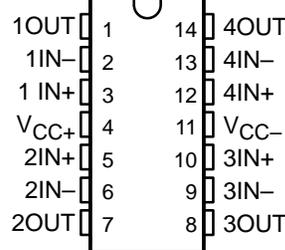


# LM148, LM248, LM348 QUADRUPLE OPERATIONAL AMPLIFIERS

SLOS058C – OCTOBER 1979 – REVISED DECEMBER 2002

- $\mu$ 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

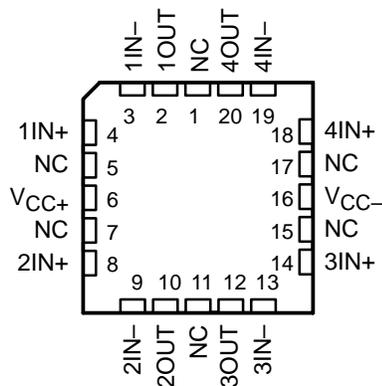
LM148 . . . J PACKAGE  
LM248 . . . D OR N PACKAGE  
LM348 . . . D, N, OR NS PACKAGE  
(TOP VIEW)



## 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  $\mu$ A741. These amplifiers exhibit low supply-current drain and input bias and offset currents that are much less than those of the  $\mu$ A741.

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	
		CDIP (J)	Tube of 25	LM148J	LM148J
-55°C to 125°C	5 mV	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](http://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**

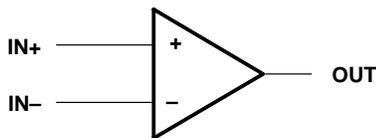
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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

# LM148, LM248, LM348 QUADRUPLE OPERATIONAL AMPLIFIERS

SLOS058C – OCTOBER 1979 – REVISED DECEMBER 2002

## symbol (each amplifier)



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

Supply voltage, $V_{CC+}$ (see Note 1):	LM148	.....	22 V
	LM248, LM348	.....	18 V
Supply voltage, $V_{CC-}$ (see Note 1):	LM148	.....	-22 V
	LM248, LM348	.....	-18 V
Differential input voltage, $V_{ID}$ (see Note 2):	LM148	.....	44 V
	LM248, LM348	.....	36 V
Input voltage, $V_I$ (either input, see Notes 1 and 3):	LM148	.....	-22 V
	LM248, LM348	.....	-18 V
Duration of output short circuit (see Note 4)		.....	Unlimited
Operating virtual junction temperature, $T_J$		.....	150°C
Package thermal impedance, $\theta_{JA}$ (see Notes 5 and 6):	D package	.....	86°C/W
	N package	.....	80°C/W
	NS package	.....	76°C/W
Package thermal impedance, $\theta_{JC}$ (see Notes 7 and 8):	FK package	.....	5.61°C/W
	J package	.....	15.05°C/W
Case temperature for 60 seconds: FK package		.....	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: J package		.....	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: D, N, or NS package		.....	260°C
Storage temperature range, $T_{stg}$		.....	-65°C to 150°C

† 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. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES:
1. All voltage values, unless otherwise noted, are with respect to the midpoint between  $V_{CC+}$  and  $V_{CC-}$ .
  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  $T_J(max)$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(max) - T_A)/\theta_{JA}$ . Operating at the absolute maximum  $T_J$  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  $T_J(max)$ ,  $\theta_{JC}$ , and  $T_C$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(max) - T_C)/\theta_{JC}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.
  8. The package thermal impedance is calculated in accordance with MIL-STD-883.

## recommended operating conditions

	MIN	MAX	UNIT
Supply voltage, $V_{CC+}$	4	18	V
Supply voltage, $V_{CC-}$	-4	-18	V



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**electrical characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$  (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	$R_L = 10\text{ k}\Omega$	25°C	±12 ±13			±12 ±13			±12 ±13			V
		Full range	±12			±12			±12			
		25°C	±10 ±12			±10 ±12			±10 ±12			
		Full range	±10			±10			±10			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10\text{ V}$ , $R_L = \geq 2\text{ k}\Omega$	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
$\phi_m$ 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 ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC\pm} = \pm 9\text{ V to } \pm 15\text{ V}$ , $V_O = 0$	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	$V_O = 0$				2.4 4.5			2.4 4.5			mA
		$V_O = V_{OM}$	2.4 3.6									
$V_{O1}/V_{O2}$ Crosstalk attenuation		$f = 1\text{ Hz to } 20\text{ kHz}$	25°C			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  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for LM148,  $-25^\circ\text{C}$  to  $85^\circ\text{C}$  for LM248, and  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for LM348.

‡ This parameter is not production tested.

# LM148, LM248, LM348 QUADRUPLE OPERATIONAL AMPLIFIERS

SLOS058C – OCTOBER 1979 – REVISED FEBRUARY 2002

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		$\text{V}/\mu\text{s}$

## PARAMETER MEASUREMENT INFORMATION

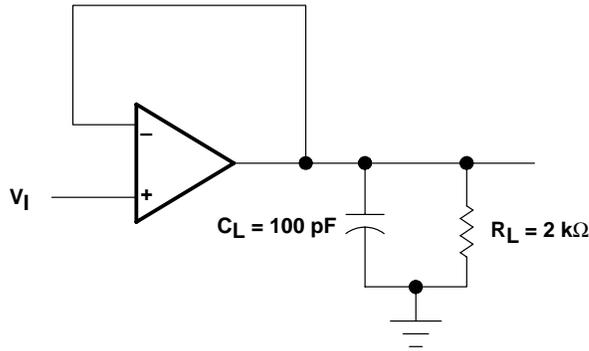


Figure 1. Unity-Gain Amplifier

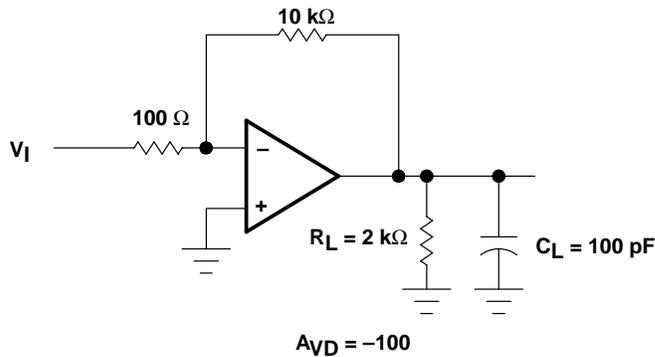


Figure 2. Inverting Amplifier

**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	
<a href="#">LM148FKB</a>	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
<a href="#">LM148J</a>	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
<a href="#">LM148JB</a>	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
<a href="#">LM248D</a>	Obsolete	Production	SOIC (D)   14	-	-	Call TI	Call TI	-25 to 85	LM248
<a href="#">LM248DR</a>	Active	Production	SOIC (D)   14	2500   LARGE T&R	Yes	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
<a href="#">LM248N</a>	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
<a href="#">LM348D</a>	Obsolete	Production	SOIC (D)   14	-	-	Call TI	Call TI	0 to 70	LM348
<a href="#">LM348DR</a>	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
<a href="#">LM348N</a>	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
<a href="#">LM348NSR</a>	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

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

<sup>(2)</sup> **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.

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

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

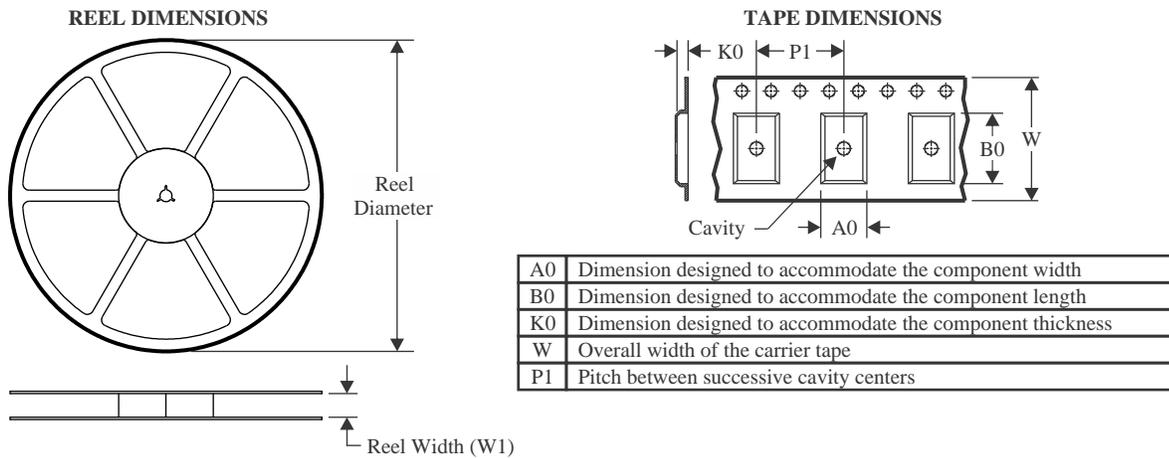
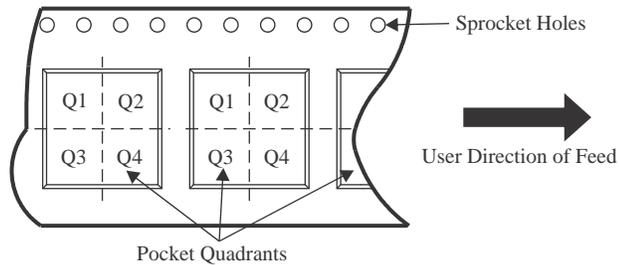
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will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

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

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

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

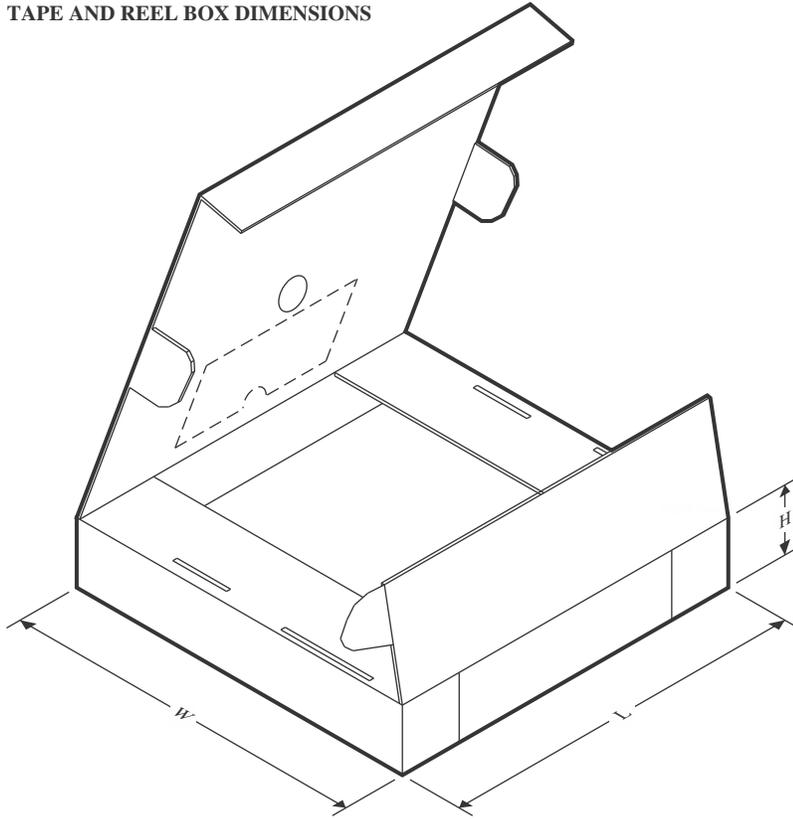
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

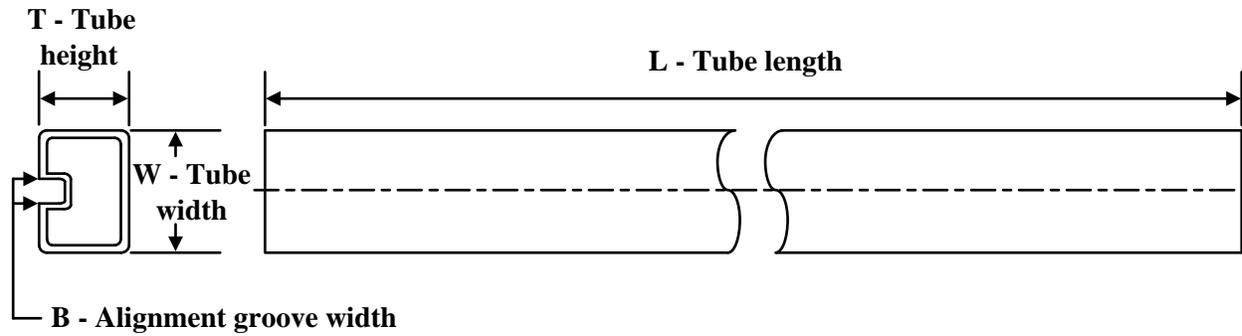
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM248DR	SOIC	D	14	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM348DR	SOIC	D	14	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM348DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
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	340.5	336.1	25.0
LM348DR	SOIC	D	14	2500	353.0	353.0	32.0
LM348NSR	SOP	NS	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)
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

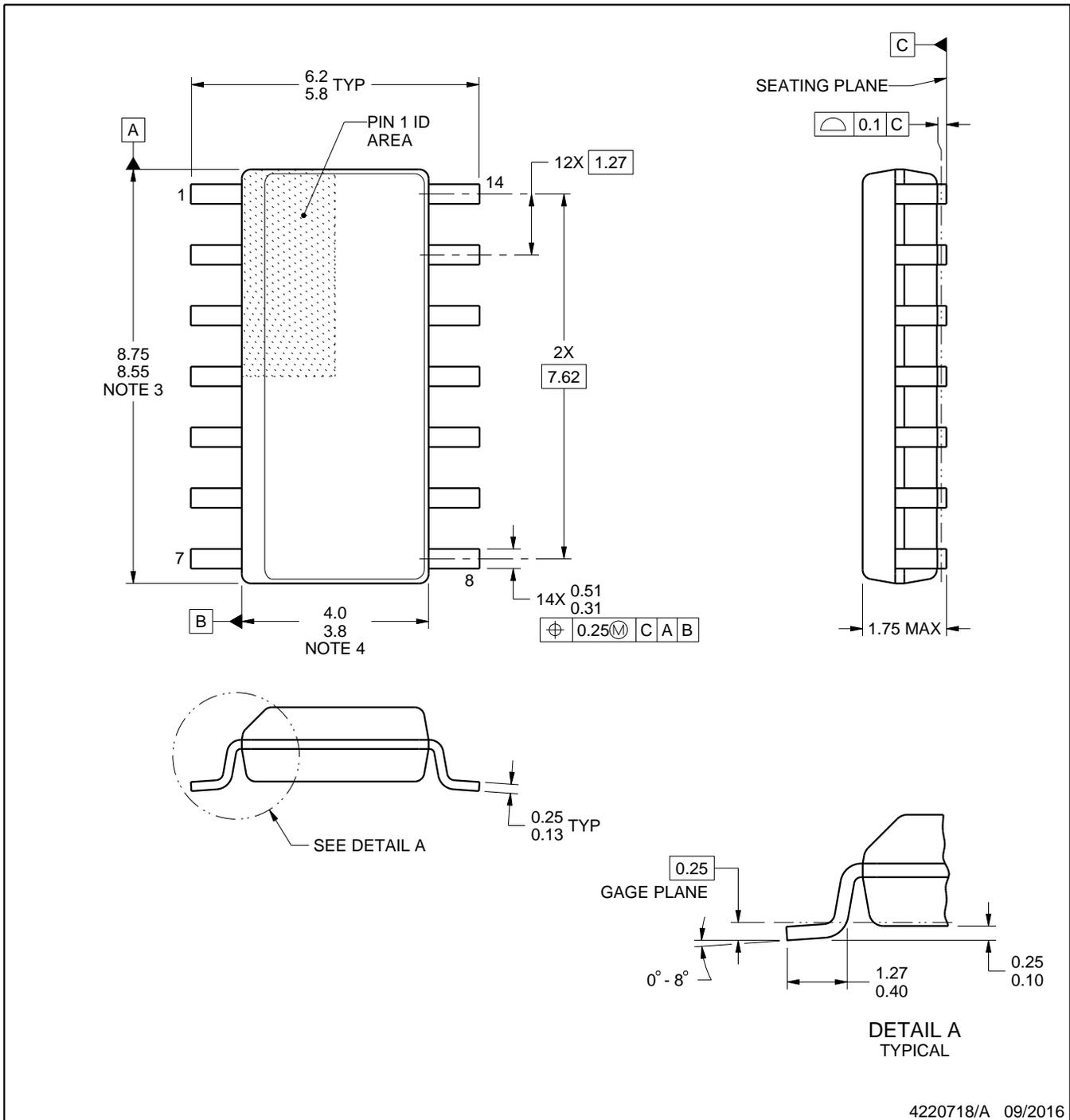
D0014A



# PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4220718/A 09/2016

NOTES:

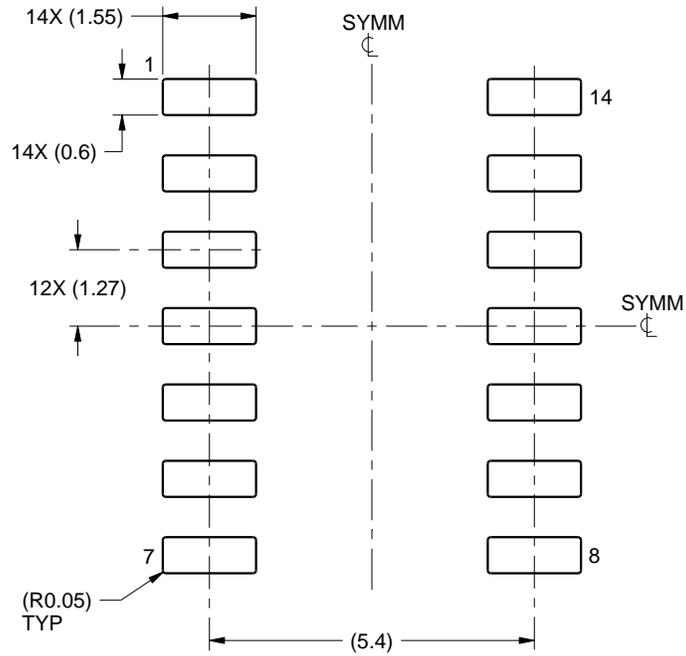
1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate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

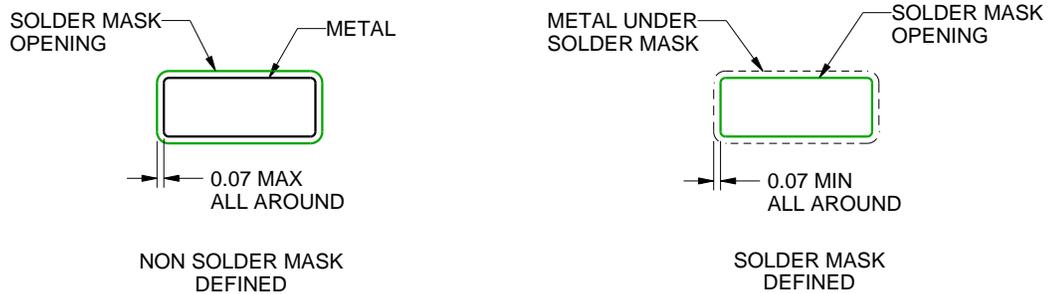
D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
SCALE:8X



SOLDER MASK DETAILS

4220718/A 09/2016

NOTES: (continued)

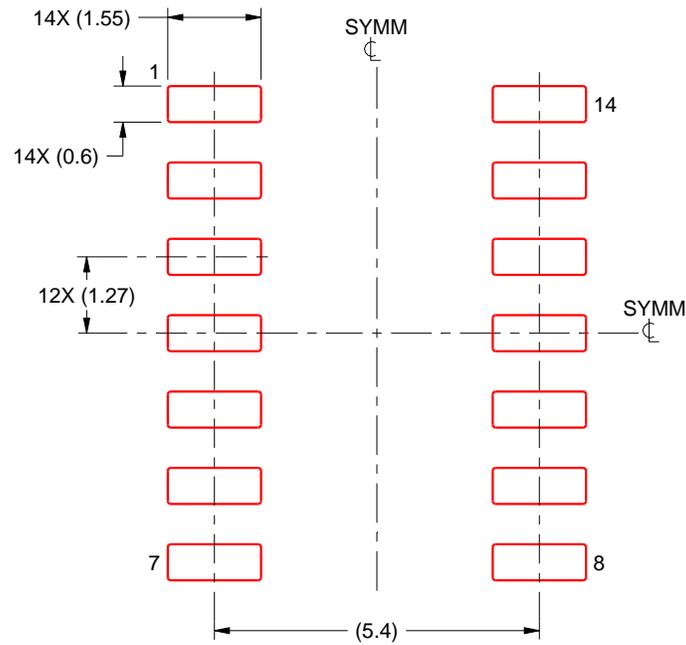
- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# 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)

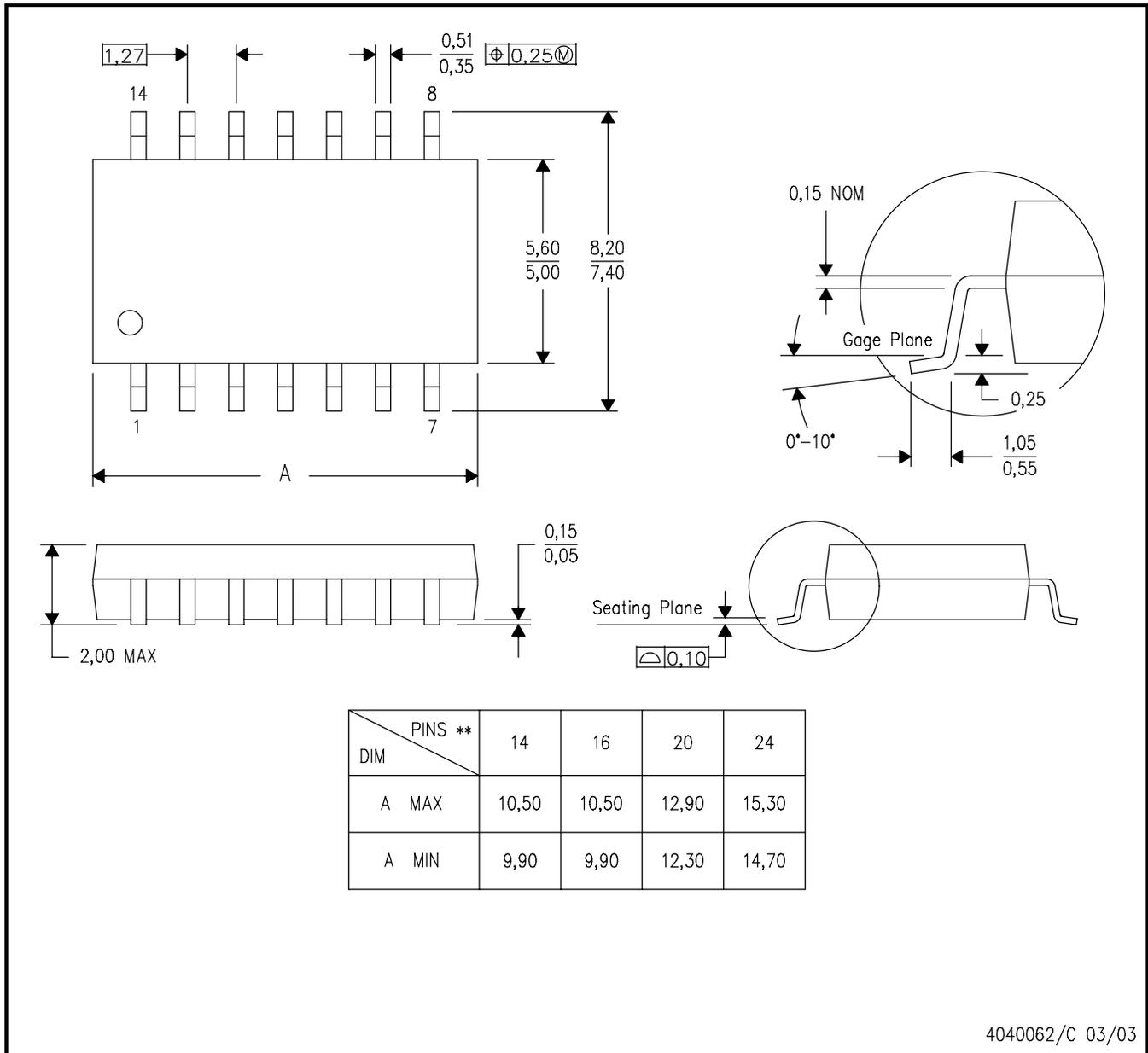
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

# MECHANICAL DATA

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

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN



- 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.

## GENERIC PACKAGE VIEW

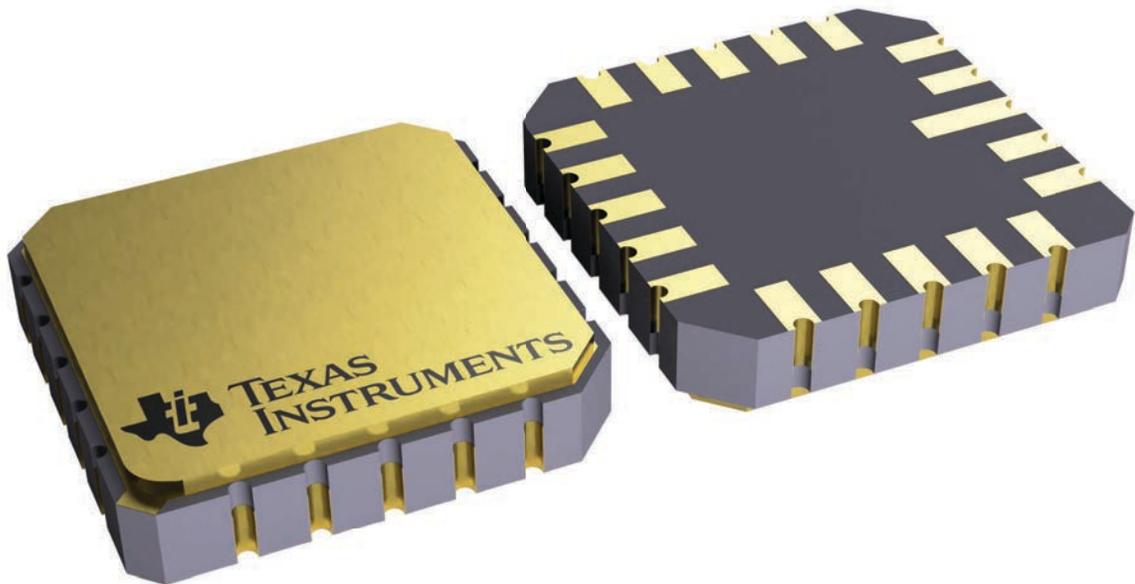
**FK 20**

**LCCC - 2.03 mm max height**

8.89 x 8.89, 1.27 mm pitch

LEADLESS CERAMIC CHIP CARRIER

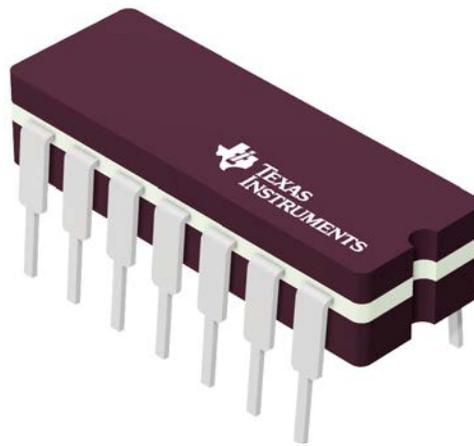
This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4229370VA\

J 14

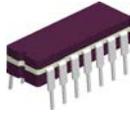
**GENERIC PACKAGE VIEW**  
**CDIP - 5.08 mm max height**  
CERAMIC DUAL IN LINE PACKAGE



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

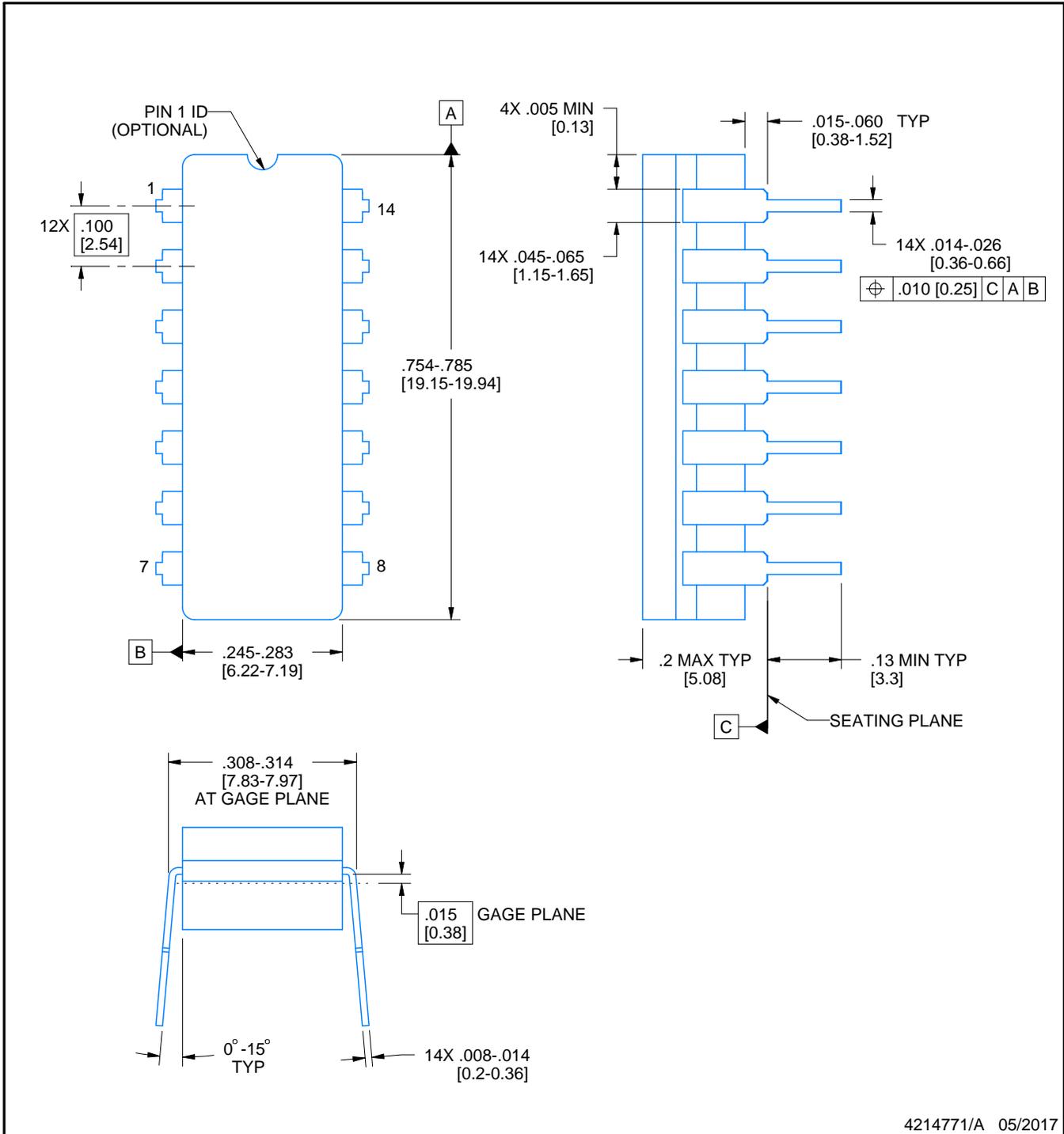
J0014A



# PACKAGE OUTLINE

CDIP - 5.08 mm max height

CERAMIC DUAL IN LINE PACKAGE



4214771/A 05/2017

NOTES:

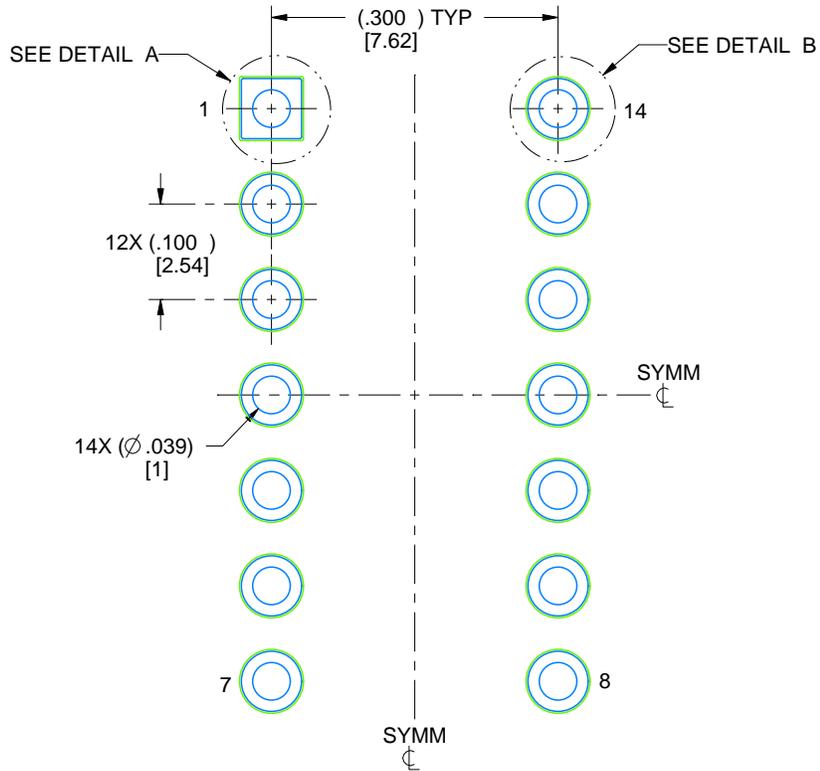
1. All controlling linear dimensions are in inches. Dimensions in brackets are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package is hermetically sealed with 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.

# EXAMPLE BOARD LAYOUT

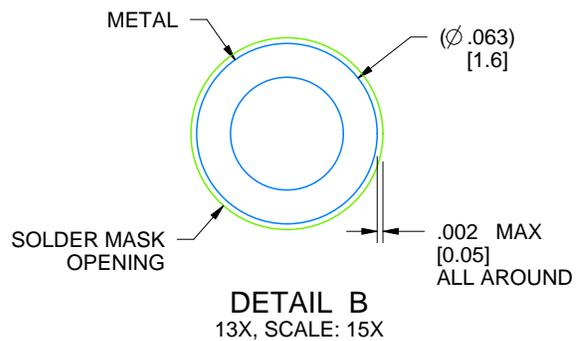
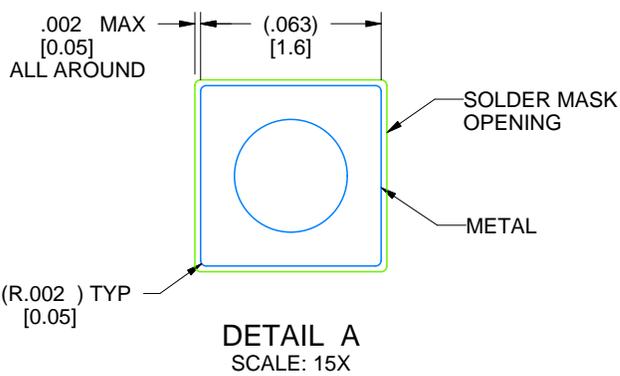
J0014A

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\*\*)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN



- 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.

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