

LP324 LP2902 Ultra-Low-Power Quadruple Operational Amplifiers

1 Features

- Low supply current: 85µA typical
- Low offset voltage: 2mV typical
- Low input bias current: 2nA typical
- Input common mode to ground
- Wide supply voltage: $3V < V_{CC} < 32V$
- Pin compatible with [LM324](#)

2 Applications

- LCD displays
- Portable instrumentation
- Sensor and metering equipment
- Consumer electronics:
 - MP3 players, toys, and more
- Power supplies

3 Description

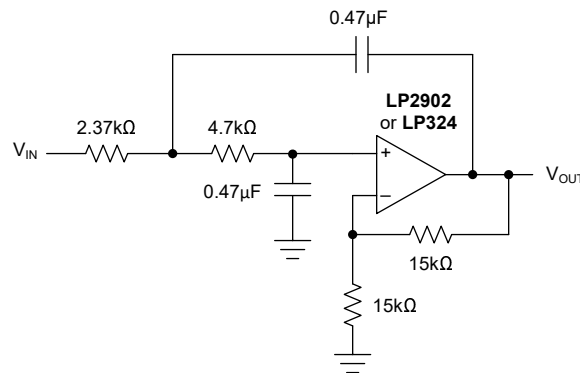
The LP324 and LP2902 are quadruple low-power operational amplifiers especially designed for battery-operated applications. Good input specifications and a wide supply-voltage range are achieved, despite the ultra-low supply current. Single-supply operation is achieved with an input common-mode range that includes ground (GND).

The LP324 and LP2902 are an excellent choice for applications where wide supply voltage and low power are more important than speed and bandwidth. These applications include portable instrumentation, LCD displays, consumer electronics (MP3 players, toys, and so forth), and power supplies.

Device Information

PART NUMBER	TEMPERATURE (T _A)	PACKAGE ⁽¹⁾
LP2902	–40°C to +85°C	D (SOIC, 14) N (PDIP, 14) PW (TSSOP, 14)
LP324	0°C to 70°C	

(1) For all available packages, see [Section 8](#).



100Hz Low-Pass Filter With a Gain of 2



Table of Contents

1 Features	1	5.5 Electrical Characteristics.....	4
2 Applications	1	6 Device and Documentation Support	6
3 Description	1	6.1 Receiving Notification of Documentation Updates.....	6
4 Pin Configuration and Functions	2	6.2 Support Resources.....	6
5 Specifications	3	6.3 Trademarks.....	6
5.1 Absolute Maximum Ratings.....	3	6.4 Electrostatic Discharge Caution.....	6
5.2 ESD Ratings	3	6.5 Glossary.....	6
5.3 Recommended Operating Conditions.....	3	7 Revision History	6
5.4 Thermal Information.....	3	8 Mechanical, Packaging, and Orderable Information	6

4 Pin Configuration and Functions

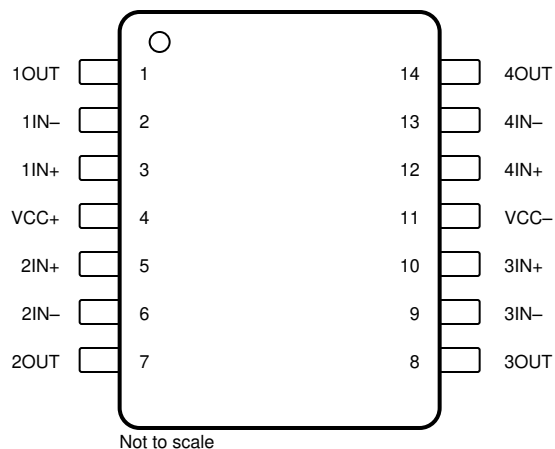


Figure 4-1. D Package, 14-Pin SOIC, N Package, 14-Pin PDIP, and PW Package, 14-Pin TSSOP (Top View)

Table 4-1. Pin Functions

PIN		TYPE	DESCRIPTION
NAME	NO.		
1IN–	2	Input	Negative input
1IN+	3	Input	Positive input
1OUT	1	Output	Output
2IN–	6	Input	Negative input
2IN+	5	Input	Positive input
2OUT	7	Output	Output
3IN–	9	Input	Negative input
3IN+	10	Input	Positive input
3OUT	8	Output	Output
4IN–	13	Input	Negative input
4IN+	12	Input	Positive input
4OUT	14	Output	Output
VCC–	11	Power	Negative (lowest) supply or ground (for single-supply operation)
VCC+	4	Power	Positive (highest) supply

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)^{(1) (2)}

			MIN	MAX	UNIT
V _{CC}	Supply voltage	Single supply		32	V
		Dual supply		±16	
V _{ID}	Differential input voltage ⁽³⁾			32	V
V _I	Input voltage (either input)		–0.3	32	V
	Duration of output short-circuit to ground (one amplifier) at or less than T _A = 25°C, V _{CC} ≤ 15V ⁽⁴⁾		Unlimited		
T _J	Operating virtual junction temperature			150	°C
T _{stg}	Storage temperature		–65	150	°C

- (1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. *Absolute Maximum Ratings* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
- (2) All voltage values (except differential voltages and V_{CC} specified for the measurement of I_{OS}) are with respect to the network ground (GND).
- (3) Differential voltages are at IN+, with respect to IN–.
- (4) Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.

5.2 ESD Ratings

			VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001	±350	V

5.3 Recommended Operating Conditions

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

			MIN	NOM	MAX	UNIT
T _A	Operating ambient temperature	LP2902	–40		85	°C
		LP324	0		70	

5.4 Thermal Information

THERMAL METRIC ^{(1) (2)}		LP2902, LP324			UNIT
		D (SOIC)	PW (TSSOP)	N (PDIP)	
		14 PINS	14 PINS	14 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	140	154	90	°C/W

- (1) For information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.
- (2) Maximum power dissipation is a function of T_{J(max)}, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is P_D = (T_{J(max)} – T_A) / θ_{JA}. Operating at the absolute maximum T_J of 150°C potentially affects reliability.

5.5 Electrical Characteristics

at $T_A = 25^\circ\text{C}$, $V_{CC} = 5\text{V}$, $V_{IC} = V_{CC} / 2$, and $R_L = 100\text{k}\Omega$ connected to GND (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN		TYP		MAX		UNIT
OFFSET VOLTAGE										
V _{IO}	Input offset voltage	LP2902		2		4		mV		
			T _A = −40°C to +85°C	10						
		LP324		2		4				
			T _A = 0°C to 70°C	9						
dV _{IO} /dT	Input offset voltage drift	LP2902, T _A = 0°C to 70°C		10				μV/°C		
		LP324, T _A = −40°C to +85°C		10						
PSRR	Power supply rejection ratio	V _{CC} = 5V to 30V		80	90		dB			
			LP2902 T _A = −40°C to +85°C	75						
			LP324 T _A = 0°C to 70°C	75						
CMRR	Common-mode rejection ratio	V _{CC} = 30V, V _{IC} = 0V to V _{CC} − 1.5V		80	90		dB			
			LP2902 T _A = −40°C to +85°C	75						
			LP324 T _A = 0°C to 70°C	75						
INPUT BIAS CURRENT										
I _{IB}	Input bias current	LP2902		2		20		nA		
			T _A = −40°C to +85°C	40						
		LP324		2		10				
			T _A = 0°C to 70°C	20						
I _{IO}	Input offset current	LP2902		0.5		4		nA		
			T _A = −40°C to +85°C	8						
		LP324		0.2		2				
			T _A = 0°C to 70°C	4						
I _{IO} /dT	Input offset current drift	LP2902		10				pA/°C		
		LP324		10						
OPEN-LOOP GAIN										
A _V	Large-signal voltage gain	V _{CC} = 30V, R _L = 10kΩ to GND	LP2902	40	70		V/mV			
			LP2902 T _A = −40°C to +85°C	30						
			LP324	50	100					
			LP324 T _A = 0°C to 70°C	40						
FREQUENCY RESPONSE										
GBW	Gain bandwidth product	V _{CC} = ±15V		100				kHz		
SR	Slew rate	V _{CC} = ±15V		50				V/ms		
OUTPUT										
V _O	Output voltage swing	I _L = 350μA to ground, V _{IC} = 0V		3.4	3.6		V			
			LP2902 T _A = −40°C to +85°C	(V _{CC}) − 1.9						
			LP324 T _A = 0°C to 70°C	(V _{CC}) − 1.9						
		I _L = 350μA to V _{CC} , V _{IC} = 0V		0.82	0.7					
			LP2902 T _A = −40°C to +85°C	1						
			LP324 T _A = 0°C to 70°C	1						

5.5 Electrical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_{CC} = 5\text{V}$, $V_{IC} = V_{CC} / 2$, and $R_L = 100\text{k}\Omega$ connected to GND (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
I _O	Output current	Source, V _O = 3V, V _{ID} = 1V		7	10		mA
			LP2902 T _A = −40°C to +85°C	4			
			LP324 T _A = 0°C to 70°C	4			
		Sink, V _O = 1.5V, V _{ID} = −1V		4	5		
			LP2902 T _A = −40°C to +85°C	3			
			LP324 T _A = 0°C to 70°C	3			
		Sink, V _O = 1.5V, V _{ID} = −1V, V _{IC} = 0V		2	4		
			LP2902 T _A = −40°C to +85°C	1			
			LP324 T _A = 0°C to 70°C	1			
I _{SC}	Short circuit current	Short to ground, V _{ID} = 1V			20	35	mA
			LP2902 T _A = −40°C to +85°C			40	
			LP324 T _A = 0°C to 70°C			40	
		Short to V _{CC} , V _{ID} = −1V			15	30	
			LP2902 T _A = −40°C to +85°C			45	
			LP324 T _A = 0°C to 70°C			45	
			POWER SUPPLY				
I _{CC}	Supply current	No load			85	150	μA
			LP2902 T _A = −40°C to +85°C			275	
			LP324 T _A = 0°C to 70°C			250	

6 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

6.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on 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.

6.2 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.

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](#).

6.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.

All trademarks are the property of their respective owners.

6.4 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.

6.5 Glossary

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

7 Revision History

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

Changes from Revision A (May 2005) to Revision B (September 2025)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document.....	1
• Added <i>Pin Configuration and Functions, Specifications, Recommended Operating Conditions, Device and Documentation Support, and Mechanical, Packaging, and Orderable Information</i> sections.....	1
• Updated front page figure.....	1
• Deleted figure, <i>Schematic (Each Amplifier)</i>	2
• Deleted note 6 in <i>Absolute Maximum Ratings</i>	3
• Moved package thermal impedance information from <i>Absolute Maximum Ratings</i> to <i>Thermal Information</i>	3
• Changed human body model value from $\pm 2\text{kV}$ to $\pm 350\text{V}$ in <i>ESD Ratings</i>	3
• Added <i>Thermal Information</i> and updated values.....	3
• Deleted notes 1, 2 and 3.....	4
• Changed power supply rejection ratio units from V to dB (typo).....	4

8 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)
LP2902D	Obsolete	Production	SOIC (D) 14	-	-	Call TI	Call TI	-40 to 85	LP2902
LP2902DR	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LP2902
LP2902DR.A	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LP2902
LP2902DR.B	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LP2902
LP2902N	Active	Production	PDIP (N) 14	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-40 to 85	LP2902N
LP2902N.A	Active	Production	PDIP (N) 14	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-40 to 85	LP2902N
LP2902PW	Obsolete	Production	TSSOP (PW) 14	-	-	Call TI	Call TI	-40 to 85	LP2902
LP2902PWR	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LP2902
LP2902PWR.A	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LP2902
LP2902PWR.B	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LP2902
LP2902PWRE4	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	-	Call TI	Call TI	-40 to 85	
LP324D	Obsolete	Production	SOIC (D) 14	-	-	Call TI	Call TI	0 to 70	LP324
LP324DR	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU SN	Level-1-260C-UNLIM	0 to 70	LP324
LP324DR.A	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LP324
LP324DR.B	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LP324
LP324DRG4	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LP324
LP324DRG4.A	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LP324
LP324N	Active	Production	PDIP (N) 14	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	0 to 70	LP324N
LP324N.A	Active	Production	PDIP (N) 14	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	0 to 70	LP324N
LP324PW	Obsolete	Production	TSSOP (PW) 14	-	-	Call TI	Call TI	0 to 70	LP324
LP324PWR	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LP324
LP324PWR.A	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LP324
LP324PWR.B	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LP324

⁽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.

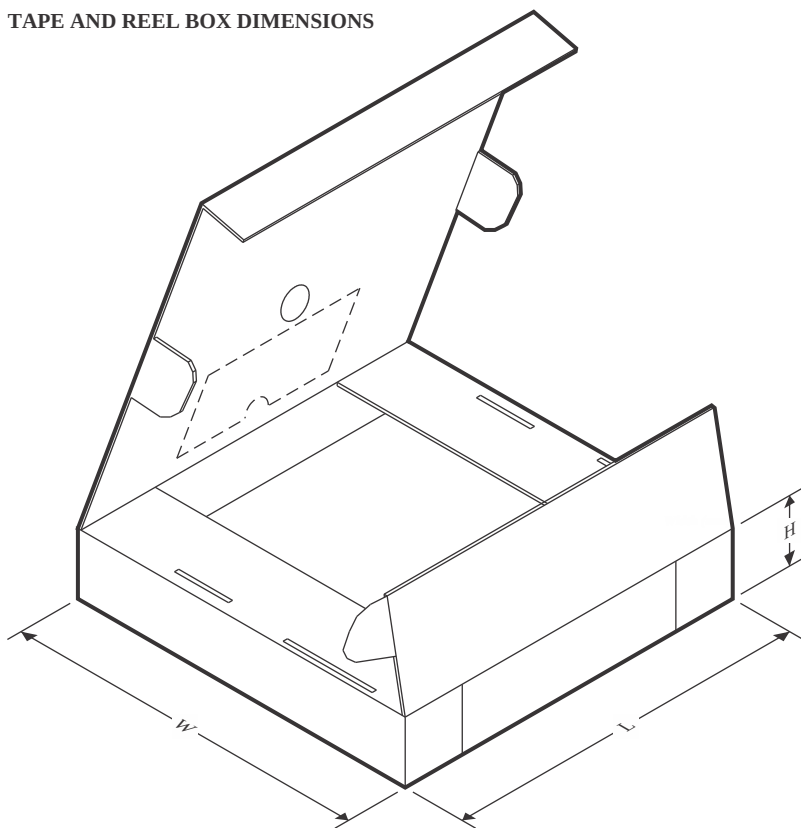
TAPE AND REEL INFORMATION



*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
LP2902DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
LP2902PWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
LP324DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
LP324DRG4	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
LP324PWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

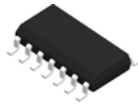
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LP2902DR	SOIC	D	14	2500	353.0	353.0	32.0
LP2902PWR	TSSOP	PW	14	2000	353.0	353.0	32.0
LP324DR	SOIC	D	14	2500	353.0	353.0	32.0
LP324DRG4	SOIC	D	14	2500	340.5	336.1	32.0
LP324PWR	TSSOP	PW	14	2000	353.0	353.0	32.0

TUBE

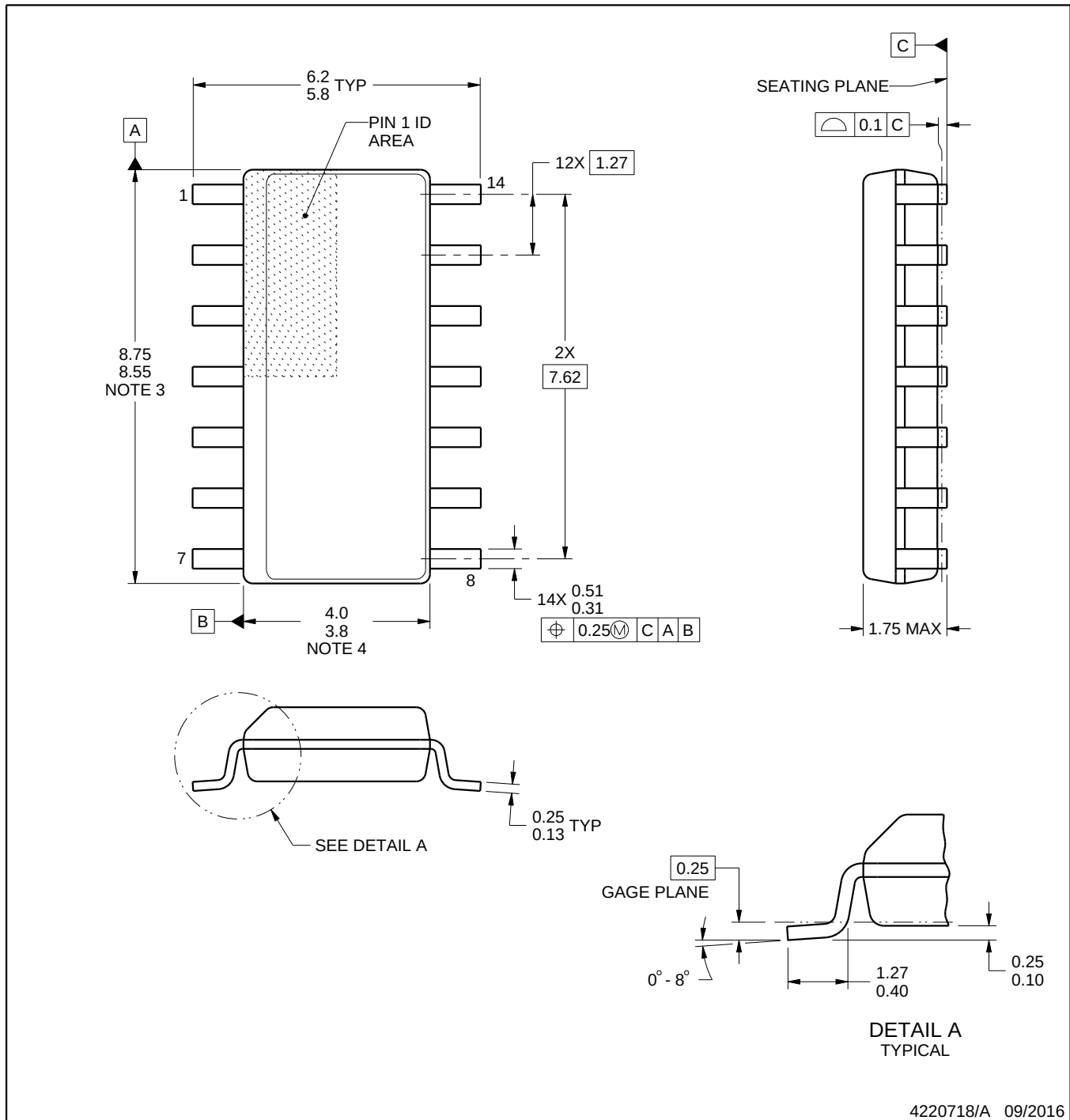


*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
LP2902N	N	PDIP	14	25	506	13.97	11230	4.32
LP2902N.A	N	PDIP	14	25	506	13.97	11230	4.32
LP324N	N	PDIP	14	25	506	13.97	11230	4.32
LP324N.A	N	PDIP	14	25	506	13.97	11230	4.32

D0014A**PACKAGE OUTLINE****SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT

**NOTES:**

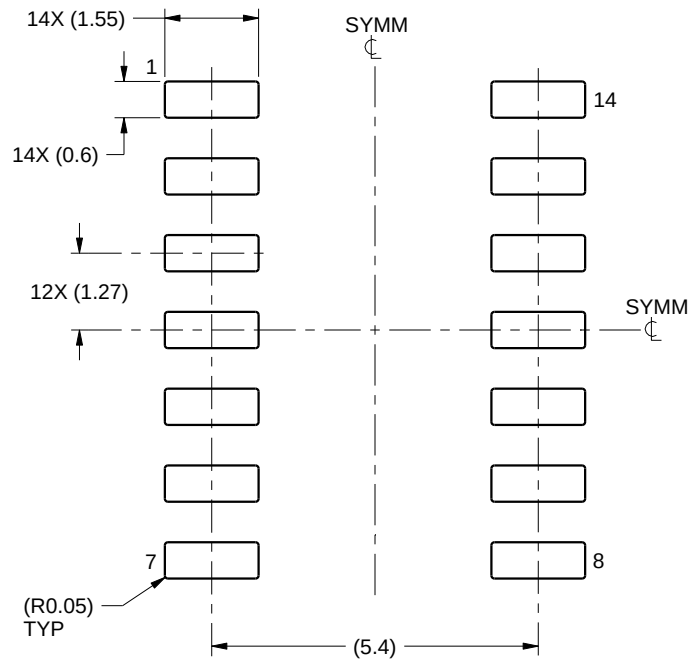
1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm, per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.43 mm, per side.
5. Reference JEDEC registration MS-012, variation AB.

EXAMPLE BOARD LAYOUT

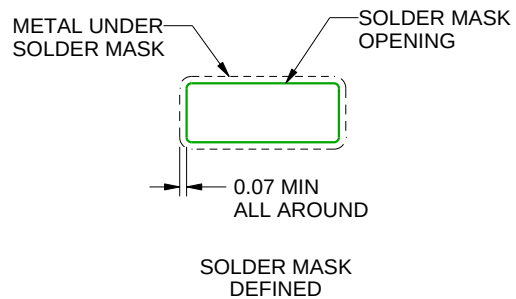
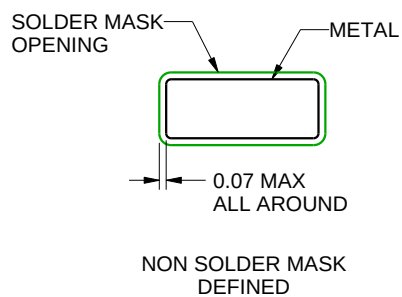
D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
SCALE:8X



SOLDER MASK DETAILS

4220718/A 09/2016

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

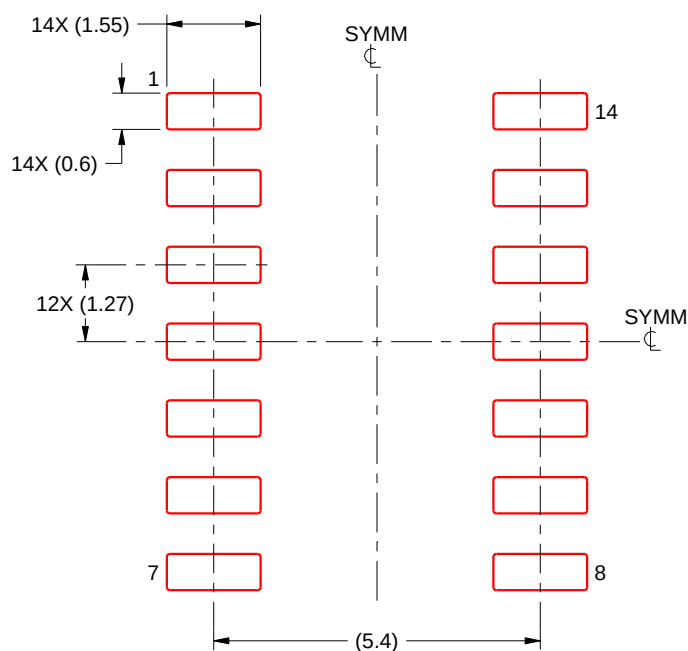
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:8X

4220718/A 09/2016

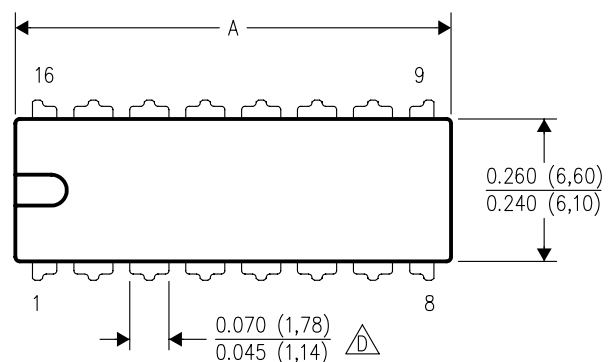
NOTES: (continued)

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.

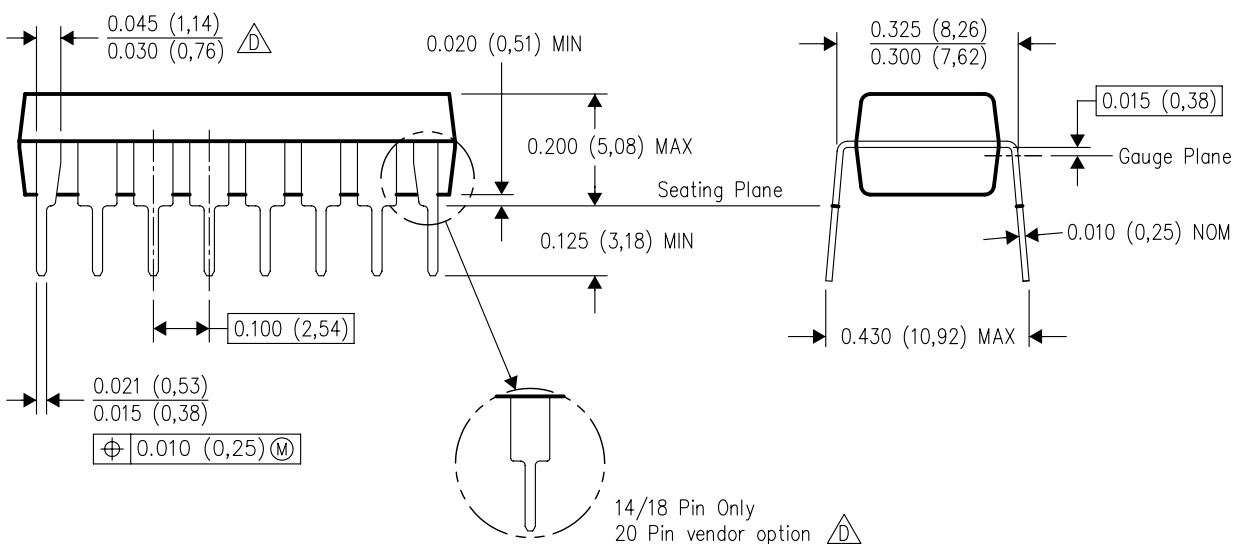
N (R-PDIP-T**)

16 PINS SHOWN

PLASTIC DUAL-IN-LINE PACKAGE



PINS ** DIM	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS-001 VARIATION	AA	BB	AC	AD



4040049/E 12/2002

NOTES:

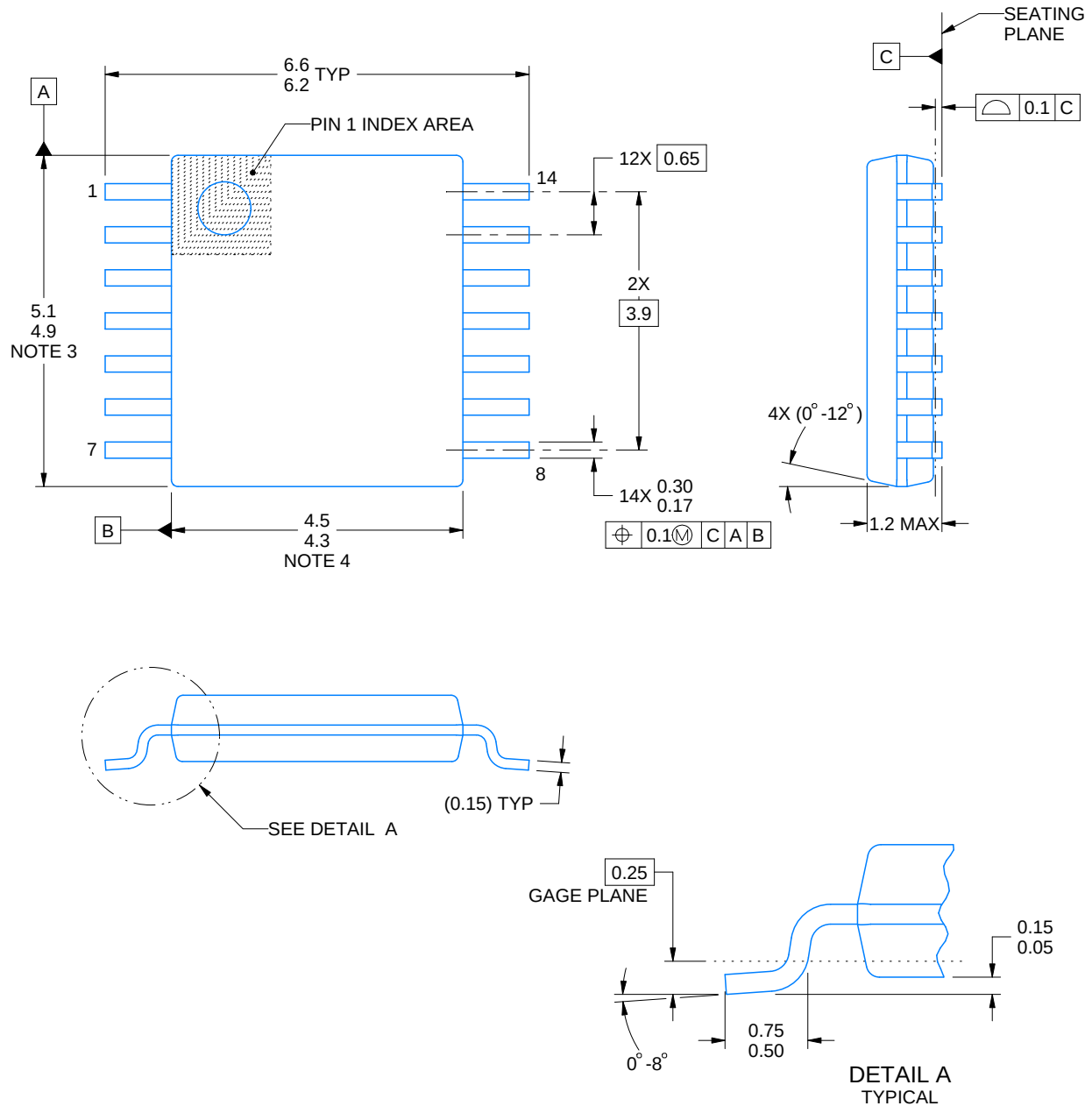
- A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
-  Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
 The 20 pin end lead shoulder width is a vendor option, either half or full width.

PW0014A

PACKAGE OUTLINE

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



4220202/B 12/2023

NOTES:

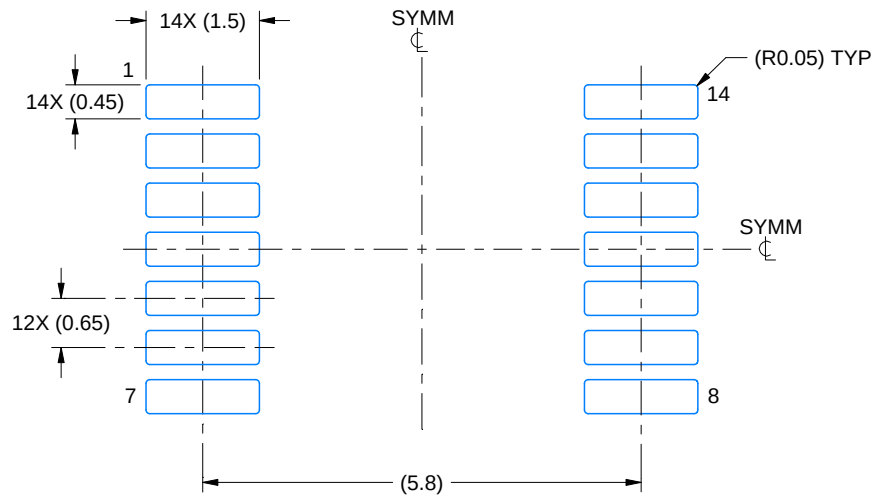
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or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

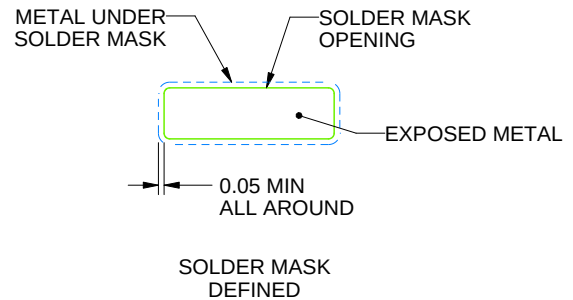
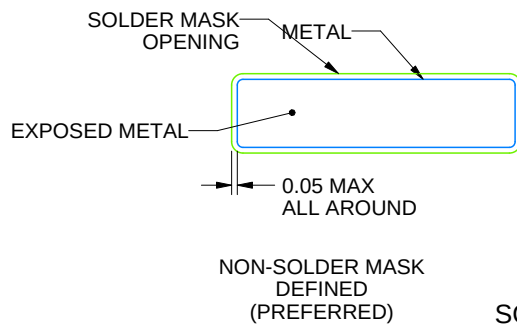
PW0014A

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.

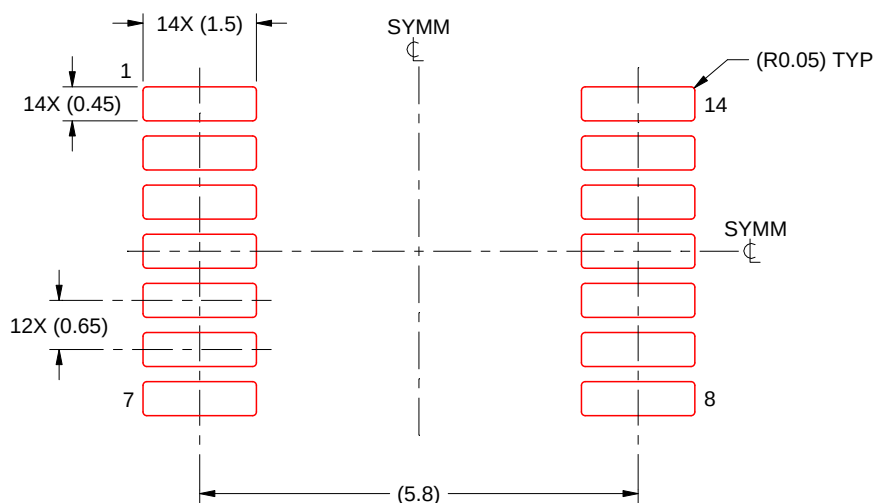
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

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.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2025, Texas Instruments Incorporated