PCA9546A Low Voltage 4-Channel I²C and SMBus Switch with Reset Function

1 Features

- 1-of-4 Bidirectional Translating Switches
- I²C Bus and SMBus Compatible
- Active-Low Reset Input
- Three Address Pins, Allowing up to Eight PCA9546A Devices on the I²C Bus
- Channel Selection Via I²C Bus, in Any Combination
- Power-up With All Switch Channels Deselected
- Low R_{ON} Switches
- Allows Voltage-Level Translation Between 1.8-V, 2.5-V, 3.3-V, and 5-V Buses
- No Glitch on Power-up
- Supports Hot Insertion
- Low Standby Current
- Operating Power-Supply Voltage Range of 2.3 V to 5.5 V
- 5.5 V Tolerant Inputs
- 0 to 400-kHz Clock Frequency
- Latch-Up Performance Exceeds 100 mA Per JESD 78
- ESD Protection Exceeds JESD 22
  - 2000-V Human-Body Model (A114-A)
  - 1000-V Charged-Device Model (C101)

2 Applications

- Servers
- Routers (Telecom Switching Equipment)
- Factory Automation
- Products With I²C Slave Address Conflicts (For Example, Multiple, Identical Temp Sensors)

3 Description

The PCA9546A is a quad bidirectional translating switch controlled via the I²C bus. The SCL/SDA upstream pair fans out to four downstream pairs, or channels. Any individual SCn/SDn channel or combination of channels can be selected, determined by the contents of the programmable control register.

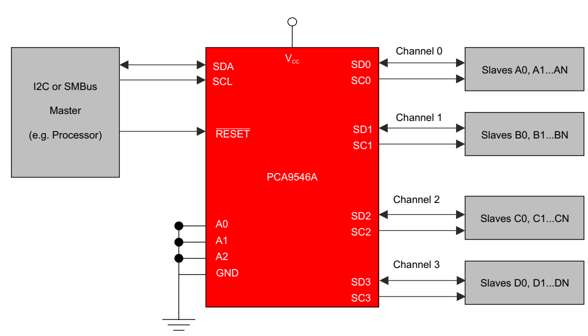
An active-low reset ($\overline{\text{RESET}}$) input allows the PCA9546A to recover from a situation in which one of the downstream I²C buses is stuck in a low state. Pulling $\overline{\text{RESET}}$ low resets the I²C state machine and causes all the channels to be deselected, as does the internal power-on reset function.

The pass gates of the switches are constructed such that the V_{CC} pin can be used to limit the maximum high voltage, which will be passed by the PCA9546A. This allows the use of different bus voltages on each pair, so that 1.8-V, 2.5-V, or 3.3-V parts can communicate with 5-V parts without any additional protection. External pull-up resistors pull the bus up to the desired voltage level for each channel. All I/O pins are 5.5-V tolerant.

Packaging Information

PART NUMBER	PACKAGE(1)	BODY SIZE (NOM)
PCA9546A	SOIC (D) (16)	9.90 mm x 3.91 mm
	TVSOP (DGV) (16)	3.60 mm x 4.40 mm
	SOIC (DW) (16)	10.3 mm x 7.50 mm
	TSSOP (PW) (16)	5.00 mm x 4.40 mm
	VQFN (RGV) (16)	4.00 mm x 4.00 mm
	VQFN (RGY) (16)	4.50 mm x 3.50 mm

(1) For all available packages, see the orderable addendum at the end of the datasheet.



Simplified Application Diagram

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4 Revision History

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

Changes from Revision H (March 2021) to Revision I (June 2022) **Page**

- Changed TSSOP (PW) (16) From: 9.70 mm x 4.40 mm To: 5.00 mm x 4.40 mm in the *Packaging Information* table....1

Changes from Revision G (May 2016) to Revision H (March 2021) **Page**

- Changed the *Packaging Information* table....1
- Moved the Package thermal impedance to the *Thermal Information* table....4
- Added the *Thermal Information* table....4
- Changed the V_{PORR} row in the *Electrical Characteristics*....5
- Added V_{PORF} row to the *Electrical Characteristics*....5
- Changed the I_{CC} Low inputs and High inputs values in the *Electrical Characteristics*....5
- Changed the R_{on} (4.5 V to 5.5 V) TYP value From: 9 Ω To: 10 Ω in the *Electrical Characteristics*....5
- Changed the R_{on} (3 V to 3.6 V) TYP value From: 11 Ω To: 13 Ω in the *Electrical Characteristics*....5
- Changed the *Power Supply Recommendations*....19

Changes from Revision F (April 2014) to Revision G (May 2016) **Page**

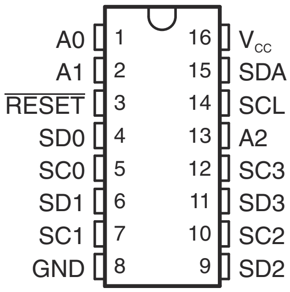
- Revised pack material addendum; pin 1 quadrant....22

Changes from Revision E (January 2008) to Revision F (April 2014) **Page**

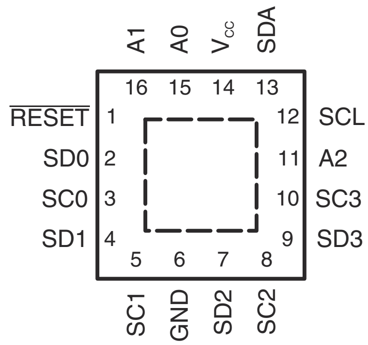
- Added $\overline{RESET}$ Errata section....11

5 Pin Configuration and Functions

D, DGV, DW, OR PW PACKAGE
(TOP VIEW)



RGV PACKAGE
(TOP VIEW)



RGY PACKAGE
(TOP VIEW)

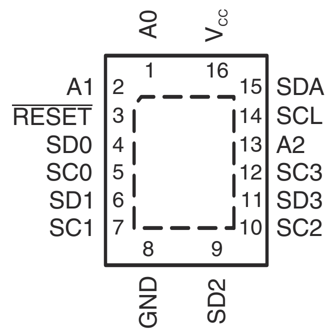


Table 5-1. Pin Functions

PIN			DESCRIPTION
NAME	NO.		
	D, DGV, DW, PW, AND RGY	RGV	
A0	1	15	Address input 0. Connect directly to V_{CC} or ground
A1	2	16	Address input 1. Connect directly to V_{CC} or ground
A2	13	11	Address input 2. Connect directly to V_{CC} or ground
GND	8	6	Ground
$\overline{RESET}$	3	1	Active low reset input. Connect to V_{DPUM} (1) through a pull-up resistor, if not used.
SD0	4	2	Serial data 0. Connect to V_{DPU0} (1) through a pull-up resistor
SC0	5	3	Serial clock 0. Connect to V_{DPU0} (1) through a pull-up resistor
SD1	6	4	Serial data 1. Connect to V_{DPU1} (1) through a pull-up resistor
SC1	7	5	Serial clock 1. Connect to V_{DPU1} (1) through a pull-up resistor
SD2	9	7	Serial data 2. Connect to V_{DPU2} (1) through a pull-up resistor
SC2	10	8	Serial clock 2. Connect to V_{DPU2} (1) through a pull-up resistor
SD3	11	9	Serial data 3. Connect to V_{DPU3} (1) through a pull-up resistor.
SC3	12	10	Serial clock 3. Connect to V_{DPU3} (1) through a pull-up resistor
SCL	14	12	Serial clock line. Connect to V_{DPUM} (1) through a pull-up resistor
SDA	15	13	Serial data line. Connect to V_{DPUM} (1) through a pull-up resistor
V_{CC}	16	14	Supply power

(1) V_{DPUX} is the pull-up reference voltage for the associated data line. V_{DPUM} is the master I^2C reference voltage while V_{DPU0} - V_{DPU3} are the slave channel reference voltages.

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V_{CC}	Supply voltage	–0.5	7	V
V_I	Input voltage [2]	–0.5	7	V
I_I	Input current		±20	mA
I_O	Output current		±25	mA
	Continuous current through V_{CC}		±100	mA
	Continuous current through GND		±100	mA
P_{tot}	Total power dissipation		400	mW
T_A	Operating free-air temperature	–40	85	°C
T_{stg}	Storage temperature	–65	150	

(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 *Recommended Operating Conditions*. 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

See [1]

			MIN	MAX	UNIT
V_{CC}	Supply voltage		2.3	5.5	V
V_{IH}	High-level input voltage	SCL, SDA	0.7 × V_{CC}	6	V
		A2–A0, $\overline{RESET}$	0.7 × V_{CC}	V_{CC} + 0.5	
V_{IL}	Low-level input voltage	SCL, SDA	–0.5	0.3 × V_{CC}	V
		A2–A0, $\overline{RESET}$	–0.5	0.3 × V_{CC}	
T_A	Operating free-air temperature		–40	85	°C

(1) All unused inputs of the device must be held at V_{CC} or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, SCBA004.

6.4 Thermal Information

THERMAL METRIC[1]		PCA9546A						UNIT
		DGV	DW	PW	RGV	RGY	D	
		16 PINS	16 PINS	16 PINS	16 PINS	16 PINS	16 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	120	57	122.3	63.2	50	92.3	°C/W

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

6.5 Electrical Characteristics

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

PARAMETER			TEST CONDITIONS		V_{CC}	MIN	TYP[(1)]	MAX	UNIT
V_{PORR}	Power-on reset voltage, V_{CC} rising		No load,	$V_I = V_{CC}$ or GND			1.2	1.5	V
V_{PORF}	Power-on reset voltage, V_{CC} falling[(2)]		No load,	$V_I = V_{CC}$ or GND		0.8	1		V
V_{pass}	Switch output voltage		$V_{SWin} = V_{CC}$,	I_{SWout} = –100 µA	5 V		3.6		V
					4.5 V to 5.5 V	2.6		4.5	
					3.3 V		1.9		
					3 V to 3.6 V	1.6		2.8	
					2.5 V		1.5		
					2.3 V to 2.7 V	1.1		2	
I_{OL}	SCL, SDA		V_{OL} = 0.4 V		2.3 V to 5.5 V	3	7		mA
			V_{OL} = 0.6 V			6	10		
I_I	SCL, SDA		$V_I = V_{CC}$ or GND		2.3 V to 5.5 V			±1	µA
	SC3–SC0, SD3–SD0							±1	
	A2–A0							±1	
	$\overline{RESET}$ [(4)]							±1	
I_{CC}	Operating mode	f_{SCL} = 100 kHz	$V_I = V_{CC}$ or GND,	$I_O = 0$	5.5 V		3	12	µA
					3.6 V		3	11	
					2.7 V		3	10	
	Standby mode	Low inputs	V_I = GND,	$I_O = 0$	5.5 V		1.6	2	
					3.6 V		1	1.3	
					2.7 V		0.7	1.1	
		High inputs	$V_I = V_{CC}$,	$I_O = 0$	5.5 V		1.6	2	
					3.6 V		1	1.3	
					2.7 V		0.7	1.1	
ΔI_{CC}	Supply-current change	SCL, SDA	SCL or SDA input at 0.6 V, Other inputs at V_{CC} or GND		2.3 V to 5.5 V		8	15	µA
			SCL or SDA input at V_{CC} – 0.6 V, Other inputs at V_{CC} or GND				8	15	
C_i	A2–A0		$V_I = V_{CC}$ or GND		2.3 V to 5.5 V		4.5	6	pF
	$\overline{RESET}$						4.5	5.5	
$C_{io(OFF)}$ [(3)]	SCL, SDA		$V_I = V_{CC}$ or GND,	Switch OFF	2.3 V to 5.5 V		15	19	pF
	SC3–SC0, SD3–SD0						6	8	
R_{ON}	Switch on-state resistance		V_O = 0.4 V,	I_O = 15 mA	4.5 V to 5.5 V	4	10	16	Ω
					3 V to 3.6 V	5	13	20	
			V_O = 0.4 V,	I_O = 10 mA	2.3 V to 2.7 V	7	16	45	

(1) All typical values are at nominal supply voltage (2.5-V, 3.3-V, or 5-V V_{CC}), T_A = 25°C.
(2) The power-on reset circuit resets the I2C bus logic with $V_{CC} < V_{PORF}$.
(3) $C_{io(ON)}$ depends on internal capacitance and external capacitance added to the SCn lines when channels(s) are ON.
(4) $\overline{RESET} = V_{CC}$ (held high) when all other input voltages, V_I = GND.

6.6 I^2C Interface Timing Requirements

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

			MIN	MAX	UNIT
I^2C BUS—STANDARD MODE					
f_{scl}	I^2C clock frequency		0	100	kHz
t_{sch}	I^2C clock high time		4		μs
t_{scl}	I^2C clock low time		4.7		μs
t_{sp}	I^2C spike time			50	ns
t_{sds}	I^2C serial-data setup time		250		ns
t_{sdh}	I^2C serial-data hold time		0[1]		ns
t_{icr}	I^2C input rise time			1000	ns
t_{icf}	I^2C input fall time			300	ns
t_{ocf}	I^2C output fall time	10-pF to 400-pF bus		300	ns
t_{buf}	I^2C bus free time between stop and start		4.7		μs
t_{sts}	I^2C start or repeated start condition setup		4.7		μs
t_{sth}	I^2C start or repeated start condition hold		4		μs
t_{sps}	I^2C stop condition setup		4		μs
$t_{vdL(Data)}$	Valid data time (high to low)[2]	SCL low to SDA output low valid		1	μs
$t_{vdH(Data)}$	Valid data time (low to high)[2]	SCL low to SDA output high valid		0.6	μs
$t_{vd(ack)}$	Valid data time of ACK condition	ACK signal from SCL low to SDA (out) low		1	μs
C_b	I^2C bus capacitive load			400	pF

(1) A device internally must provide a hold time of at least 300 ns for the SDA signal (referred to the V_{IH} min of the SCL signal), in order to bridge the undefined region of the falling edge of SCL.
(2) Data taken using a 1-kΩ pull-up resistor and 50-pF load (see Figure 7-1)

			MIN	MAX	UNIT
I^2C BUS—FAST MODE					
f_{scl}	I^2C clock frequency		0	400	kHz
t_{sch}	I^2C clock high time		0.6		μs
t_{scl}	I^2C clock low time		1.3		μs
t_{sp}	I^2C spike time			50	ns
t_{sds}	I^2C serial-data setup time		100		ns
t_{sdh}	I^2C serial-data hold time		0[1]		ns
t_{icr}	I^2C input rise time		$20 + 0.1C_b$ [2]	300	ns
t_{icf}	I^2C input fall time		$20 + 0.1C_b$ [2]	300	ns
t_{ocf}	I^2C output fall time	10-pF to 400-pF bus	$20 + 0.1C_b$ [2]	300	ns
t_{buf}	I^2C bus free time between stop and start		1.3		μs
t_{sts}	I^2C start or repeated start condition setup		0.6		μs
t_{sth}	I^2C start or repeated start condition hold		0.6		μs
t_{sps}	I^2C stop condition setup		0.6		μs
$t_{vdL(Data)}$	Valid data time (high to low)[3]	SCL low to SDA output low valid		1	μs
$t_{vdH(Data)}$	Valid data time (low to high)[3]	SCL low to SDA output high valid		0.6	
$t_{vd(ack)}$	Valid data time of ACK condition	ACK signal from SCL low to SDA (out) low		1	μs
C_b	I^2C bus capacitive load			400	pF

(1) A device internally must provide a hold time of at least 300 ns for the SDA signal (referred to the V_{IH} min of the SCL signal), in order to bridge the undefined region of the falling edge of SCL.
(2) C_b = total bus capacitance of one bus line in pF
(3) Data taken using a 1-kΩ pull-up resistor and 50-pF load (see Figure 7-1)

6.7 Interrupt and Reset Timing Requirements

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

PARAMETER		MIN	MAX	UNIT
t_{WL}	Pulse duration, $\overline{\text{RESET}}$ low	6		ns
t_{rst} [(1)]	$\overline{\text{RESET}}$ time (SDA clear)		500	ns
$t_{REC(STA)}$	Recovery time from $\overline{\text{RESET}}$ to start	0		ns

(1) t_{rst} is the propagation delay measured from the time the $\overline{\text{RESET}}$ pin is first asserted low to the time the SDA pin is asserted high, signaling a stop condition. It must be a minimum of t_{WL}.

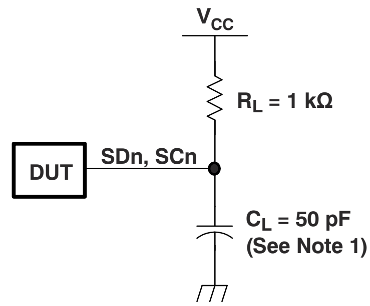
6.8 Switching Characteristics

over recommended operating free-air temperature range, $C_L \leq 100$ pF (unless otherwise noted) (see Figure 7-1)

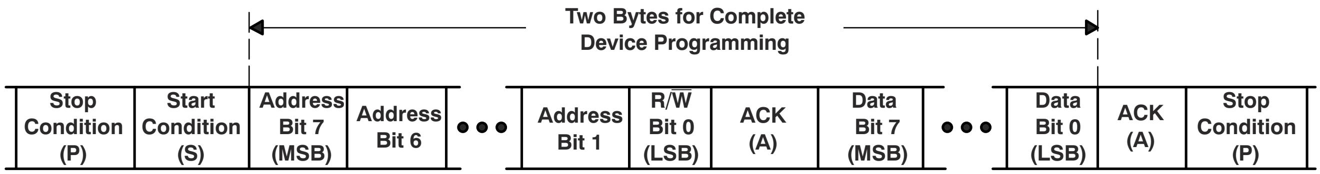
PARAMETER			FROM (INPUT)	TO (OUTPUT)	MIN	MAX	UNIT
t_{pd} [(1)]	Propagation delay time	$R_{ON} = 20\ \Omega$, $C_L = 15$ pF	SDA or SCL	SDn or SCn		0.3	ns
		$R_{ON} = 20\ \Omega$, $C_L = 50$ pF				1	

(1) The propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance).

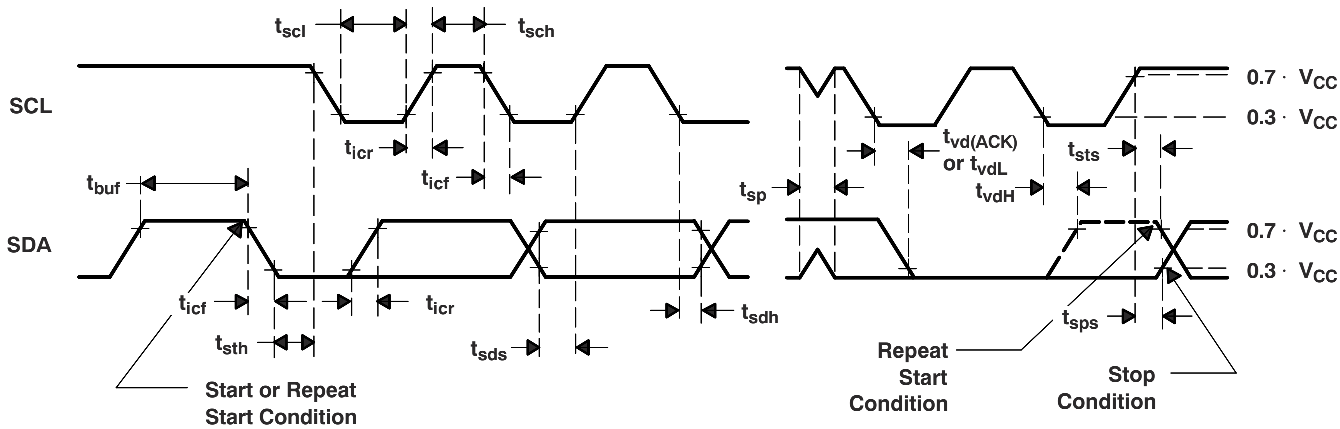
7 Parameter Measurement Information



I²C PORT LOAD CONFIGURATION



BYTE	DESCRIPTION
1	I²C address + R/W̄
2	Control register data



VOLTAGE WAVEFORMS

A. C_L includes probe and jig capacitance.

B. All input pulses 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.

Figure 7-1. I²C Interface Load Circuit, Byte Descriptions, and Voltage Waveforms

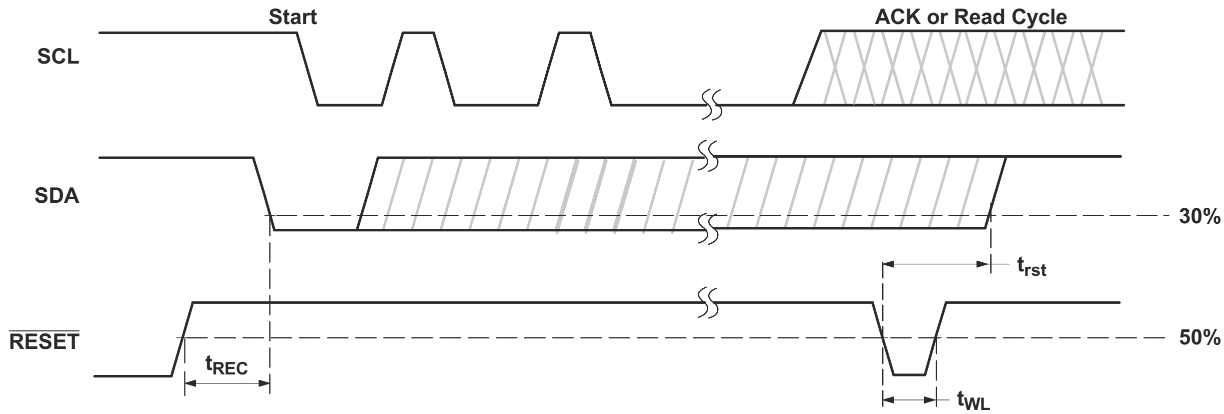


Figure 7-2. Reset Timing

8 Detailed Description

8.1 Overview

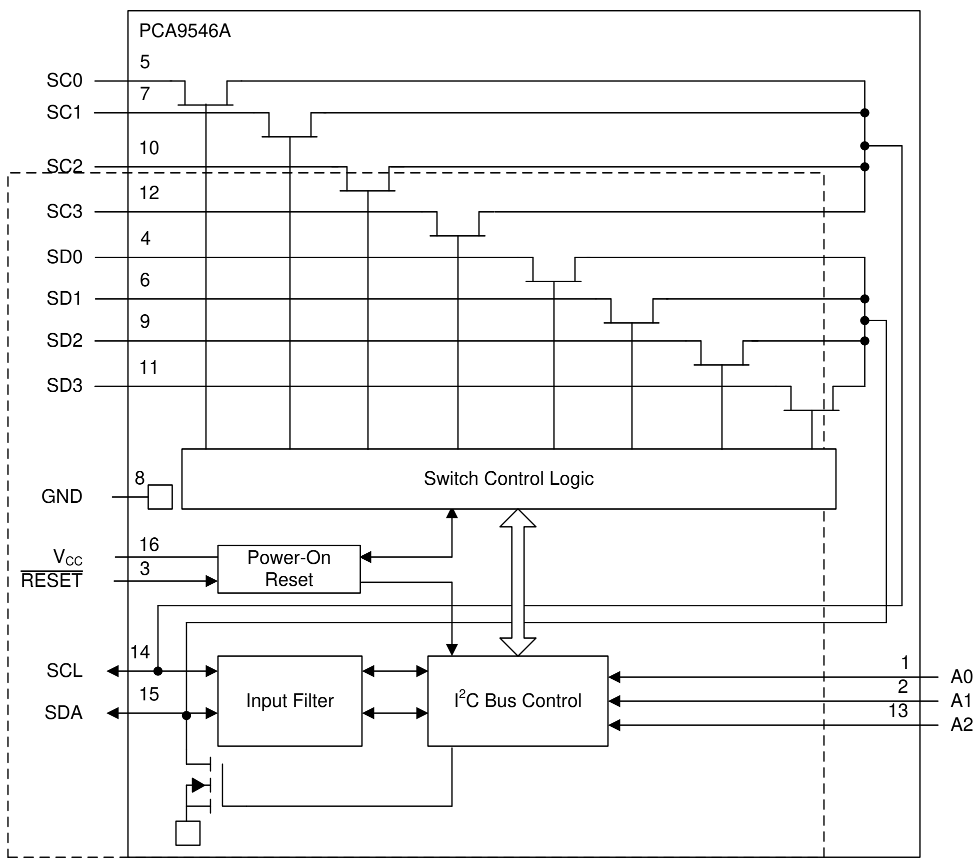
The PCA9546A is a 4-channel, bidirectional translating I²C switch. The master SCL/SDA signal pair is directed to four channels of slave devices, SC0/SD0-SC3/SD3. Any individual downstream channel can be selected as well as any combination of the four channels.

The device offers an active-low $\overline{\text{RESET}}$ input which resets the state machine and allows the PCA9546A to recover should one of the downstream I²C buses get stuck in a low state. The state machine of the device can also be reset by cycling the power supply, V_{CC}, also known as a power-on reset (POR). Both the $\overline{\text{RESET}}$ function and a POR will cause all channels to be deselected.

The connections of the I²C data path are controlled by the same I²C master device that is switched to communicate with multiple I²C slaves. After the successful acknowledgment of the slave address (hardware selectable by A0 and A1 pins), a single 8-bit control register is written to or read from to determine the selected channels.

The PCA9546A may also be used for voltage translation, allowing the use of different bus voltages on each SCn/SDn pair such that 1.8-V, 2.5-V, or 3.3-V parts can communicate with 5-V parts. This is achieved by using external pull-up resistors to pull the bus up to the desired voltage for the master and each slave channel.

8.2 Functional Block Diagram



8.3 Feature Description

The PCA9546A is a 4-channel, bidirectional translating switch for I^2C buses that supports Standard-Mode (100 kHz) and Fast-Mode (400 kHz) operation. The PCA9546A features I^2C control using a single 8-bit control register in which the four least significant bits control the enabling and disabling of the 4 switch channels of I^2C data flow. Depending on the application, voltage translation of the I^2C bus can also be achieved using the PCA9546A to allow 1.8-V, 2.5-V, or 3.3-V parts to communicate with 5-V parts. Additionally, in the event that communication on the I^2C bus enters a fault state, the PCA9546A can be reset to resume normal operation using the $\overline{\text{RESET}}$ pin feature or by a power-on reset which results from cycling power to the device.

8.4 Device Functional Modes

8.4.1 $\overline{\text{RESET}}$ Input

The $\overline{\text{RESET}}$ input is an active-low signal that may be used to recover from a bus-fault condition. When this signal is asserted low for a minimum of t_{WL}, the PCA9546A resets its registers and I^2C state machine and deselects all channels. The $\overline{\text{RESET}}$ input must be connected to V_{CC} through a pull-up resistor.

8.4.1.1 $\overline{\text{RESET}}$ Errata

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

System Impact

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

System Workaround

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

8.4.2 Power-On Reset

When power is applied to V_{CC}, an internal power-on reset holds the PCA9546A in a reset condition until V_{CC} has reached V_{POR}. At this point, the reset condition is released, and the PCA9546A registers and I^2C state machine are initialized to their default states, all zeroes, causing all the channels to be deselected. Thereafter, V_{CC} must be lowered below V_{POR} to reset the device.

8.5 Programming

8.5.1 I^2C Interface

The I^2C bus is for two-way two-line communication between different ICs or modules. The two lines are a serial data line (SDA) and a serial clock line (SCL). Both lines must be connected to a positive supply via a pull-up resistor when connected to the output stages of a device. Data transfer can be initiated only when the bus is not busy.

One data bit is transferred during each clock pulse. The data on the SDA line must remain stable during the high period of the clock pulse, as changes in the data line at this time are interpreted as control signals (see Figure 8-1).

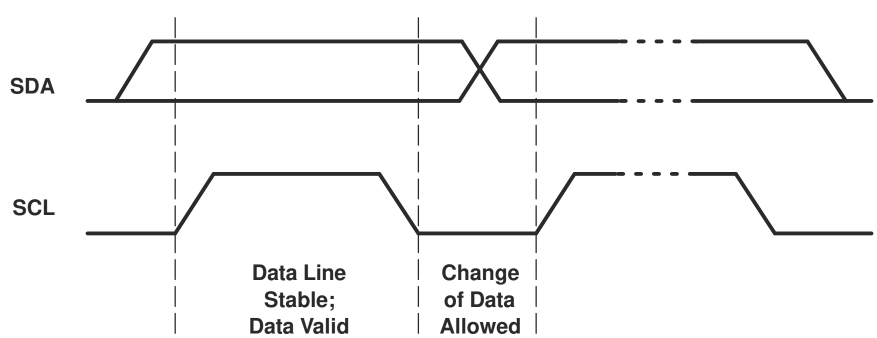


Figure 8-1. Bit Transfer

Both data and clock lines remain high when the bus is not busy. A high-to-low transition of the data line while the clock is high is defined as the start condition (S). A low-to-high transition of the data line while the clock is high is defined as the stop condition (P) (see Figure 8-2).

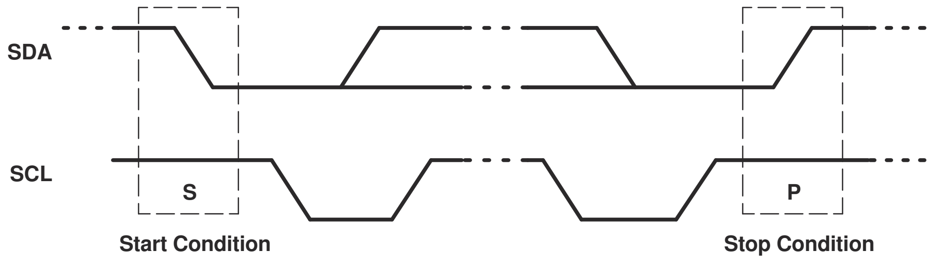


Figure 8-2. Definition of Start and Stop Conditions

A device generating a message is a transmitter; a device receiving is the receiver. The device that controls the message is the master, and the devices that are controlled by the master are the slaves (see Figure 8-3).

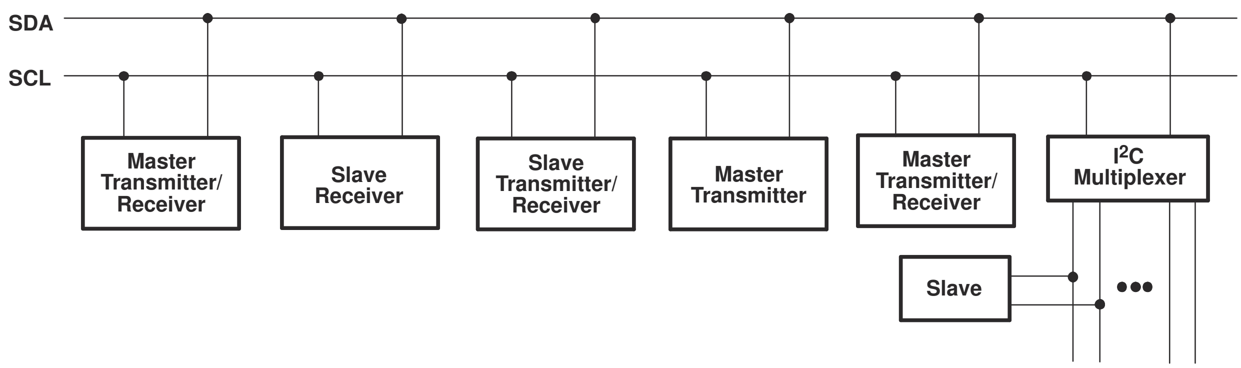


Figure 8-3. System Configuration

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

When a slave receiver is addressed, it must generate an ACK after the reception of each byte. Also, a master must generate an ACK after the reception of each byte that has been clocked out of the slave transmitter. The device that acknowledges must pull down the SDA line during the ACK clock pulse so that the SDA line is stable low during the high pulse of the ACK-related clock period (see Figure 8-4). Setup and hold times must be taken into account.

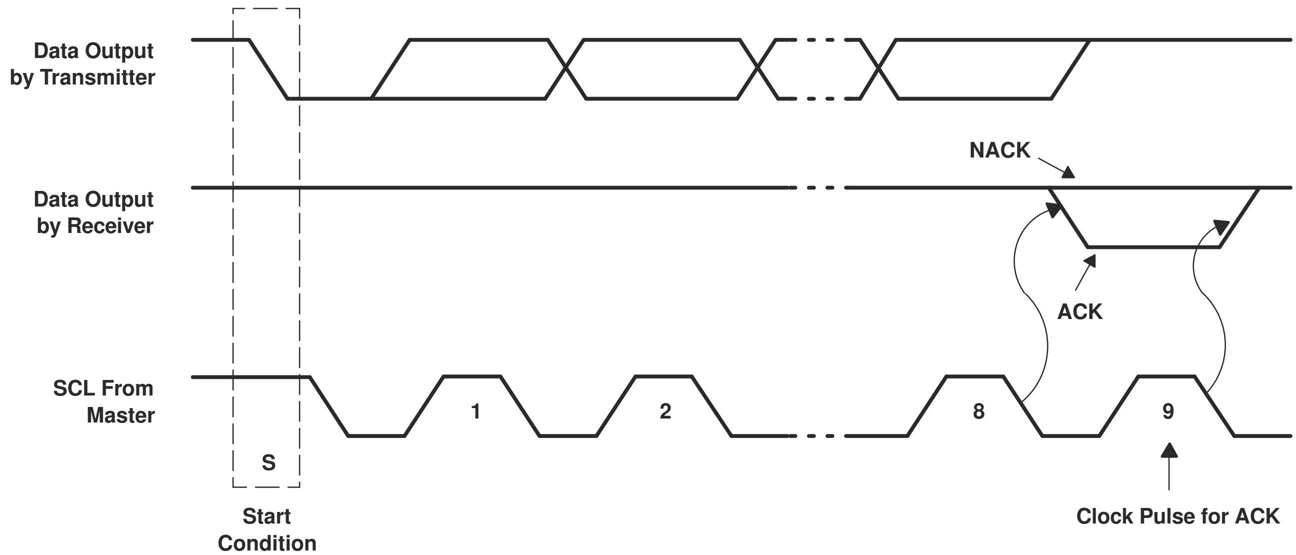


Figure 8-4. Acknowledgment on the I²C Bus

Data is transmitted to the PCA9546A control register using the write mode shown in Figure 8-5.

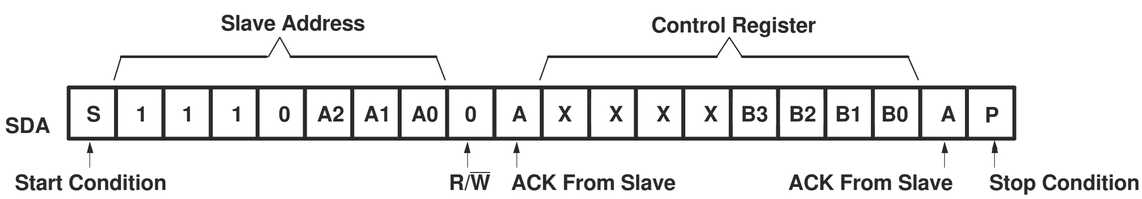


Figure 8-5. Write Control Register

Data is read from the PCA9546A control register using the read mode shown in Figure 8-6.

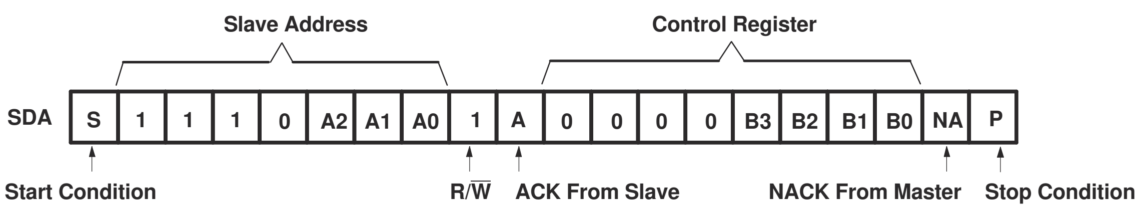


Figure 8-6. Read Control Register

8.6 Control Register

8.6.1 Device Address

Following a start condition, the bus master must output the address of the slave it is accessing. The address of the PCA9546A is shown in Figure 8-7. To conserve power, no internal pull-up resistors are incorporated on the hardware-selectable address pins, and they must be pulled high or low.

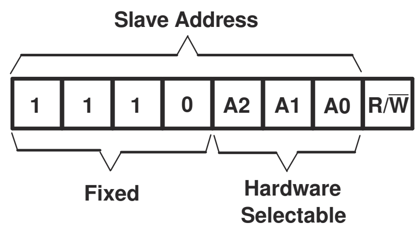


Figure 8-7. PCA9546A Address

The last bit of the slave address defines the operation to be performed. When set to a logic 1, a read is selected, while a logic 0 selects a write operation.

8.6.2 Control Register Description

Following the successful acknowledgment of the slave address, the bus master sends a byte to the PCA9546A, which is stored in the control register (see Figure 8-8). If multiple bytes are received by the PCA9546A, it will save the last byte received. This register can be written and read via the I^2C bus.

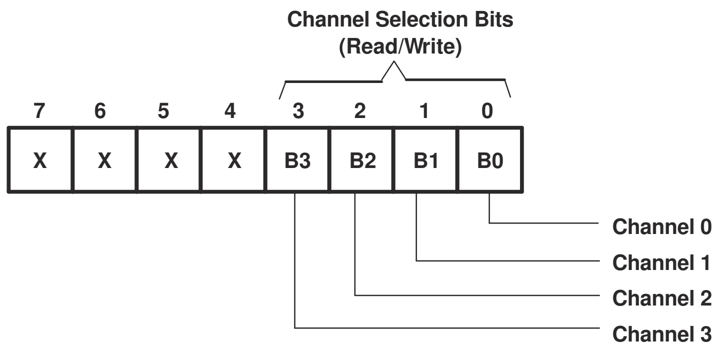


Figure 8-8. Control Register

8.6.3 Control Register Definition

One or several SCn/SDn downstream pairs, or channels, are selected by the contents of the control register (see Table 8-1). This register is written after the PCA9546A has been addressed. The four LSBs of the control byte are used to determine which channel or channels are to be selected. When a channel is selected, the channel becomes active after a stop condition has been placed on the I^2C bus. This ensures that all SCn/SDn lines are in a high state when the channel is made active, so that no false conditions are generated at the time of connection. A stop condition always must occur right after the acknowledge cycle.

Table 8-1. Control Register Write (Channel Selection), Control Register Read (Channel Status)[(1)]

B7	B6	B5	B4	B3	B2	B1	B0	COMMAND
X	X	X	X	X	X	X	0	Channel 0 disabled
							1	Channel 0 enabled
X	X	X	X	X	X	0	X	Channel 1 disabled
						1		Channel 1 enabled
X	X	X	X	X	0	X	X	Channel 2 disabled
					1			Channel 2 enabled
X	X	X	X	0	X	X	X	Channel 3 disabled
				1				Channel 3 enabled
0	0	0	0	0	0	0	0	No channel selected, power-up/reset default state

(1) Several channels can be enabled at the same time. For example, B3 =0, B2 = 1, B1 = 1, B0 = 0 means that channels 0 and 3 are disabled, and channels 1 and 2 are enabled. Care must be taken not to exceed the maximum bus capacity.

9 Application Information Disclaimer

Note

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

9.1 Application Information

Applications of the PCA9546A will contain an I^2C (or SMBus) master device and up to four I^2C slave devices. The downstream channels are ideally used to resolve I^2C slave address conflicts. For example, if four identical digital temperature sensors are needed in the application, one sensor can be connected at each channel: 0, 1, 2, and 3. When the temperature at a specific location must be read, the appropriate channel can be enabled and all other channels switched off, the data can be retrieved, and the I^2C master can move on and read the next channel.

In an application where the I^2C bus will contain many additional slave devices that do not result in I^2C slave address conflicts, these slave devices can be connected to any desired channel to distribute the total bus capacitance across multiple channels. If multiple switches will be enabled simultaneously, additional design requirements must be considered (See *Design Requirements* and *Detailed Design Procedure*).

9.2 Typical Application

A typical application of the PCA9546A will contain anywhere from 1 to 5 separate data pull-up voltages, V_{DPUX} , one for the master device (V_{DPUM}) and one for each of the selectable slave channels (V_{DPU0} – V_{DPU3}). In the event where the master device and all slave devices operate at the same voltage, then the pass voltage, V_{pass} = V_{DPUX}. Once the maximum V_{pass} is known, V_{CC} can be selected easily using Figure 9-2. In an application where voltage translation is necessary, additional design requirements must be considered (See *Design Requirements*).

Figure 9-1 shows an application in which the PCA9546A can be used.

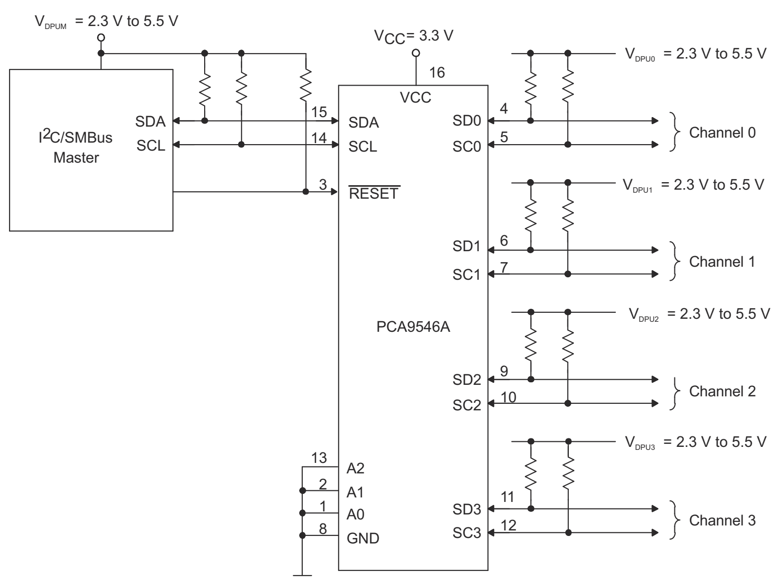


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Figure 9-1. PCA9546A Typical Application Schematic

9.2.1 Design Requirements

The A0, A1, and A2 pins are hardware selectable to control the slave address of the PCA9546A. These pins may be tied directly to GND or V_{CC} in the application.

If multiple slave channels will be activated simultaneously in the application, then the total I_{OL} from SCL/SDA to GND on the master side will be the sum of the currents through all pull-up resistors, R_p.

The pass-gate transistors of the PCA9546A are constructed such that the V_{CC} voltage can be used to limit the maximum voltage that is passed from one I^2C bus to another.

Figure 9-2 shows the voltage characteristics of the pass-gate transistors (note that the graph was generated using data specified in the *Electrical Characteristics* section of this data sheet). In order for the PCA9546A to act as a voltage translator, the V_{pass} voltage must be equal to or lower than the lowest bus voltage. For example, if the main bus is running at 5 V and the downstream buses are 3.3 V and 2.7 V, V_{pass} must be equal to or below 2.7 V to effectively clamp the downstream bus voltages. As shown in Figure 9-2, $V_{pass(max)}$ is 2.7 V when the PCA9546A supply voltage is 4 V or lower, so the PCA9546A supply voltage could be set to 3.3 V. Pull-up resistors then can be used to bring the bus voltages to their appropriate levels (see Figure 9-1).

9.2.2 Detailed Design Procedure

Once all the slaves are assigned to the appropriate slave channels and bus voltages are identified, the pull-up resistors, R_p, for each of the buses need to be selected appropriately. The minimum pull-up resistance is a function of V_{DPUX}, $V_{OL,(max)}$, and I_{OL} as shown in Equation 1:

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

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 as shown in Equation 2:

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

The maximum bus capacitance for an I^2C bus must not exceed 400 pF for fast-mode operation. The bus capacitance can be approximated by adding the capacitance of the PCA9546A, $C_{io(OFF)}$, the capacitance of wires/connections/traces, and the capacitance of each individual slave on a given channel. If multiple channels will be activated simultaneously, each of the slaves on all channels will contribute to total bus capacitance.

9.2.3 Application Curves

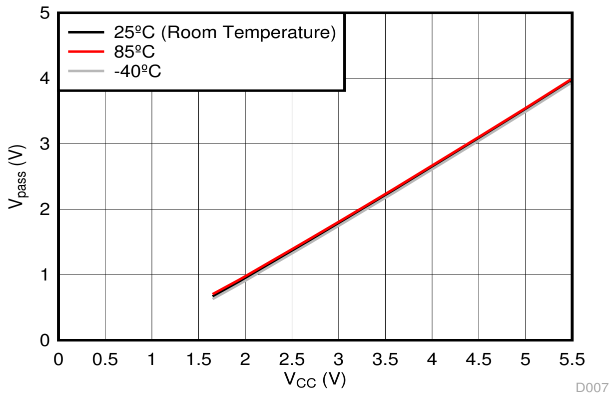
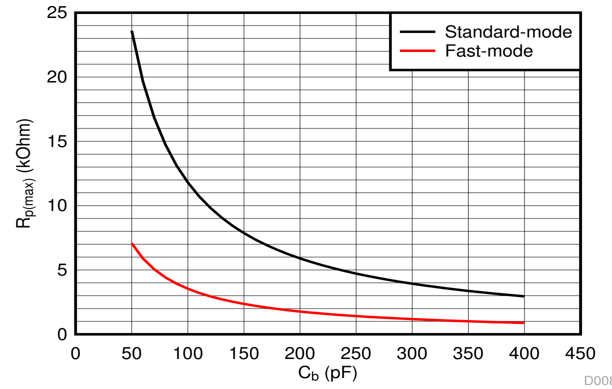


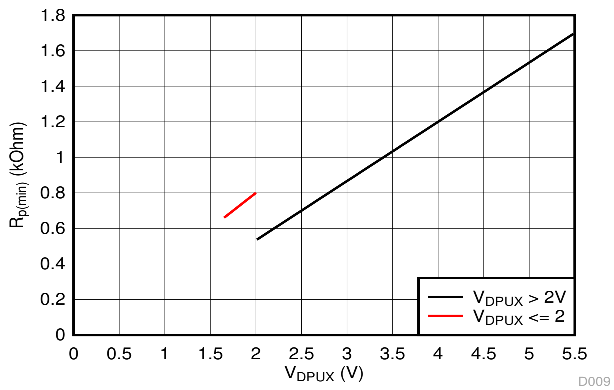
Figure 9-2. Pass-Gate Voltage (V_{pass}) vs Supply Voltage (V_{CC}) at Three Temperature Points



Standard-mode (f_{SCL}= 100 kHz, t_r = 1 µs)

Fast-mode (f_{SCL}= 400 kHz, t_r= 300 ns)

Figure 9-3. Maximum Pull-Up resistance ($R_{p(max)}$) vs Bus Capacitance (C_b)



V_{OL} = 0.2*V_{DPUX}, I_{OL} = 2 mA when V_{DPUX} ≤ 2 V

V_{OL} = 0.4 V, I_{OL} = 3 mA when V_{DPUX} > 2 V

Figure 9-4. Minimum Pull-Up Resistance ($R_{p(min)}$) vs Pull-Up Reference Voltage (V_{DPUX})

10 Power Supply Recommendations

10.1 Power-On Reset Requirements

In the event of a glitch or data corruption, PCA9546A can be reset to its default conditions by using the power-on reset feature. Power-on reset requires that the device go through a power cycle to be completely reset. This reset also happens when the device is powered on for the first time in an application.

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

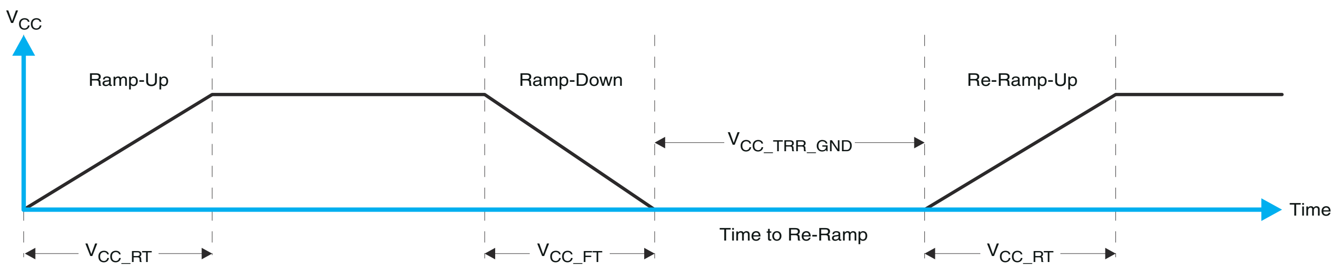


Figure 10-1. V_{CC} Is Lowered Below 0.2 V Or 0 V And Then Ramped Up To V_{CC}

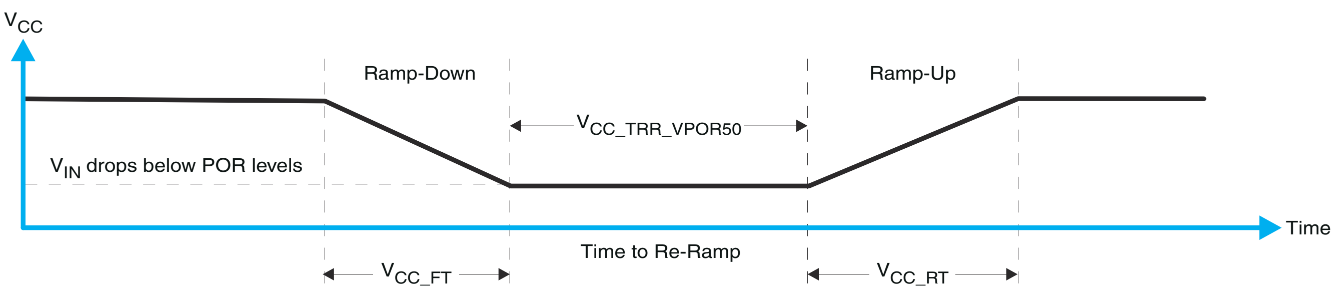


Figure 10-2. V_{CC} Is Lowered Below The Por Threshold, Then Ramped Back Up To V_{CC}

Table 10-1 specifies the performance of the power-on reset feature for PCA9546A for both types of power-on reset.

Table 10-1. Recommended Supply Sequencing And Ramp Rates(1)

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

(1) T_A = –40°C to 85°C (unless otherwise noted)

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

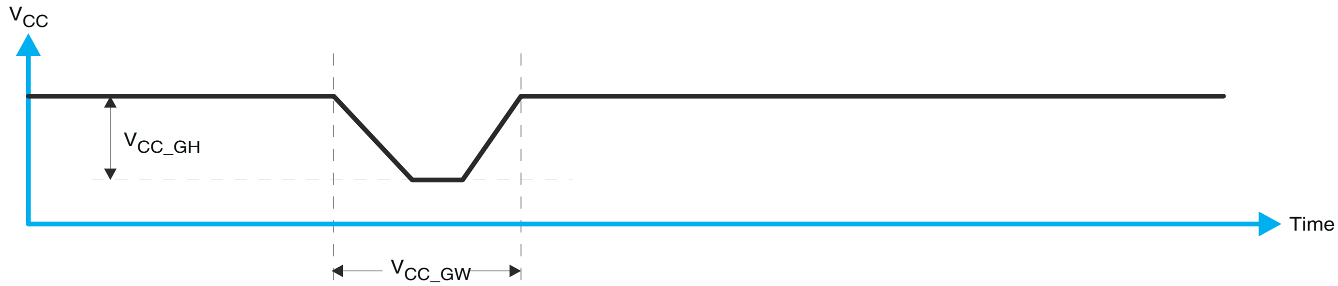


Figure 10-3. Glitch Width And Glitch Height

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 I²C/SMBus state machine are initialized to their default states. The value of V_{POR} differs based on the V_{CC} being lowered to or from 0. Figure 10-4 and Table 10-1 provide more details on this specification.

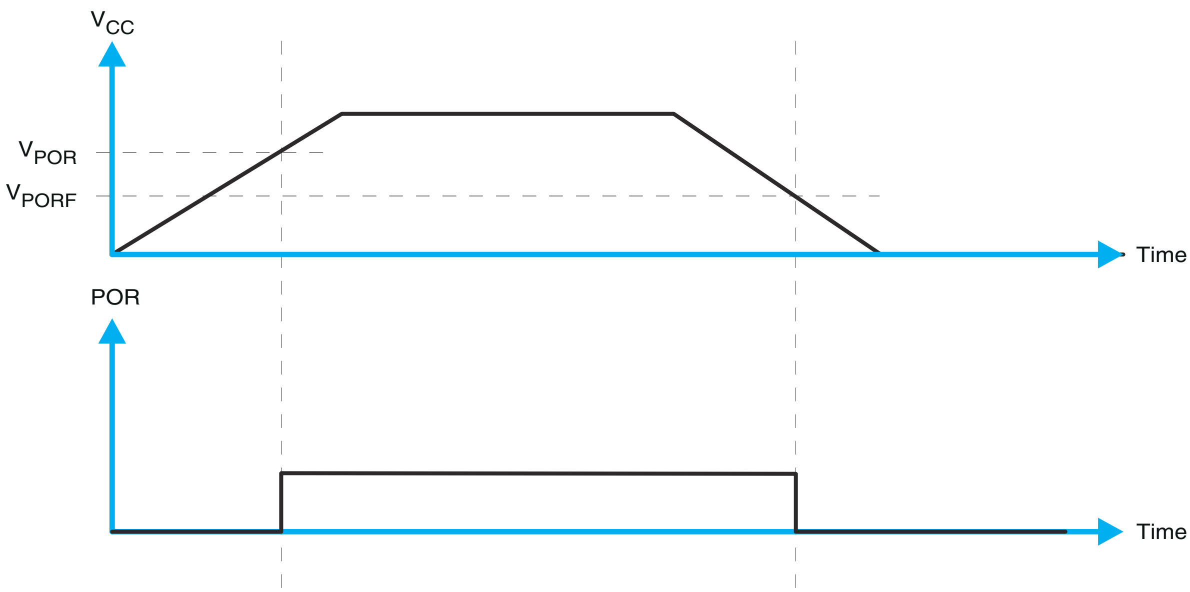


Figure 10-4. V_{POR}

11 Layout

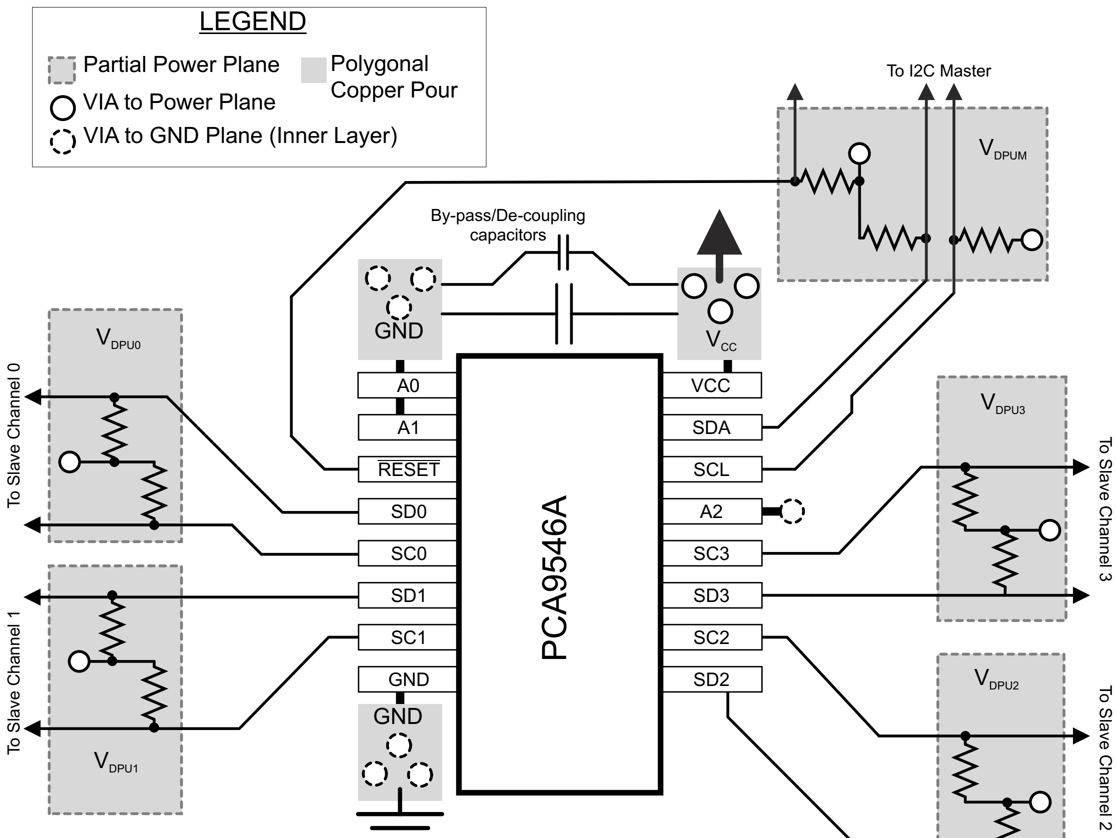
11.1 Layout Guidelines

For PCB layout of the PCA9546A, common PCB layout practices must be followed but additional concerns related to high-speed data transfer such as matched impedances and differential pairs are not a concern for I²C signal speeds. It is common to have a dedicated ground plane on an inner layer of the board and pins that are connected to ground must have a low-impedance path to the ground plane in the form of wide polygon pours and multiple vias. By-pass and de-coupling capacitors are commonly used to control the voltage on the V_{CC} 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.

In an application where voltage translation is not required, all V_{DPUX} voltages and V_{CC} could be at the same potential and a single copper plane could connect all of pull-up resistors to the appropriate reference voltage. In an application where voltage translation is required, V_{DPUM}, V_{DPU0}, V_{DPU1}, V_{DPU2}, and V_{DPU3} may all be on the same layer of the board with split planes to isolate different voltage potentials.

To reduce the total I²C bus capacitance added by PCB parasitics, data lines (SCn and SDn) must be a short as possible and the widths of the traces must also be minimized (e.g. 5-10 mils depending on copper weight).

11.2 Layout Example



12 Device and Documentation Support

12.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* 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.

12.2 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.

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12.3 Trademarks

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12.4 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.

12.5 Glossary

TI Glossary   This glossary lists and explains terms, acronyms, and definitions.

13 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
PCA9546ADGVR	LIFEBUY	TVSOP	DGV	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PD546A	
PCA9546ADR	ACTIVE	SOIC	D	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PCA9546A	Samples
PCA9546ADW	LIFEBUY	SOIC	DW	16	40	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PCA9546A	
PCA9546ADWR	LIFEBUY	SOIC	DW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PCA9546A	
PCA9546APWR	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PD546A	Samples
PCA9546APWRE4	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PD546A	Samples
PCA9546APWRG4	ACTIVE	TSSOP	PW	16	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	PD546A	Samples
PCA9546ARGVR	ACTIVE	VQFN	RGV	16	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	PD546A	Samples
PCA9546ARGYR	NRND	VQFN	RGY	16	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	PD546A	

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

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

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

[6] Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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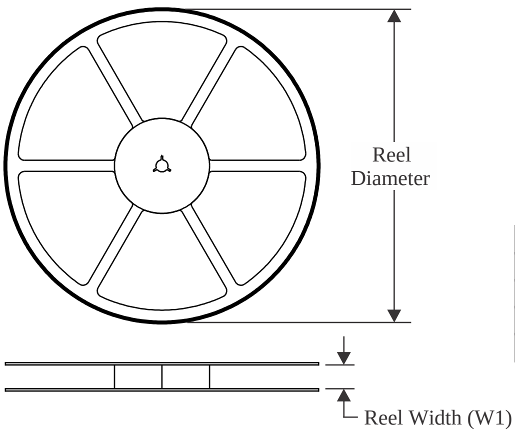
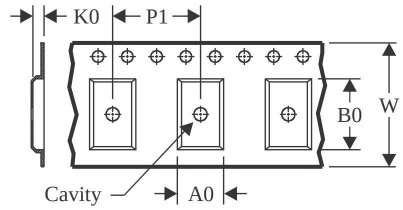
TAPE AND REEL INFORMATION

REEL DIMENSIONS

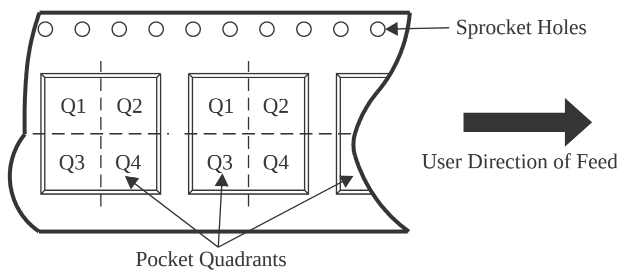


TAPE DIMENSIONS



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

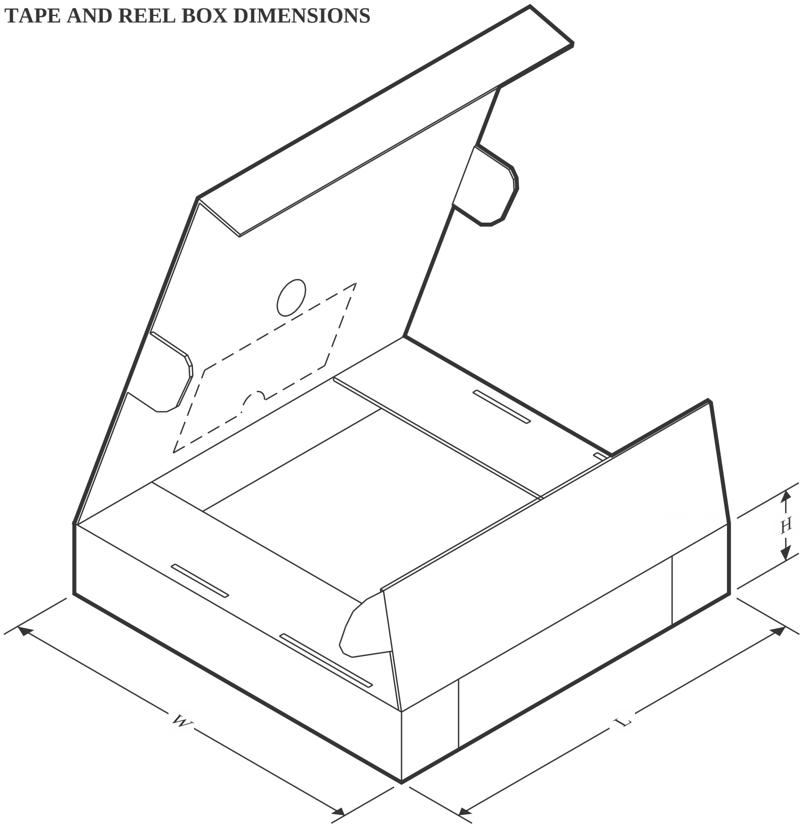
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
PCA9546ADGVR	TVSOP	DGV	16	2000	330.0	12.4	6.8	4.0	1.6	8.0	12.0	Q1
PCA9546ADR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
PCA9546ADWR	SOIC	DW	16	2000	330.0	16.4	10.75	10.7	2.7	12.0	16.0	Q1
PCA9546APWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
PCA9546APWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
PCA9546ARGVR	VQFN	RGV	16	2500	330.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2
PCA9546ARGYR	VQFN	RGY	16	3000	330.0	12.4	3.8	4.3	1.5	8.0	12.0	Q1

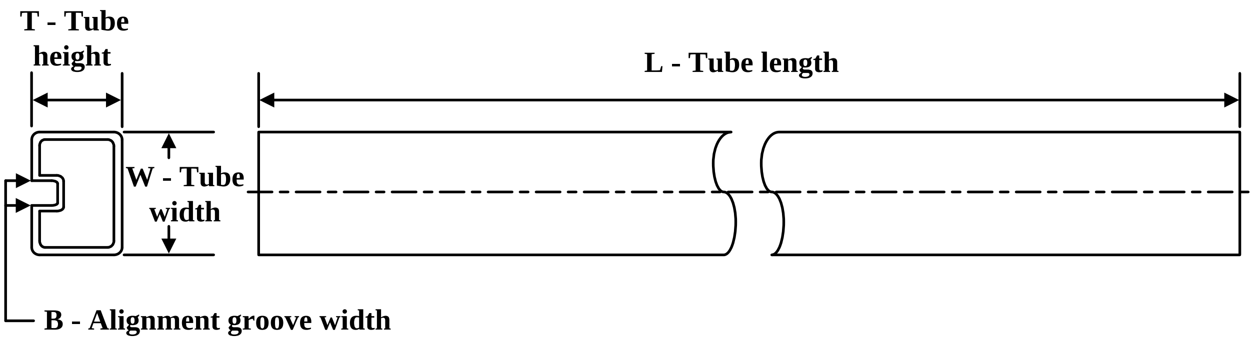
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PCA9546ADGVR	TVSOP	DGV	16	2000	356.0	356.0	35.0
PCA9546ADR	SOIC	D	16	2500	356.0	356.0	35.0
PCA9546ADWR	SOIC	DW	16	2000	350.0	350.0	43.0
PCA9546APWR	TSSOP	PW	16	2000	356.0	356.0	35.0
PCA9546APWR	TSSOP	PW	16	2000	367.0	367.0	35.0
PCA9546ARGVR	VQFN	RGV	16	2500	367.0	367.0	35.0
PCA9546ARGYR	VQFN	RGY	16	3000	356.0	356.0	35.0

TUBE



*All dimensions are nominal

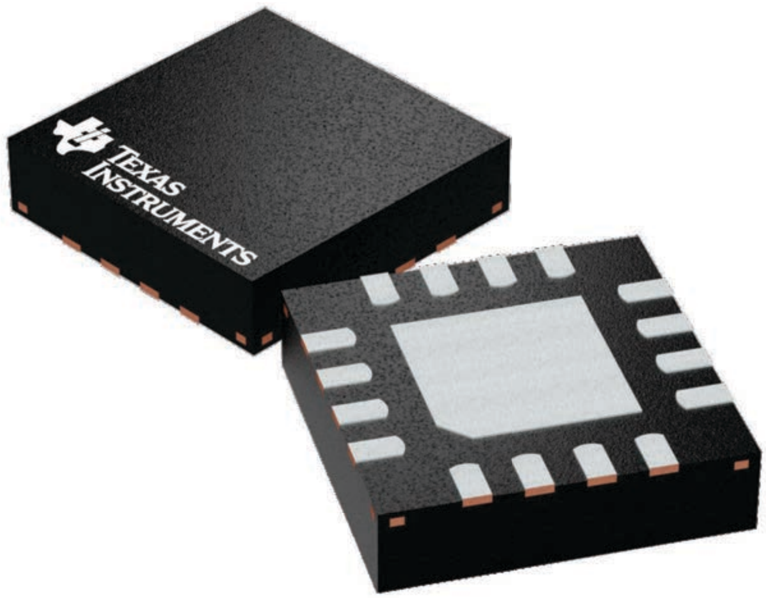
Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
PCA9546ADW	DW	SOIC	16	40	506.98	12.7	4826	6.6

RGV 16

VQFN - 1 mm max height

4 x 4, 0.65 mm pitch

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.

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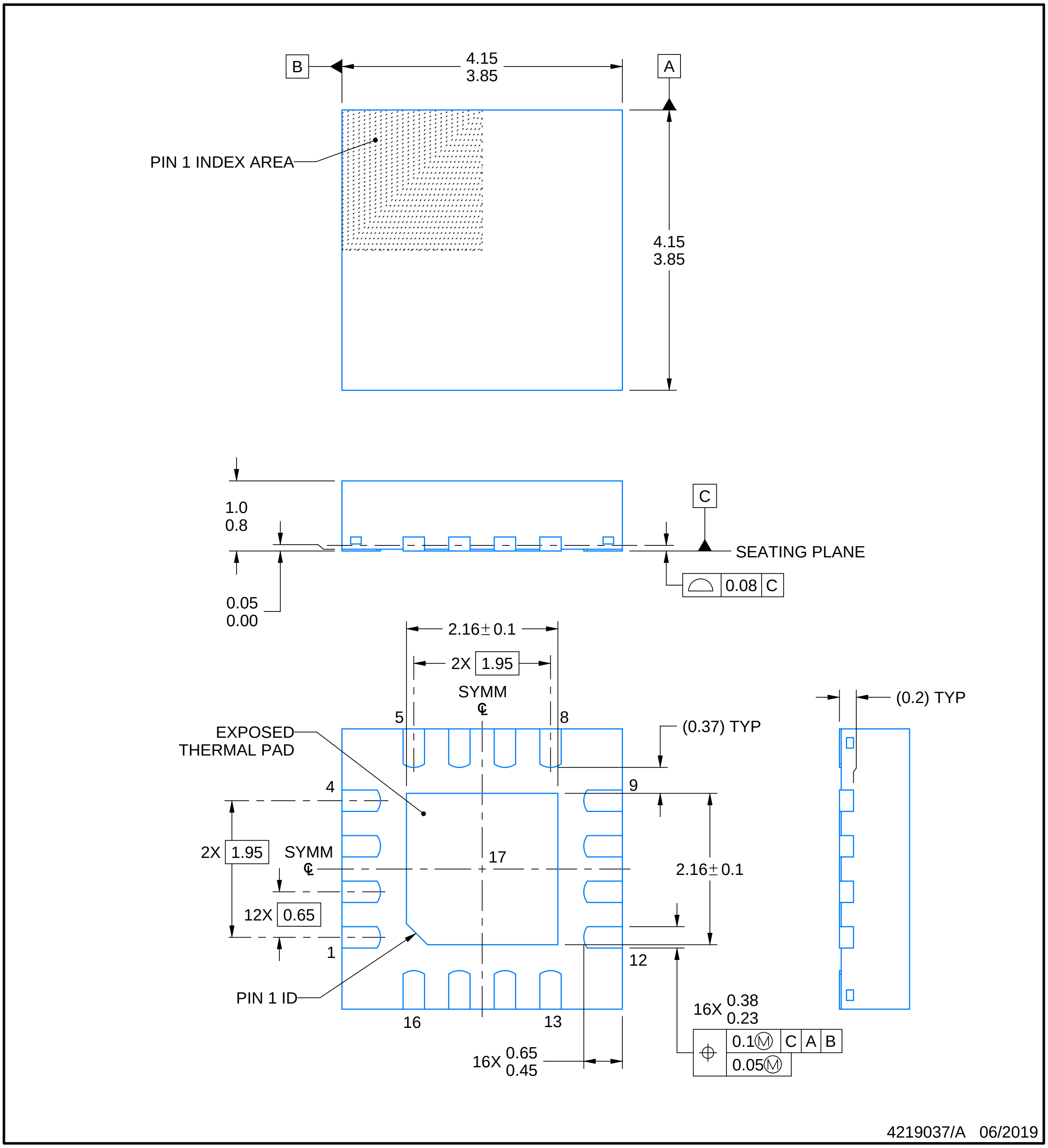

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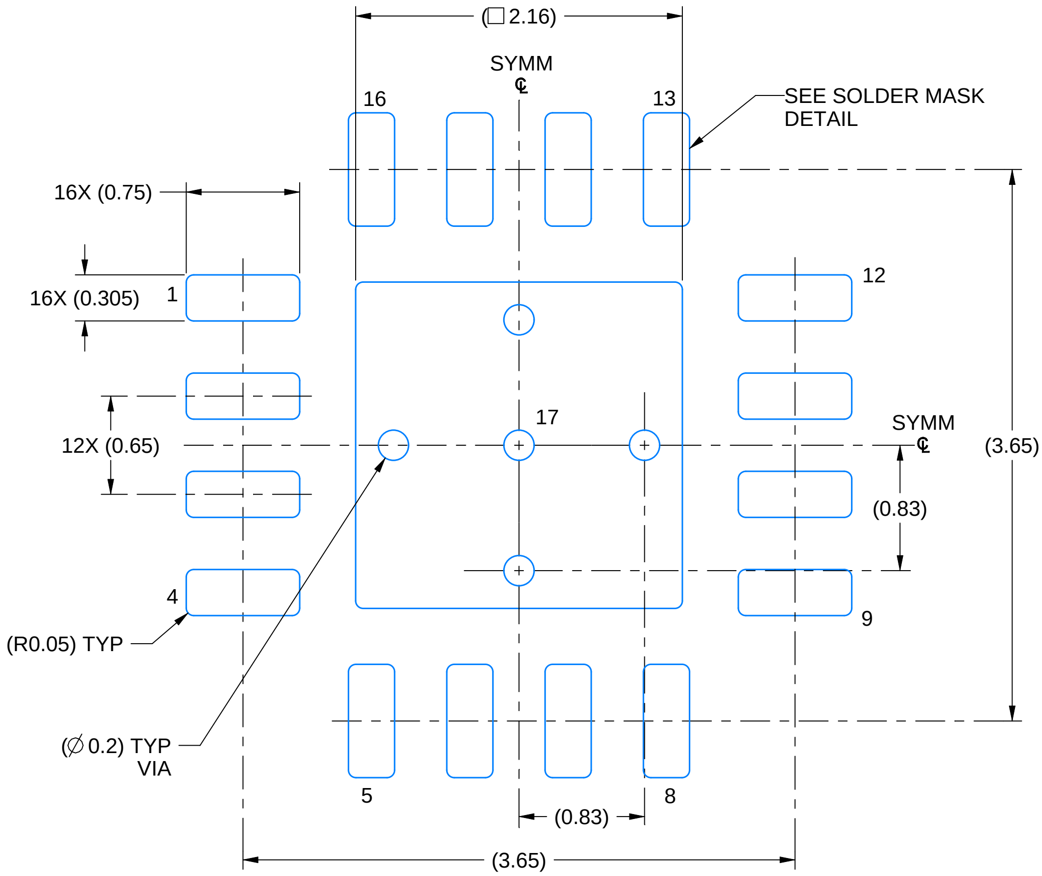
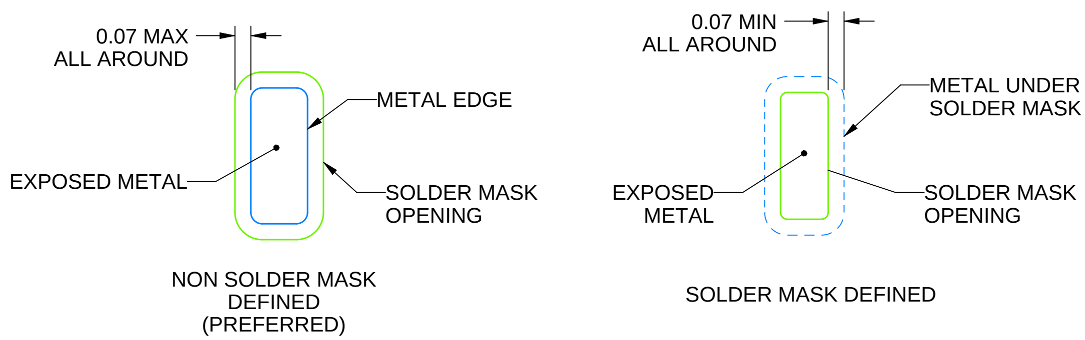
NOTES:

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 20X

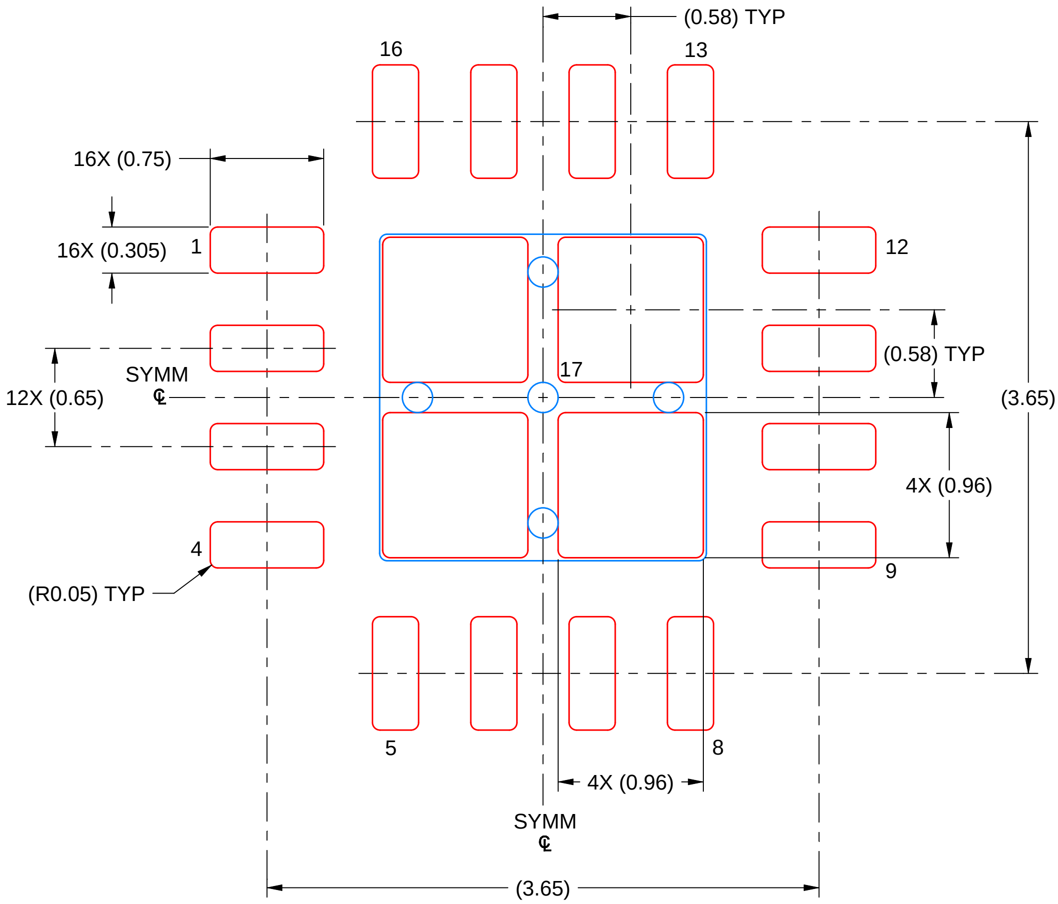


SOLDER MASK DETAILS

4219037/A 06/2019

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).
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.



SOLDER PASTE EXAMPLE
BASED ON 0.125 MM THICK STENCIL
SCALE: 20X

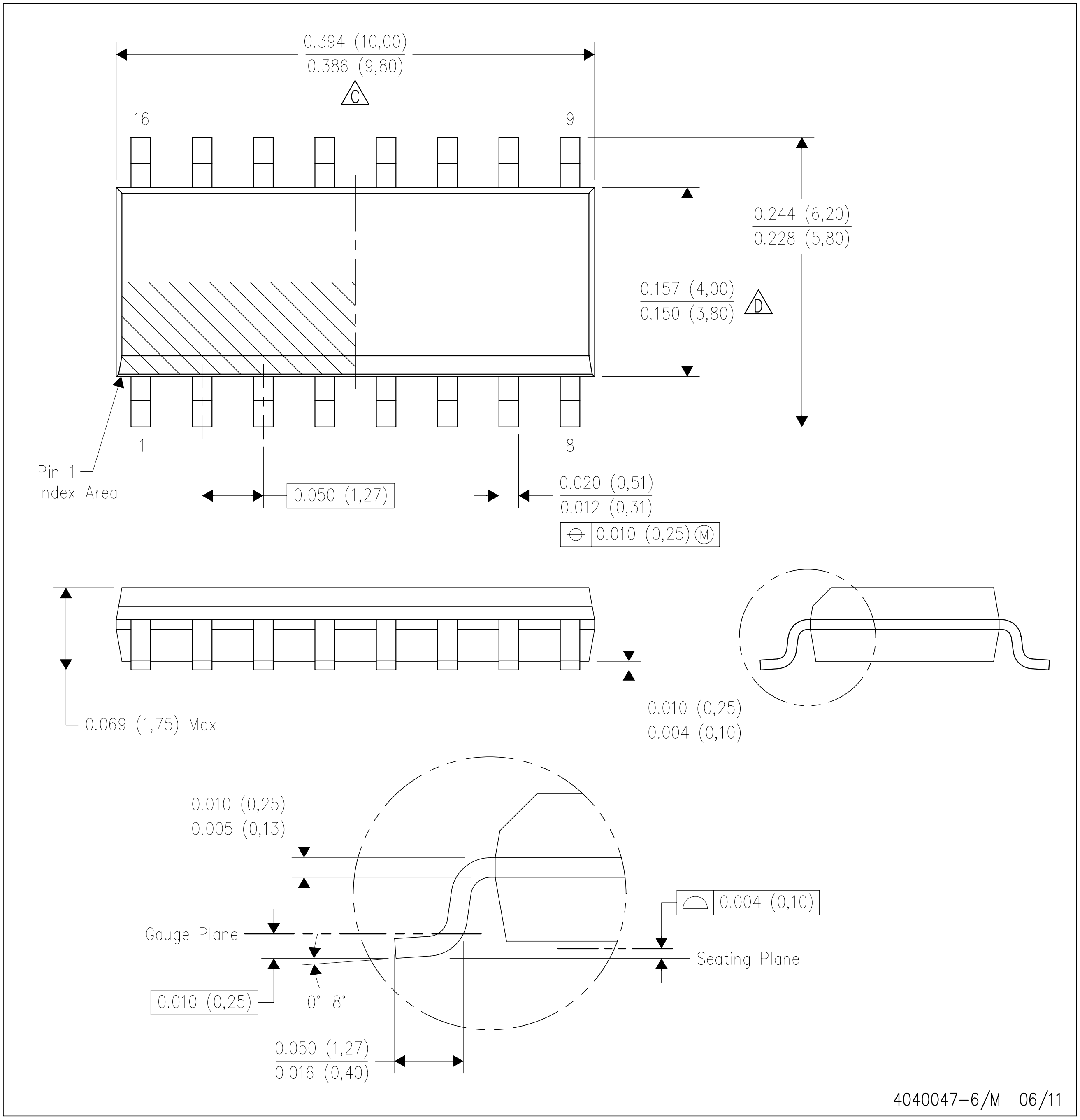
EXPOSED PAD 17
79% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

4219037/A 06/2019

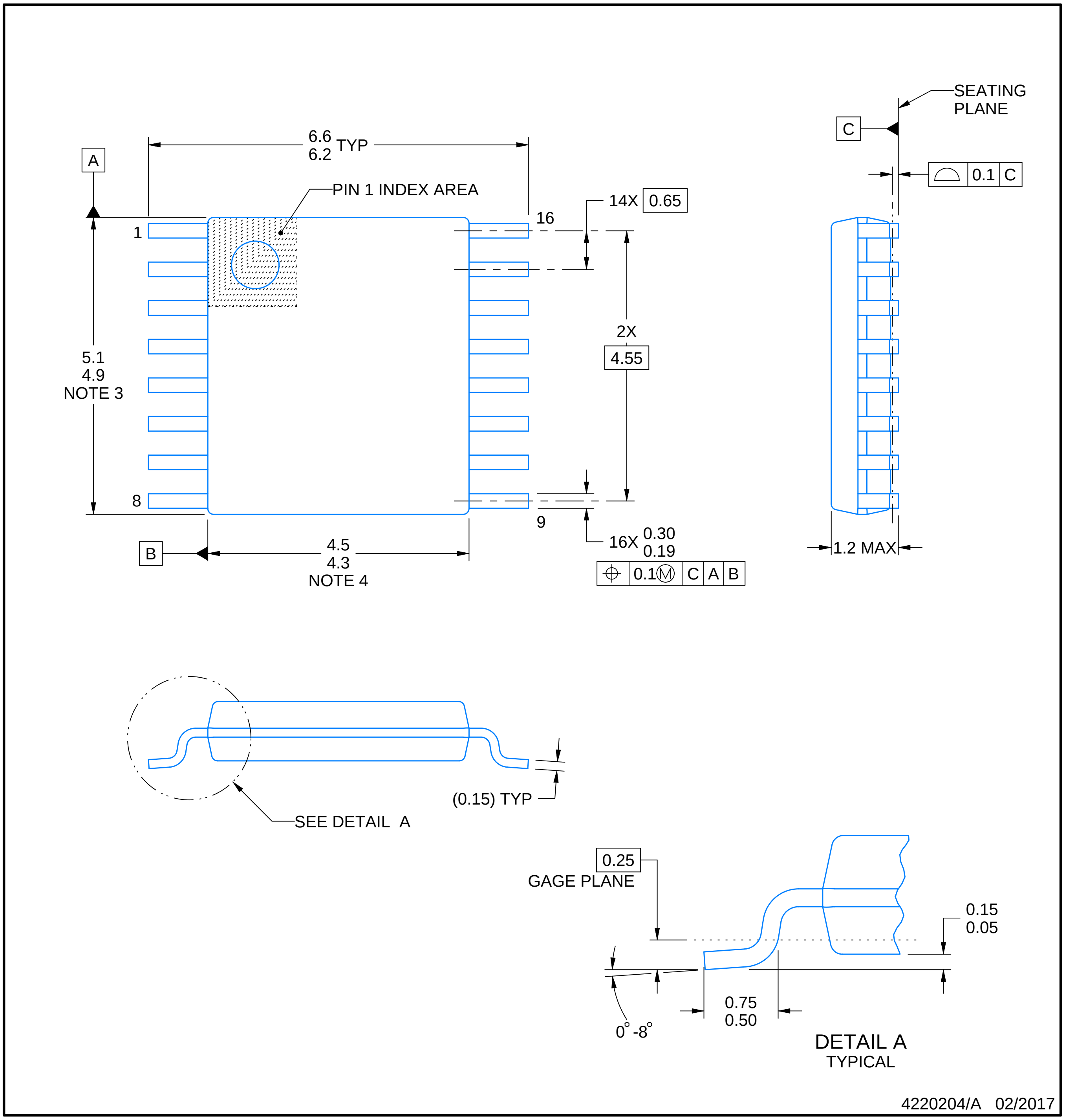
NOTES: (continued)

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

D (R–PDSO–G16) PLASTIC SMALL OUTLINE

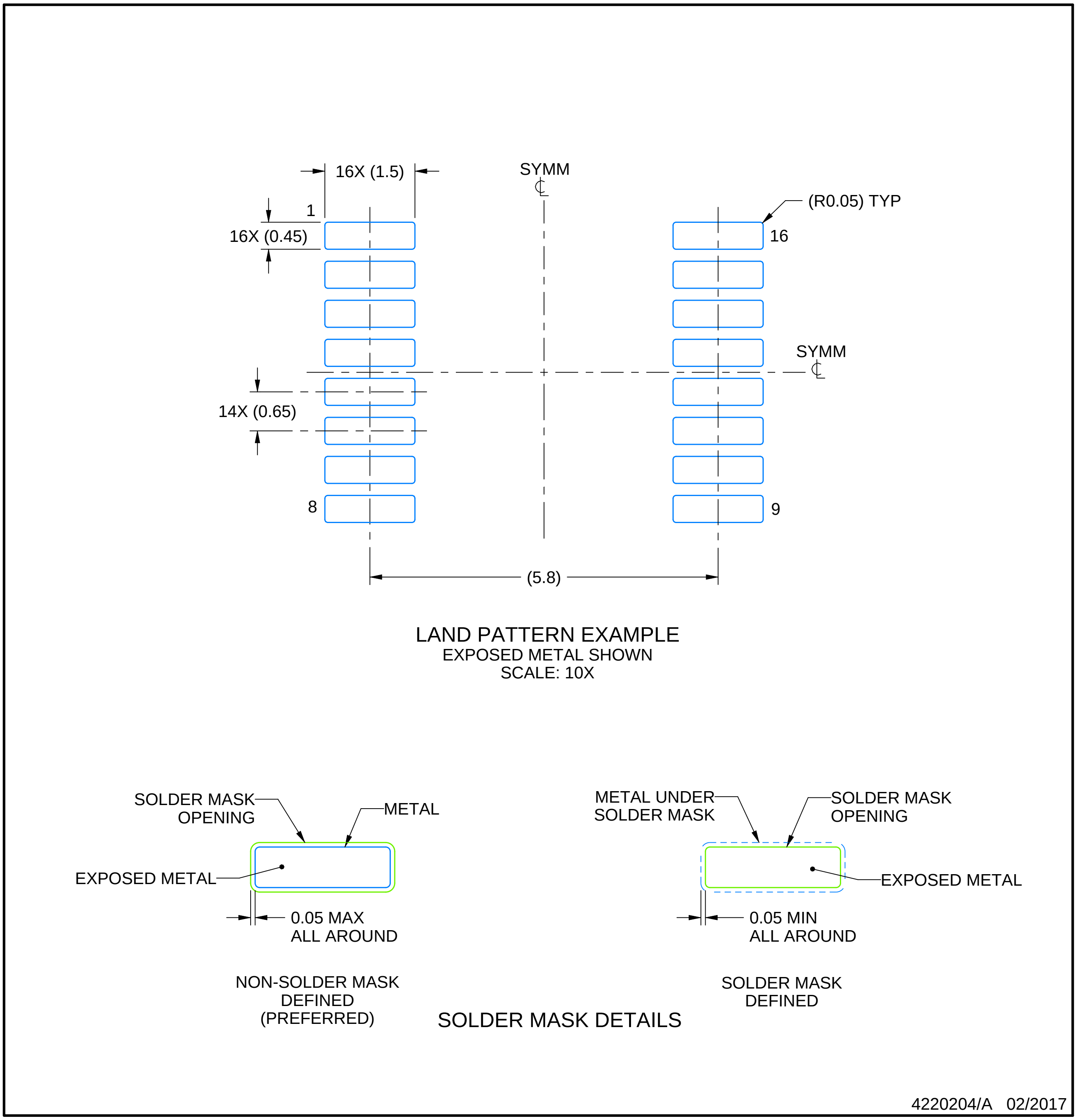


NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
- E. Reference JEDEC MS–012 variation AC.



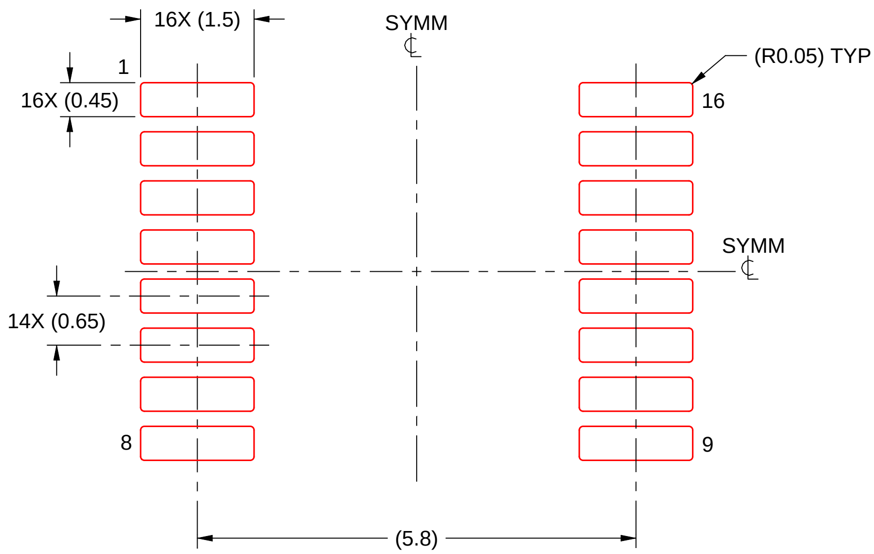
NOTES:

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.



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/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.

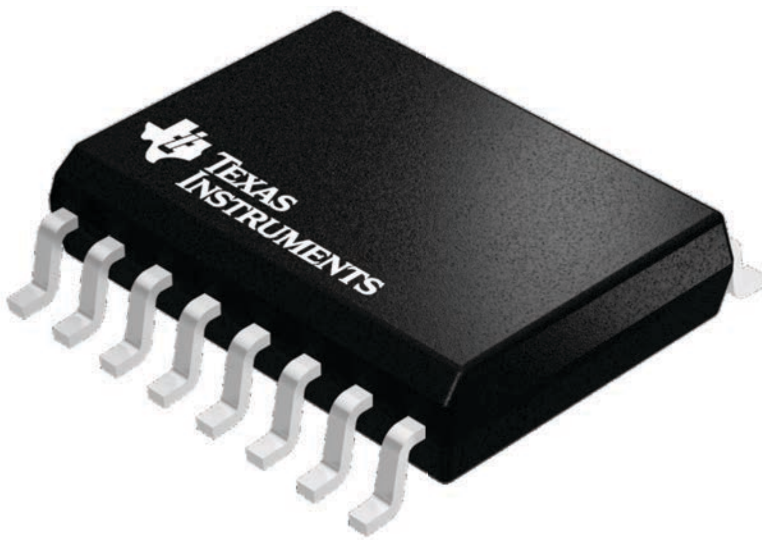
DW 16

SOIC - 2.65 mm max height

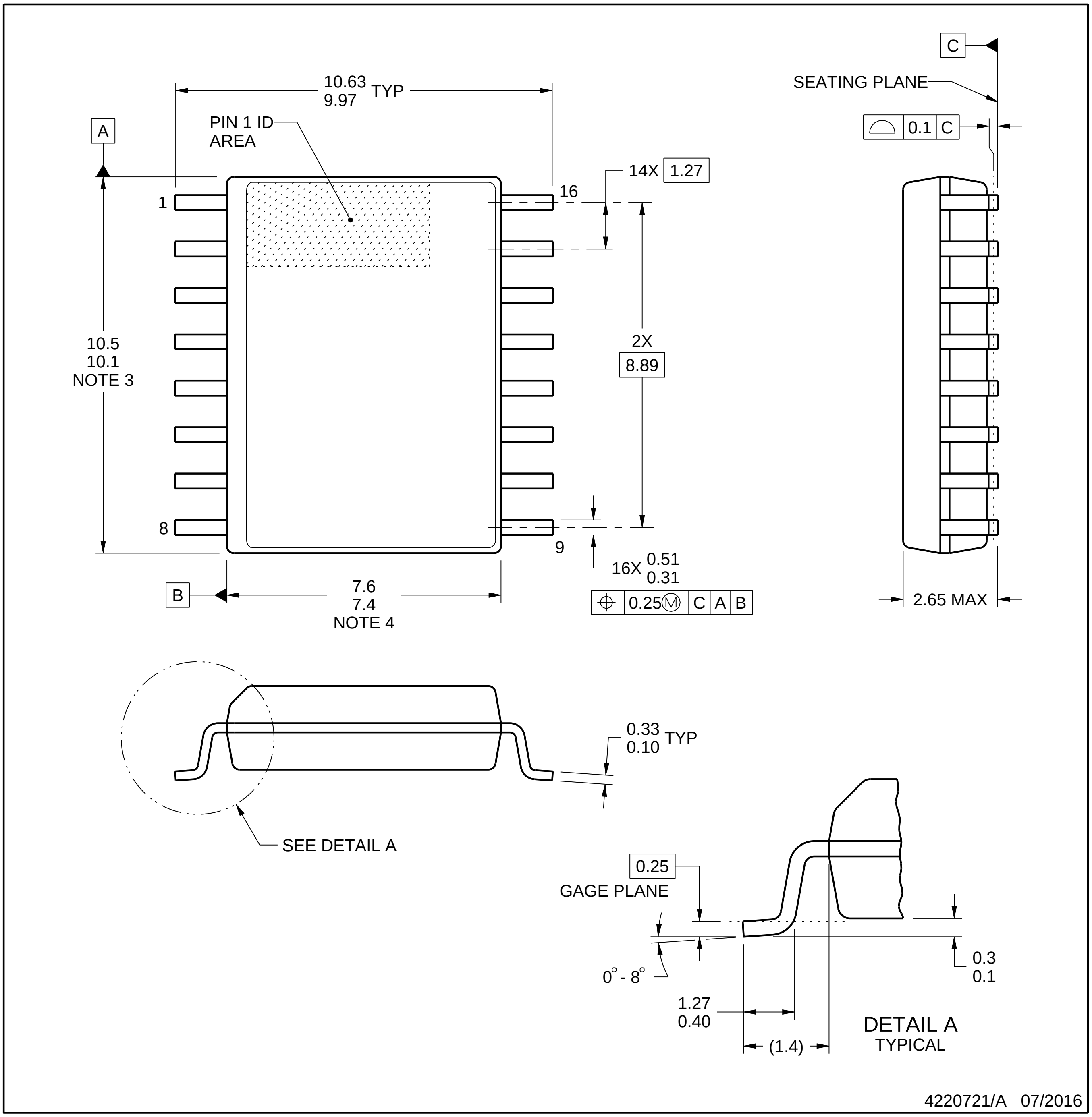
7.5 x 10.3, 1.27 mm pitch

SMALL OUTLINE INTEGRATED CIRCUIT

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

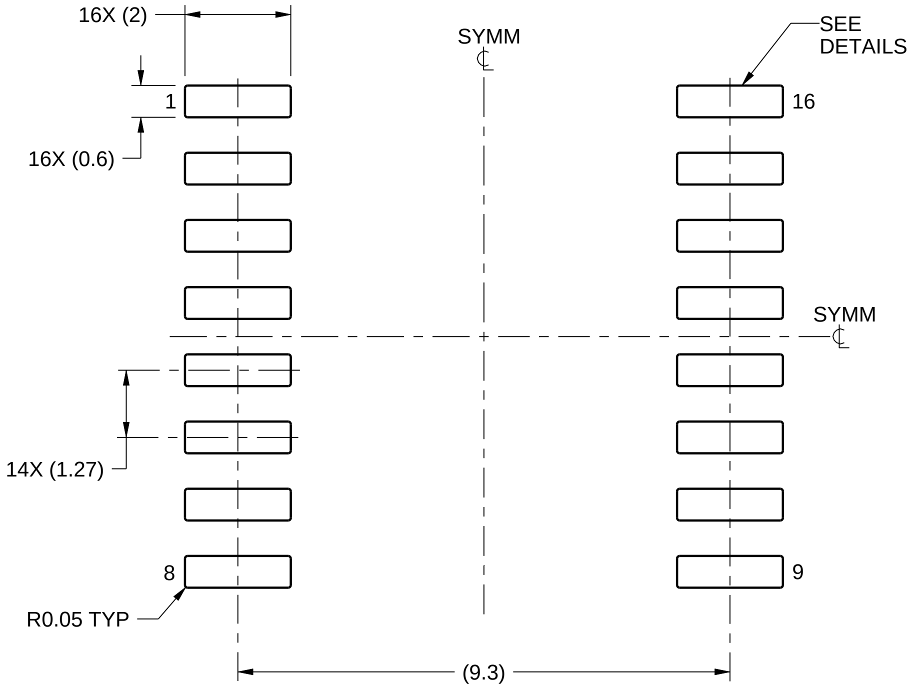


4224780/A

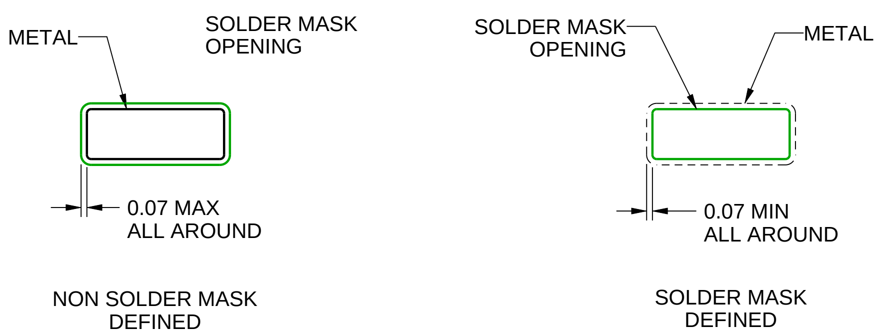


NOTES:

1. All linear dimensions are in millimeters. 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 MS-013.



LAND PATTERN EXAMPLE
SCALE:7X

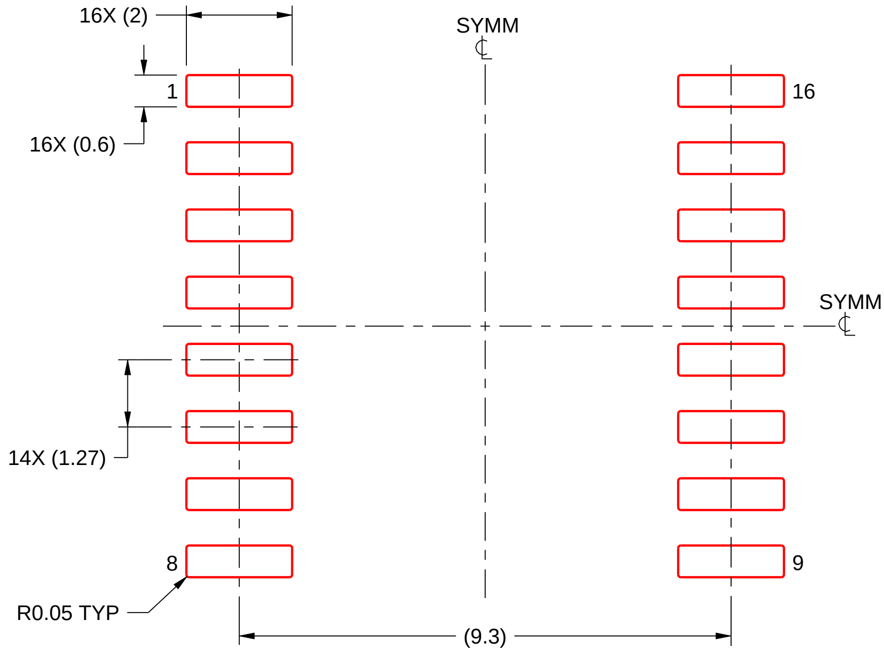


SOLDER MASK DETAILS

4220721/A 07/2016

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.



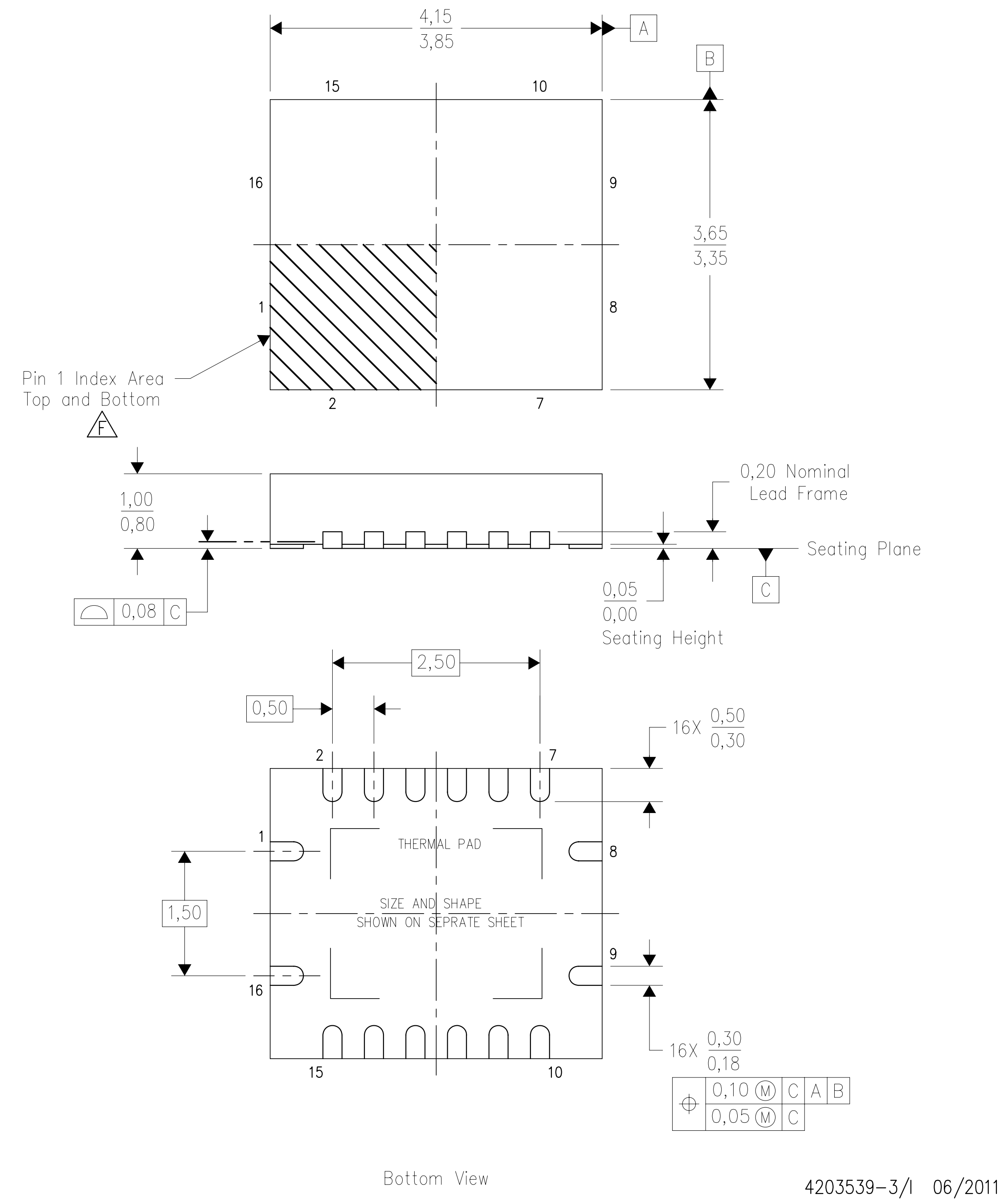
SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:7X

4220721/A 07/2016

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.

RGY (R-PVQFN-N16) PLASTIC QUAD FLATPACK NO-LEAD



4203539-3/I 06/2011

NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
- B. This drawing is subject to change without notice.
- C. QFN (Quad Flatpack No-Lead) package configuration.
- D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
- E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
- F. Pin 1 identifiers are located on both top and bottom of the package and within the zone indicated. The Pin 1 identifiers are either a molded, marked, or metal feature.
- G. Package complies to JEDEC MO-241 variation BA.

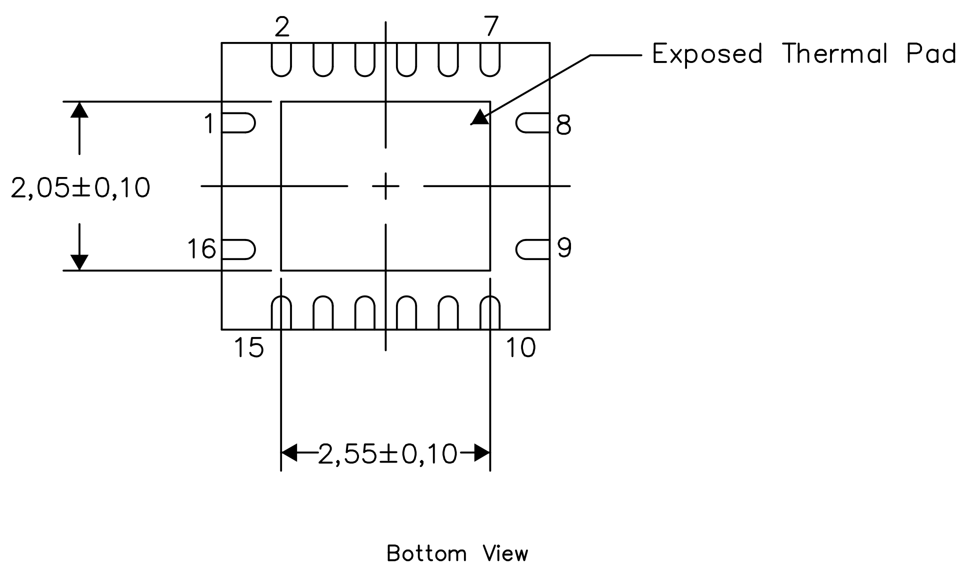
RGY (R–PVQFN–N16) PLASTIC QUAD FLATPACK NO–LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No–Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.

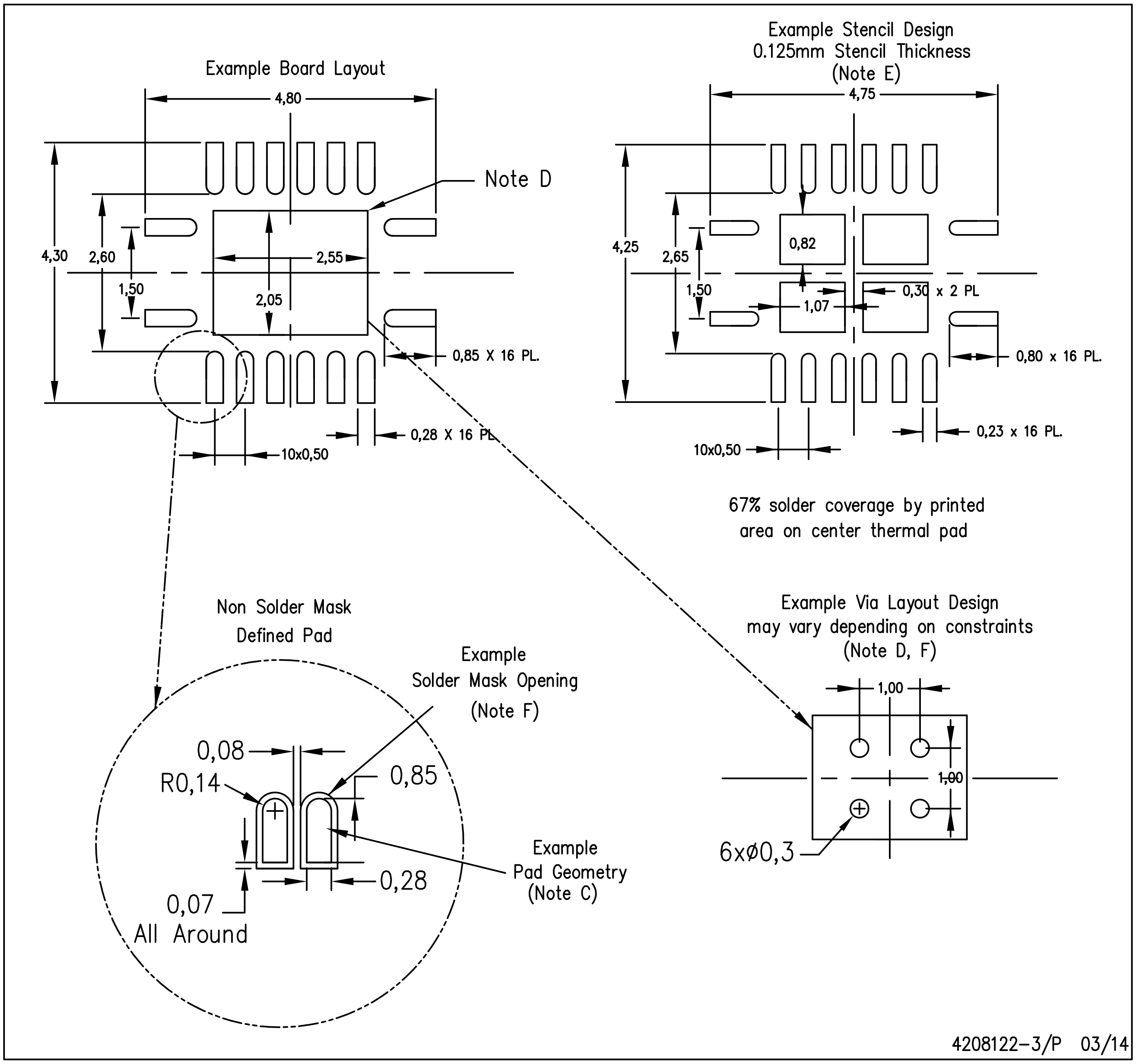


Exposed Thermal Pad Dimensions

4206353-3/P 03/14

NOTE: All linear dimensions are in millimeters

RGY (R-PVQFN-N16) PLASTIC QUAD FLATPACK NO-LEAD



4208122-3/P 03/14

NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat-Pack QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <http://www.ti.com>.
- E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
- F. Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.