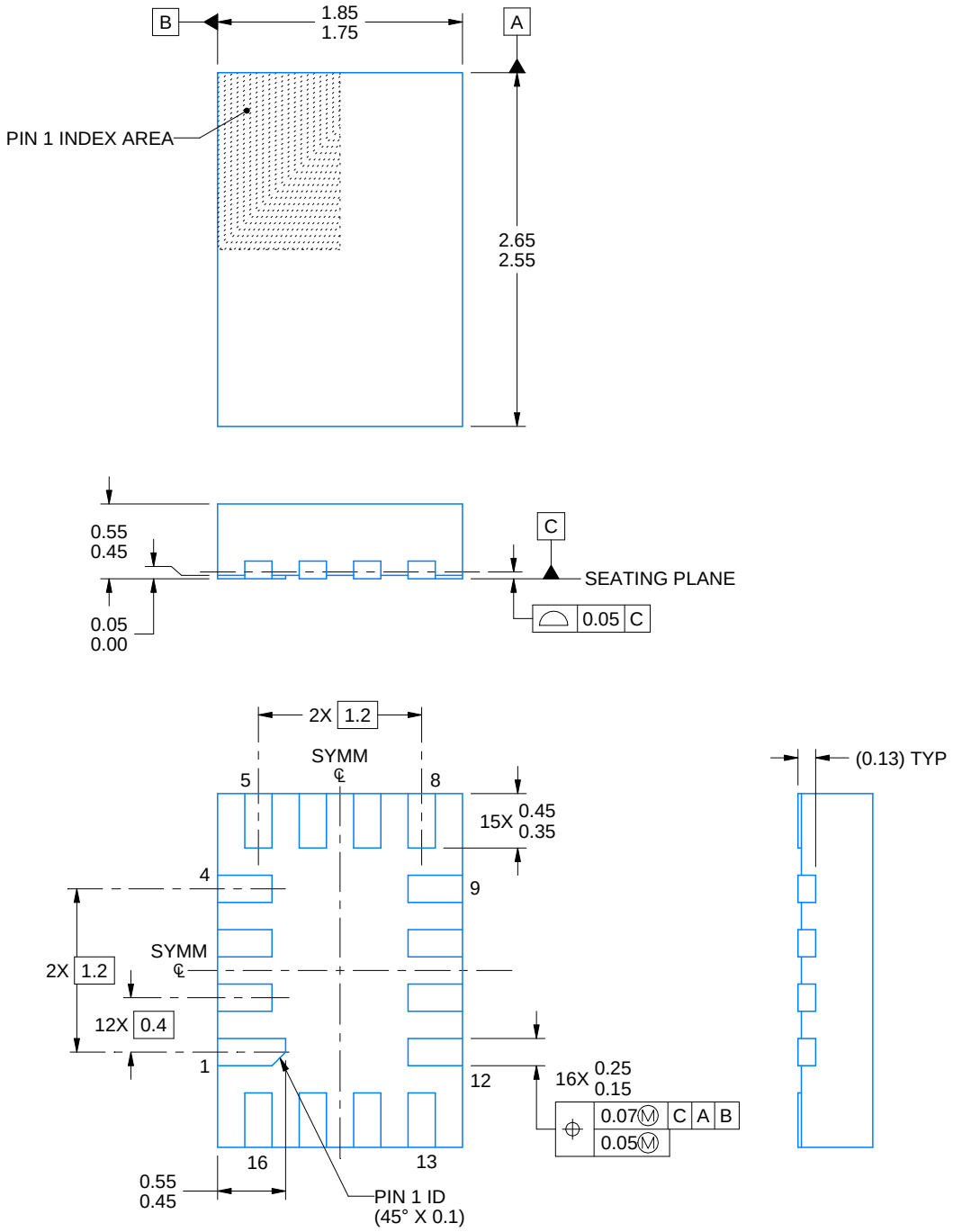
4231225/A

RSV0016A

PACKAGE OUTLINE

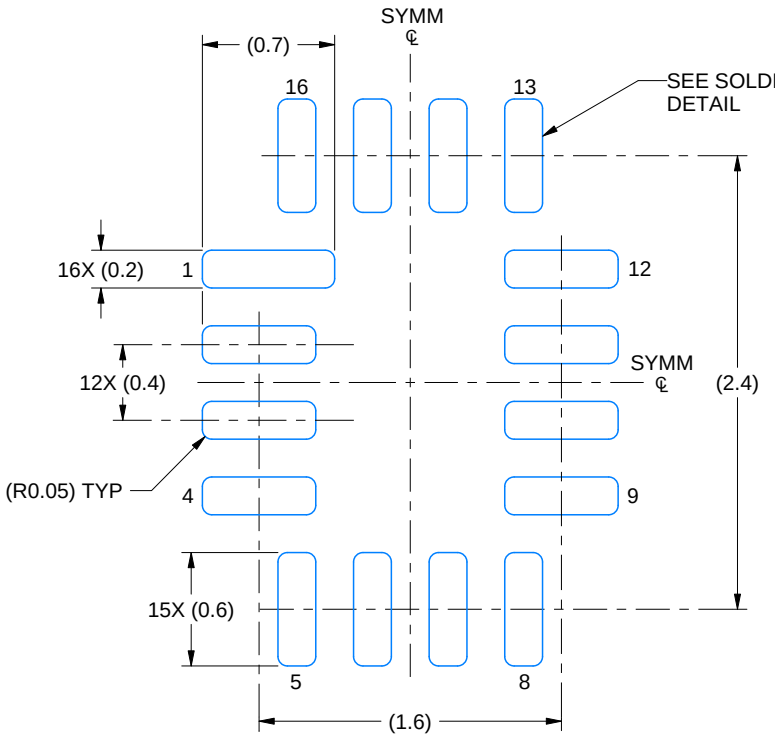
UQFN - 0.55 mm max height

ULTRA THIN QUAD FLATPACK - NO LEAD

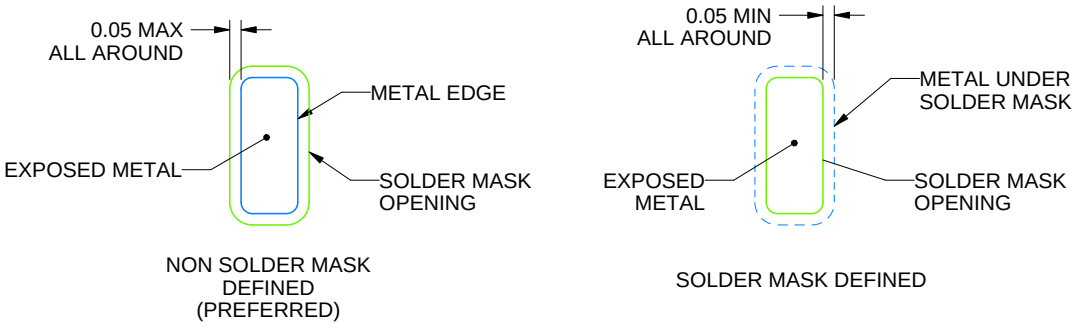


NOTES:

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 25X

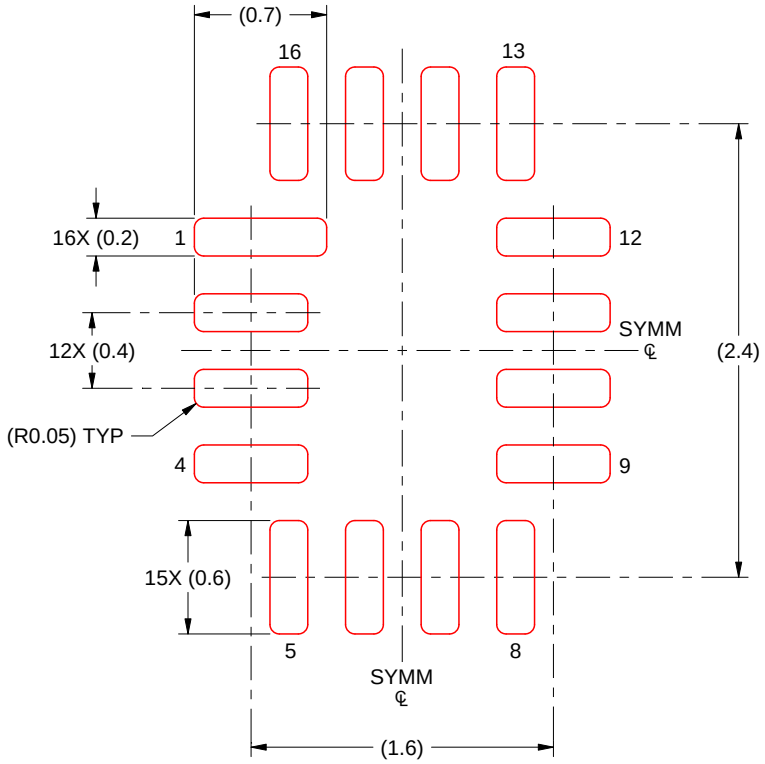


SOLDER MASK DETAILS

4220314/C 02/2020

NOTES: (continued)

3. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).



SOLDER PASTE EXAMPLE
BASED ON 0.125 MM THICK STENCIL
SCALE: 25X

4220314/C 02/2020

NOTES: (continued)

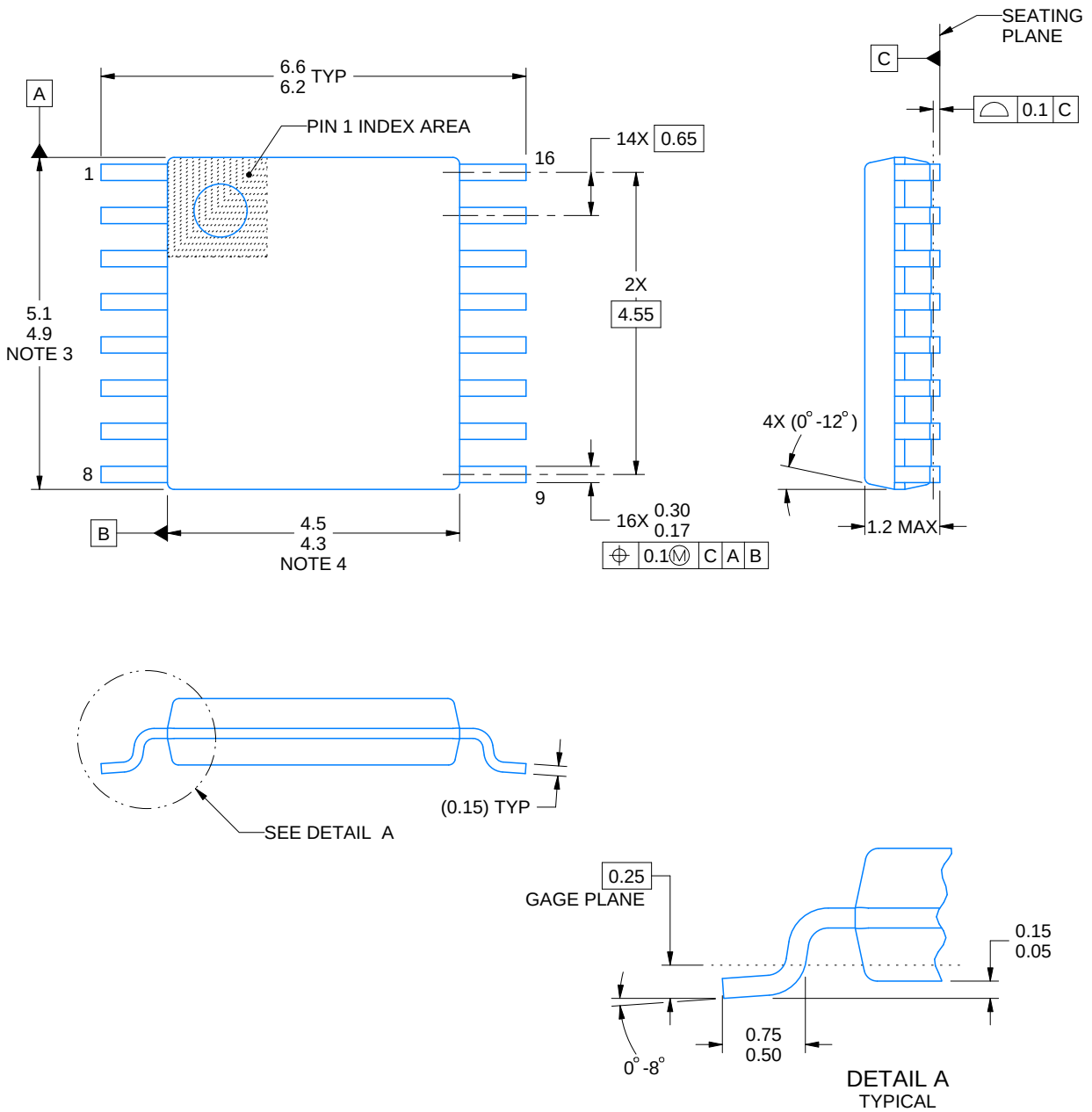
4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

PACKAGE OUTLINE

PW0016A

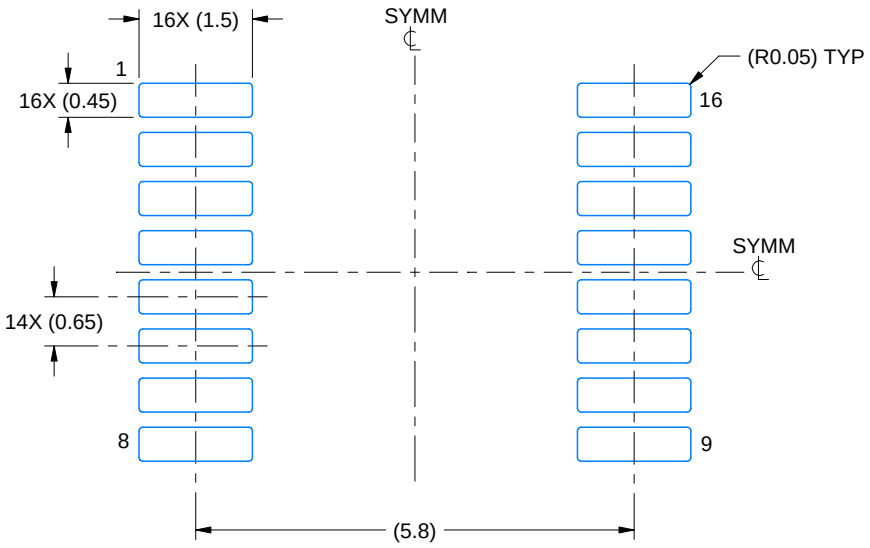
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X

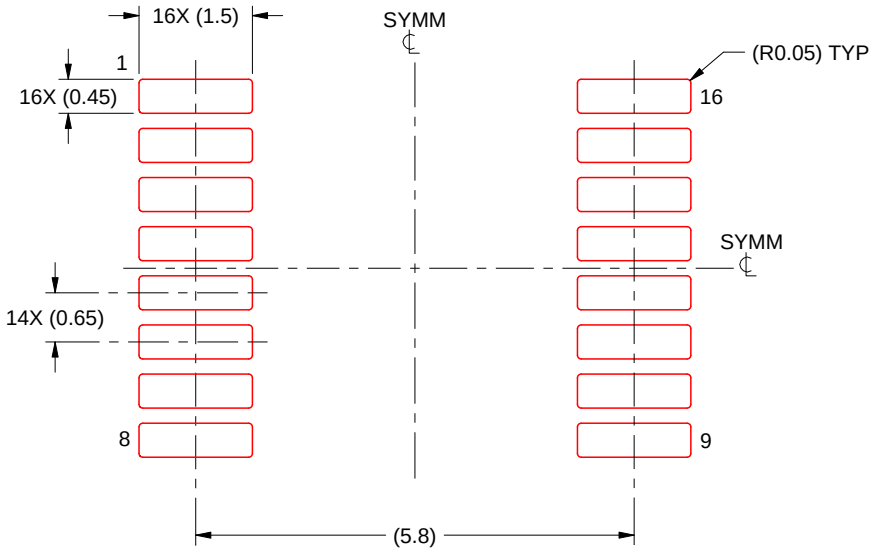


SOLDER MASK DETAILS

4220204/B 12/2023

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.



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

4220204/B 12/2023

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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