

LM148, LM248, LM348 QUADRUPLE OPERATIONAL AMPLIFIERS

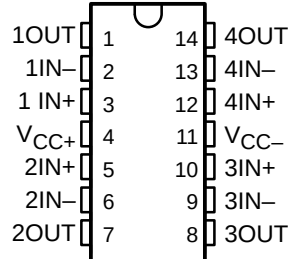
SLOS058C – OCTOBER 1979 – REVISED DECEMBER 2002

- μ A741 Operating Characteristics
- Low Supply-Current Drain . . . 0.6 mA Typ (per amplifier)
- Low Input Offset Voltage
- Low Input Offset Current
- Class AB Output Stage
- Input/Output Overload Protection
- Designed to Be Interchangeable With Industry Standard LM148, LM248, and LM348

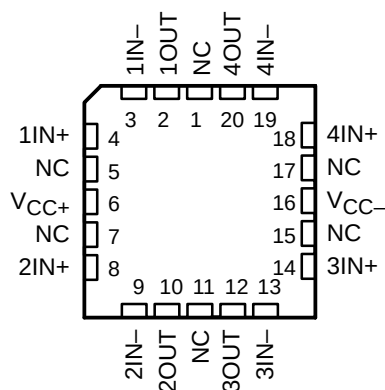
description/ordering information

The LM148, LM248, and LM348 are quadruple, independent, high-gain, internally compensated operational amplifiers designed to have operating characteristics similar to the μ A741. These amplifiers exhibit low supply-current drain and input bias and offset currents that are much less than those of the μ A741.

LM148 . . . J PACKAGE
LM248 . . . D OR N PACKAGE
LM348 . . . D, N, OR NS PACKAGE
(TOP VIEW)



LM148 . . . FK PACKAGE
(TOP VIEW)



NC – No internal connection

ORDERING INFORMATION

T_A	V_{IOmax} AT 25°C	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	6 mV	PDIP (N)	Tube of 25	LM348N	LM348N
		SOIC (D)	Tube of 50	LM348D	LM348
			Reel of 2500	LM348DR	
		SOP (NS)	Reel of 2000	LM348NSR	LM348
–25°C to 85°C	6 mV	PDIP (N)	Tube of 25	LM248N	LM248N
		SOIC (D)	Tube of 50	LM248D	LM248
			Reel of 2500	LM248DR	
–55°C to 125°C	5 mV	CDIP (J)	Tube of 25	LM148J	LM148J
		LCCC (FK)	Tube of 50	LM148FK	LM148FK

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS
INSTRUMENTS**

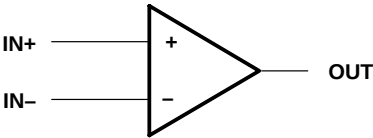
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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

LM148, LM248, LM348
QUADRUPLE OPERATIONAL AMPLIFIERS

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symbol (each amplifier)



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Table with 2 columns: Parameter and Rating. Rows include Supply voltage (VCC+), Supply voltage (VCC-), Differential input voltage (VID), Input voltage (VI), Duration of output short circuit, Operating virtual junction temperature (TJ), Package thermal impedance (thetaJA), Package thermal impedance (thetaJC), Case temperature for 60 seconds, Lead temperature, and Storage temperature range.

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied.

- NOTES: 1. All voltage values, unless otherwise noted, are with respect to the midpoint between VCC+ and VCC-.
2. Differential voltages are at IN+ with respect to IN-.
3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or the value specified in the table, whichever is less.
4. The output may be shorted to ground or either power supply. Temperature and/or supply voltages must be limited to ensure that the dissipation rating is not exceeded.
5. Maximum power dissipation is a function of TJ(max), thetaJA, and TA. The maximum allowable power dissipation at any allowable ambient temperature is PD = (TJ(max) - TA)/thetaJA. Operating at the absolute maximum TJ of 150°C can affect reliability.
6. The package thermal impedance is calculated in accordance with JESD 51-7.
7. Maximum power dissipation is a function of TJ(max), thetaJC, and TC. The maximum allowable power dissipation at any allowable ambient temperature is PD = (TJ(max) - TC)/thetaJC. Operating at the absolute maximum TJ of 150°C can affect reliability.
8. The package thermal impedance is calculated in accordance with MIL-STD-883.

recommended operating conditions

Table with 4 columns: Parameter, MIN, MAX, UNIT. Rows include Supply voltage (VCC+) and Supply voltage (VCC-).

electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm 15$ V (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		LM148			LM248			LM348			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	Input offset voltage	V _O = 0	25°C	1	5	1	6	1	6	mV			
			Full range	6	7.5	7.5							
I _{IO}	Input offset current	V _O = 0	25°C	4	25	4	50	4	50	nA			
			Full range	75	125	100							
I _{IB}	Input bias current	V _O = 0	25°C	30	100	30	200	30	200	nA			
			Full range	325	500	400							
V _{ICR}	Common-mode input voltage range		Full range	±12		±12		±12		V			
V _{OM}	Maximum peak output voltage swing	R _L = 10 kΩ	25°C	±12 ±13		±12 ±13		±12 ±13		V			
		R _L ≥ 10 kΩ	Full range	±12		±12		±12					
		R _L = 2 kΩ	25°C	±10 ±12		±10 ±12		±10 ±12					
		R _L ≥ 2 kΩ	Full range	±10		±10		±10					
A _{VD}	Large-signal differential voltage amplification	V _O = ±10 V, R _L = ≥ 2 kΩ	25°C	50	160	25	160	25	160	V/mV			
			Full range	25	15	15							
r _i	Input resistance‡		25°C	0.8	2.5	0.8	2.5	0.8	2.5	MΩ			
B ₁	Unity-gain bandwidth	A _{VD} = 1	25°C	1		1		1		MHz			
φ _m	Phase margin	A _{VD} = 1	25°C	60°		60°		60°					
CMRR	Common-mode rejection ratio	V _{IC} = V _{ICRmin} , V _O = 0	25°C	70	90	70	90	70	90	dB			
			Full range	70	70	70							
k _{SVR}	Supply-voltage rejection ratio (ΔV _{CC±} /ΔV _{IO})	V _{CC±} = ±9 V to ±15 V, V _O = 0	25°C	77	96	77	96	77	96	dB			
			Full range	77	77	77							
I _{OS}	Short-circuit output current		25°C	±25		±25		±25		mA			
I _{CC}	Supply current (four amplifiers)	No load	25°C			2.4 4.5		2.4 4.5		mA			
		V _O = 0		2.4 3.6									
V _{O1} /V _{O2}	Crosstalk attenuation	f = 1 Hz to 20 kHz	25°C	120		120		120		dB			

[†] All characteristics are measured under open-loop conditions with zero common-mode input voltage, unless otherwise specified. Full range for T_A is -55°C to 125°C for LM148, -25°C to 85°C for LM248, and 0°C to 70°C for LM348.

[‡] This parameter is not production tested.

LM148, LM248, LM348

QUADRUPLE OPERATIONAL AMPLIFIERS

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operating characteristics, $V_{CC\pm} = \pm 15\text{ V}$, $T_A = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, See Figure 1		0.5		V/ μs

PARAMETER MEASUREMENT INFORMATION

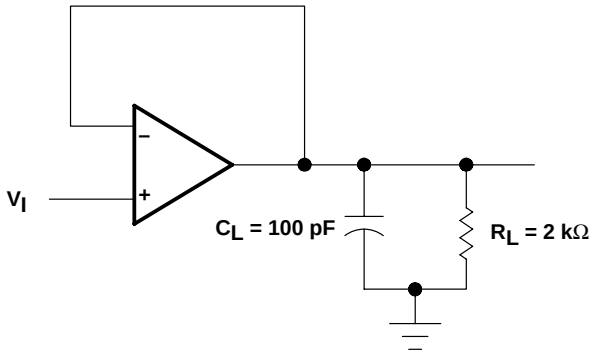


Figure 1. Unity-Gain Amplifier

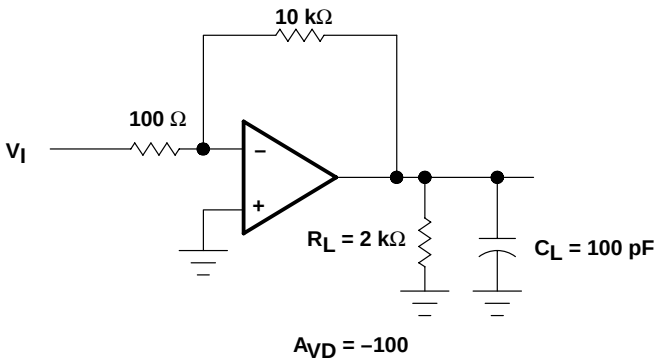


Figure 2. Inverting Amplifier

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)
LM148 MW8	Active	Production	WAFERSALE (YS) 0	1 NOT REQUIRED	-	Call TI	Level-1-NA-UNLIM	-55 to 125	
LM148FKB	Active	Production	LCCC (FK) 20	55 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	LM148FKB
LM148FKB.A	Active	Production	LCCC (FK) 20	55 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	LM148FKB
LM148J	Active	Production	CDIP (J) 14	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	LM148J
LM148J.A	Active	Production	CDIP (J) 14	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	LM148J
LM148JB	Active	Production	CDIP (J) 14	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	LM148JB
LM148JB.A	Active	Production	CDIP (J) 14	25 TUBE	No	SNPB	N/A for Pkg Type	-55 to 125	LM148JB
LM248D	Obsolete	Production	SOIC (D) 14	-	-	Call TI	Call TI	-25 to 85	LM248
LM248DR	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM248
LM248DR.A	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM248
LM248N	Active	Production	PDIP (N) 14	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-25 to 85	LM248N
LM248N.A	Active	Production	PDIP (N) 14	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	-25 to 85	LM248N
LM348D	Obsolete	Production	SOIC (D) 14	-	-	Call TI	Call TI	0 to 70	LM348
LM348DR	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM348
LM348DR.A	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM348
LM348DRE4	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM348
LM348DRG4	Active	Production	SOIC (D) 14	2500 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM348
LM348N	Active	Production	PDIP (N) 14	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	0 to 70	LM348N
LM348N.A	Active	Production	PDIP (N) 14	25 TUBE	Yes	NIPDAU	N/A for Pkg Type	0 to 70	LM348N
LM348NSR	Active	Production	SOP (NS) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM348
LM348NSR.A	Active	Production	SOP (NS) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM348

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

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

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

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

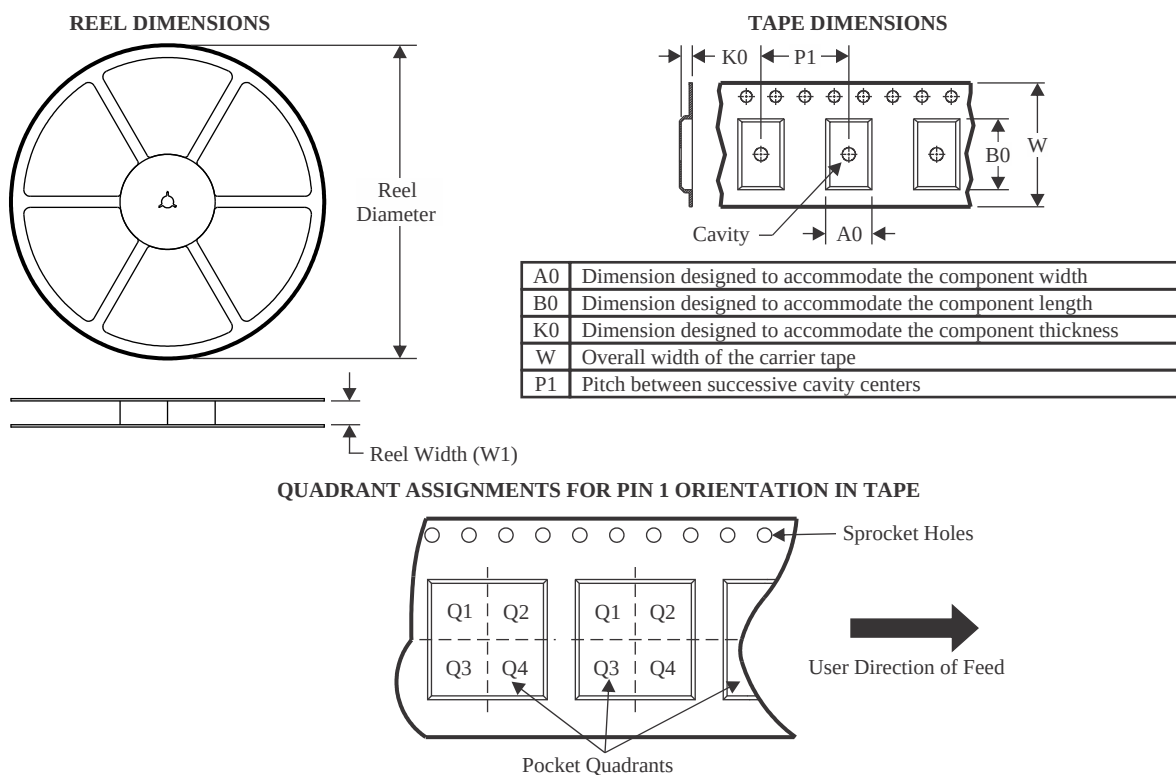
(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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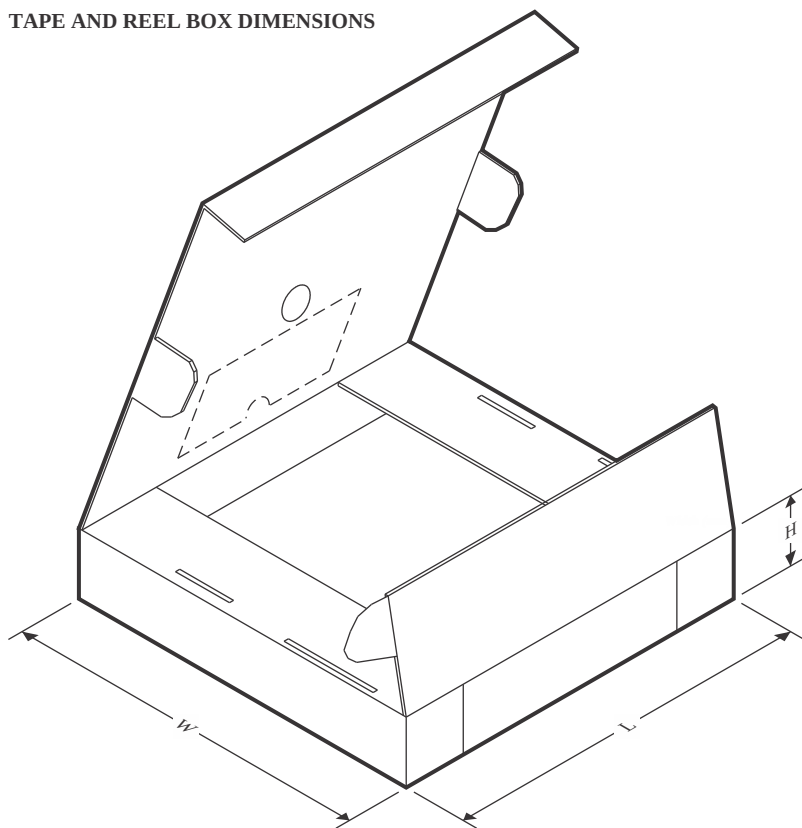
TAPE AND REEL INFORMATION



*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
LM248DR	SOIC	D	14	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM348DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
LM348DR	SOIC	D	14	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM348NSR	SOP	NS	14	2000	330.0	16.4	8.45	10.55	2.5	12.0	16.2	Q1

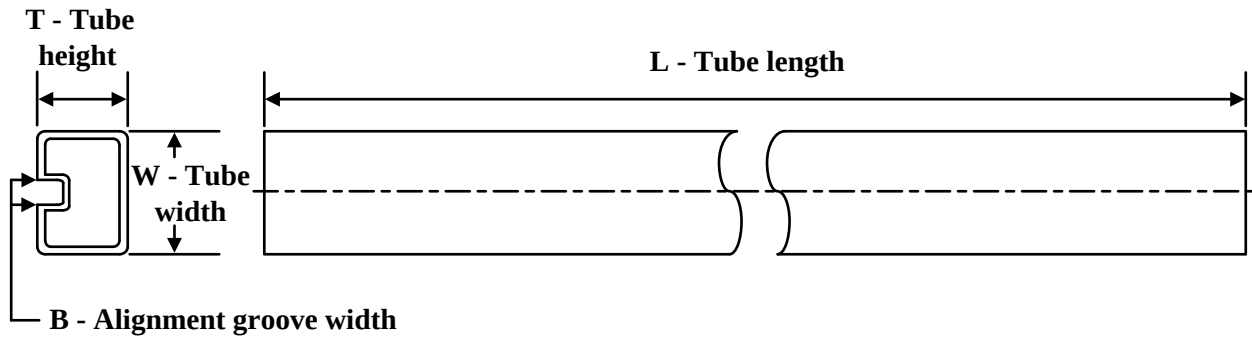
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM248DR	SOIC	D	14	2500	340.5	336.1	25.0
LM348DR	SOIC	D	14	2500	353.0	353.0	32.0
LM348DR	SOIC	D	14	2500	340.5	336.1	25.0
LM348NSR	SOP	NS	14	2000	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)
LM148FKB	FK	LCCC	20	55	506.98	12.06	2030	NA
LM148FKB.A	FK	LCCC	20	55	506.98	12.06	2030	NA
LM248N	N	PDIP	14	25	506	13.97	11230	4.32
LM248N	N	PDIP	14	25	506	13.97	11230	4.32
LM248N.A	N	PDIP	14	25	506	13.97	11230	4.32
LM248N.A	N	PDIP	14	25	506	13.97	11230	4.32
LM348N	N	PDIP	14	25	506	13.97	11230	4.32
LM348N	N	PDIP	14	25	506	13.97	11230	4.32
LM348N.A	N	PDIP	14	25	506	13.97	11230	4.32
LM348N.A	N	PDIP	14	25	506	13.97	11230	4.32

GENERIC PACKAGE VIEW

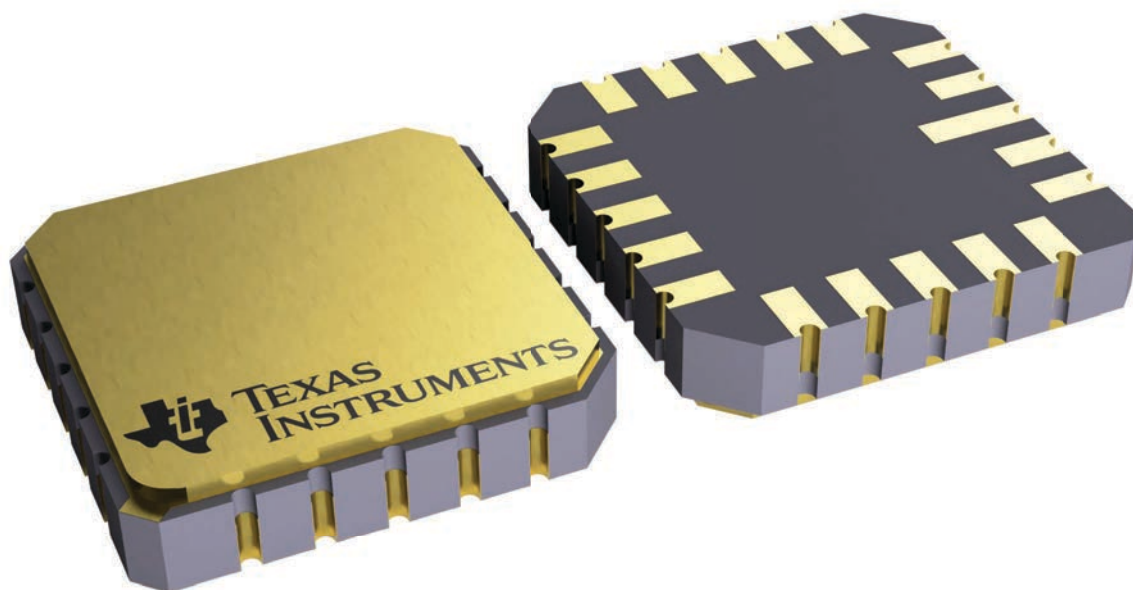
FK 20

LCCC - 2.03 mm max height

8.89 x 8.89, 1.27 mm pitch

LEADLESS CERAMIC CHIP CARRIER

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



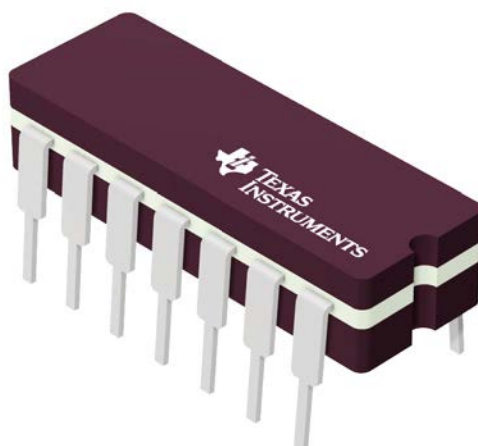
4229370VA\

J 14

GENERIC PACKAGE VIEW

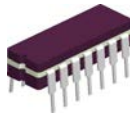
CDIP - 5.08 mm max height

CERAMIC DUAL IN LINE PACKAGE

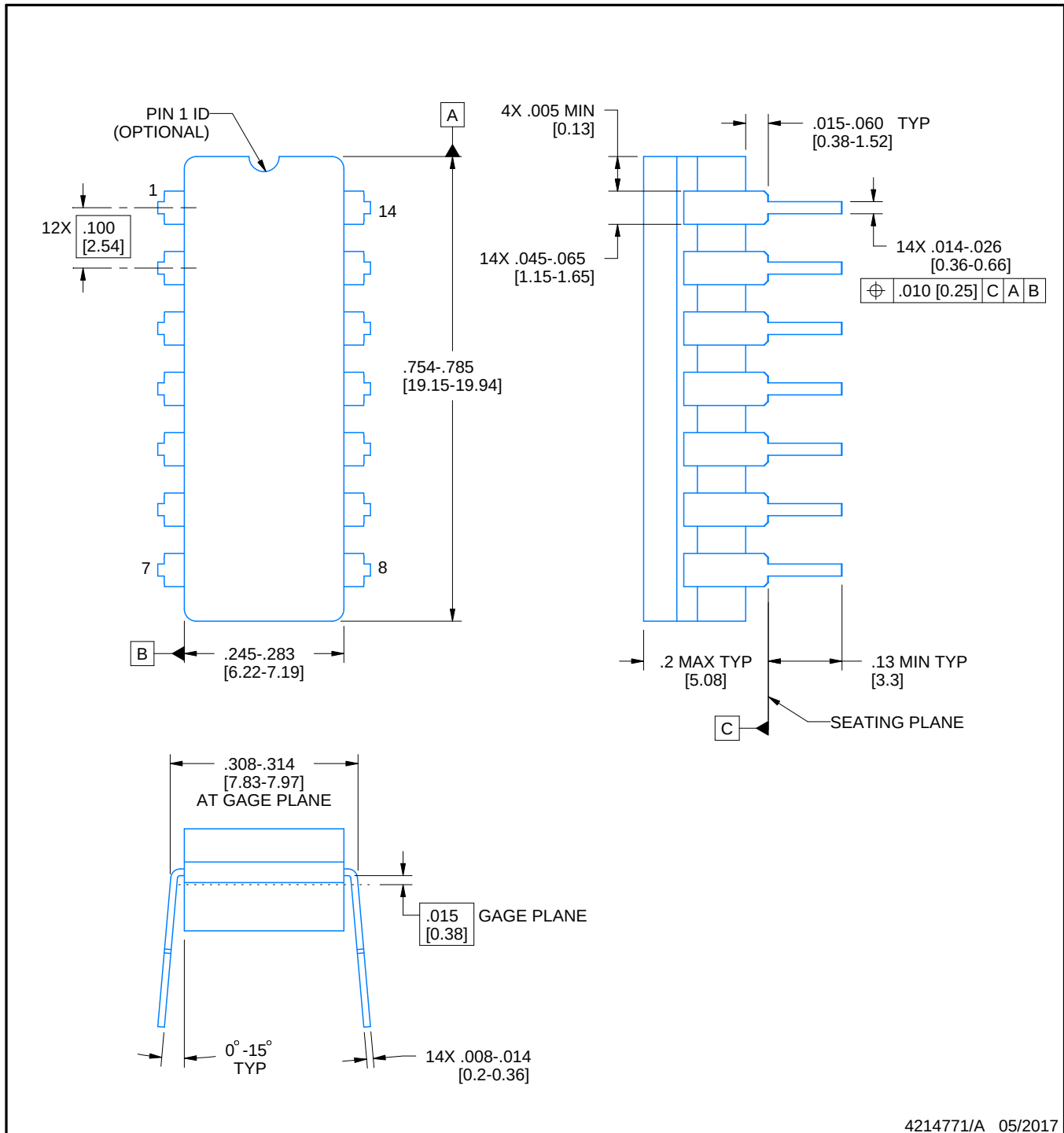


Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4040083-5/G

J0014A**PACKAGE OUTLINE****CDIP - 5.08 mm max height**

CERAMIC DUAL IN LINE PACKAGE



4214771/A 05/2017

NOTES:

1. All controlling linear dimensions are in inches. Dimensions in brackets are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package is hermetically sealed with a ceramic lid using glass frit.
4. Index point is provided on cap for terminal identification only and on press ceramic glass frit seal only.
5. Falls within MIL-STD-1835 and GDIP1-T14.



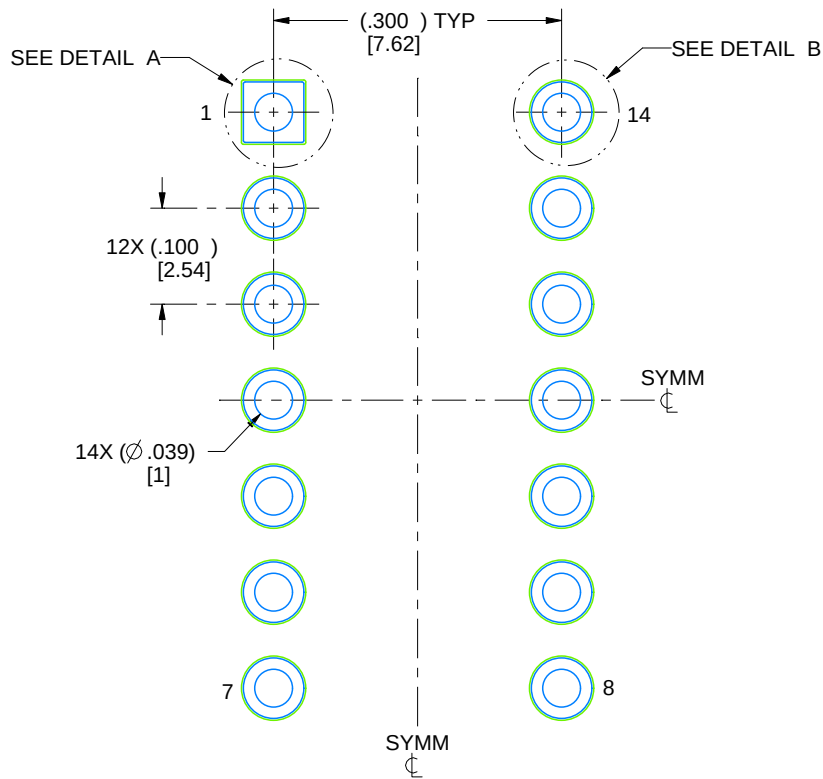
**TEXAS
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EXAMPLE BOARD LAYOUT

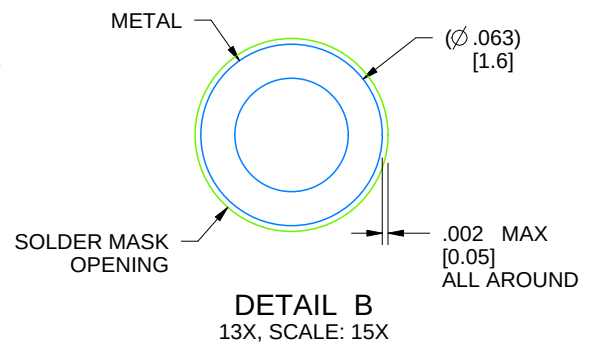
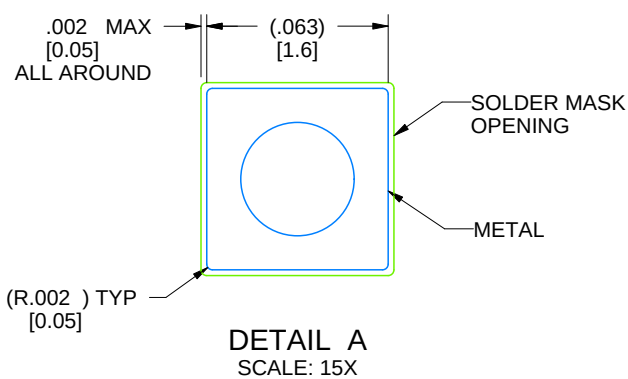
J0014A

CDIP - 5.08 mm max height

CERAMIC DUAL IN LINE PACKAGE



LAND PATTERN EXAMPLE
NON-SOLDER MASK DEFINED
SCALE: 5X

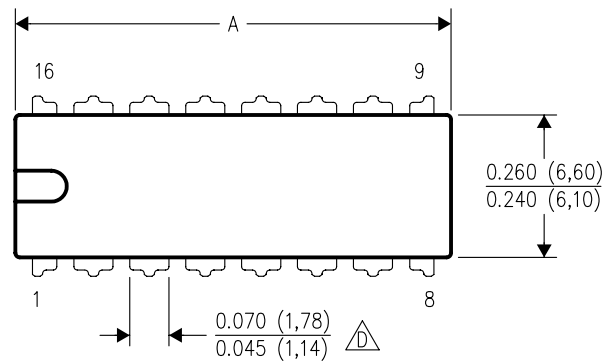


4214771/A 05/2017

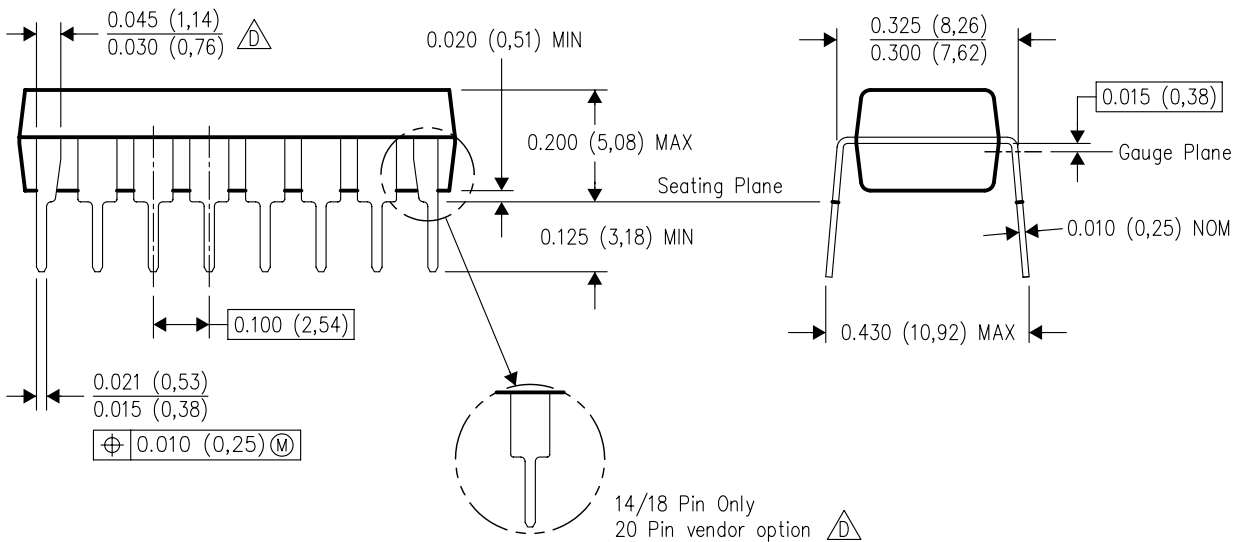
N (R-PDIP-T**)

16 PINS SHOWN

PLASTIC DUAL-IN-LINE PACKAGE

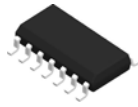


PINS **	14	16	18	20
DIM				
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS-001 VARIATION	AA	BB	AC	AD

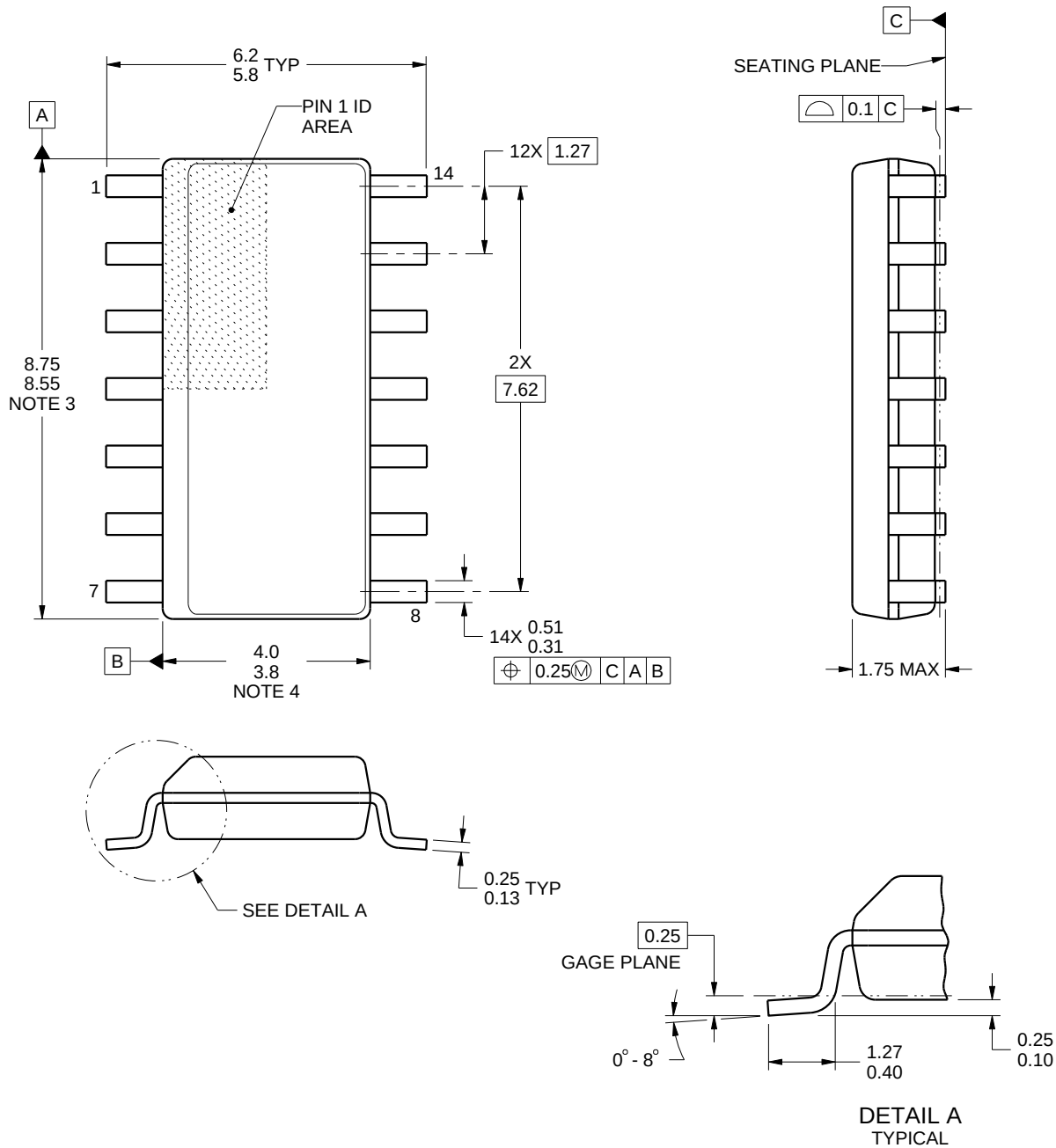


4040049/E 12/2002

- 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.

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

SMALL OUTLINE INTEGRATED CIRCUIT



4220718/A 09/2016

NOTES:

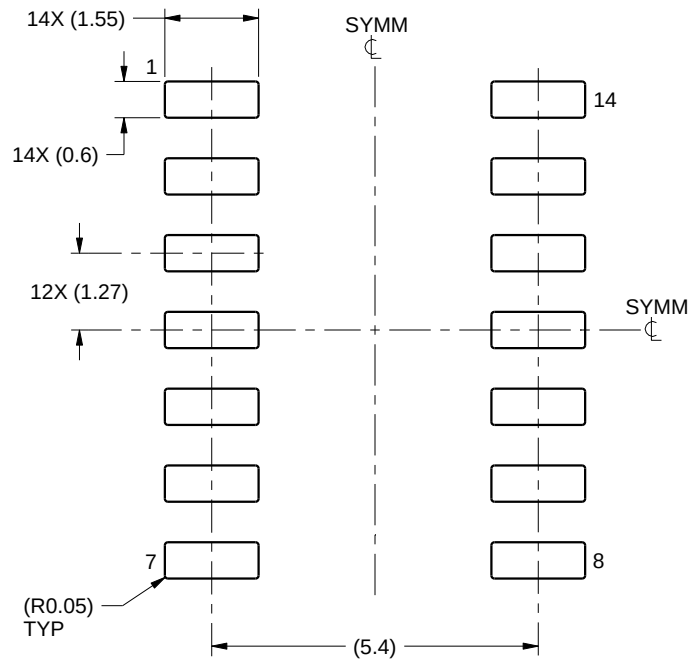
1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate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

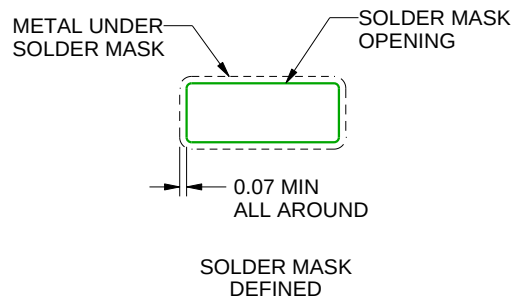
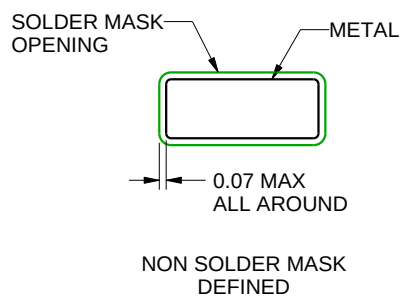
D0014A

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.

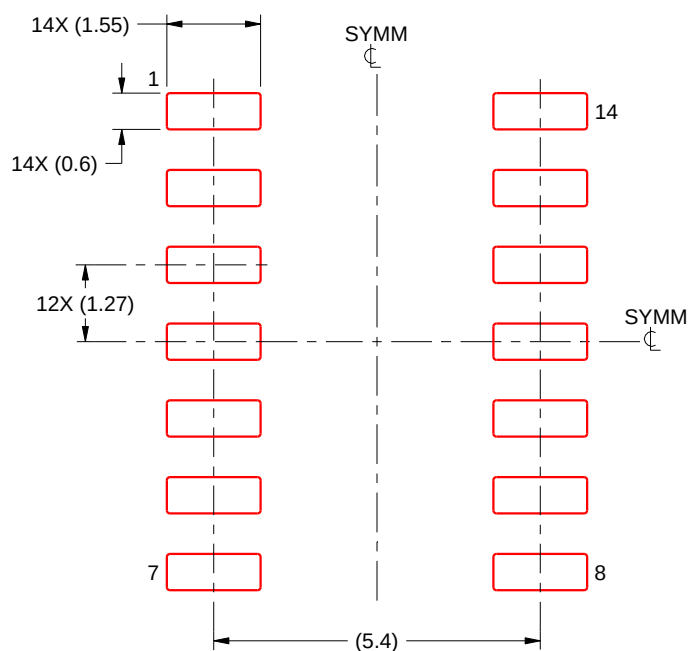
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

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)

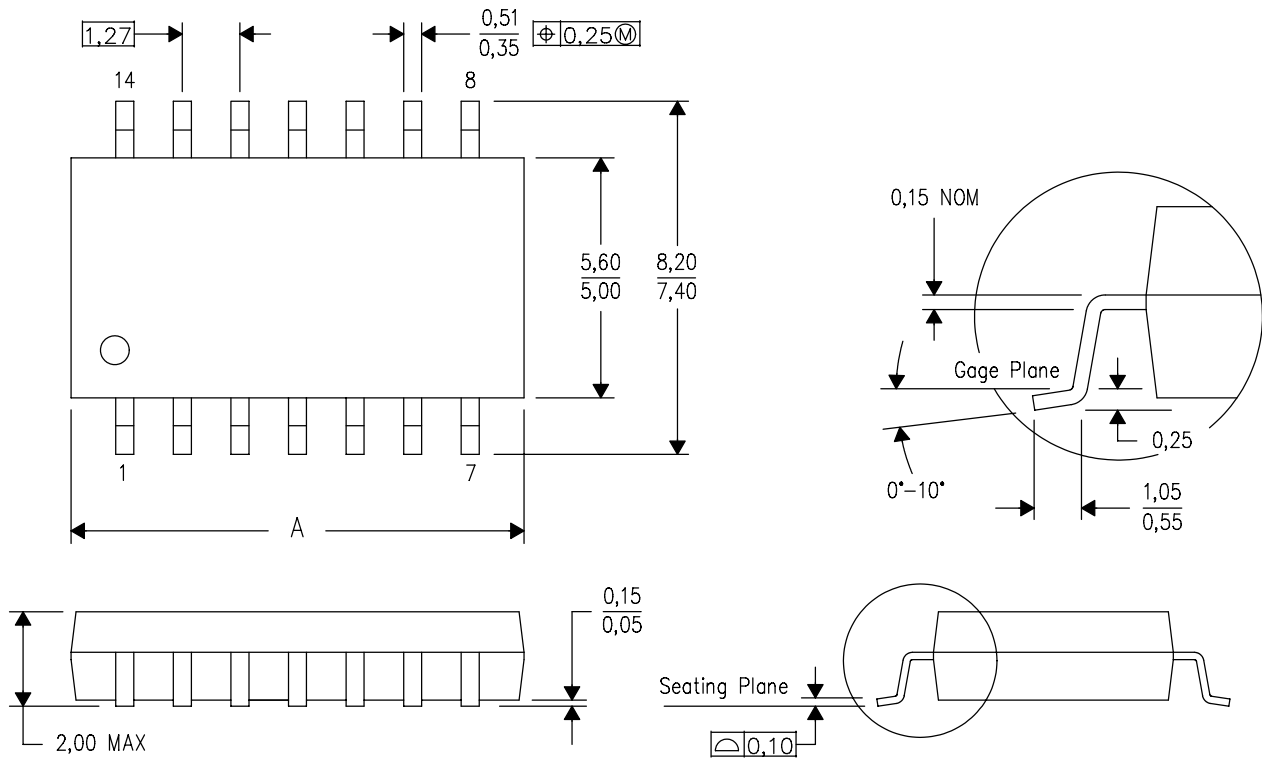
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

MECHANICAL DATA

NS (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN



DIM \ PINS **	14	16	20	24
A MAX	10,50	10,50	12,90	15,30
A MIN	9,90	9,90	12,30	14,70

4040062/C 03/03

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

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