

SN74AC04-Q1 Automotive Hex Schmitt-Trigger Inverter

1 Features

- Qualified for automotive applications
- V_{CC} operation of 2V to 6V
- Inputs accept voltages to 6V
- Max t_{pd} of 7ns at 5V

2 Applications

- [Synchronize inverted clock inputs](#)
- [Debounce a switch](#)
- Invert a digital signal

3 Description

The SN74AC04-Q1 device contains six independent inverters. The device performs the Boolean function $Y = \bar{A}$.

Package Information

PART NUMBER	PACKAGE ⁽¹⁾	PACKAGE SIZE ⁽²⁾	BODY SIZE ⁽³⁾
SN74AC04-Q1	BQA (WQFN, 14)	3.00mm × 2.50mm	3.00mm × 2.50mm
	PW (TSSOP, 14)	5mm × 6.4mm	5mm × 4.4mm

- (1) For more information, see [Section 11](#).
- (2) The package size (length × width) is a nominal value and includes pins, where applicable.
- (3) The body size (length × width) is a nominal value and does not include pins.



Logic Diagram (Positive Logic)



Table of Contents

1 Features	1	7.2 Functional Block Diagram.....	7
2 Applications	1	7.3 Feature Description.....	7
3 Description	1	7.4 Device Functional Modes.....	8
4 Pin Configuration and Functions	3	8 Application Information Disclaimer	9
5 Specifications	4	8.1 Power Supply Recommendations.....	9
5.1 Absolute Maximum Ratings.....	4	8.2 Layout.....	9
5.2 ESD Ratings.....	4	9 Device and Documentation Support	10
5.3 Recommended Operating Conditions.....	4	9.1 Documentation Support.....	10
5.4 Thermal Information.....	5	9.2 Receiving Notification of Documentation Updates....	10
5.5 Electrical Characteristics.....	5	9.3 Support Resources.....	10
5.6 Switching Characteristics.....	5	9.4 Trademarks.....	10
5.7 Switching Characteristics.....	5	9.5 Electrostatic Discharge Caution.....	10
5.8 Operating Characteristics.....	5	9.6 Glossary.....	10
6 Parameter Measurement Information	6	10 Revision History	10
7 Detailed Description	7	11 Mechanical, Packaging, and Orderable Information	11
7.1 Overview.....	7		

4 Pin Configuration and Functions

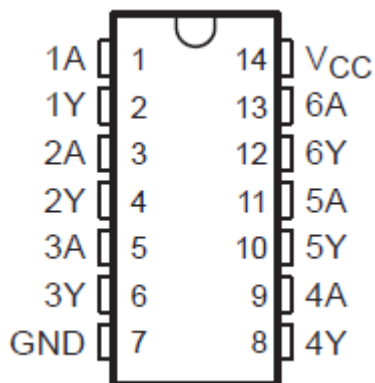


Figure 4-1. PW Package, 14-Pin TSSOP (Top View)

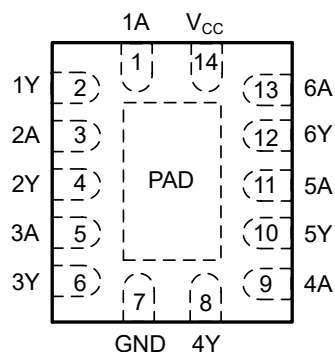


Figure 4-2. BQA Package, 14-Pin WQFN (Top View)

Table 4-1. Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
1A	1	Input	Channel 1, Input A
1Y	2	Output	Channel 1, Output Y
2A	3	Input	Channel 2, Input A
2Y	4	Output	Channel 2, Output Y
3A	5	Input	Channel 3, Input A
3Y	6	Output	Channel 3, Output Y
GND	7	—	Ground
4Y	8	Output	Channel 4, Output Y
4A	9	Input	Channel 4, Input A
5Y	10	Output	Channel 5, Output Y
5A	11	Input	Channel 5, Input A
6Y	12	Output	Channel 6, Output Y
6A	13	Input	Channel 6, Input A
V _{CC}	14	—	Positive Supply
Thermal Pad ⁽¹⁾		—	The thermal pad can be connected to GND or left floating. Do not connect to any other signal or supply

(1) BQA package only.

5 Specifications

5.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V_{CC}	Supply voltage range	–0.5	7	V
V_I	Input voltage range ⁽¹⁾	–0.5	$V_{CC} + 0.5$	V
V_O	Output voltage range ⁽¹⁾	–0.5	$V_{CC} + 0.5$	V
I_{IK}	Input clamp current	$V_I < 0$ or $V_I > V_{CC}$		±20 mA
I_{OK}	Output clamp current	$V_O < 0$ or $V_O > V_{CC}$		±20 mA
I_O	Continuous output current	$V_O = 0$ to V_{CC}		±50 mA
	Continuous current through V_{CC} or GND			±200 mA
T_{stg}	Storage temperature range	–65	150	°C

(1) The input and output voltage ratings may be exceeded if the input and output current ratings are observed.

5.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins ⁽¹⁾	±1500	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins ⁽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.

5.3 Recommended Operating Conditions

			MIN	MAX	UNIT
V_{CC}	Supply voltage		2	6	V
V_{IH}	High-level input voltage	$V_{CC} = 3$ V	2.1		V
		$V_{CC} = 4.5$ V	3.15		
		$V_{CC} = 5.5$ V	3.85		
V_{IL}	Low-level input voltage	$V_{CC} = 3$ V		0.9	V
		$V_{CC} = 4.5$ V		1.35	
		$V_{CC} = 5.5$ V		1.65	
V_I	Input voltage		0	V_{CC}	V
V_O	Output voltage		0	V_{CC}	V
I_{OH}	High-level output current	$V_{CC} = 3$ V		– 12	mA
		$V_{CC} = 4.5$ V		– 24	
		$V_{CC} = 5.5$ V		– 24	
I_{OL}	Low-level output current	$V_{CC} = 3$ V		12	mA
		$V_{CC} = 4.5$ V		24	
		$V_{CC} = 5.5$ V		24	
$\Delta t/\Delta v$	Input transition rise or fall rate			8	ns/V
T_A	Operating free-air temperature	Q- suffix devices	– 40	125	°C
		I- suffix devices	– 40	85	

5.4 Thermal Information

THERMAL METRIC ⁽¹⁾		SN74AC04-Q1		UNIT
		BQA (WQFN)	PW (TSSOP)	
		14 PINS	14 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	93.4	148	°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 _{CC}	T _A = 25°C			T _A = -40°C TO 125°C		T _A = -40°C TO 85°C		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
V _{OH}	I _{OH} = -50 μA	3 V	2.9	2.99		2.9		2.9		V
	I _{OH} = -12 mA	4.5 V	4.4	4.49		4.4		4.4		
	I _{OH} = -24 mA	5.5 V	5.4	5.49		5.4		5.4		
V _{OL}	I _{OL} = 50 μA	3 V		0.002	0.1		0.1		0.1	V
		4.5 V		0.001	0.1		0.1		0.1	
		5.5 V		0.001	0.1		0.1		0.1	
	I _{OL} = 12 mA	3 V			0.36		0.5		0.44	
		4.5 V			0.36		0.5		0.44	
		5.5 V			0.36		0.5		0.44	
I _I	V _I = V _{CC} or GND	5.5 V			± 0.1		± 0.1		± 0.1	μA
I _{CC}	V _I = V _{CC} or GND, I _O = 0	5.5 V			2		40		20	μA
C _i	V _I = V _{CC} or GND			2.8						pF

5.6 Switching Characteristics

over recommended operating free-air temperature range, V_{CC} = 3.3 V ± 0.3 V (unless otherwise noted) (see [Load Circuit and Voltage Waveforms](#))

PARAMETER	FROM (INPUT)	TO (OUTPUT)	T _A = 25°C			T _A = -40°C to 125°C		T _A = -40°C to 85°C		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t _{PLH}	A	Y	1.5	4.5	9	1	11	1	10	ns
t _{PHL}			1.5	4.5	8.5	1	10	1	9.5	

5.7 Switching Characteristics

over recommended operating free-air temperature range, V_{CC} = 5 V ± 0.5 V (unless otherwise noted) (see [Load Circuit and Voltage Waveforms](#))

PARAMETER	FROM (INPUT)	TO (OUTPUT)	T _A = 25°C			T _A = -40°C to 125°C		T _A = -40°C to 85°C		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t _{PLH}	A	Y	1.5	4	7	1	8.5	1	7.5	ns
t _{PHL}			1.5	3.5	6.5	1	7.5	1	7	

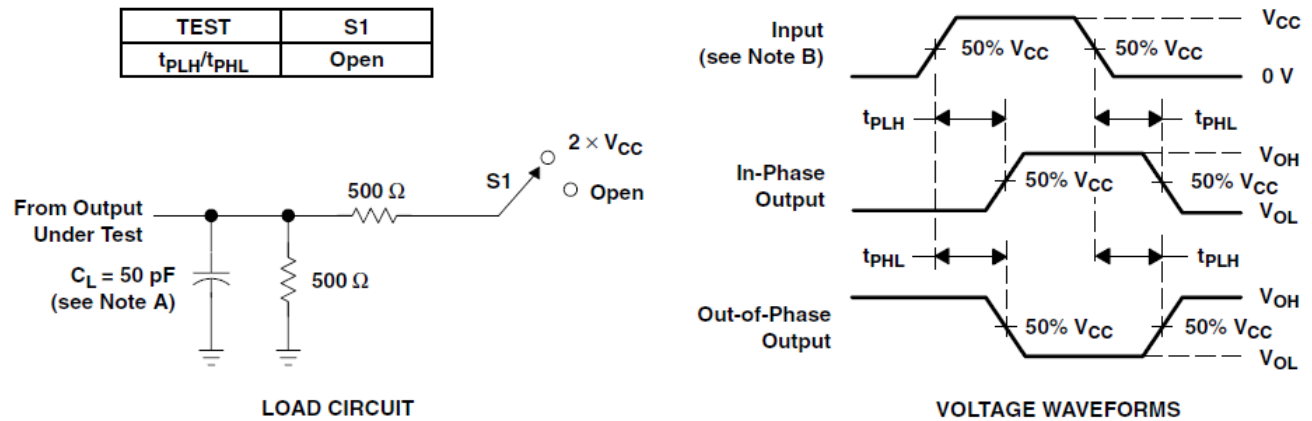
5.8 Operating Characteristics

V_{CC} = 5 V, T_A = 25°C

PARAMETER	TEST CONDITIONS	TYP	UNIT
C _{pd} Power dissipation capacitance	C _L = 50 pF, f = 1 MHz	45	pF

6 Parameter Measurement Information

6.1



- NOTES: A. C_L includes probe and jig capacitance.
 B. All input pulses are supplied by generators having the following characteristics: $PRR \leq 1$ MHz, $Z_O = 50 \Omega$, $t_r \leq 2.5$ ns, $t_f \leq 2.5$ ns.
 C. The outputs are measured one at a time, with one input transition per measurement.

Figure 6-1. Load Circuit and Voltage Waveforms

7 Detailed Description

7.1 Overview

These SN74AC04-Q1 devices perform the Boolean function $Y = \bar{A}$. Because of the Schmitt action, they have different input threshold levels for positive-going (V_{T+}) and for negative-going (V_{T-}) signals.

These circuits are temperature compensated and can be triggered from the slowest of input ramps and still give clean, jitter-free output signals. They also have a greater noise margin than conventional inverters.

7.2 Functional Block Diagram



7.3 Feature Description

- V_{CC} is optimized at 5 V
- Allows up voltage translation from 3.3 V to 5 V
 - Inputs accept V_{IH} levels of 2 V
- Slow edge rates minimize output ringing
- Inputs are TTL-Voltage compatible

7.3.1 Balanced CMOS Push-Pull Outputs

This device includes balanced CMOS push-pull outputs. The term *balanced* indicates that the device can sink and source similar currents. The drive capability of this device may create fast edges into light loads, so routing and load conditions should be considered to prevent ringing. Additionally, the outputs of this device are capable of driving larger currents than the device can sustain without being damaged. It is important to limit the output power of the device to avoid damage due to overcurrent. The electrical and thermal limits defined in the *Absolute Maximum Ratings* must be followed at all times.

Unused push-pull CMOS outputs must be left disconnected.

7.3.2 Clamp Diode Structure

As shown in Figure 7-1, the inputs and outputs to this device have both positive and negative clamping diodes.

CAUTION

Voltages beyond the values specified in the *Absolute Maximum Ratings* table can cause damage to the device. The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.

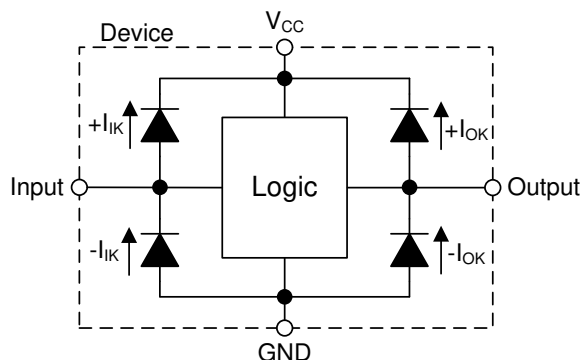


Figure 7-1. Electrical Placement of Clamping Diodes for Each Input and Output

7.4 Device Functional Modes

Table 7-1. Function Table

INPUT	OUTPUT
A	Y
H	L
L	H

8 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.

8.1 Power Supply Recommendations

The power supply can be any voltage between the MIN and MAX supply voltage rating located in the [Section 5.3](#) table.

Each V_{CC} pin should have a good bypass capacitor to prevent power disturbance. For devices with a single supply, 0.1 μF is recommended. If there are multiple V_{CC} pins, 0.01 μF or 0.022 μF is recommended for each power pin. It is acceptable to parallel multiple bypass caps to reject different frequencies of noise. A 0.1 μF and 1 μF are commonly used in parallel. The bypass capacitor should be installed as close to the power pin as possible for best results.

8.2 Layout

8.2.1 Layout Guidelines

When using multiple bit logic devices, inputs should not float. In many cases, functions or parts of functions of digital logic devices are unused. Some examples are when only two inputs of a triple-input AND gate are used, or when only 3 of the 4-buffer gates are used. Such input pins should not be left unconnected because the undefined voltages at the outside connections result in undefined operational states.

Specified in [Layout Diagram](#) are rules that must be observed under all circumstances. All unused inputs of digital logic devices must be connected to a high or low bias to prevent them from floating. The logic level that should be applied to any particular unused input depends on the function of the device. Generally they will be tied to GND or V_{CC} , whichever makes more sense or is more convenient. It is acceptable to float outputs unless the part is a transceiver. If the transceiver has an output enable pin, it will disable the outputs section of the part when asserted. This will not disable the input section of the I/Os so they also cannot float when disabled.

8.2.2 Layout Example

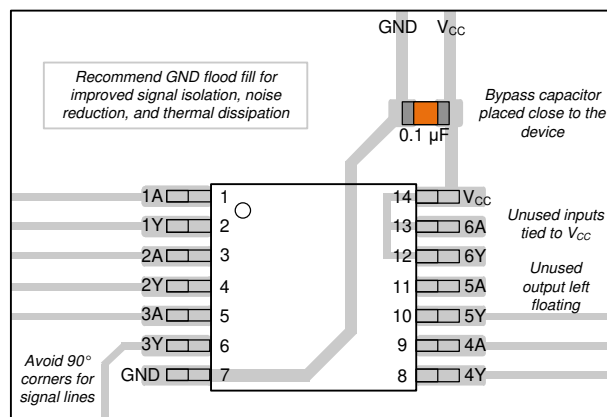


Figure 8-1. Example Layout for the SN74AC04-Q1

9 Device and Documentation Support

9.1 Documentation Support

9.1.1 Related Documentation

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 9-1. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
SN74AC04-Q1	Click here	Click here	Click here	Click here	Click here

9.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.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.

9.3 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](#).

9.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

9.5 Electrostatic Discharge Caution



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

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

9.6 Glossary

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

10 Revision History

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

Changes from Revision C (January 2023) to Revision D (July 2024) Page

- Added BQA package size to *Package Information* table, Pin Configuration and Functions section, and *Thermal Information* table..... 1
- Added package size to *Package Information* table..... 1
- Updated RθJA values: PW = 113 to 148, all values in °C/W..... 5

Changes from Revision B (January 2008) to Revision C (January 2023) Page

- Added *Applications*, *Device Information* table, *Pin Functions* table, *ESD Ratings* table, *Thermal Information* table, *Typical Characteristics*, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section..... 1

-
- Updated *Layout Example* image..... 9
-

11 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)
SN74AC04QPWRG4Q1	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AC04Q
SN74AC04QPWRG4Q1.A	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AC04Q
SN74AC04QPWRQ1	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AC04Q
SN74AC04QPWRQ1.A	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AC04Q
SN74AC04WBQARQ1	Active	Production	WQFN (BQA) 14	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AC04Q
SN74AC04WBQARQ1.A	Active	Production	WQFN (BQA) 14	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	AC04Q

⁽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.

OTHER QUALIFIED VERSIONS OF SN74AC04-Q1 :

- Catalog : [SN74AC04](#)
- Enhanced Product : [SN74AC04-EP](#)
- Military : [SN54AC04](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications
- Military - QML certified for Military and Defense Applications

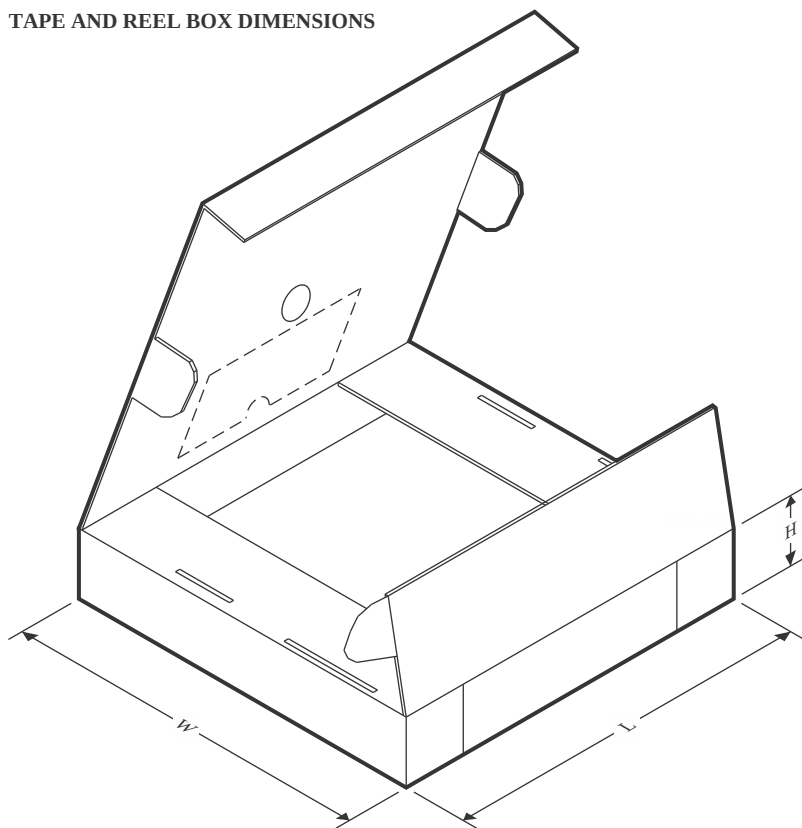
TAPE AND REEL INFORMATION



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
SN74AC04QPWRG4Q1	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
SN74AC04QPWRQ1	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
SN74AC04WBQARQ1	WQFN	BQA	14	3000	180.0	12.4	2.8	3.3	1.1	4.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74AC04QPWRG4Q1	TSSOP	PW	14	2000	353.0	353.0	32.0
SN74AC04QPWRQ1	TSSOP	PW	14	2000	353.0	353.0	32.0
SN74AC04WBQARQ1	WQFN	BQA	14	3000	210.0	185.0	35.0

GENERIC PACKAGE VIEW

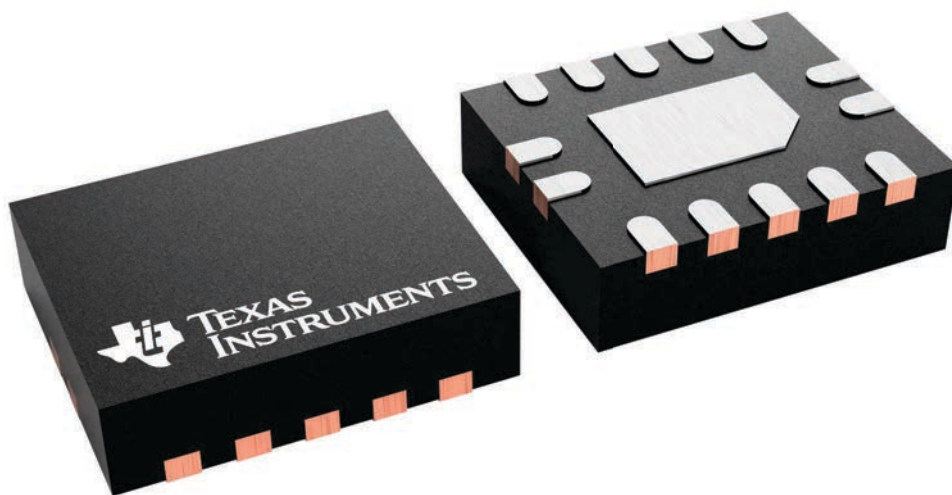
BQA 14

WQFN - 0.8 mm max height

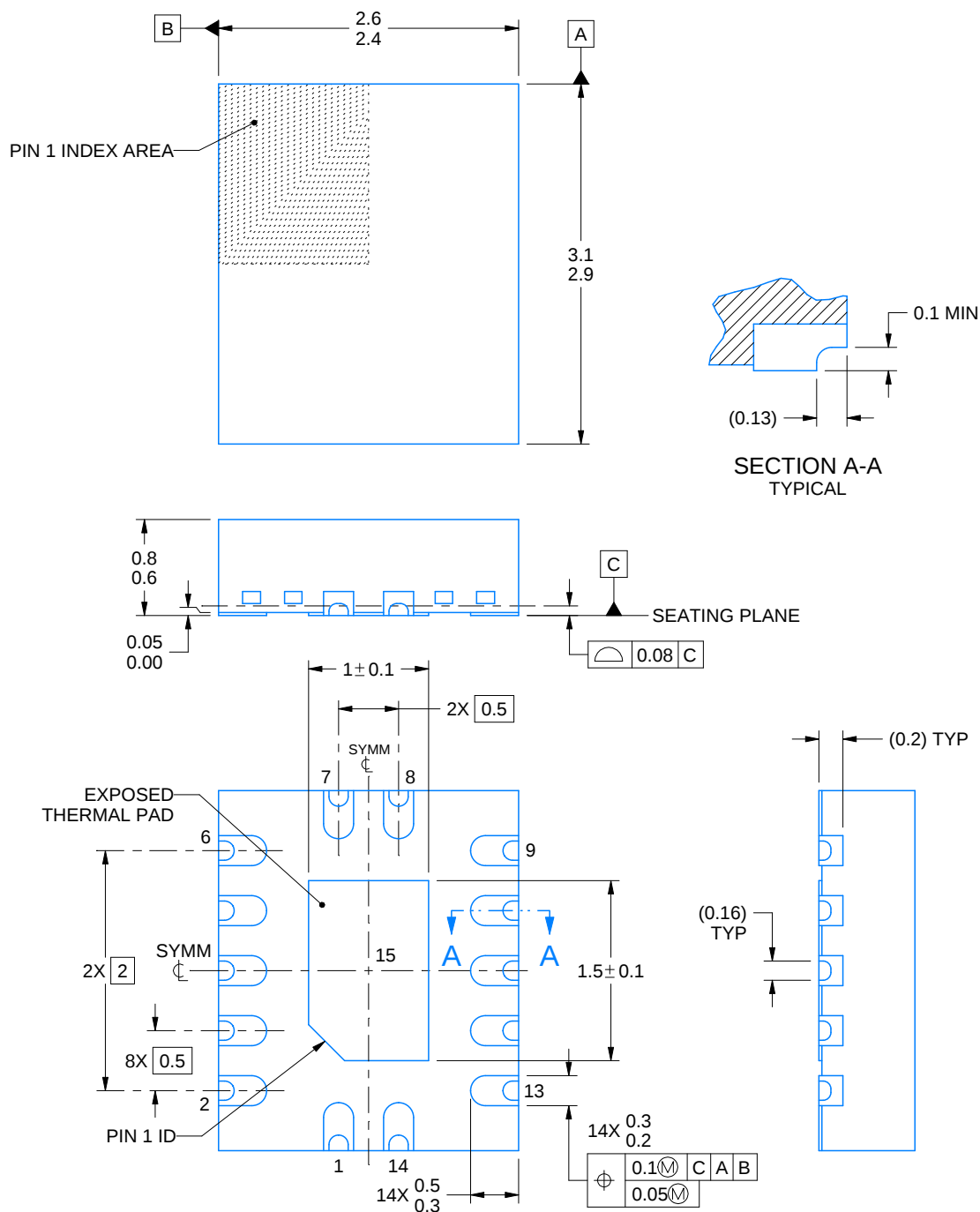
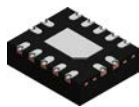
2.5 x 3, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD

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



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NOTES:

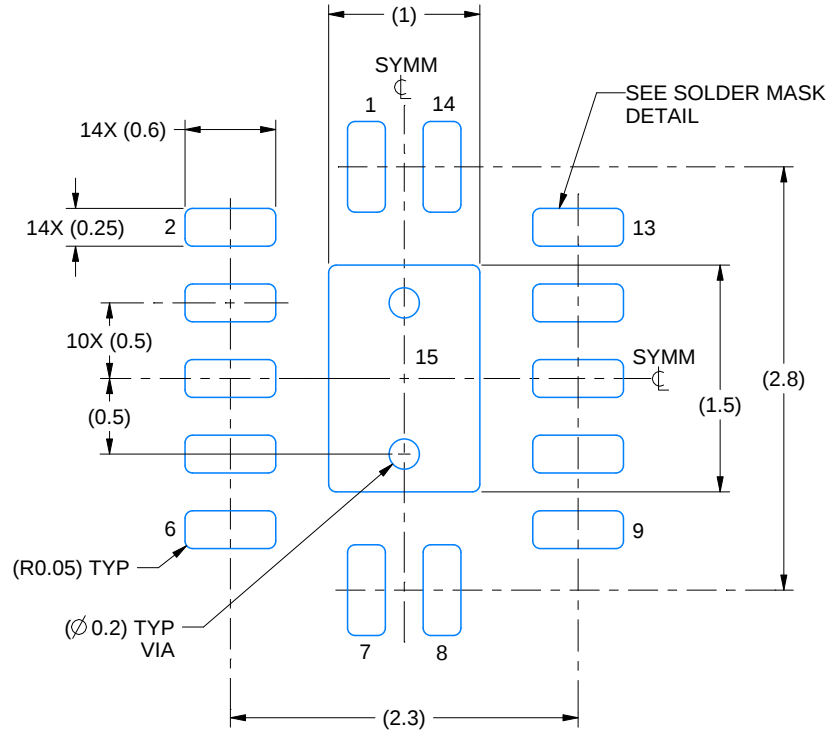
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

EXAMPLE BOARD LAYOUT

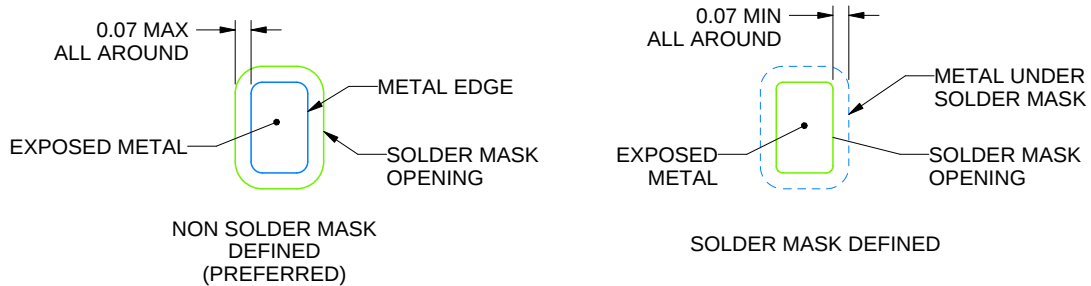
BQA0014B

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 20X



SOLDER MASK DETAILS

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NOTES: (continued)

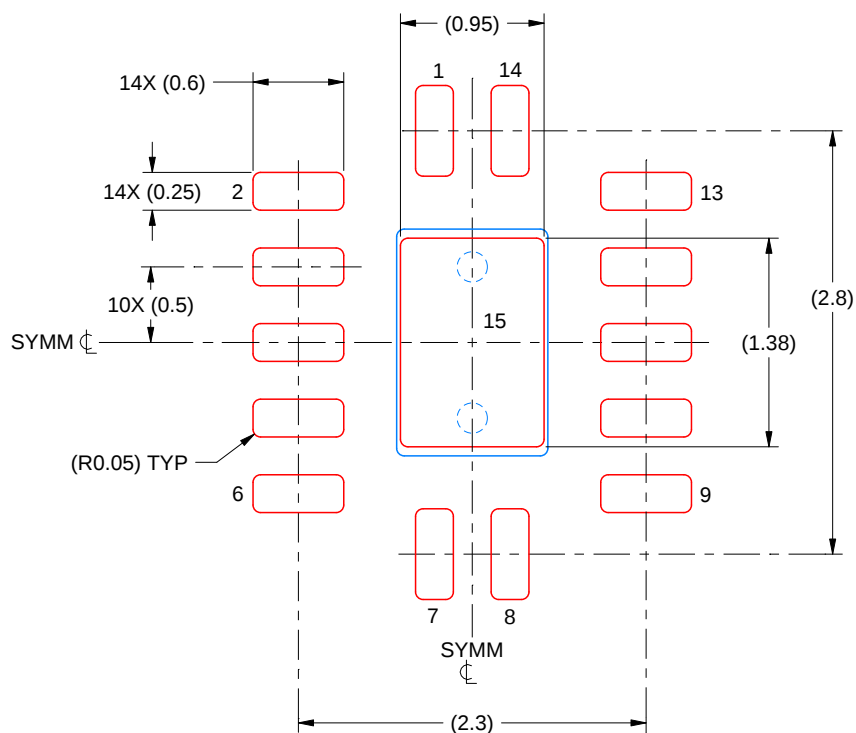
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/sluea271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown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

EXAMPLE STENCIL DESIGN

BQA0014B

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



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

EXPOSED PAD 15
87% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

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NOTES: (continued)

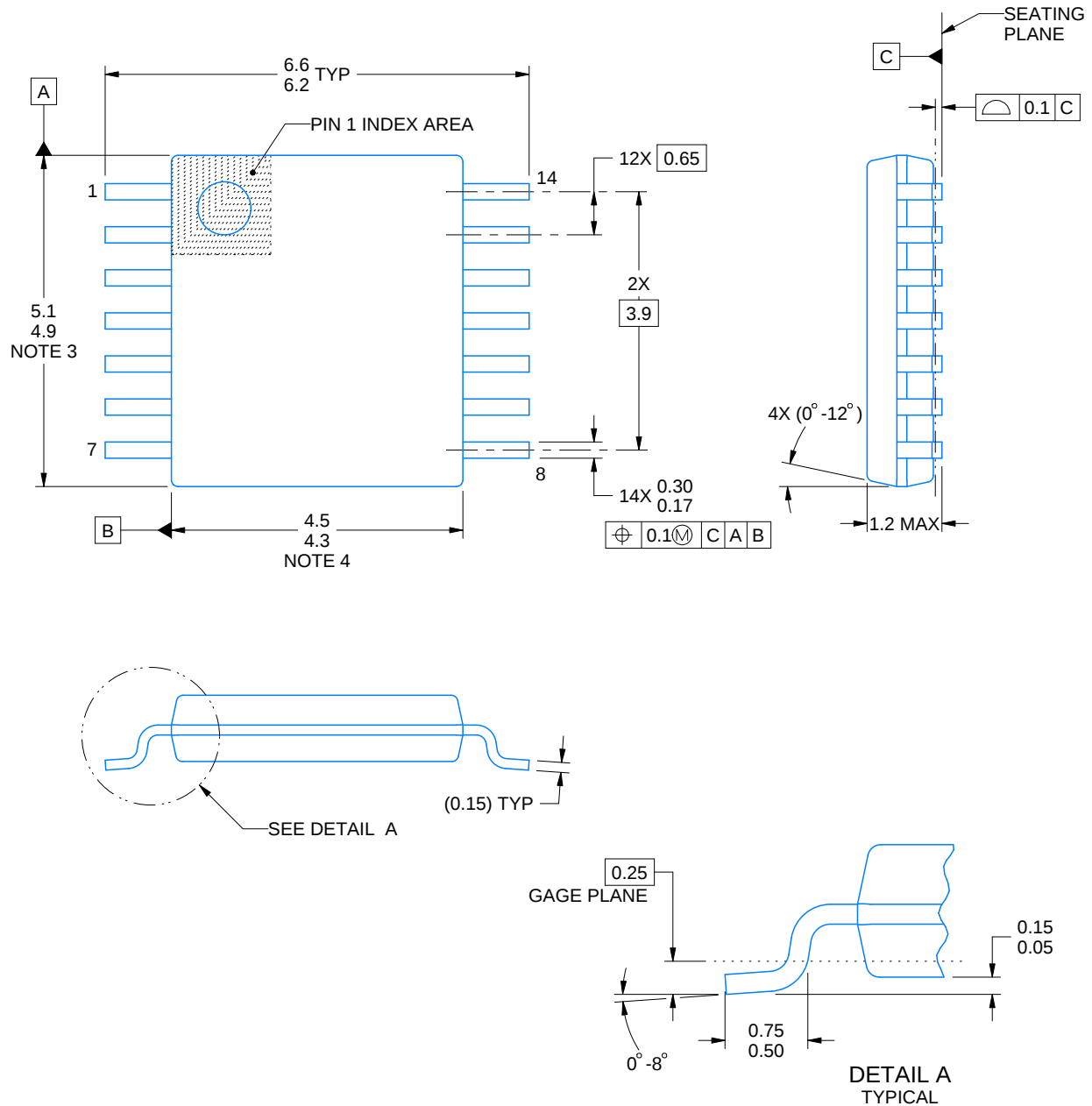
6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

PW0014A

PACKAGE OUTLINE

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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NOTES:

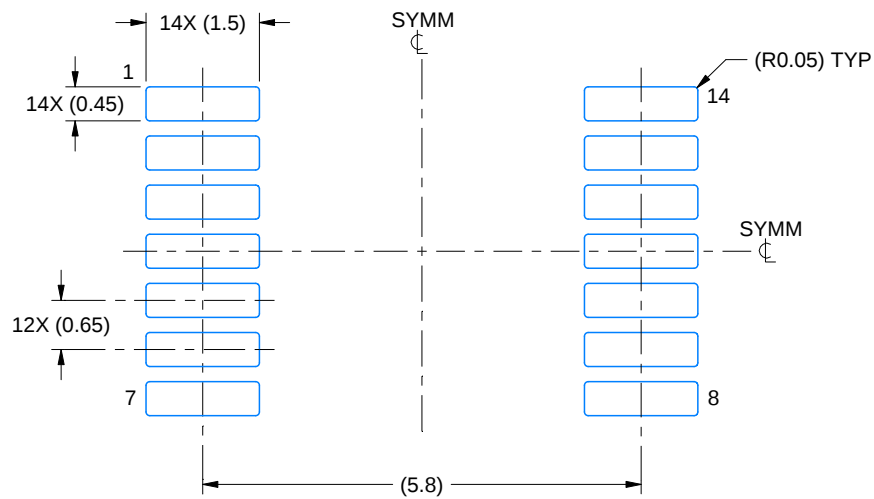
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or 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

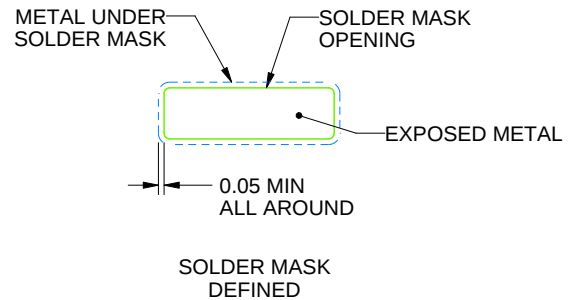
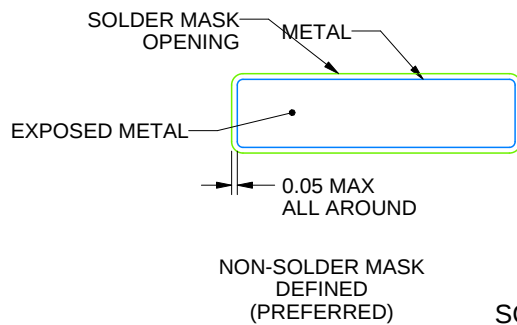
PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

4220202/B 12/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

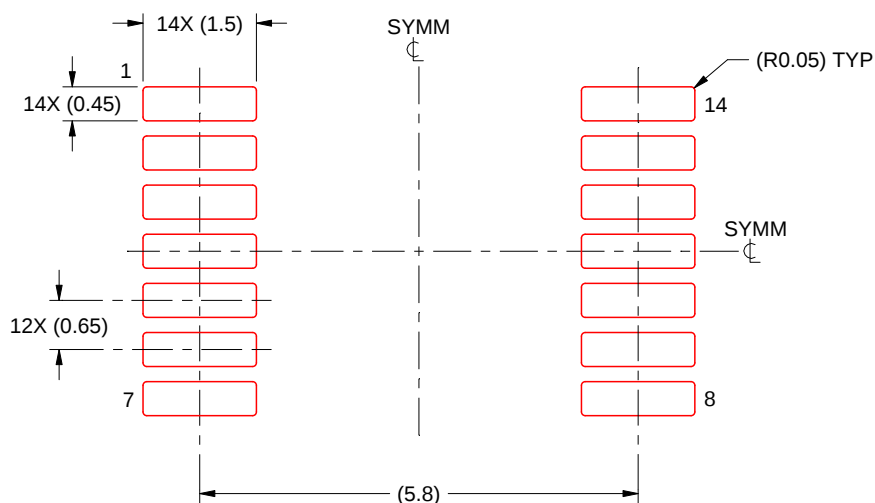
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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

4220202/B 12/2023

NOTES: (continued)

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

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