

# PCF8575 Remote 16-BIT I<sup>2</sup>C AND SMBus I/O Expander with Interrupt Output

## 1 Features

- I<sup>2</sup>C to parallel-port expander
- Open-drain interrupt output
- Low standby-current consumption of 10µA maximum
- Compatible with most microcontrollers
- 400kHz Fast I<sup>2</sup>C bus
- Address by three hardware address pins for use of up to eight devices
- Latched outputs with high-current drive capability for directly driving LEDs
- Current source to V<sub>CC</sub> for actively driving a high at the output
- Latch-up performance exceeds 100mA Per JESD 78, class II
- ESD Protection exceeds JESD 22
  - 2000V Human-body model
  - 200V Machine model
  - 1000V Charged-device model

## 2 Applications

- Telecom shelters: filter units
- Servers
- Routers (telecom switching equipment)
- [Personal computers](#)
- [Personal electronics](#)
- [Industrial automation](#)
- Products with GPIO-lessors

## 3 Description

This 16-bit I/O expander for the two-line bidirectional bus (I<sup>2</sup>C) is designed for 2.5V to 5.5V V<sub>CC</sub> operation.

The PCF8575 device provides general-purpose remote I/O expansion for most microcontroller families by way of the I<sup>2</sup>C interface [serial clock (SCL), serial data (SDA)].

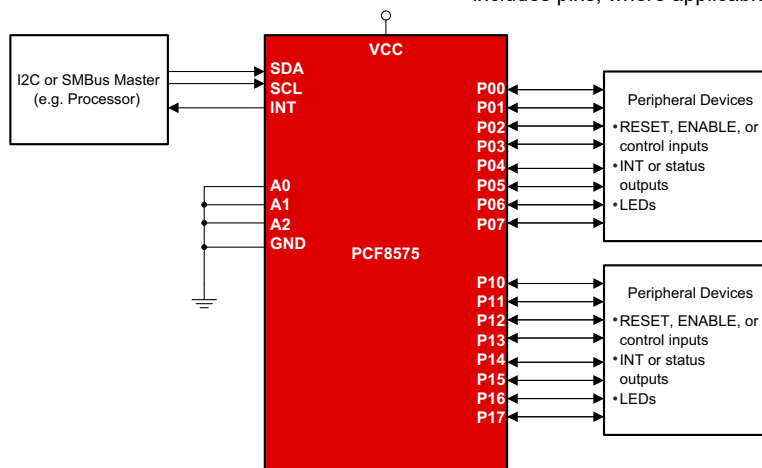
The device features a 16-bit quasi-bidirectional input/output (I/O) port (P07–P00, P17–P10), including latched outputs with high-current drive capability for directly driving LEDs. Each quasi-bidirectional I/O can be used as an input or output without the use of a data-direction control signal. At power on, the I/Os are high. In this mode, only a current source to V<sub>CC</sub> is active.

### Package Information

PART NUMBER	PACKAGE <sup>(1)</sup>	PACKAGE SIZE <sup>(2)</sup>
PCF8575	SSOP (DB, 24)	8.2mm × 7.8mm
	SSOP (DBQ, 24)	8.65mm × 6mm
	TVSOP (DGV, 24)	5mm × 6.4mm
	SOIC (DW, 24)	15.5mm × 10.3mm
	TSSOP (PW, 24)	7.8mm × 6.4mm
	VQFN (RGV, 24)	4mm × 4mm

(1) For available packages, see [Section 12](#).

(2) The package size (length × width) is a nominal value and includes pins, where applicable.



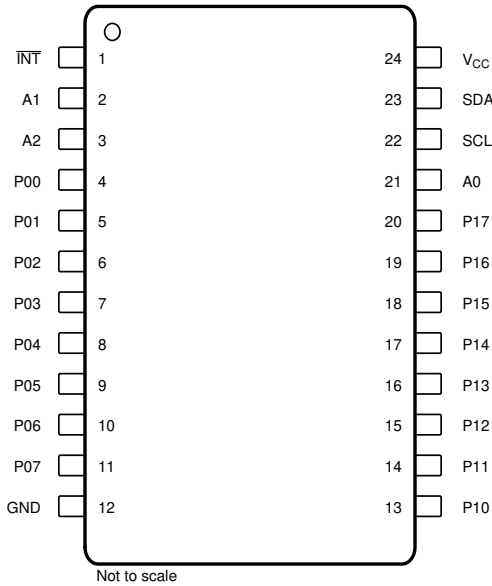
**Simplified Schematic**



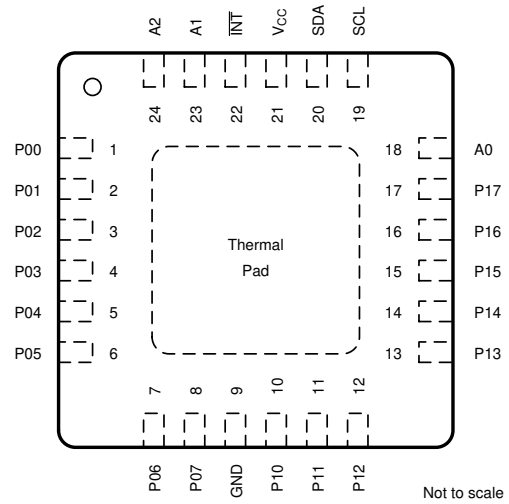
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## 4 Pin Configuration and Functions



**Figure 4-1. DB, DBQ, DGV, DW, or PW Package  
SSOP, TVSOP, SOIC, TSSOP  
(Top View)**



**Figure 4-2. RGE Package VQFN  
(Top View)**

NAME	PIN		TYPE	DESCRIPTION
	DB, DBQ, DGV, DW, AND PW	RGE		
A0	21	18	I	Address input 0. Connect directly to V <sub>CC</sub> or ground. Pull-up resistors are not needed.
A1	2	23	I	Address input 1. Connect directly to V <sub>CC</sub> or ground. Pull-up resistors are not needed.
A2	3	24	I	Address input 2. Connect directly to V <sub>CC</sub> or ground. Pull-up resistors are not needed.
INT	1	22	O	Interrupt output. Connect to V <sub>CC</sub> through a pull-up resistor.
P00	4	1	I/O	P-port input/output. Push-pull design structure.
P01	5	2	I/O	P-port input/output. Push-pull design structure.
P02	6	3	I/O	P-port input/output. Push-pull design structure.
P03	7	4	I/O	P-port input/output. Push-pull design structure.
P04	8	5	I/O	P-port input/output. Push-pull design structure.
P05	9	6	I/O	P-port input/output. Push-pull design structure.
P06	10	7	I/O	P-port input/output. Push-pull design structure.
P07	11	8	I/O	P-port input/output. Push-pull design structure.
GND	12	9	—	Ground
P10	13	10	I/O	P-port input/output. Push-pull design structure.
P11	14	11	I/O	P-port input/output. Push-pull design structure.
P12	15	12	I/O	P-port input/output. Push-pull design structure.
P13	16	13	I/O	P-port input/output. Push-pull design structure.
P14	17	14	I/O	P-port input/output. Push-pull design structure.
P15	18	15	I/O	P-port input/output. Push-pull design structure.
P16	19	16	I/O	P-port input/output. Push-pull design structure.
P17	20	17	I/O	P-port input/output. Push-pull design structure.
SCL	22	19	I	Serial clock line. Connect to V <sub>CC</sub> through a pull-up resistor
SDA	23	20	I/O	Serial data line. Connect to V <sub>CC</sub> through a pull-up resistor.
V <sub>CC</sub>	24	21	—	Supply voltage

## 5 Specifications

### 5.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V <sub>CC</sub>	Supply voltage range	-0.5	6.5	V
V <sub>I</sub>	Input voltage range <sup>(2)</sup>	-0.5	V <sub>CC</sub> + 0.5	V
V <sub>O</sub>	Output voltage range <sup>(2)</sup>	-0.5	V <sub>CC</sub> + 0.5	V
I <sub>IK</sub>	Input clamp current		-20	mA
I <sub>OK</sub>	Output clamp current		-20	mA
I <sub>OK</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		-4	mA
	Continuous current through V <sub>CC</sub> or GND		±100	mA
T <sub>stg</sub>	Storage temperature range		150	°C

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under [Section 5.3](#) is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.

### 5.2 ESD Ratings

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

### 5.3 Recommended Operating Conditions

		MIN	MAX	UNIT
V <sub>CC</sub>	Supply voltage	2.5	5.5	V
V <sub>IH</sub>	High-level input voltage	0.7 × V <sub>CC</sub>	V <sub>CC</sub> + 0.5	V
V <sub>IL</sub>	Low-level input voltage	-0.5	0.3 × V <sub>CC</sub>	V
I <sub>OH</sub>	P-port high-level output current		-1	mA
I <sub>OHT</sub>	P-port transient pullup current		-10	mA
I <sub>OL</sub>	P-port low-level output current		25	mA
T <sub>A</sub>	Operating free-air temperature	-40	85	°C

### 5.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>	PCF8575							UNIT
	DB	DBQ	DGV	DW	PW	RGE		
	24 PINS							
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	87.8	61	86	75.6	99.7	53.6	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	51.9			47.9	42.5	50.8	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	56.8			50.1	66.1	31.5	°C/W
Ψ <sub>JT</sub>	Junction-to-top characterization parameter	14.3			21.1	2.7	3.4	°C/W
Ψ <sub>JB</sub>	Junction-to-board characterization parameter	56.2			49.7	65.5	31.4	°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	-			-	-	14.8	°C/W

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

## 5.5 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	V <sub>CC</sub>	MIN	TYP <sup>(1)</sup>	MAX	UNIT
V <sub>IK</sub>	Input diode clamp voltage	I <sub>I</sub> = -18 mA	2.5 V to 5.5 V	-1.2			V
V <sub>POR</sub>	Power-on reset voltage	V <sub>I</sub> = V <sub>CC</sub> or GND, I <sub>O</sub> = 0	V <sub>POR</sub>		1.2	1.8	V
I <sub>OH</sub>	P port	V <sub>O</sub> = GND	2.5 V to 5.5 V	-30		-300	μA
I <sub>OHT</sub>	P-port transient pullup current	High during ACK, V <sub>OHT</sub> = GND	2.5 V	-0.5	-1		mA
I <sub>OL</sub>	SDA	V <sub>OL</sub> = 0.4 V	2.5 V to 5.5 V	3			mA
	P port	V <sub>OL</sub> = 0.4 V		5	15		
		V <sub>OL</sub> = 1 V		10	25		
	INT	V <sub>OL</sub> = 0.4 V		1.6			
I <sub>I</sub>	SCL, SDA	V <sub>I</sub> = V <sub>CC</sub> or GND	2.5 V to 5.5 V			±5	μA
	A0, A1, A2					±1	
I <sub>IHL</sub>	P port	-250mV < V <sub>I</sub> < GND	2.5 V to 5.5 V			±400	μA
I <sub>CC</sub>	Operating mode	V <sub>I</sub> = V <sub>CC</sub> or GND, I <sub>O</sub> = 0, f <sub>scl</sub> = 400 kHz	5.5 V		100	200	μA
			3.6 V		30	75	
			2.7 V		20	50	
	Standby mode	V <sub>I</sub> = V <sub>CC</sub> or GND, I <sub>O</sub> = 0, f <sub>scl</sub> = 0 kHz	5.5 V		2.5	10	
			3.6 V		2.5	10	
			2.7 V		2.5	10	
ΔI <sub>CC</sub>	Supply current increase	One input at V <sub>CC</sub> - 0.6 V, Other inputs at V <sub>CC</sub> or GND	2.5 V to 5.5 V			200	μA
C <sub>I</sub>	SCL	V <sub>I</sub> = V <sub>CC</sub> or GND	2.5 V to 5.5 V		3	7	pF
C <sub>io</sub>	SDA	V <sub>IO</sub> = V <sub>CC</sub> or GND	2.5 V to 5.5 V		3	7	pF
	P port				4	10	

(1) All typical values are at nominal supply voltage (2.5-V, 3.3-V, or 5-V V<sub>CC</sub>) and T<sub>A</sub> = 25°C.

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

over recommended operating free-air temperature range (unless otherwise noted) (see Figure 6-1)

			MIN	MAX	UNIT
f <sub>scl</sub>	I <sup>2</sup> C clock frequency			400	kHz
t <sub>sch</sub>	I <sup>2</sup> C clock high time		0.6		μs
t <sub>scl</sub>	I <sup>2</sup> C clock low time		1.3		μs
t <sub>sp</sub>	I <sup>2</sup> C spike time			50	ns
t <sub>sds</sub>	I <sup>2</sup> C serial data setup time		100		ns
t <sub>sdh</sub>	I <sup>2</sup> C serial data hold time		0		ns
t <sub>icr</sub>	I <sup>2</sup> C input rise time		20 + 0.1C <sub>b</sub> <sup>(1)</sup>	300	ns
t <sub>icf</sub>	I <sup>2</sup> C input fall time		20 + 0.1C <sub>b</sub> <sup>(1)</sup>	300	ns
t <sub>ocf</sub>	I <sup>2</sup> C output fall time	10-pF to 400-pF bus		300	ns
t <sub>buf</sub>	I <sup>2</sup> C bus free time between Stop and Start		1.3		μs
t <sub>sts</sub>	I <sup>2</sup> C start or repeated Start condition setup		0.6		μs
t <sub>sth</sub>	I <sup>2</sup> C start or repeated Start condition hold		0.6		μs
t <sub>sps</sub>	I <sup>2</sup> C Stop condition setup		0.6		μs
t <sub>vd</sub>	Valid-data time	SCL low to SDA output valid		1.2	μs
C <sub>b</sub>	I <sup>2</sup> C bus capacitive load			400	pF

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

## 5.7 Switching Characteristics

over recommended operating free-air temperature range,  $C_L \leq 100$  pF (unless otherwise noted) (see Figure 6-2 and Figure 6-3)

PARAMETER		FROM (INPUT)	TO (OUTPUT)	MIN	MAX	UNIT
$t_{iv}$	Interrupt valid time	P port	$\overline{INT}$		4	$\mu\text{s}$
$t_{ir}$	Interrupt reset delay time	SCL	$\overline{INT}$		4	$\mu\text{s}$
$t_{pv}$	Output data valid	SCL	P port		4	$\mu\text{s}$
$t_{su}$	Input data setup time	P port	SCL	0		$\mu\text{s}$
$t_h$	Input data hold time	P port	SCL	4		$\mu\text{s}$

## 6 Typical Characteristics

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

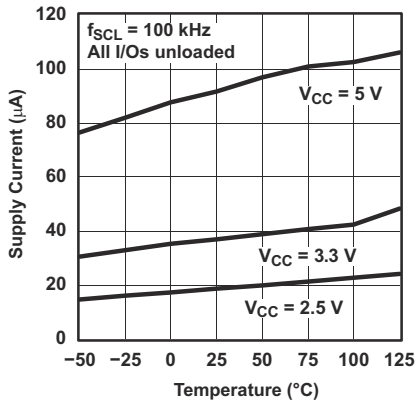


Figure 6-1. Supply Current vs Temperature

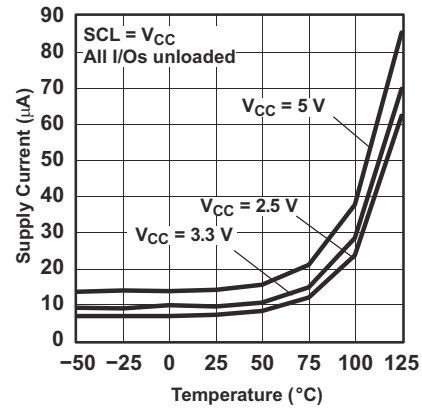


Figure 6-2. Standby Supply Current vs Temperature

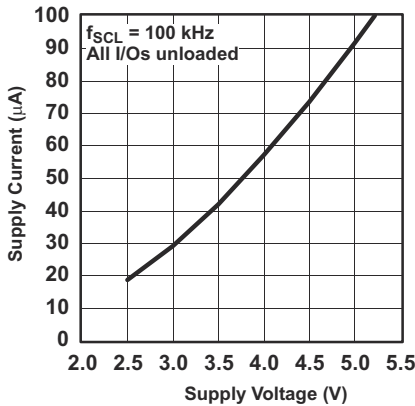


Figure 6-3. Supply Current vs Supply Voltage

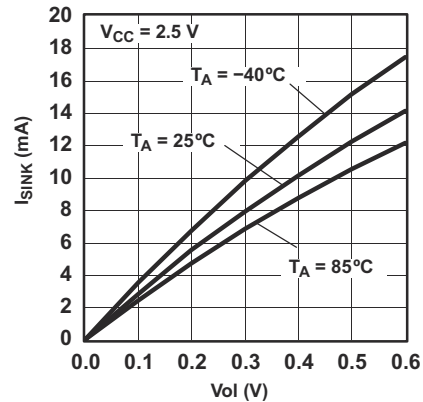


Figure 6-4. I/O Sink Current vs Output Low Voltage

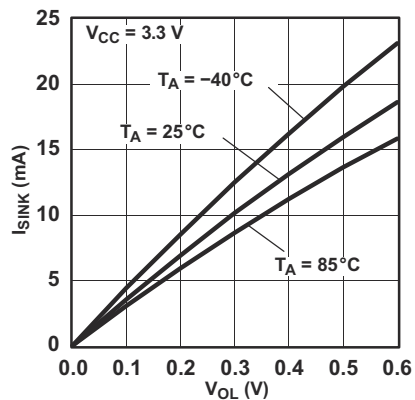


Figure 6-5. I/O Sink Current vs Output Low Voltage

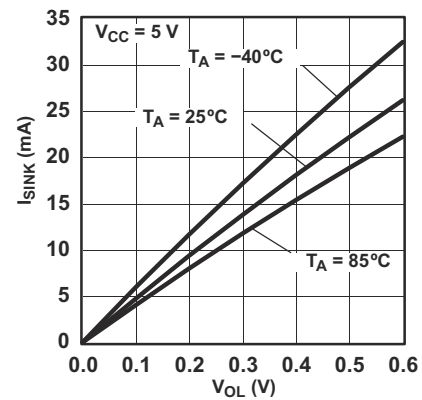


Figure 6-6. I/O Sink Current vs Output Low Voltage

## 6 Typical Characteristics (continued)

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

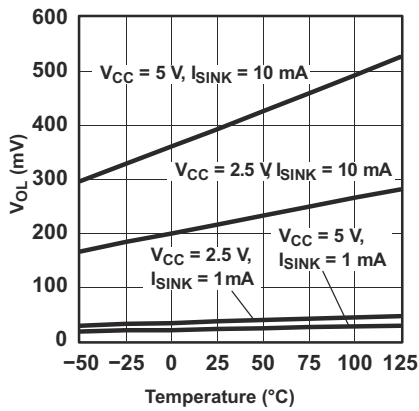


Figure 6-7. I/O Output Low Voltage vs Temperature

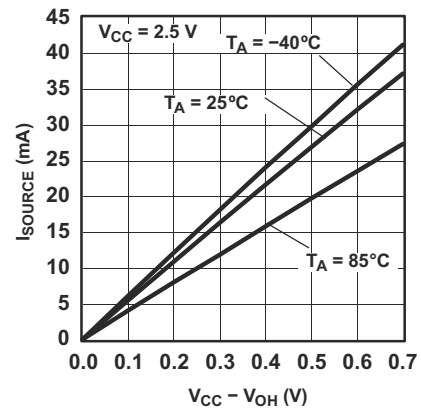


Figure 6-8. I/O Source Current vs Output High Voltage

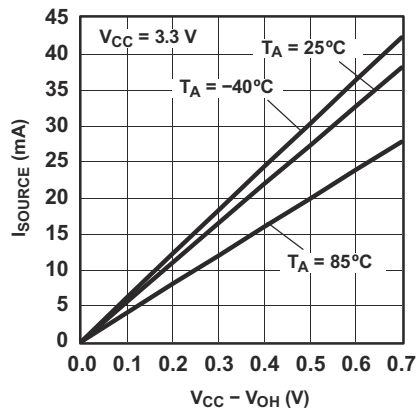


Figure 6-9. I/O Source Current vs Output High Voltage

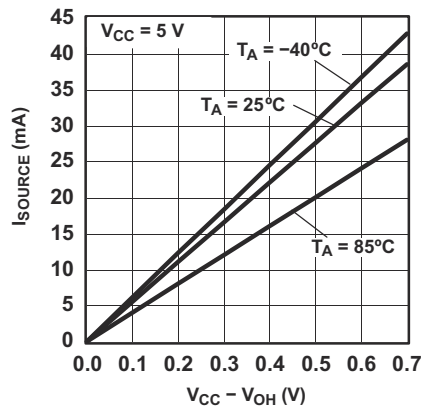


Figure 6-10. I/O Source Current vs Output High Voltage

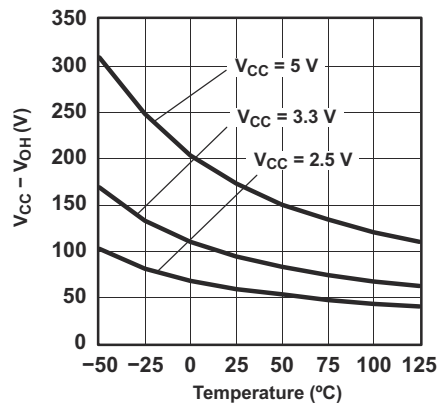
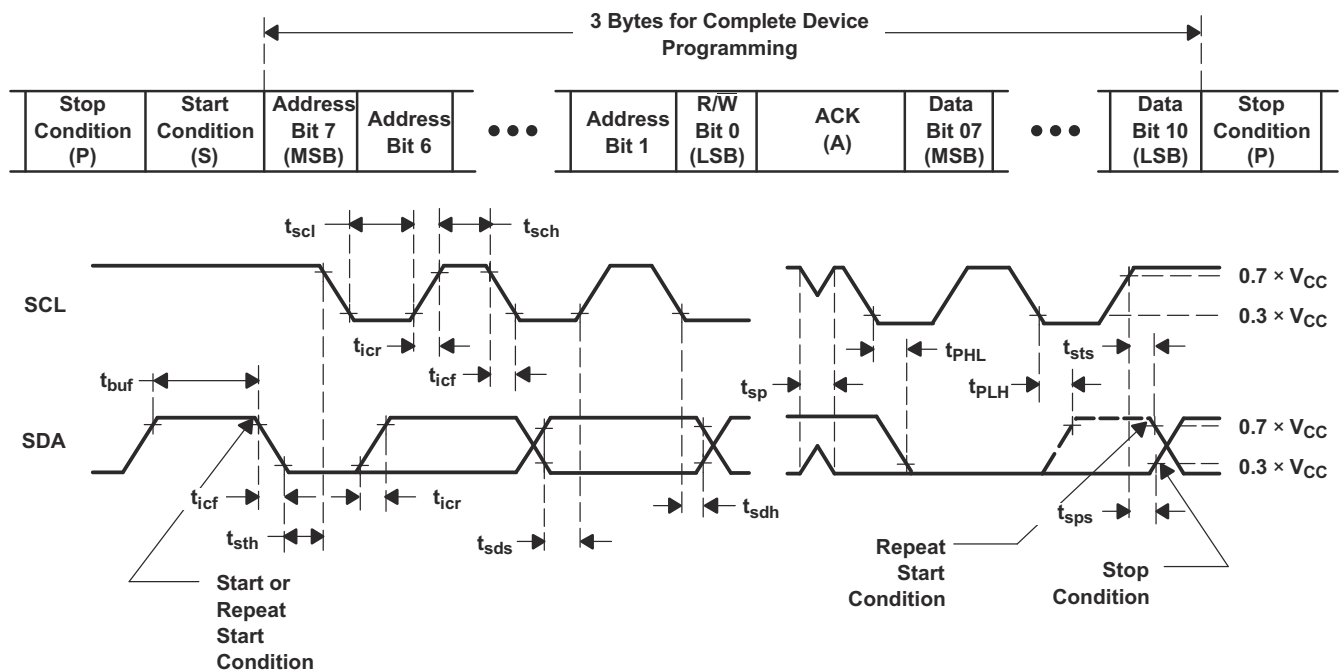
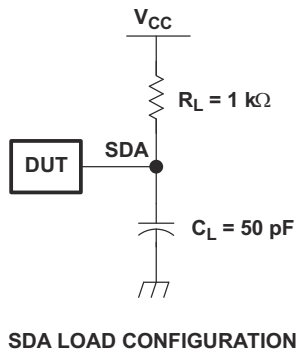


Figure 6-11. I/O High Voltage vs Temperature

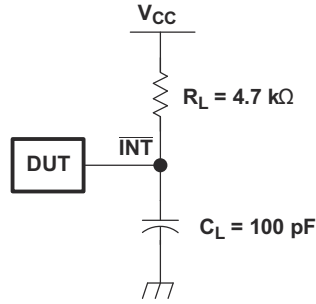


## 7 Parameter Measurement Information



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

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



INTERRUPT LOAD CONFIGURATION

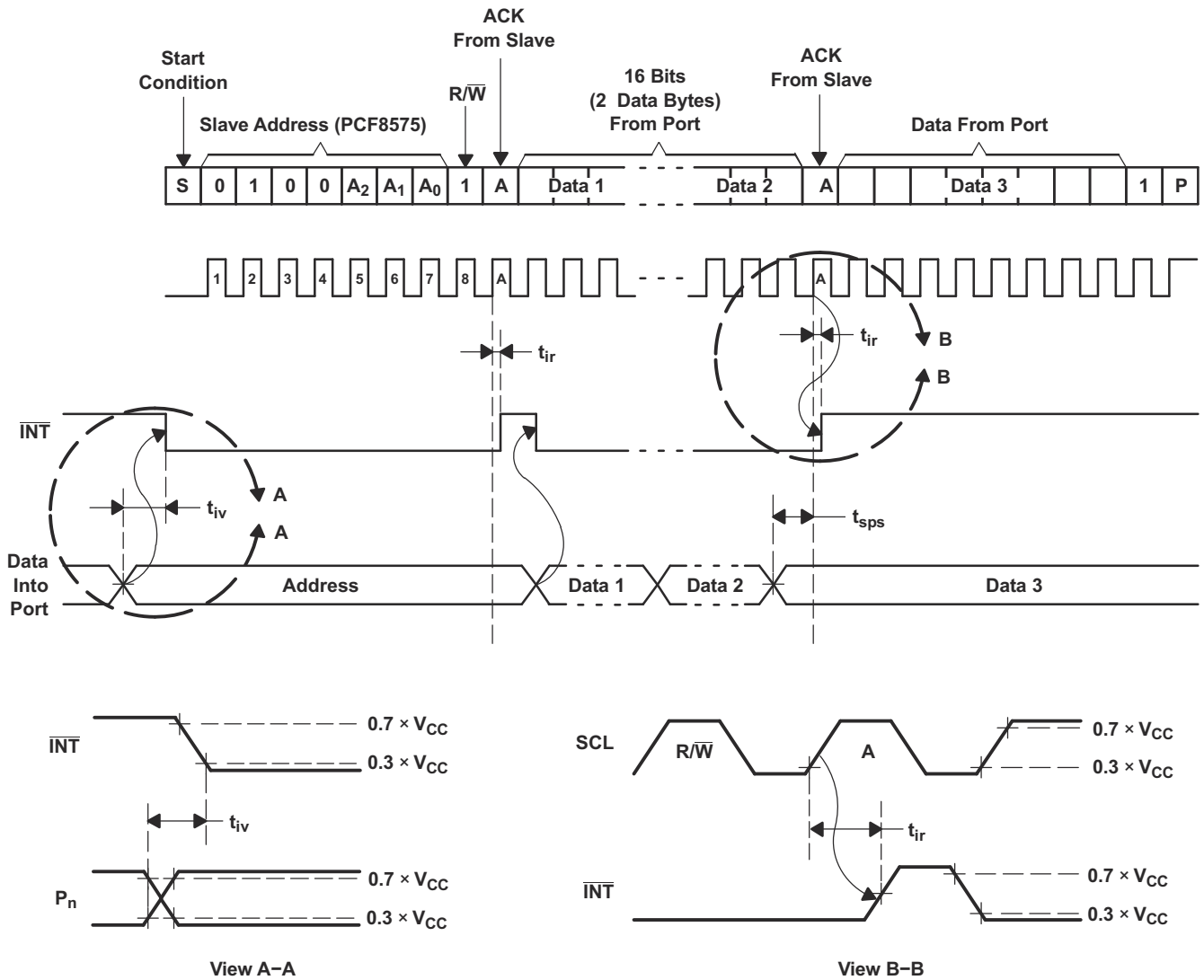


Figure 7-2. Interrupt Load Circuit and Voltage Waveforms

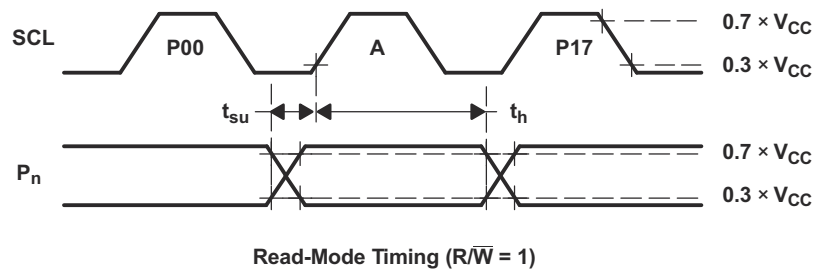
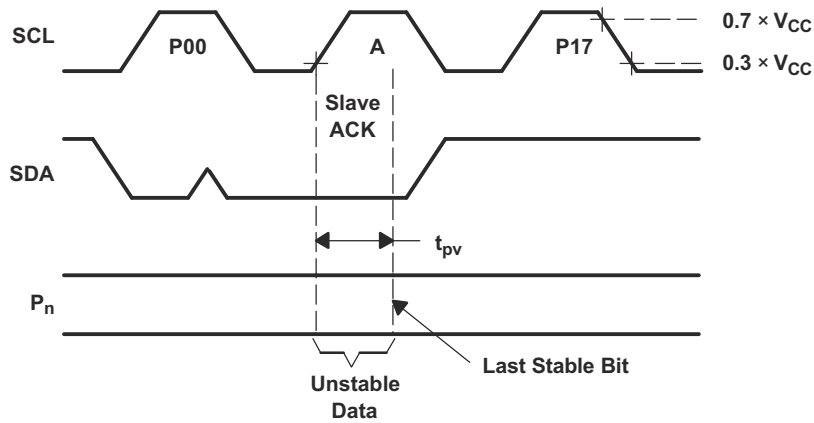
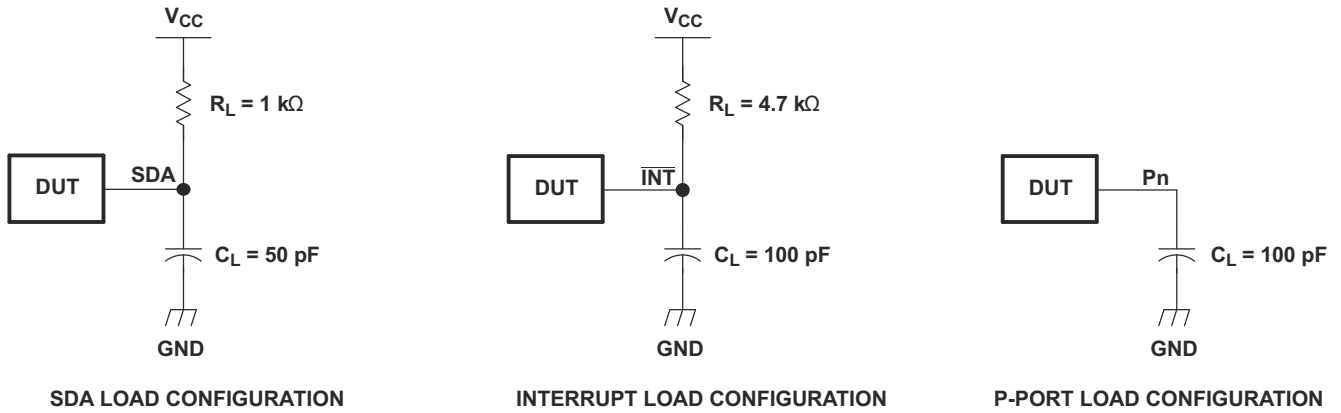


Figure 7-3. P-Port Load Circuits and Voltage Waveforms

## 8 Detailed Description

### 8.1 Overview

The PCF8575 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 device features a 16-bit quasi-bidirectional input/output (I/O) port (P07–P00, P17–P10), including latched outputs with high-current drive capability for directly driving LEDs. Each quasi-bidirectional I/O can be used as an input or output without the use of a data-direction control signal. At power on, the I/Os are high. In this mode, only a current source ( $I_{OH}$ ) to  $V_{CC}$  is active. An additional strong pullup to  $V_{CC}$  ( $I_{OHT}$ ) allows fast-rising edges into heavily loaded outputs. This device turns on when an output is written high and is switched off by the negative edge of SCL. The I/Os should be high before being used as inputs. After power on, as all the I/Os are set high, all of them can be used as inputs. Any change in setting of the I/Os as either input or outputs can be done with the write mode. If a high is applied externally to an I/O that has been written earlier to low, a large current ( $I_{OL}$ ) will flow to GND.

The PCF8575 provides an open-drain interrupt ( $\overline{INT}$ ) output, which can be connected to the interrupt input of a microcontroller. 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 and reactivating the interrupt circuit is achieved when data on the port is changed to the original setting, or data is read from or written to 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 or in the write mode at the ACK bit after the falling edge of the SCL signal. Interrupts that occur during the ACK 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. This device does not have internal configuration or status registers. Instead, read or write to the device I/Os directly after sending the device address (see [Figure 8-6](#) and [Figure 8-7](#)).

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 PCF8575 can remain a simple target device.

Every data transmission to or from the PCF8575 must consist of an even number of bytes. The first data byte in every pair refers to port 0 (P07–P00), and the second data byte in every pair refers to port 1 (P17–P10). To write to the ports (output mode), the controller first addresses the target device, setting the last bit of the byte containing the target address to logic 0. The PCF8575 acknowledges, and the controller sends the first data byte for P07–P00. After the first data byte is acknowledged by the PCF8575, the second data byte (P17–P10) is sent by the controller. Once again, the PCF8575 acknowledges the receipt of the data, after which this 16-bit data is presented on the port lines.

The number of data bytes that can be sent successively is not limited. After every two bytes, the previous data is overwritten. When the PCF8575 receives the pairs of data bytes, the first byte is referred to as P07–P00 and the second byte as P17–P10. The third byte is referred to as P07–P00, the fourth byte as P17–P10, and so on.

Before reading from the PCF8575, all ports desired as input should be set to logic 1. To read from the ports (input mode), the controller first addresses the target device, setting the last bit of the byte containing the target address to logic 1. The data bytes that follow on the SDA are the values on the ports. If the data on the input port changes faster than the controller can read, this data may be lost.

When power is applied to  $V_{CC}$ , an internal power-on reset holds the PCF8575 in a reset state until  $V_{CC}$  has reached  $V_{POR}$ . At that time, the reset condition is released, and the device I<sup>2</sup>C-bus state machine initializes the bus to its default state.

The hardware pins (A0, A1, and A2) are used to program and vary the fixed I<sup>2</sup>C address and allow up to eight devices to share the same I<sup>2</sup>C bus or SMBus. The fixed I<sup>2</sup>C address of the PCF8575 is the same as the PCF8575C, PCF8574, PCA9535, and PCA9555, allowing up to eight of these devices, in any combination, to share the same I<sup>2</sup>C bus or SMBus.

## 8.2 Functional Block Diagram

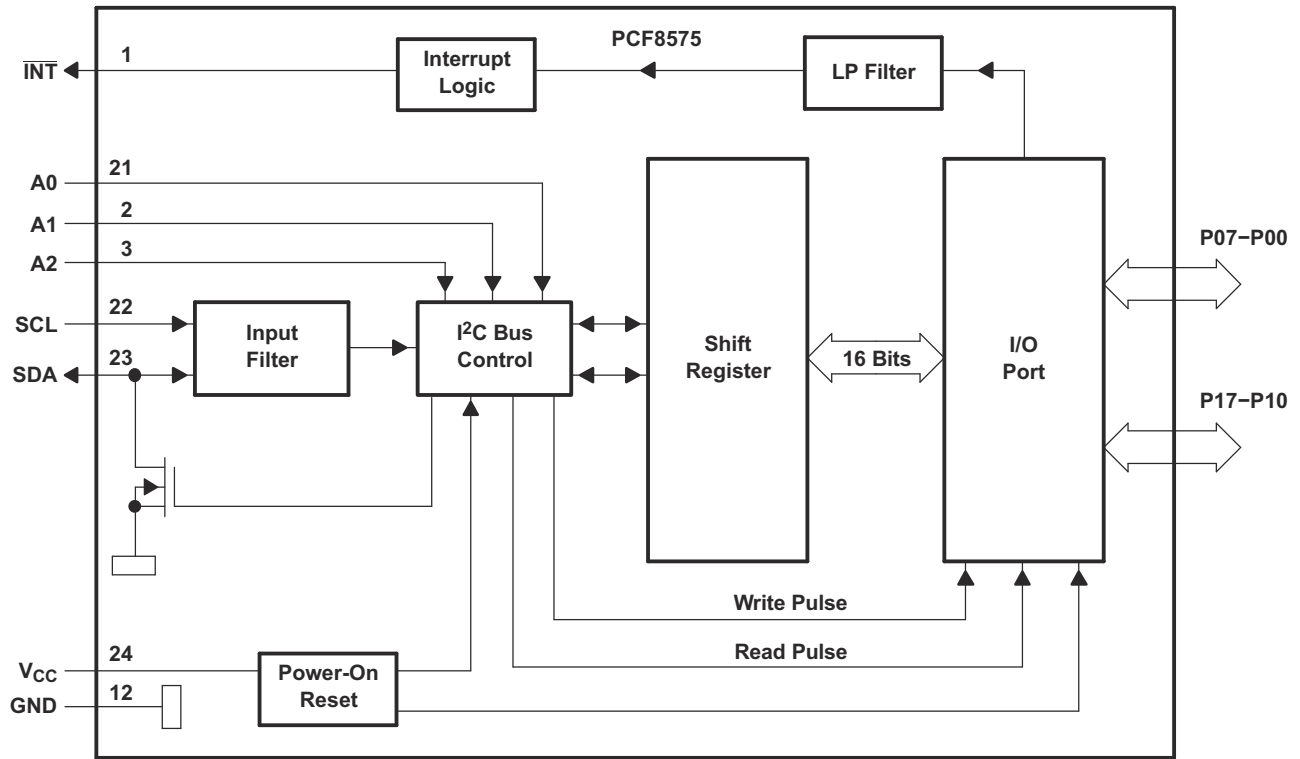


Figure 8-1. Logic Diagram (Positive Logic)

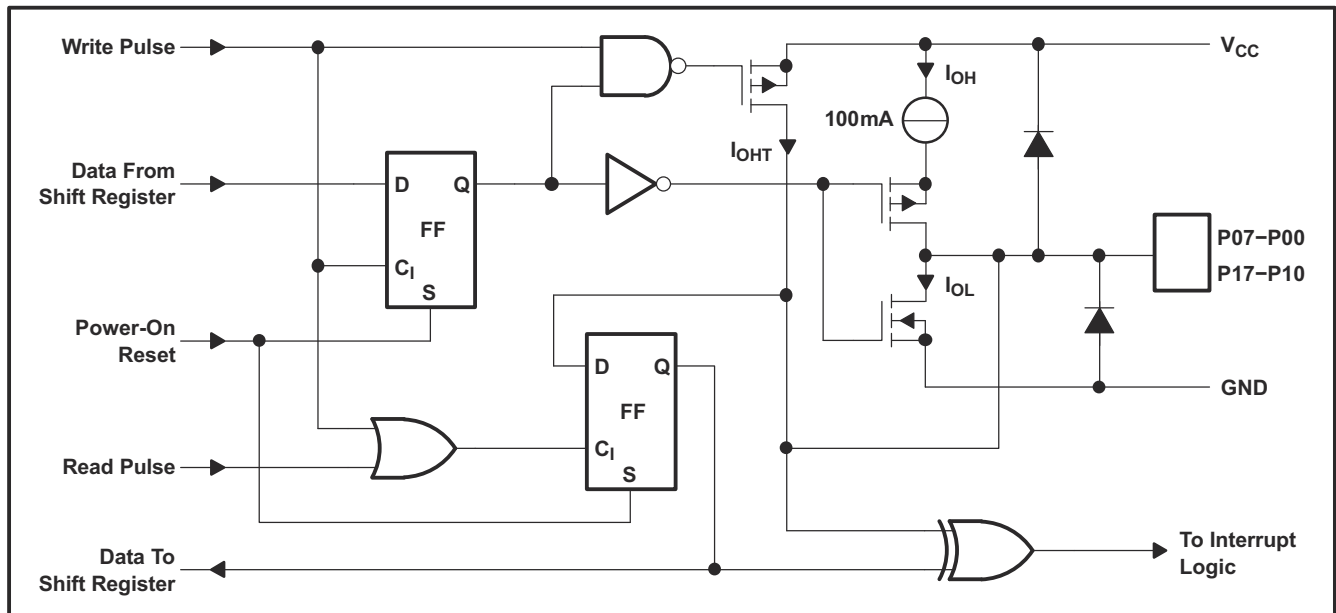


Figure 8-2. Simplified Schematic Diagram of Each P-Port Input or Output

## 8.3 Feature Description

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

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

I<sup>2</sup>C communication with this device is initiated by a controller sending a Start condition, a high-to-low transition on the SDA input/output while the SCL input is high (see Figure 8-3). After the Start condition, the device address byte is sent, most significant bit (MSB) first, including the data direction bit (R/  $\bar{W}$ ). This device does not respond to the general call address. After receiving the valid address byte, this device responds with an ACK, a low on the SDA input/output during the high of the ACK-related clock pulse. The address inputs (A2–A0) of the target device must not be changed between the Start and Stop conditions.

The data byte follows the address ACK. If the R/  $\bar{W}$  bit is high, the data from this device are the values read from the P port. If the R/  $\bar{W}$  bit is low, the data are from the controller, to be output to the P port. The data byte is followed by an ACK sent from this device. If other data bytes are sent from the controller, following the ACK, they are ignored by this device. Data are output only if complete bytes are received and acknowledged. The output data is valid at time ( $t_{pv}$ ) after the low-to-high transition of SCL, during the clock cycle for the ACK.

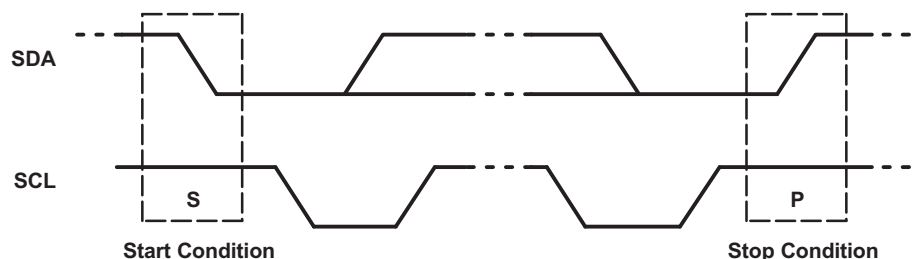
On the I<sup>2</sup>C bus, only one data bit is transferred during each clock pulse. The data on the SDA line must remain stable during the high pulse of the clock period, as changes in the data line at this time are interpreted as control commands (Start or Stop) (see Figure 8-4).

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

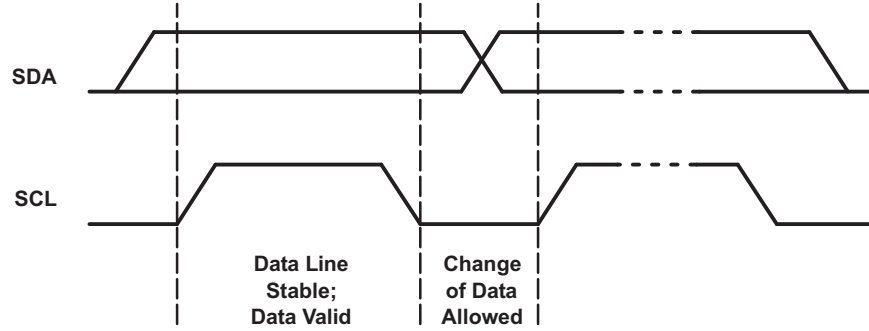
The number of data bytes transferred between the Start and Stop conditions from transmitter to receiver is not limited. Each byte of eight bits is followed by one ACK bit. The transmitter must release the SDA line before the receiver can send an ACK bit.

A target receiver that is addressed must generate an ACK after the reception of each byte. Also, a controller must generate an ACK after the reception of each byte that has been clocked out of the target transmitter. The device that acknowledges has to pull down the SDA line during the ACK clock pulse so that the SDA line is stable low during the high pulse of the ACK-related clock period (see Figure 8-5). Setup and hold times must be taken into account.

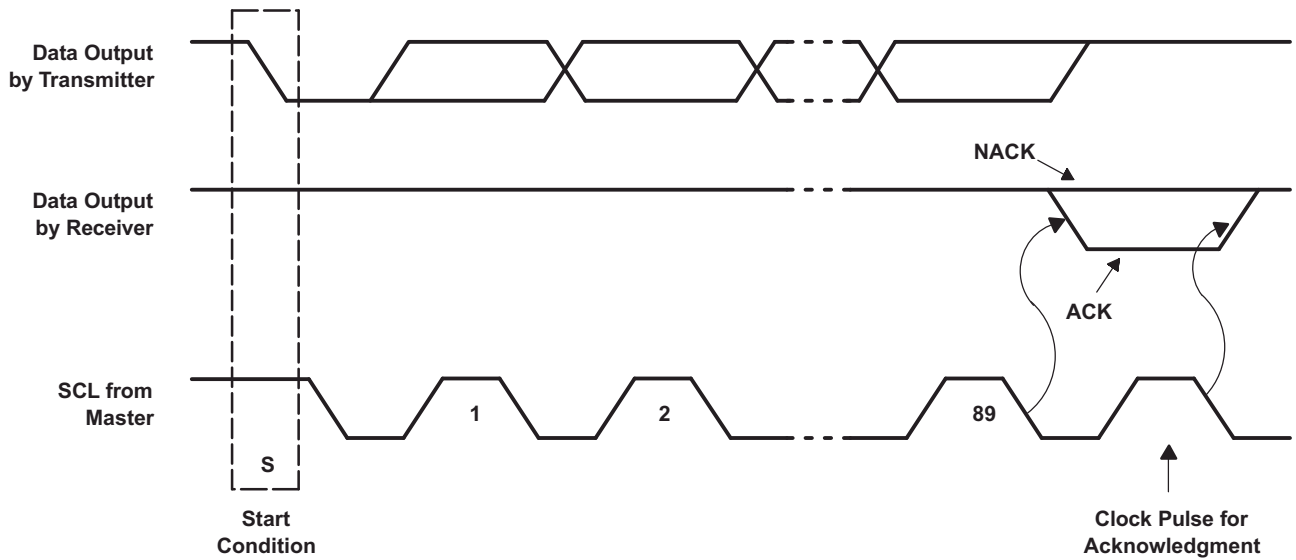
A controller receiver must signal an end of data to the transmitter by not generating an acknowledge (NACK) after the last byte that has been clocked out of the target. This is done by the controller receiver by holding the SDA line high. In this event, the transmitter must release the data line to enable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



**Figure 8-3. Definition of Start and Stop Conditions**



**Figure 8-4. Bit Transfer**



**Figure 8-5. Acknowledgment on I<sup>2</sup>C Bus**

### 8.3.2 Interface Definition

BYTE	BIT							
	7 (MSB)	6	5	4	3	2	1	0 (LSB)
I <sup>2</sup> C target address	L	H	L	L	A2	A1	A0	R/ W
P0x I/O data bus	P07	P06	P05	P04	P03	P02	P01	P00
P1x I/O data bus	P17	P16	P15	P14	P13	P12	P11	P10

### 8.3.3 Address Reference

INPUTS			I <sup>2</sup> C BUS TARGET 8-BIT READ ADDRESS	I <sup>2</sup> C BUS TARGET 8-BIT WRITE ADDRESS
A2	A1	A0		
L	L	L	65 (decimal), 41 (hexadecimal)	64 (decimal), 40 (hexadecimal)
L	L	H	67 (decimal), 43 (hexadecimal)	66 (decimal), 42 (hexadecimal)
L	H	L	69 (decimal), 45 (hexadecimal)	68 (decimal), 44 (hexadecimal)
L	H	H	71 (decimal), 47 (hexadecimal)	70 (decimal), 46 (hexadecimal)
H	L	L	73 (decimal), 49 (hexadecimal)	72 (decimal), 48 (hexadecimal)
H	L	H	75 (decimal), 4B (hexadecimal)	74 (decimal), 4A (hexadecimal)
H	H	L	77 (decimal), 4D (hexadecimal)	76 (decimal), 4C (hexadecimal)
H	H	H	79 (decimal), 4F (hexadecimal)	78 (decimal), 4E (hexadecimal)

### 8.4 Device Functional Modes

Figure 8-6 and Figure 8-7 show the address and timing diagrams for the write and read modes, respectively.

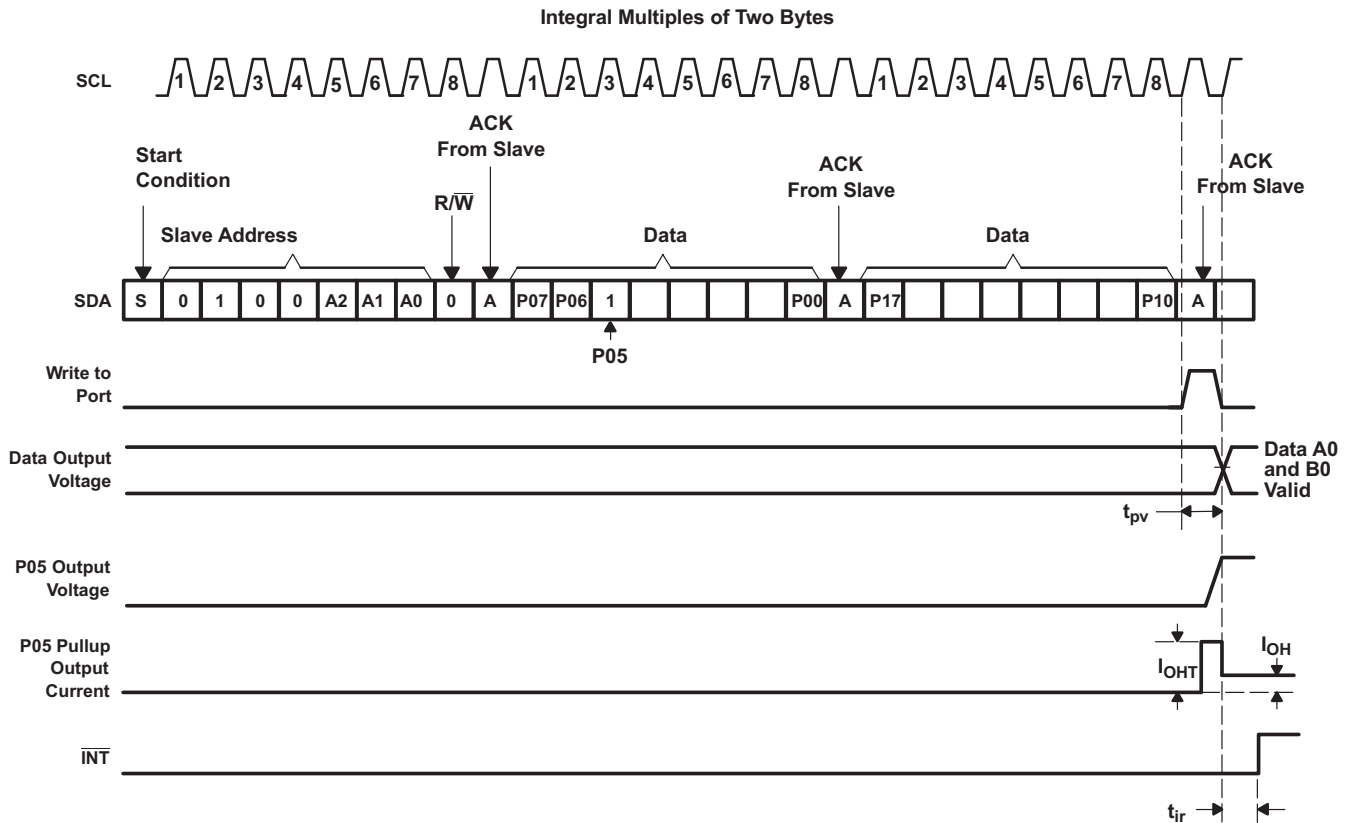


Figure 8-6. Write Mode (Output)



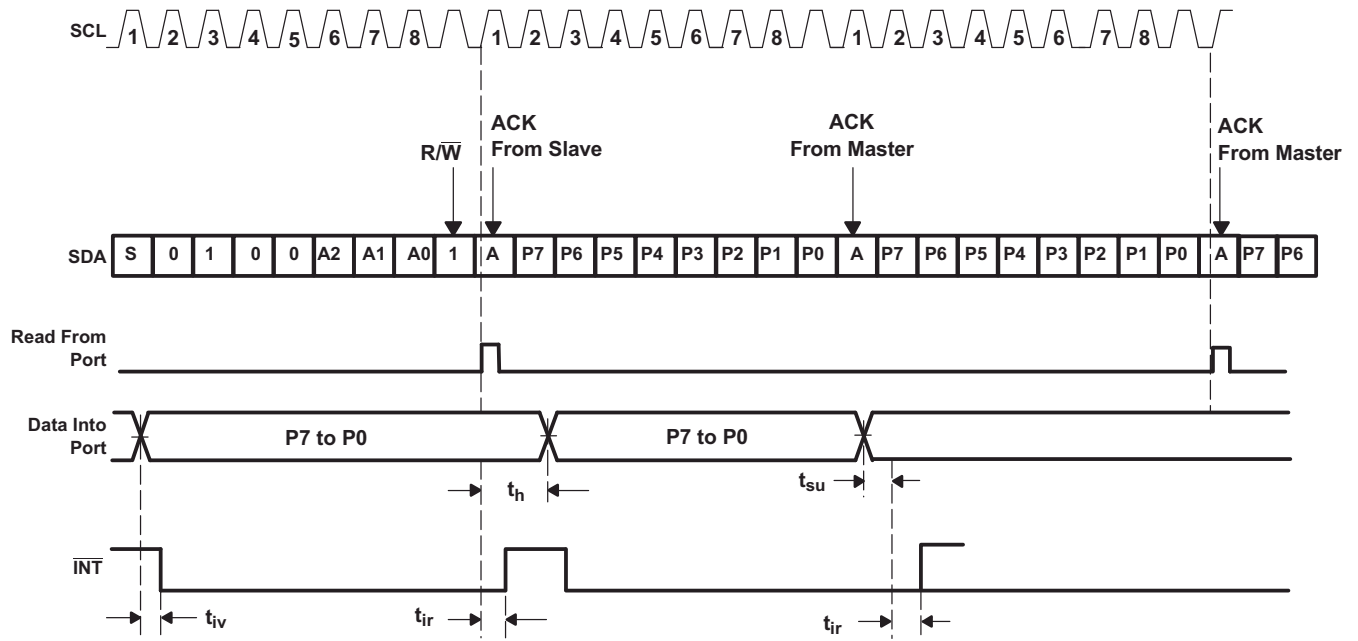


Figure 8-7. Read Mode (Input)

## 9 Application and Implementation

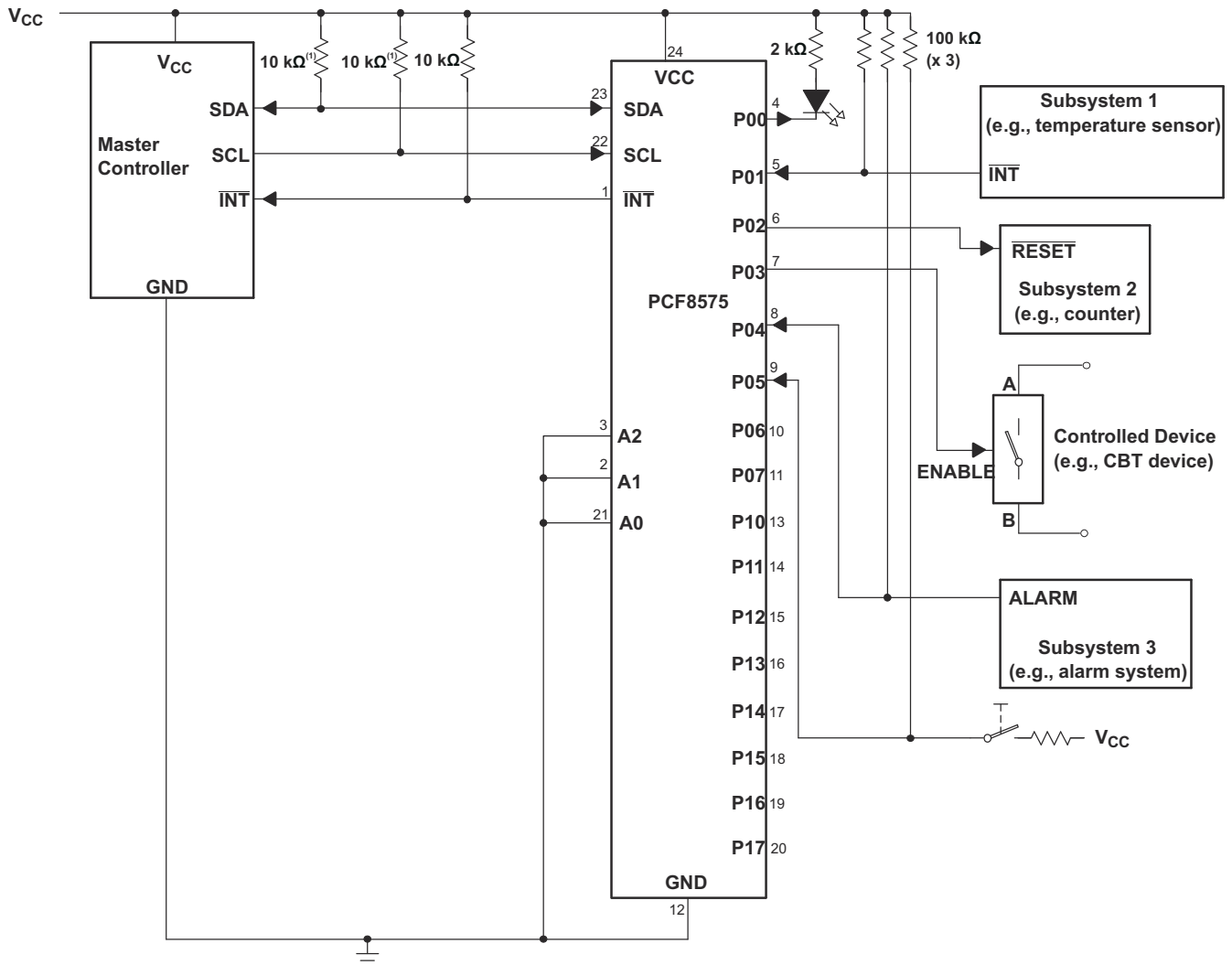
### Note

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, as well as validating and testing their design implementation to confirm system functionality.

### 9.1 Application Information

Figure 9-1 shows an application in which PCF8575 can be used.

### 9.2 Typical Application



- The SCL and SDA pins must be tied directly to VCC because if SCL and SDA are tied to an auxiliary power supply that could be powered on while VCC is powered off, then the supply current, ICC, will increase as a result.
- Device address is configured as 0100000 for this example.
- P0, P2, and P3 are configured as outputs.
- P1, P4, and P5 are configured as inputs.
- P6 and P7 are not used and must be configured as outputs.

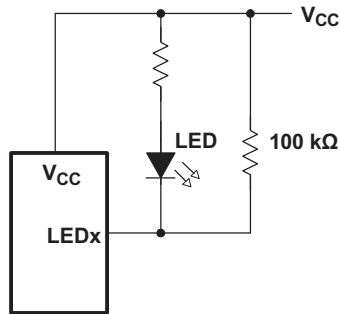
**Figure 9-1. Application Schematic**

## 9.2.1 Design Requirements

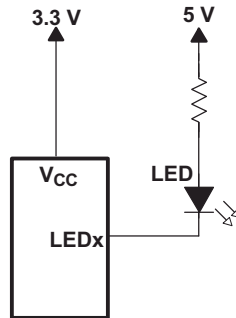
### 9.2.1.1 Minimizing $I_{CC}$ When I/Os Control LEDs

When the I/Os are used to control LEDs, normally they are connected to  $V_{CC}$  through a resistor as shown in Figure 9-1. For a P-port configured as an input,  $I_{CC}$  increases as  $V_I$  becomes lower than  $V_{CC}$ . The LED is a diode, with threshold voltage  $V_T$ , and when a P-port is configured as an input the LED will be off but  $V_I$  is a  $V_T$  drop below  $V_{CC}$ .

For battery-powered applications, it is essential that the voltage of P-ports controlling LEDs is greater than or equal to  $V_{CC}$  when the P-ports are configured as input to minimize current consumption. Figure 9-2 shows a high-value resistor in parallel with the LED. Figure 9-3 shows  $V_{CC}$  less than the LED supply voltage by at least  $V_T$ . Both of these methods maintain the I/O  $V_I$  at or above  $V_{CC}$  and prevents additional supply current consumption when the P-port is configured as an input and the LED is off.



**Figure 9-2. High-Value Resistor in Parallel With LED**



**Figure 9-3. Device Supplied by a 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  $I_{OL}$ :

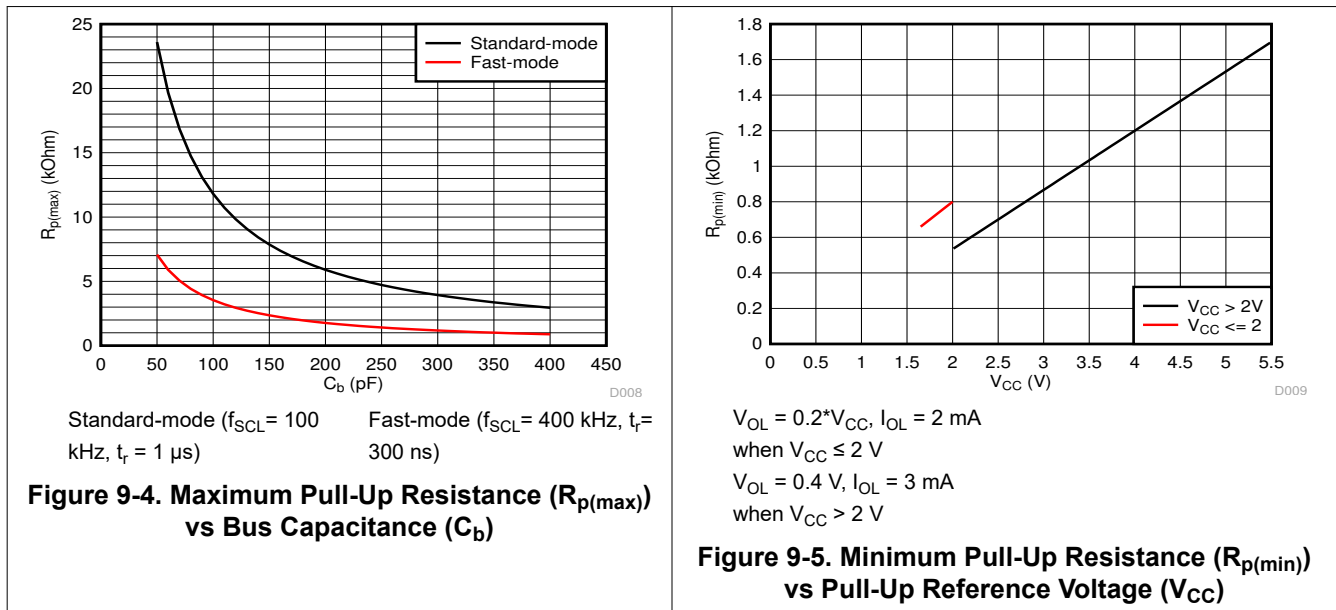
$$R_{p(min)} = \frac{V_{CC} - V_{OL(max)}}{I_{OL}} \quad (1)$$

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<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 PCF8575,  $C_i$  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

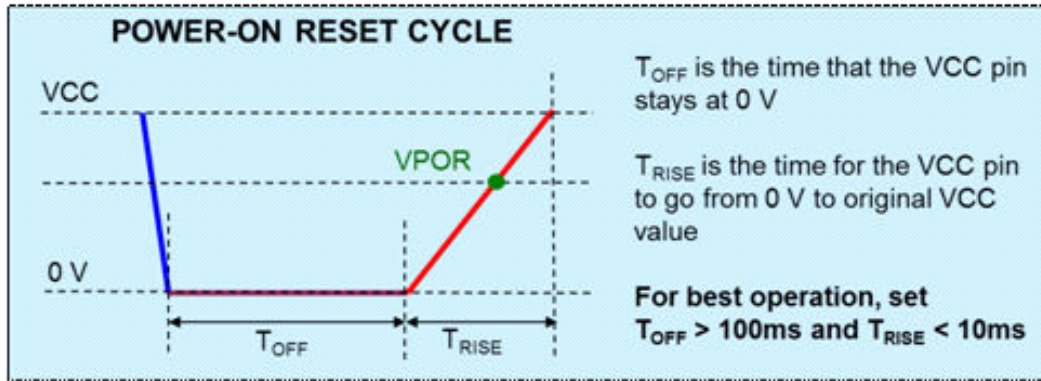


## 9.3 Power Supply Recommendations

The operating power-supply voltage range of the PCF8575 is 2.5 V to 5.5 V applied at the VCC pin. When the PCF8575 is powered on for the first time or anytime the device needs to be reset by cycling the power supply, the power-on reset requirements must be followed to ensure the I<sup>2</sup>C bus logic is initialized properly.

### 9.3.1 Power-On Reset

A power-on reset condition can be missed if the VCC ramps are outside specification listed below.



### 9.3.2 System Impact

If ramp conditions are outside timing allowances above, POR condition can be missed, causing the device to lock up.

## 9.4 Layout

### 9.4.1 Layout Guidelines

For printed circuit board (PCB) layout of the PCF8575 device, 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<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 should be placed as close to the PCF8575 as possible. These best practices are shown in [Figure 9-6](#).

For the layout example provided in [Figure 9-6](#), 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 needs to 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 9-6](#).

### 9.4.2 Layout Example

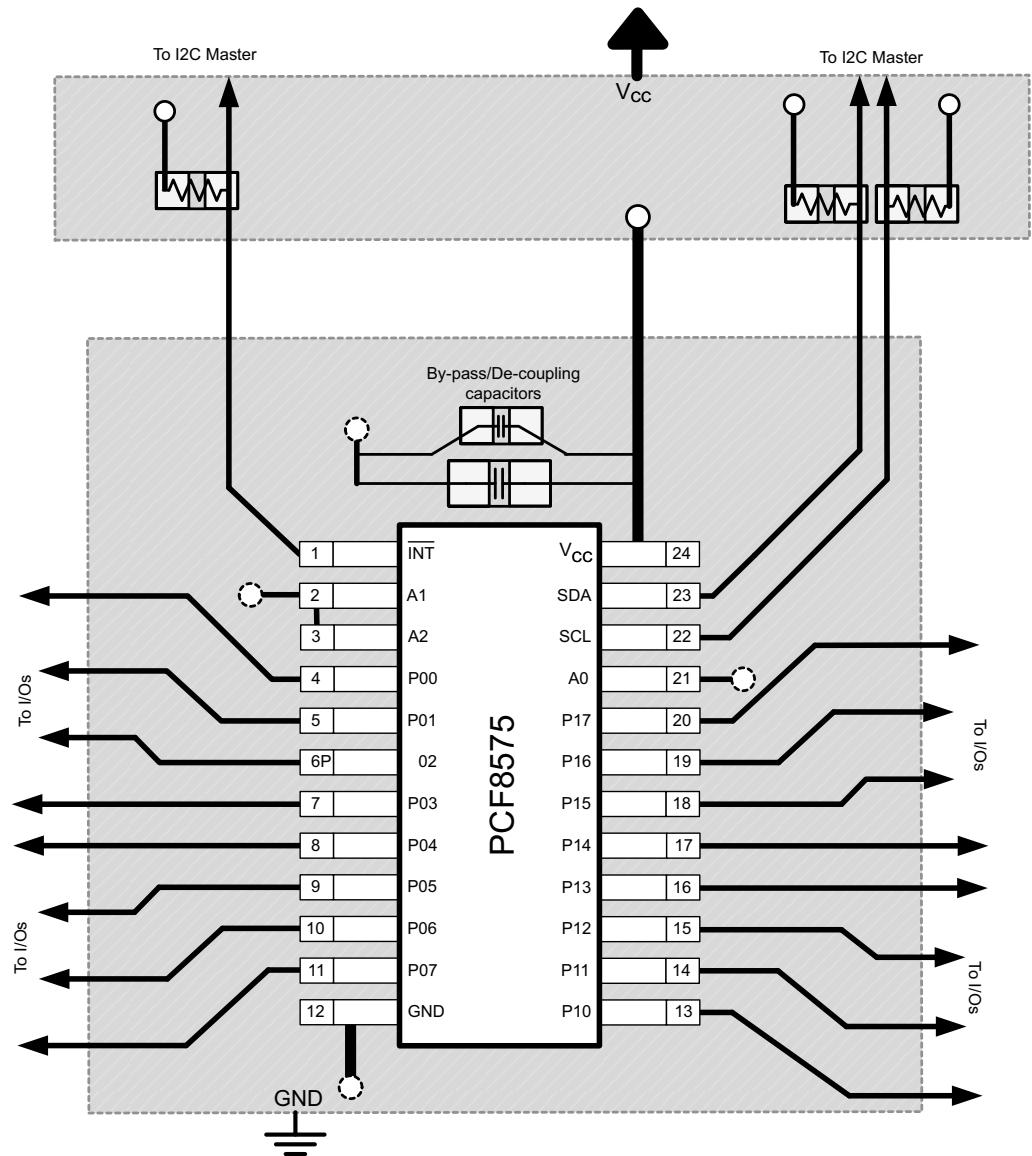
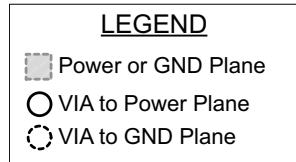


Figure 9-6. Layout Example for PCF8575

## 10 Device and Documentation Support

### 10.1 Device Support

### 10.2 Documentation Support

### 10.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](http://ti.com). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 10.4 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

### 10.5 Trademarks

TI E2E™ is a trademark of Texas Instruments.  
All trademarks are the property of their respective owners.

### 10.6 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.

### 10.7 Glossary

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

## 11 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>Changes from Revision H (February 2020) to Revision I (August 2024)</b>	<b>Page</b>
• Updated all instances of legacy terminology to controller and target where I <sup>2</sup> C is mentioned.....	1
• Updated the Device Information table to the <i>Package information</i> table.....	1
• Updated Thermal Information.....	4
• Removed footnote #2 from Electrical Characteristics.....	5
• Updated I <sub>IHL</sub> test condition.....	5

<b>Changes from Revision G (August 2018) to Revision H (February 2020)</b>	<b>Page</b>
• Updated <a href="#">Figure 8-6</a> .....	16

## 12 Mechanical, Packaging, and Orderable Information

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

**PACKAGING INFORMATION**

Orderable part number	Status (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)
PCF8575DBQR	Active	Production	SSOP (DBQ)   24	2500   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	PCF8575
PCF8575DBR	Active	Production	SSOP (DB)   24	2000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PF575
PCF8575DGVR	Active	Production	TVSOP (DGV)   24	2000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PF575
PCF8575DW	Obsolete	Production	SOIC (DW)   24	-	-	Call TI	Call TI	-40 to 85	PCF8575
PCF8575DWR	Active	Production	SOIC (DW)   24	2000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PCF8575
PCF8575PW	Obsolete	Production	TSSOP (PW)   24	-	-	Call TI	Call TI	-40 to 85	PF575
PCF8575PWR	Active	Production	TSSOP (PW)   24	2000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PF575
PCF8575RGER	Active	Production	VQFN (RGE)   24	3000   LARGE T&R	Yes	NIPDAU   NIPDAU	Level-2-260C-1 YEAR	-40 to 85	PF575 Q1

(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.

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



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

**TAPE AND REEL INFORMATION**

**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
PCF8575DBQR	SSOP	DBQ	24	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
PCF8575DBR	SSOP	DB	24	2000	330.0	16.4	8.2	8.8	2.5	12.0	16.0	Q1
PCF8575DBR	SSOP	DB	24	2000	330.0	16.4	8.2	8.8	2.5	12.0	16.0	Q1
PCF8575DGVR	TVSOP	DGV	24	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
PCF8575DWR	SOIC	DW	24	2000	330.0	24.4	10.75	15.7	2.7	12.0	24.0	Q1
PCF8575RGER	VQFN	RGE	24	3000	330.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PCF8575DBQR	SSOP	DBQ	24	2500	356.0	356.0	35.0
PCF8575DBR	SSOP	DB	24	2000	356.0	356.0	35.0
PCF8575DBR	SSOP	DB	24	2000	356.0	356.0	35.0
PCF8575DGVR	TVSOP	DGV	24	2000	356.0	356.0	35.0
PCF8575DWR	SOIC	DW	24	2000	350.0	350.0	43.0
PCF8575RGER	VQFN	RGE	24	3000	367.0	367.0	35.0

**RGE 24**

**GENERIC PACKAGE VIEW**

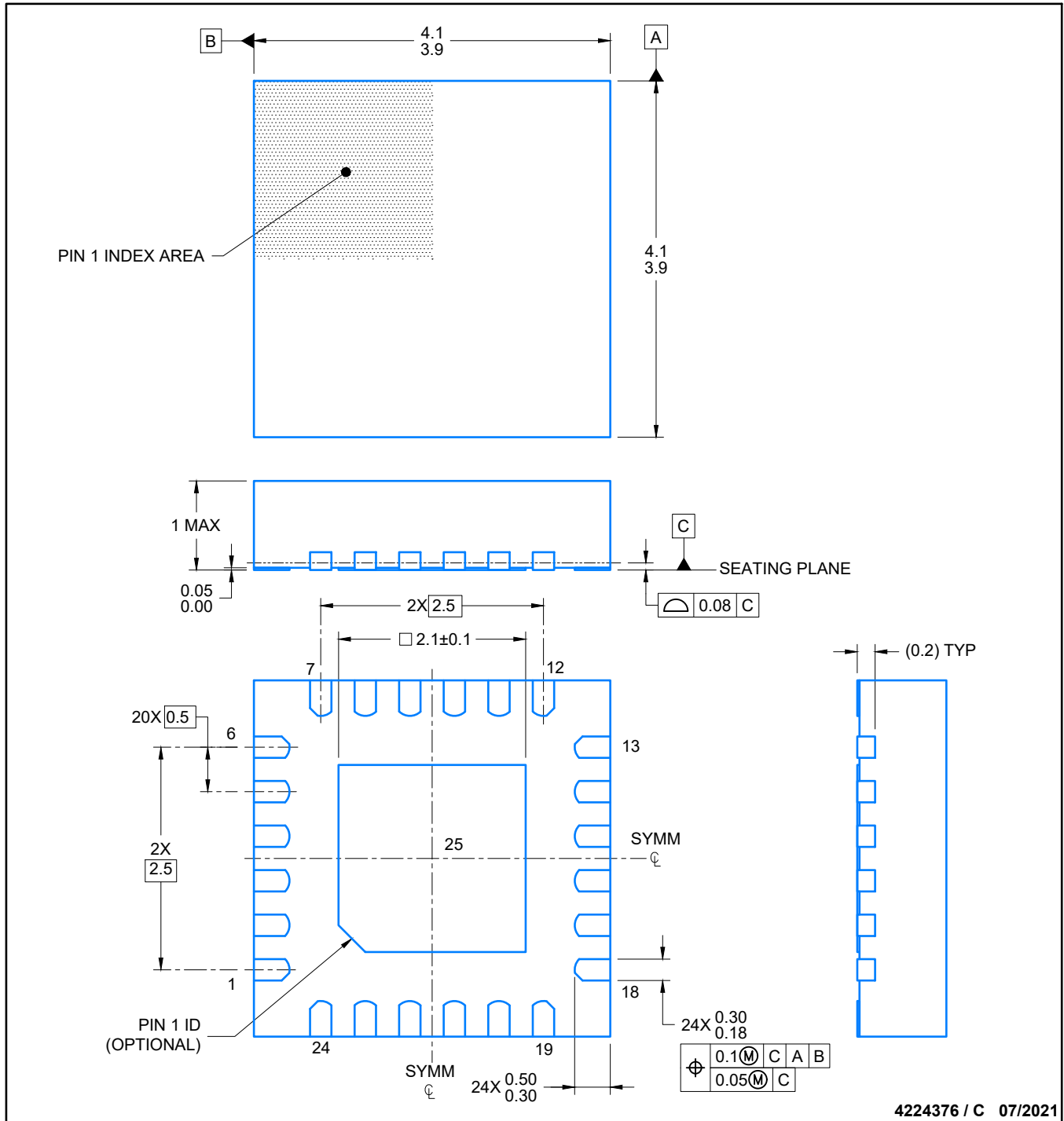
**VQFN - 1 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



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

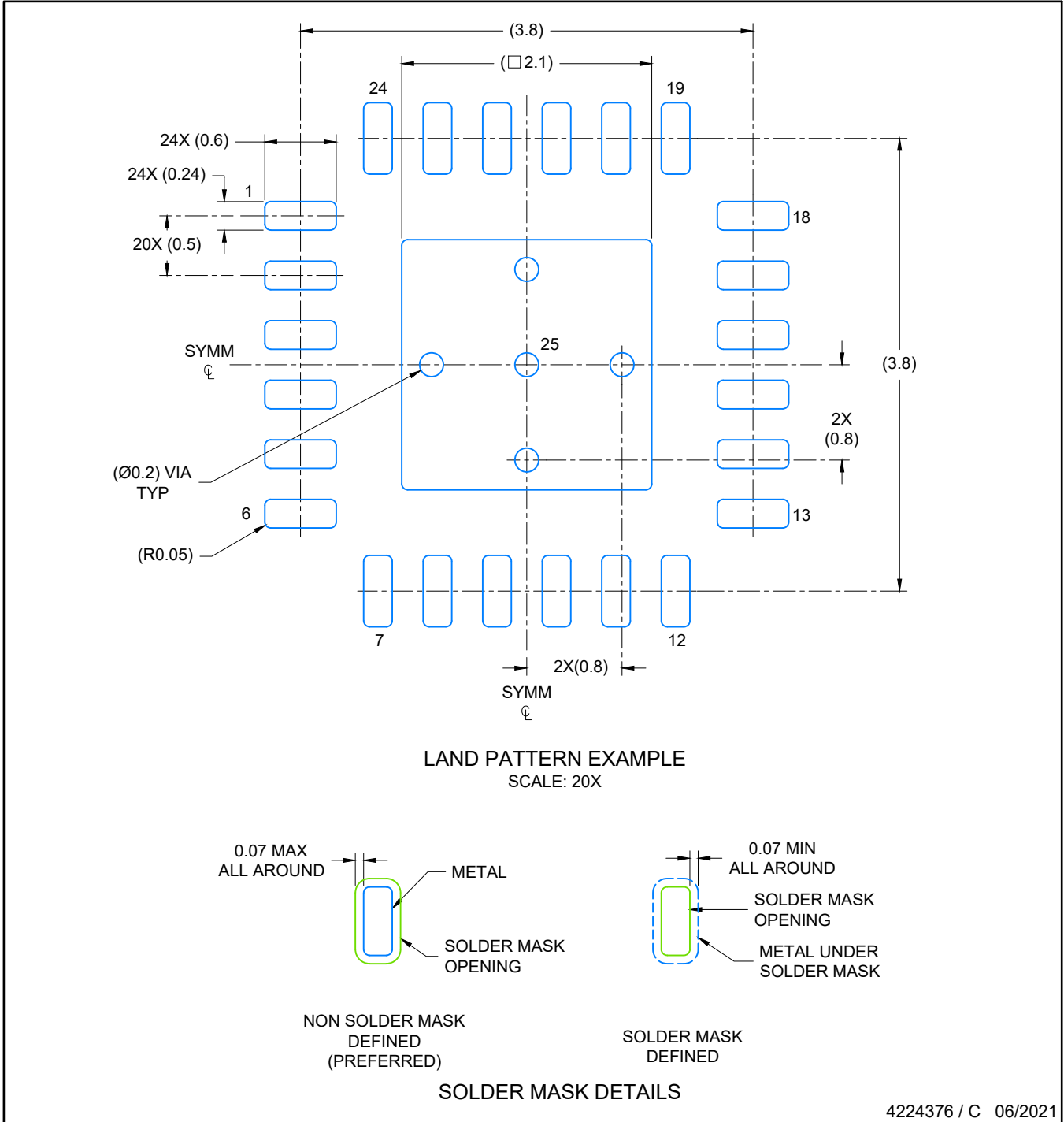
4204104/H



4224376 / C 07/2021

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.



NOTES: (continued)

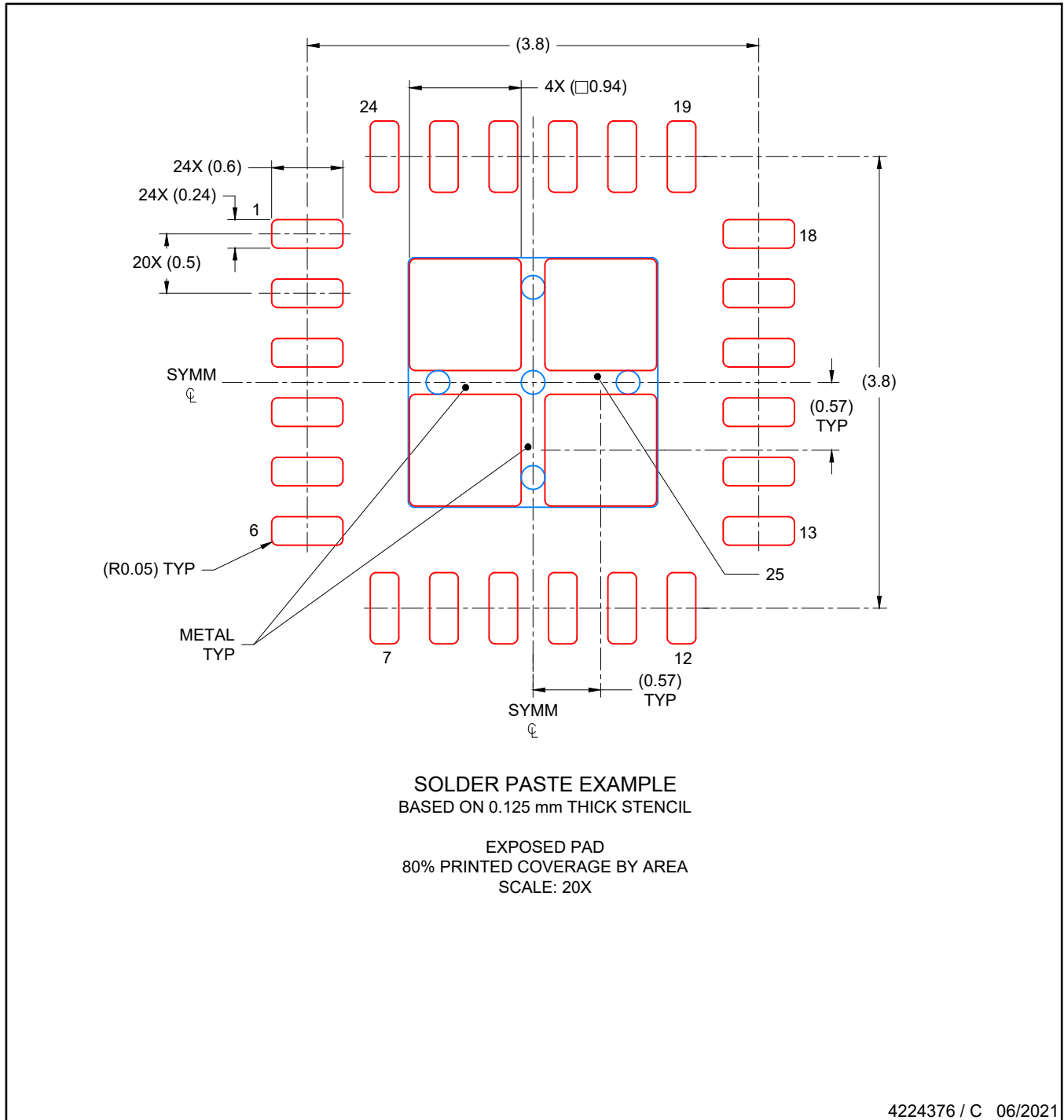
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

RGE0024C

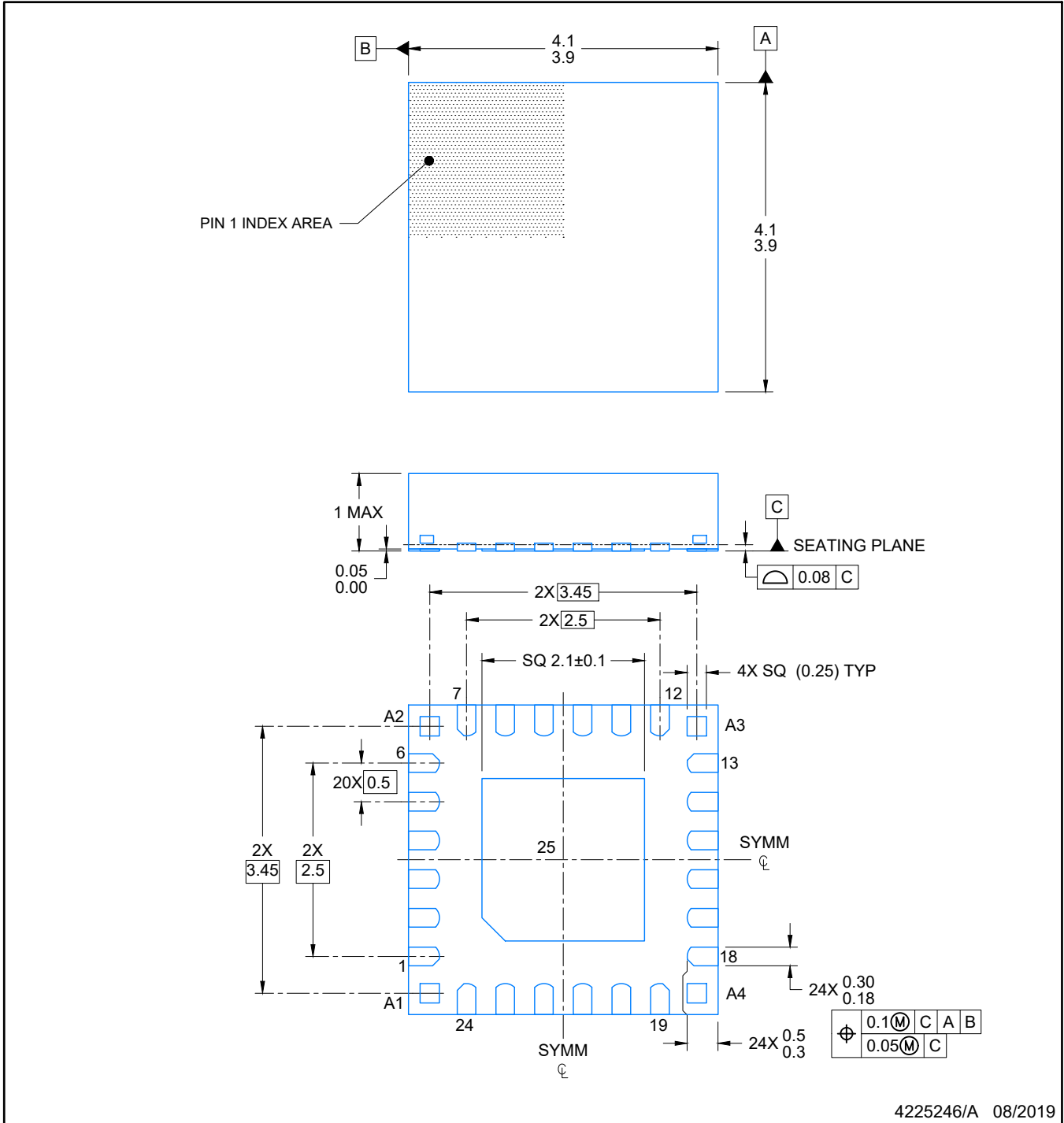
VQFN - 1 mm max height

PLASTIC QUAD FLATPACK- NO LEAD



NOTES: (continued)

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



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 optimal thermal and mechanical performance.

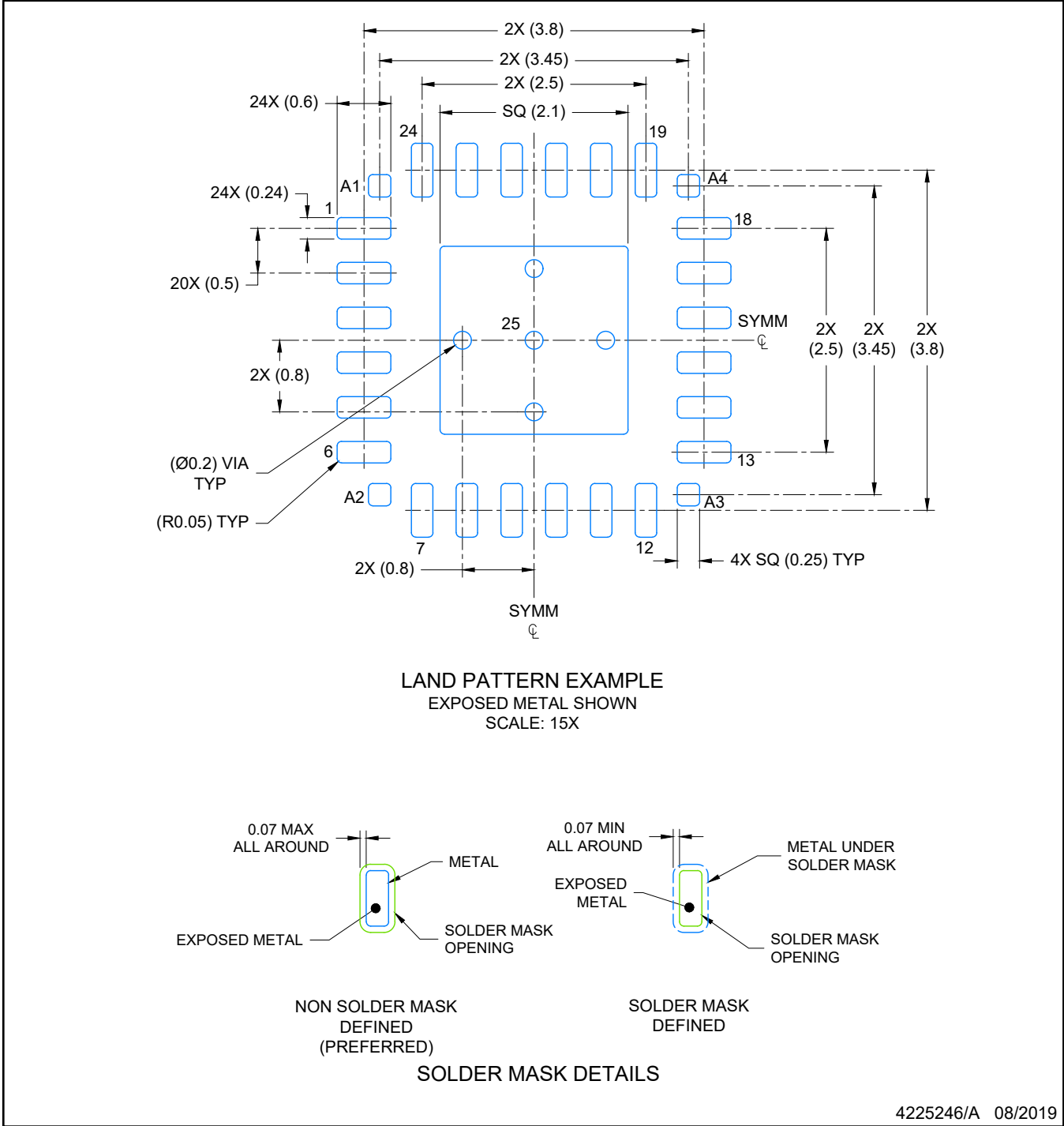


# EXAMPLE BOARD LAYOUT

RGE0024R

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK-NO LEAD



NOTES: (continued)

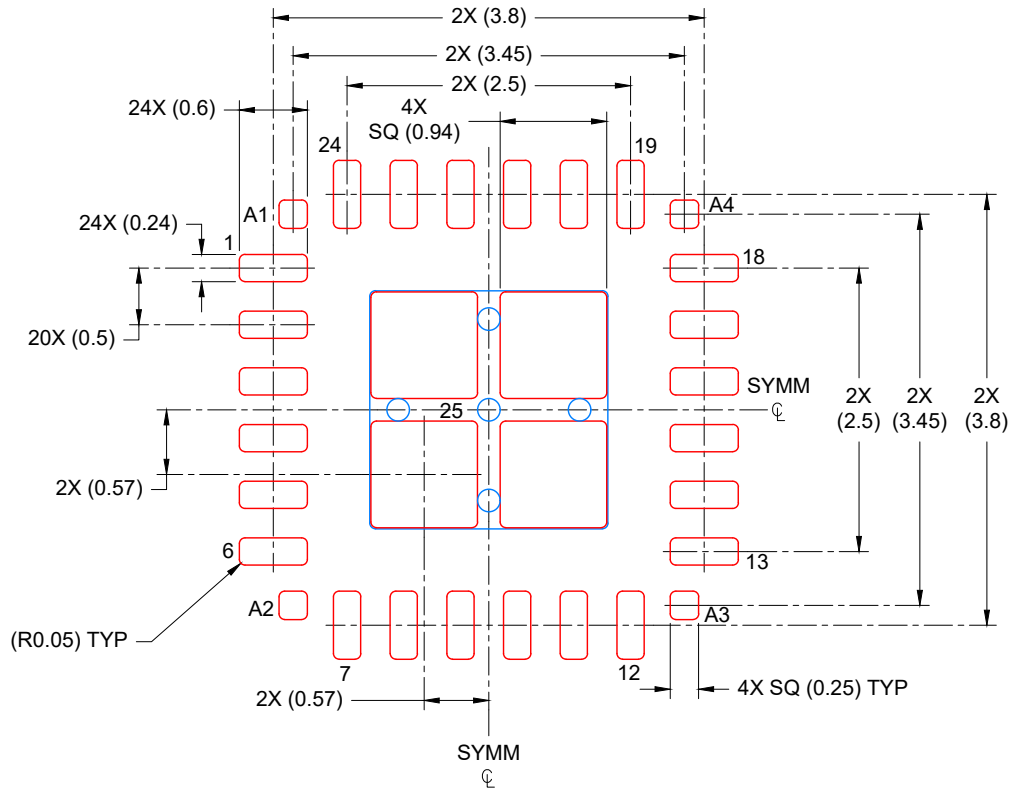
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

RGE0024R

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK-NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD  
80% PRINTED COVERAGE BY AREA  
SCALE: 15X

4225246/A 08/2019

NOTES: (continued)

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



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

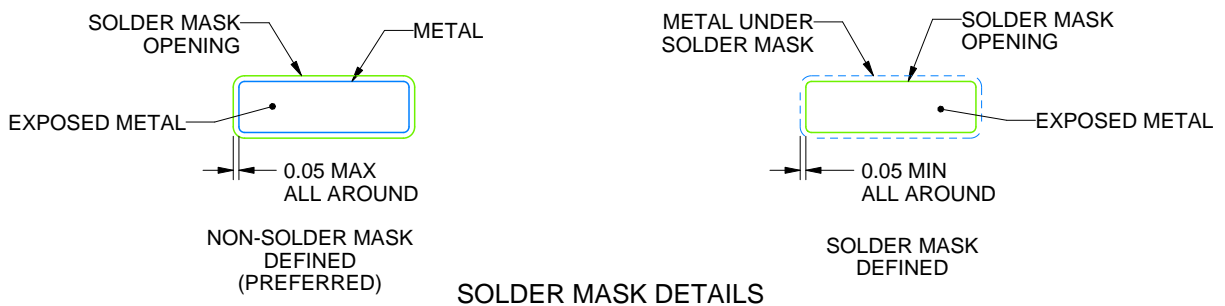
PW0024A

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)

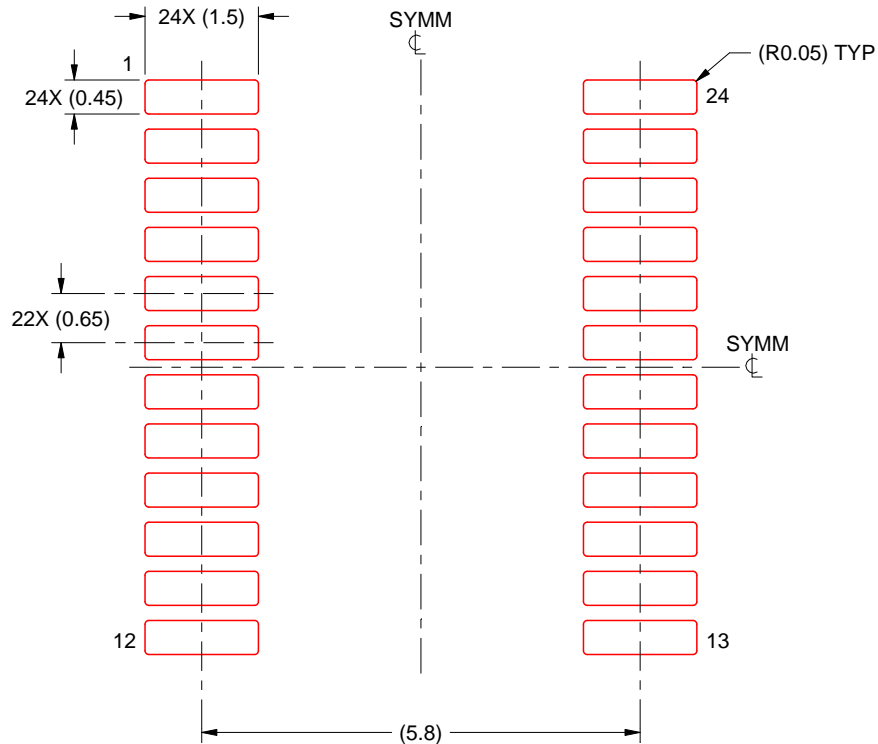
- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

PW0024A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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

4220208/A 02/2017

NOTES: (continued)

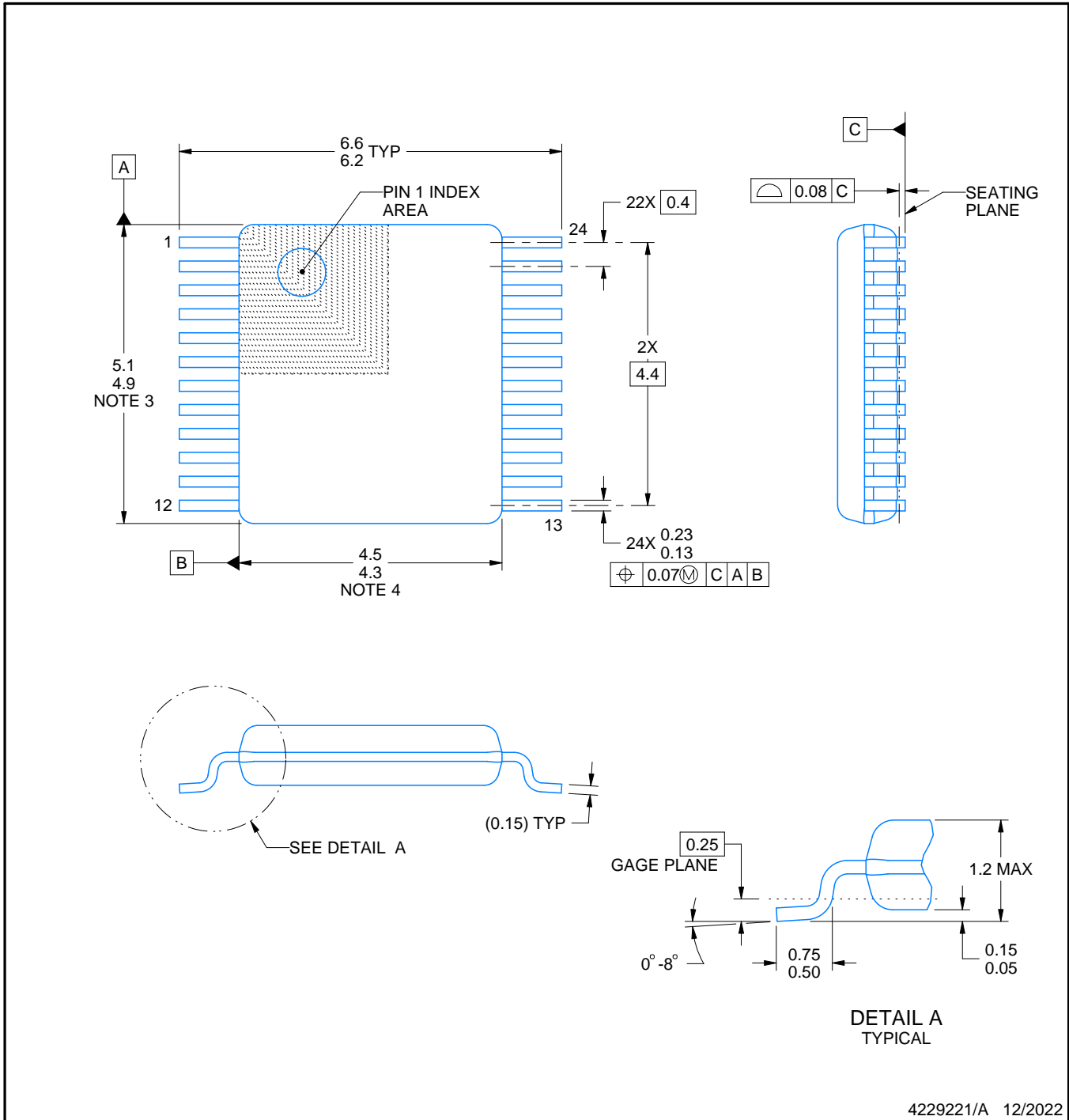
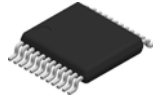
- 8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
- 9. Board assembly site may have different recommendations for stencil design.

DW (R-PDSO-G24)

PLASTIC SMALL OUTLINE



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



4229221/A 12/2022

NOTES:

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

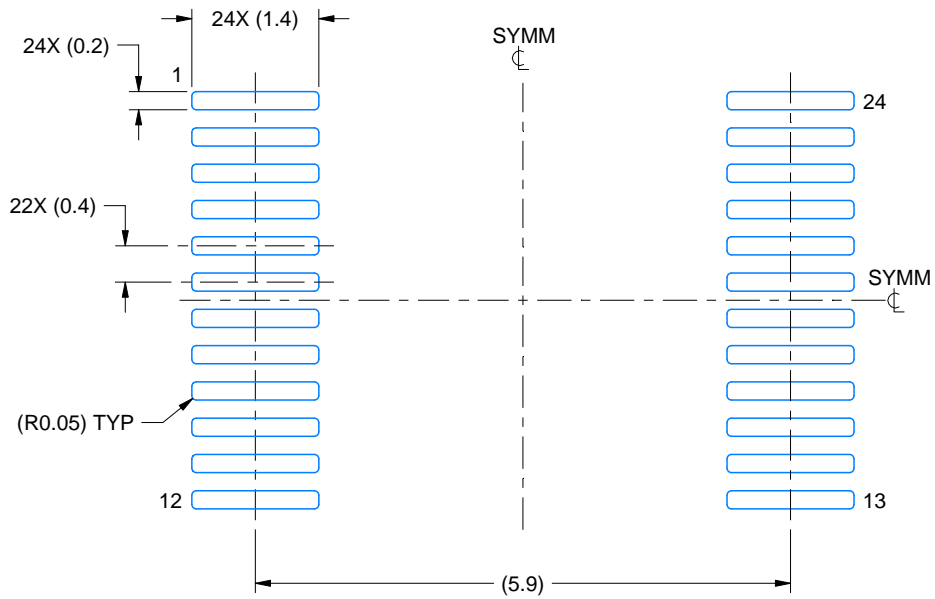


# EXAMPLE BOARD LAYOUT

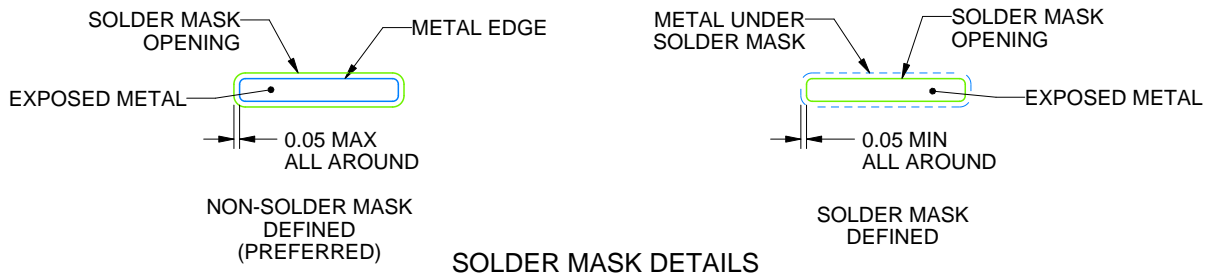
DGV0024A

TVSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 12X



SOLDER MASK DETAILS

4229221/A 12/2022

NOTES: (continued)

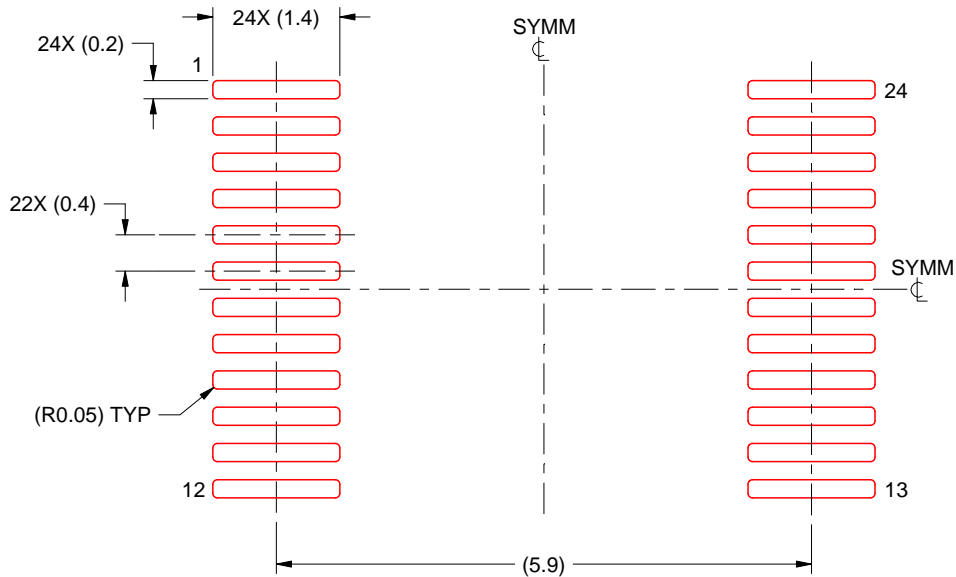
- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

DGV0024A

TVSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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

4229221/A 12/2022

NOTES: (continued)

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

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

PLASTIC SMALL-OUTLINE

28 PINS SHOWN



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

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