QUADRUPLE OPERATIONAL AMPLIFIER

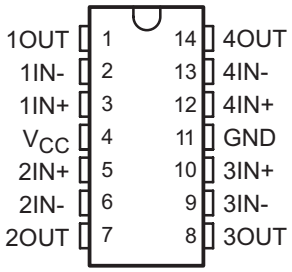
Check for Samples: LM124-SP, LM124A-SP

FEATURES

- **QML-V Qualified, SMD 5962-7704301VCA, 5962-9950403VCA and 5962-9950403V9B**
- **Rad-Tolerant: 50 kRad (Si) TID (5962-9950403VCA and 5962-9950403V9B)** (1)
  - **TID Dose Rate = 0.01 rad/sec (Si)**
- **Wide Supply Ranges**
  - **Single Supply: 3 V to 32 V**
  - **Dual Supplies: ±1.5 V to ±16 V**
- **Low Supply-Current Drain Independent of Supply Voltage: 0.8 mA (Typ)**
- **Low Input Bias and Offset Parameters**
  - **Input Offset Voltage: 1 mV Typ**
  - **Input Offset Current: 2 nA Typ**
  - **Input Bias Current: 30 nA Typ**
- **Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near Ground**
- **Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage: ±32 V**
- **Open-Loop Differential Voltage Amplification: 100 V/mV Typ**
- **Internal Frequency Compensation**

(1) Radiation tolerance is a typical value based upon initial device qualification with dose rate = 0.01 rad/sec. Radiation lot acceptance testing is available - contact factory for details.

J PACKAGE
(TOP VIEW)



DESCRIPTION/ORDERING INFORMATION

These devices consist of four independent high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is 3 V to 32 V, and V_{CC} is at least 1.5 V more positive than the input common-mode voltage. The low supply-current drain is independent of the magnitude of the supply voltage.

Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational-amplifier circuits that now can be more easily implemented in single-supply-voltage systems. For example, the LM124 can be operated directly from the standard 5-V supply that is used in digital systems and provides the required interface electronics, without requiring additional ±15-V supplies.

Table 1. ORDERING INFORMATION(1)

T_A	V_{IO}max AT 25°C	MAX V_{CC}	PACKAGE(2)	ORDERABLE PART NUMBER		TOP-SIDE MARKING
–55°C to 125°C	5 mV	30 V	J	LM124	5962-7704301VCA	5962-7704301VCA
	3 mV	30 V		LM124A	5962-9950403VCA(3)	5962-9950403VCA
	3 mV	30 V	KGD	5962-9950403V9B(3)		N/A

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.
(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.
(3) Radiation tolerant

BARE DIE INFORMATION

DIE THICKNESS	BACKSIDE FINISH	BACKSIDE POTENTIAL	BON PAD METALLIZATION COMPOSITION	BOND PAD THICKNESS
15 mils	Silicon with backgrind	Floating	AlCu (0.5%)	0.055 mils

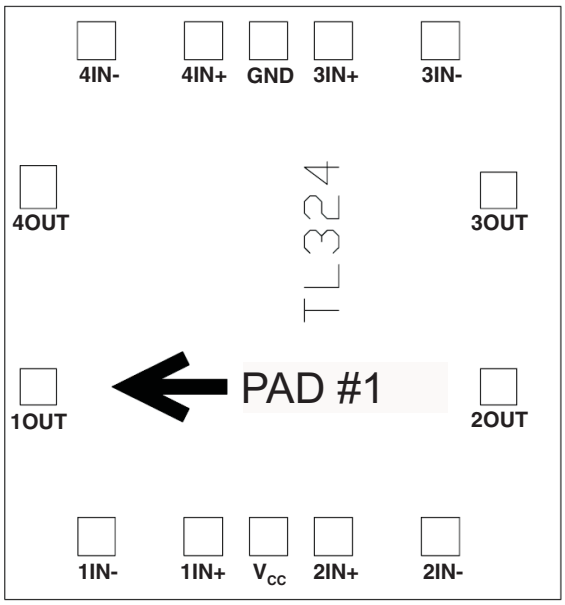
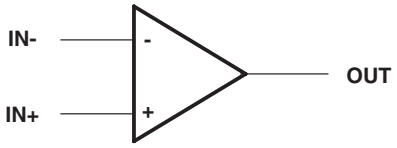


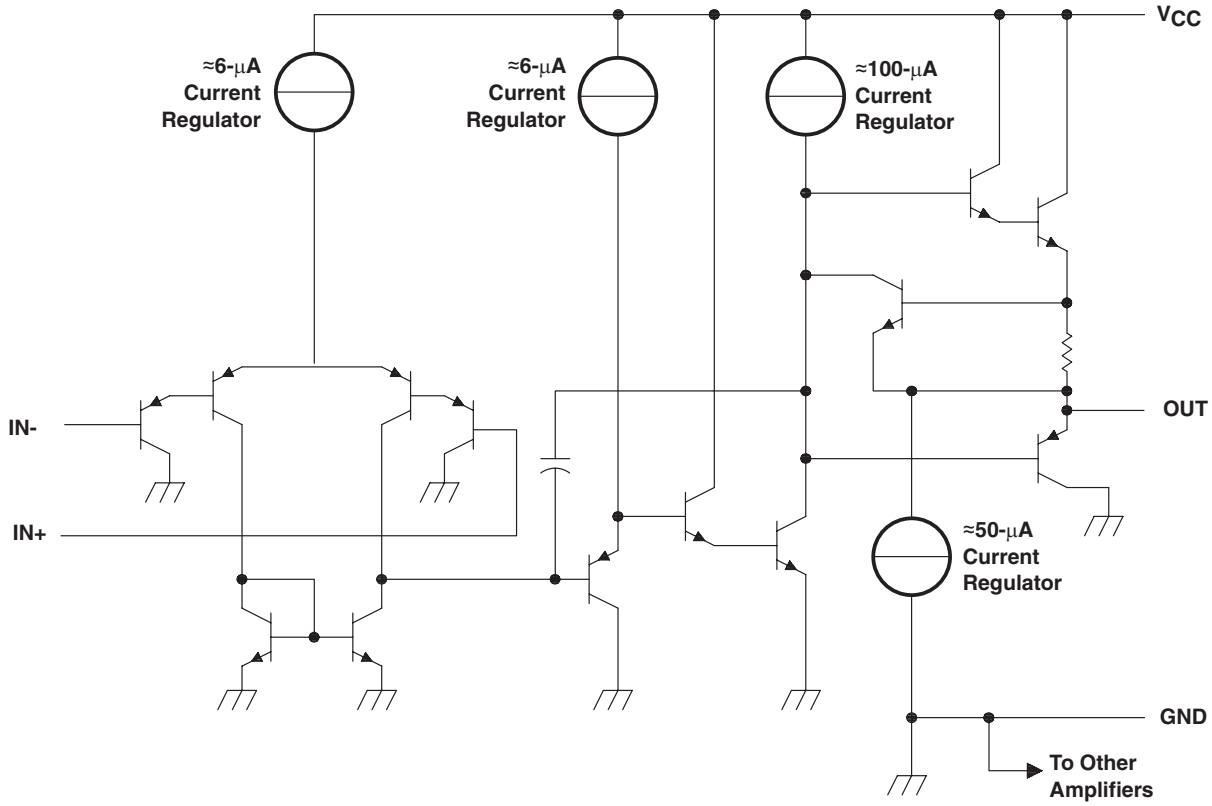
Table 2. Bond Pad Coordinates in Microns

DISCRIPTION	PAD NUMBER	Xmin	Ymin	Xmax	Ymax
1OUT	1	426.72	1249.68	523.24	1346.20
1IN-	2	25.40	1093.47	127	1192.53
1IN+	3	25.40	808.99	127	910.59
V_{CC}	4	25.40	635	127	734.06
2IN+	5	25.40	462.28	127	563.88
2IN-	6	25.40	177.80	127	279.40
2OUT	7	426.72	25.40	523.24	121.92
3OUT	8	949.96	25.40	1046.48	121.92
3IN-	9	1346.20	177.80	1447.80	279.40
3IN+	10	1346.20	462.28	1447.80	563.88
GND	11	1346.20	635	1447.80	736.60
4IN+	12	1346.20	807.72	1447.80	909.32
4IN-	13	1346.20	1092.2	1447.80	1193.80
4OUT	14	949.96	1249.68	1046.48	1346.20

SYMBOL (EACH COMPARATOR)



SCHEMATIC (EACH AMPLIFIER)



COMPONENT COUNT (total device)	
Epi-FET	1
Transistors	95
Diodes	4
Resistors	11
Capacitors	4

ABSOLUTE MAXIMUM RATINGS(1)

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

			MIN	MAX	UNIT
V_{CC}	Supply voltage(2)			±16 or 32	V
V_{ID}	Differential input voltage(3)			±32	V
V_I	Input voltage range (either input)		–0.3	32	V
	Duration of output short circuit to ground(4)			Unlimited	
θ_{JC}	Package thermal impedance, junction to case(5) (6)	J package		15.05	°C/W
T_J	Operating virtual-junction temperature			150	°C
	Lead temperature 1,6 mm (1/16 in) from case for 60 s			300	°C
T_{stg}	Storage temperature range		–65	150	°C

(1) 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.
(2) All voltage values, except differential voltages, are with respect to network ground.
(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) Maximum power dissipation is a function of T_J (max), θ_{JC}, and T_C. The maximum allowable power dissipation at any allowable case temperature is $P_D = (T_J (max) – T_C)/\theta_{JC}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
(6) The package thermal impedance is calculated in accordance with MIL-STD-883.

ELECTRICAL CHARACTERISTICS FOR LM124

at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS(1)		T_A(2)	MIN	TYP(3)	MAX	UNIT
V_{IO}	Input offset voltage	V_{CC} = 5 V to MAX, V_{IC} = V_{ICR} min, V_O = 1.4 V		25°C		3	5	mV
				Full range			7	
I_{IO}	Input offset current	V_O = 1.4 V		25°C		2	30	nA
				Full range			100	
I_{IB}	Input bias current	V_O = 1.4 V		25°C		–20	–150	nA
				Full range			–300	
V_{ICR}	Common-mode input-voltage range	V_{CC} = 5 V to MAX		25°C	0 to V_{CC} – 1.5			V
				Full range	0 to V_{CC} – 2			
V_{OH}	High-level output voltage	R_L = 2 kΩ		25°C	V_{CC} – 1.5			V
		R_L = 10 kΩ		25°C				
		V_{CC} = MAX	R_L = 2 kΩ	Full range	26			
			R_L ≥ 10 kΩ	Full range	27	28		
V_{OL}	Low-level output voltage	R_L ≤ 10 kΩ		Full range		5	20	mV
A_{VD}	Large-signal differential-voltage amplification	V_{CC} = 15 V, V_O = 1 V to 11 V, R_L ≥ 2 kΩ		25°C	50	100		V/mV
				Full range	25			
CMRR	Common-mode rejection ratio	V_{IC} = V_{ICR}min		25°C	70	80		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)			25°C	65	100		dB
V_{O1}/ V_{O2}	Crosstalk attenuation	f = 1 kHz to 20 kHz		25°C		120		dB
I_O	Output current	V_{CC} = 15 V, V_{ID} = 1 V, V_O = 0	Source	25°C	–20	–30	–60	mA
				Full range	–10			
		V_{CC} = 15 V, V_{ID} = –1 V, V_O = 15 V	Sink	25°C	10	20		
				Full range	5			
		V_{ID} = −1 V,	V_O = 200 mV	25°C	12	30		
I_{OS}	Short-circuit output current	V_{CC} at 5 V, GND at −5 V,	V_O = 0 V	25°C		±40	±60	
I_{CC}	Supply current (four amplifiers)	V_O = 2.5 V,	No load	Full range		0.7	1.2	mA
		V_{CC} = MAX, V_O = 0.5 V_{CC},	No load	Full range		1.4	3	

(1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 30 V.
(2) Full range is −55°C to 125°C for LM124.
(3) All typical values are at T_A = 25°C.

ELECTRICAL CHARACTERISTICS FOR LM124A

at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS(1)	T_A(2)	MIN	TYP(3)	MAX	UNIT
V_{IO}	Input offset voltage	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, V_{CM} = 15 V	25°C			±3	mV
			Full range			±5	
		$+V_{CC}$ = 2 V, $-V_{CC}$ = -28 V, V_{CM} = -13 V	25°C			±3	mV
			Full range			±5	
		$+V_{CC}$ = 5 V, $-V_{CC}$ = GND, V_{CM} = 1.4 V	25°C			±3	mV
			Full range			±5	
		$+V_{CC}$ = 2.5 V, $-V_{CC}$ = -2.5 V, V_{CM} = -1.1 V	25°C			±3	mV
			Full range			±5	
I_{IO}	Input offset current	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, V_{CM} = 15 V	25°C			±10	nA
			Full range			±30	
		$+V_{CC}$ = 2 V, $-V_{CC}$ = -28 V, V_{CM} = -13 V	25°C			±10	nA
			Full range			±30	
		$+V_{CC}$ = 5 V, $-V_{CC}$ = GND, V_{CM} = 1.4 V	25°C			±10	nA
			Full range			±30	
		$+V_{CC}$ = 2.5 V, $-V_{CC}$ = -2.5 V, V_{CM} = -1.1 V	25°C			±10	nA
			Full range			±30	
$+I_{IB}$	Input bias current	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, V_{CM} = 15 V	25°C	-85		0.1	nA
			Full range	-100		0.1	
		$+V_{CC}$ = 2 V, $-V_{CC}$ = -28 V, V_{CM} = -13 V	25°C	-50		0.1	nA
			Full range	-100		0.1	
		$+V_{CC}$ = 5 V, $-V_{CC}$ = GND, V_{CM} = 1.4 V	25°C	-50		0.1	nA
			Full range	-100		0.1	
		$+V_{CC}$ = 2.5 V, $-V_{CC}$ = -2.5 V, V_{CM} = -1.1 V	25°C	-50		0.1	nA
			Full range	-100		0.1	
$-I_{IB}$	Input bias current	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, V_{CM} = 15 V	25°C	-85		0.1	nA
			Full range	-100		0.1	
		$+V_{CC}$ = 2 V, $-V_{CC}$ = -28 V, V_{CM} = -13 V	25°C	-50		0.1	nA
			Full range	-100		0.1	
		$+V_{CC}$ = 5 V, $-V_{CC}$ = GND, V_{CM} = -1.4 V	25°C	-50		0.1	nA
			Full range	-100		0.1	
		$+V_{CC}$ = 2.5 V, $-V_{CC}$ = -2.5 V, V_{CM} = -1.1 V	25°C	-50		0.1	nA
			Full range	-100		0.1	
PSRR	Power supply rejection ratio	$-V_{CC}$ = GND, V_{CM} = 1.4 V 5 V = VCC = 30 V	Full range	-100		100	µV/V
CMRR	Common-mode rejection ratio	V_{IC} = V_{ICR}min	Full range	76			dB
I_{OS}	Short-circuit output current	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, V_{OUT} = 25 V	Full range	-70			mA

(1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 30 V.
(2) Full range is −55°C to 125°C for LM124A.
(3) All typical values are at T_A = 25°C.

ELECTRICAL CHARACTERISTICS FOR LM124A (continued)

at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS[1]	T_A[2]	MIN	TYP[3]	MAX	UNIT
I_{CC}	Power supply current	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND,	125°C			3	mA
			-55°C			4	
$\Delta V_{IO}/\Delta T$	Input offset voltage temperature sensitivity[4]	$+V_{CC}$ = 5 V, $-V_{CC}$ = GND, V_{CM} = 1.4 V	125°C, -55°C	-30		30	µV/°C
$\Delta I_{IO}/\Delta T$	Input offset current temperature sensitivity[4]	$+V_{CC}$ = 5 V, $-V_{CC}$ = GND, V_{CM} = 1.4 V	125°C	-400		400	pA/°C
			-55°C	-700		700	
V_{OL}	Low-level output voltage	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, R_L = 10 kΩ	Full range			35	mV
		$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, I_{OL} = 5 mA	Full range			1.5	V
		$+V_{CC}$ = 4.5 V, $-V_{CC}$ = GND, I_{OL} = 2 µA	Full range			0.4	
V_{OH}	High-level output voltage	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, I_{OH} = 10 mA	Full range	27			V
		$+V_{CC}$ = 4.5 V, $-V_{CC}$ = GND, I_{OH} = -10 mA	Full range	2.4			
A_{VS+}	Voltage gain	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, 1 V ≤ V_{OUT} ≤ 26 V R_L = 10 kΩ	25°C	50			V/mV
			Full range	25			
		$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, 5 V ≤ V_{OUT} ≤ 20 V R_L = 2 kΩ	25°C	50			
			Full range	25			
A_{VS}	Voltage gain	$+V_{CC}$ = 5 V, $-V_{CC}$ = GND, 1 V ≤ V_{OUT} ≤ 2.5 V R_L = 10 kΩ	Full range	10			V/mV
		$+V_{CC}$ = 5 V, $-V_{CC}$ = GND, 5 V ≤ V_{OUT} ≤ 2.5 V R_L = 2 kΩ	Full range	10			
$+V_{OP}$	Maximum output voltage swing	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, V_{OUT} = 30 V R_L = 10 kΩ	Full range	27			V
		$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, V_{OUT} = 30 V R_L = 2 kΩ	Full range	26			
TR(t_r)	Transient response: rise time[4]	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND	Full range			1	µs
SR+	Slew rate: rise[4]	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND	Full range	0.1			V/µs
SR-	Slew rate: fall[4]	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND	Full range	0.1			V/µs
NI(BB)	Noise broadband[4]	$+V_{CC}$ = 15 V, $-V_{CC}$ = -15 V, BW = 10 Hz to 5 kHz	25°C			15	µV/rms

(4) Parameter characterized over temperature, but not production tested.

ELECTRICAL CHARACTERISTICS FOR LM124A (continued)

at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS(1)	T_A(2)	MIN	TYP(3)	MAX	UNIT
NI(PC)	Noise popcorn(5)	+VCC = 15 V, -VCC = -15 V, R_S = 20 kΩ, BW = 10 Hz to 5 kHz	25°C			50	μV/peak
CS	Channel separation	$+V_{CC}$ = 30 V, $-V_{CC}$ = GND, R_L = 2 kΩ	25°C	80			dB
		R_L = 2 kΩ, V_{IN} = 1 V and 16 V	25°C	80			

(5) Parameter characterized over temperature, but not production tested.

OPERATING CONDITIONS

V_{CC} = ±15 V, T_A = 25°C

PARAMETER		TEST CONDITIONS	TYP	UNIT
SR	Slew rate at unity gain	R_L = 1 MΩ, C_L = 30 pF, V_I = ±10 V (see Figure 1)	0.5	V/μs
B_1	Unity-gain bandwidth	R_L = 1 MΩ, C_L = 20 pF (see Figure 1)	1.2	MHz
V_n	Equivalent input noise voltage	R_S = 100 Ω, V_I = 0 V, f = 1 kHz (see Figure 2)	35	nV/√Hz

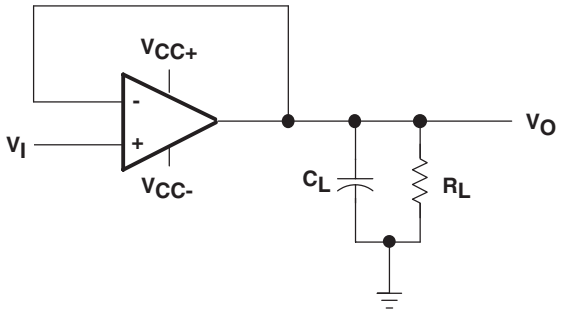


Figure 1. Unity-Gain Amplifier

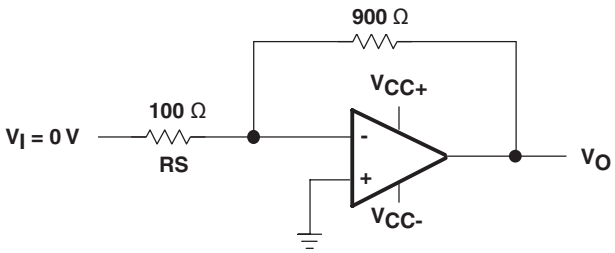


Figure 2. Noise-Test Circuit

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
5962-7704301VCA	ACTIVE	CDIP	J	14	1	Non-RoHS & Non-Green	SNPB	N / A for Pkg Type	-55 to 125	5962-7704301VCA LM124JQMLV	Samples
5962-9950403V9B	ACTIVE	XCEPT	KGD	0	100	Non-RoHS & Non-Green	Call TI	N / A for Pkg Type	-55 to 125		Samples
5962-9950403VCA	ACTIVE	CDIP	J	14	1	Non-RoHS & Non-Green	SNPB	N / A for Pkg Type	-55 to 125	5962-9950403VCA LM124AJQMLV	Samples

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

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

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

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

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

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

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 LM124-SP :

- Catalog: LM124
- Military: LM124M

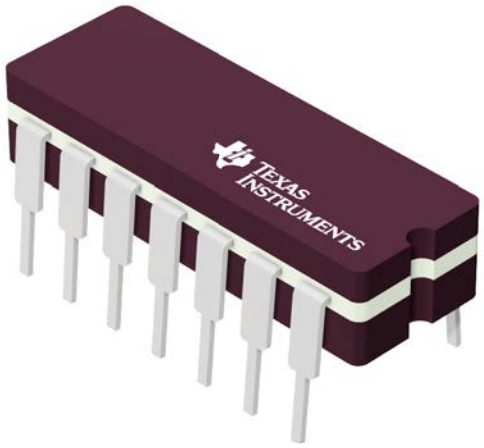
NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Military - QML certified for Military and Defense Applications

GENERIC PACKAGE VIEW

J 14 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.

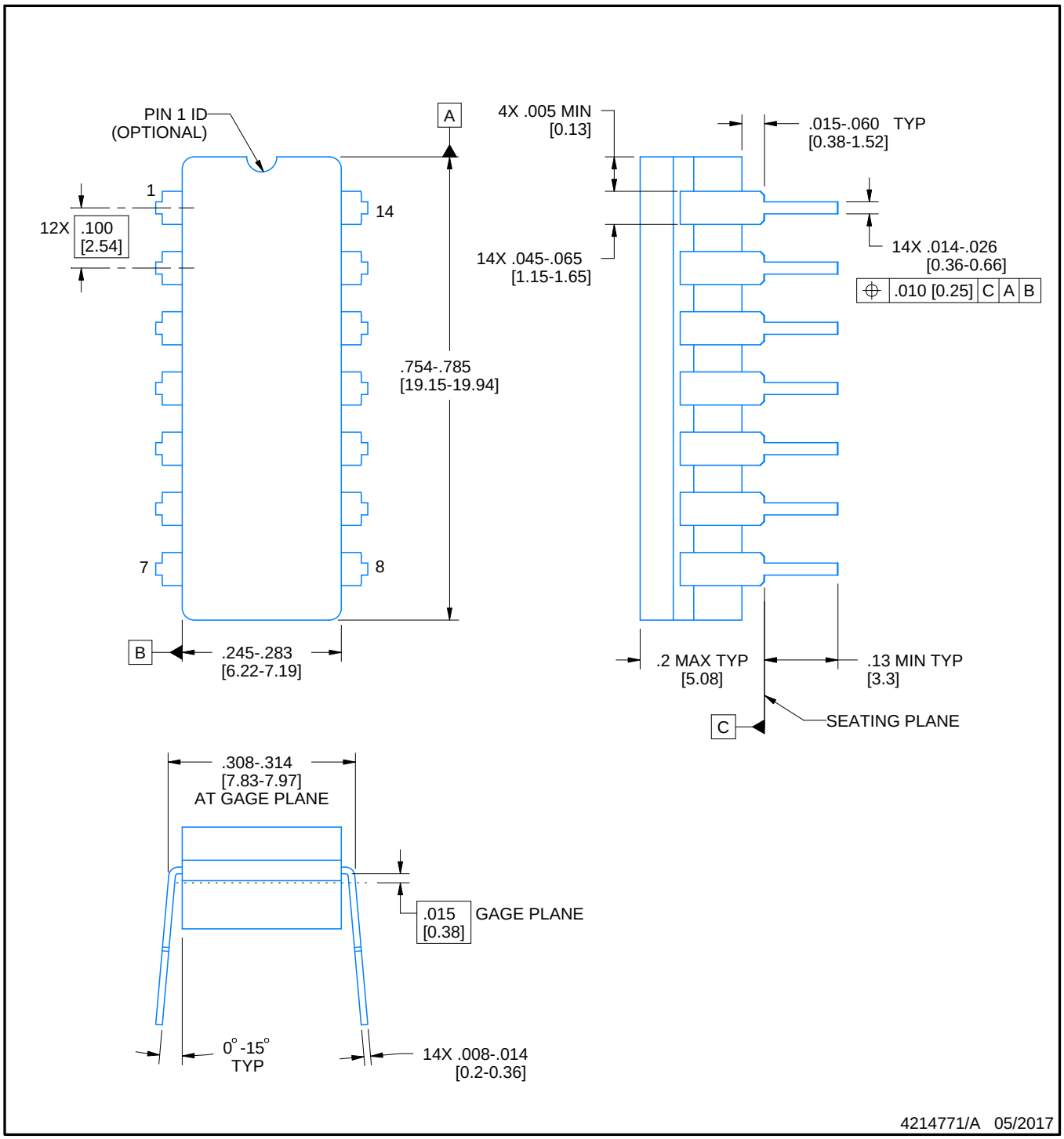
4040083-5/G

PACKAGE OUTLINE

J0014A

CDIP - 5.08 mm max height

CERAMIC DUAL IN LINE PACKAGE



NOTES:

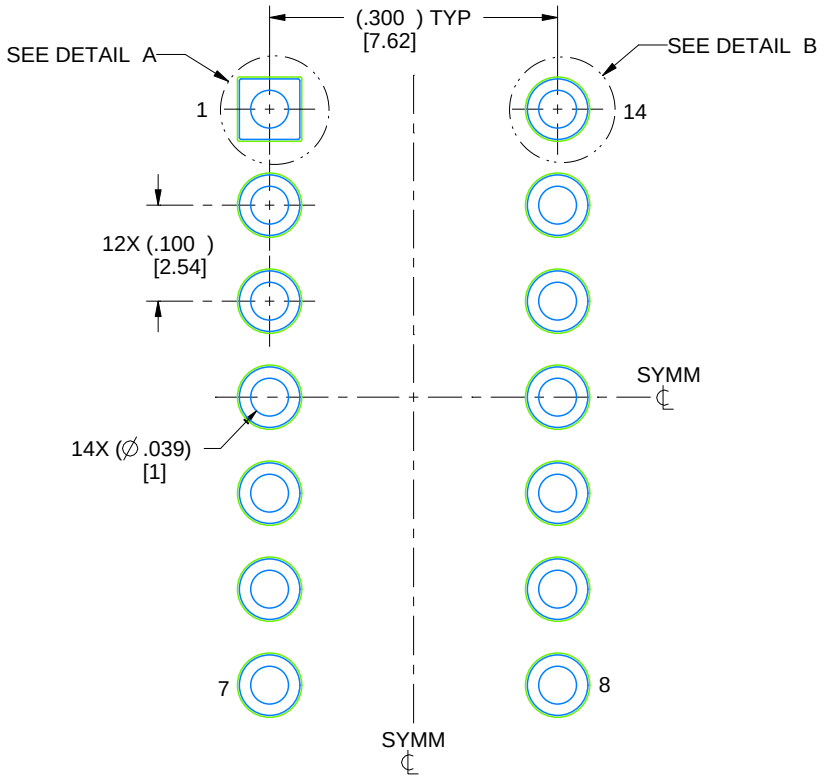
1. All controlling linear dimensions are in inches. Dimensions in brackets are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package is hermitically sealed with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

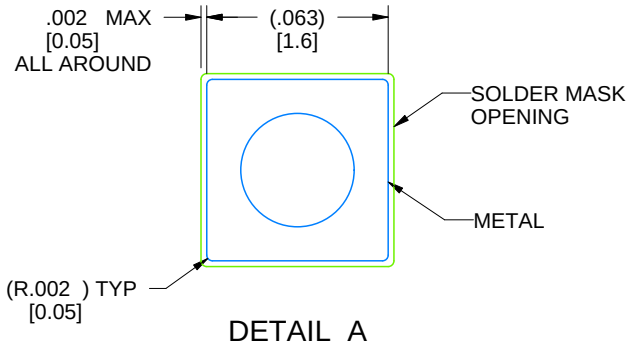
J0014A

CDIP - 5.08 mm max height

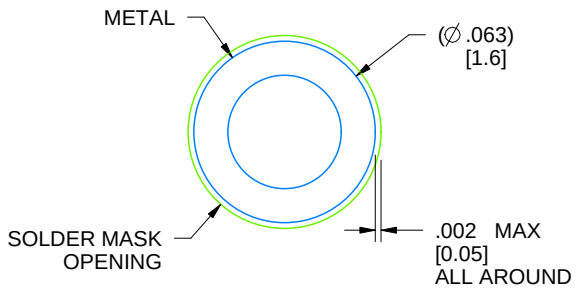
CERAMIC DUAL IN LINE PACKAGE



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



DETAIL A
SCALE: 15X



DETAIL B
13X, SCALE: 15X

4214771/A 05/2017

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265