LM741-MIL Operational Amplifier

1 Features

- Overload Protection on the Input and Output
- No Latch-Up When the Common-Mode Range is Exceeded

2 Applications

- Comparators
- Multivibrators
- DC Amplifiers
- Summing Amplifiers
- Integrator or Differentiators
- Active Filters

3 Description

The LM741-MIL is a general-purpose operational amplifier which features improved performance over industry standards such as the LM709. It is a direct, plug-in replacement for the 709C, LM201, MC1439, and 748 in most applications.

The amplifier offers many features which make applications nearly foolproof such as overload protection on the input and output, no latch-up when the common-mode range is exceeded, and freedom from oscillations.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM741-MIL	TO-99 (8)	9.08 mm × 9.08 mm
	CDIP (8)	10.16 mm × 6.502 mm
	PDIP (8)	9.81 mm × 6.35 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Simplified Application

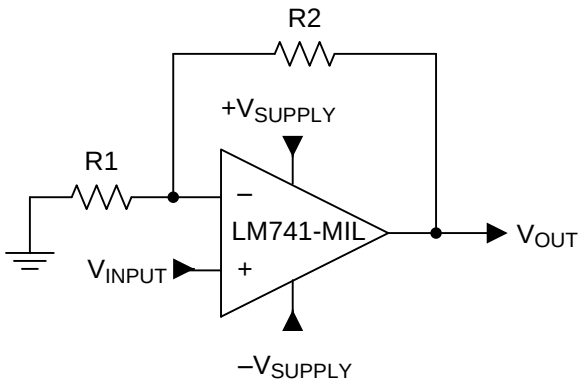


Table of Contents

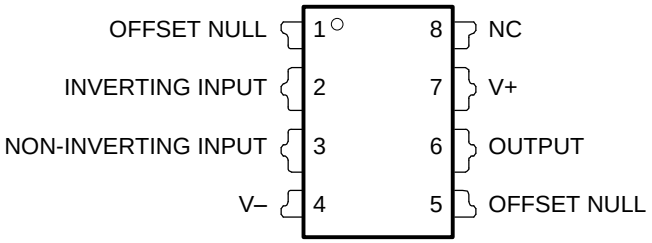
4 Revision History

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

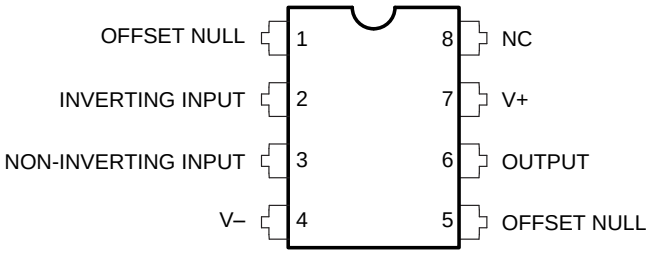
DATE	REVISION	NOTES
June 2017	*	Initial release.

5 Pin Configuration and Functions

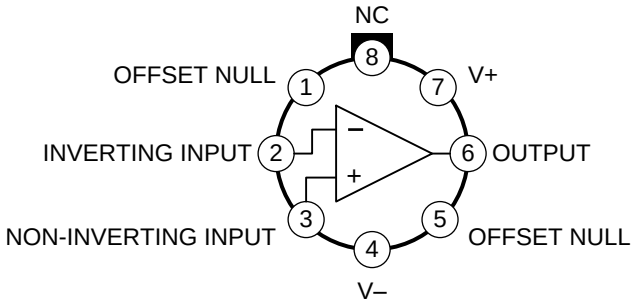
P Package
8-Pin PDIP
Top View



NAB Package
8-Pin CDIP
Top View



LMC Package
8-Pin TO-99
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
INVERTING INPUT	2	I	Inverting signal input
NC	8	N/A	No Connect, leave floating
NONINVERTING INPUT	3	I	Noninverting signal input
OFFSET NULL	1	I	Offset null pin used to eliminate the offset voltage and balance the input voltages.
OFFSET NULL	5		
OUTPUT	6	O	Amplified signal output
V+	7	I	Positive supply voltage
V–	4	I	Negative supply voltage

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)(2)(3)

	MIN	MAX	UNIT
Supply voltage		±22	V
Power dissipation (4)		500	mW
Differential input voltage		±30	V
Input voltage (5)		±15	V
Output short circuit duration	Continuous		
Operating temperature	–50	125	°C
Junction temperature, $T_{J(max)}$		150	°C
Storage temperature, T_{stg}	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those specified in the *Recommended Operating Conditions* table. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) For military specifications see RETS741X for LM741-MIL and RETS741AX for LM741-MILA.
(3) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
(4) For operation at elevated temperatures, these devices must be derated based on thermal resistance, and $T_{J(max)}$. (listed in the *Absolute Maximum Ratings* table). $T_j = T_A + (\theta_{JA} \times P_D)$.
(5) For supply voltages less than ±15 V, the absolute maximum input voltage is equal to the supply voltage.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±400	V

(1) Level listed above is the passing level per ANSI, ESDA, and JEDEC JS-001. JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
Supply voltage (VDD-GND)		±10	±15	±22	V
Temperature		–55		125	°C

6.4 Thermal Information

THERMAL METRIC(1)		LM741-MIL			UNIT
		LMC (TO-99)	NAB (CDIP)	P (PDIP)	
		8 PINS	8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	170	100	100	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	25	—	—	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

6.5 Electrical Characteristics

V_S = ±15 V, −55°C ≤ T_A ≤ 125°C (unless otherwise specified)

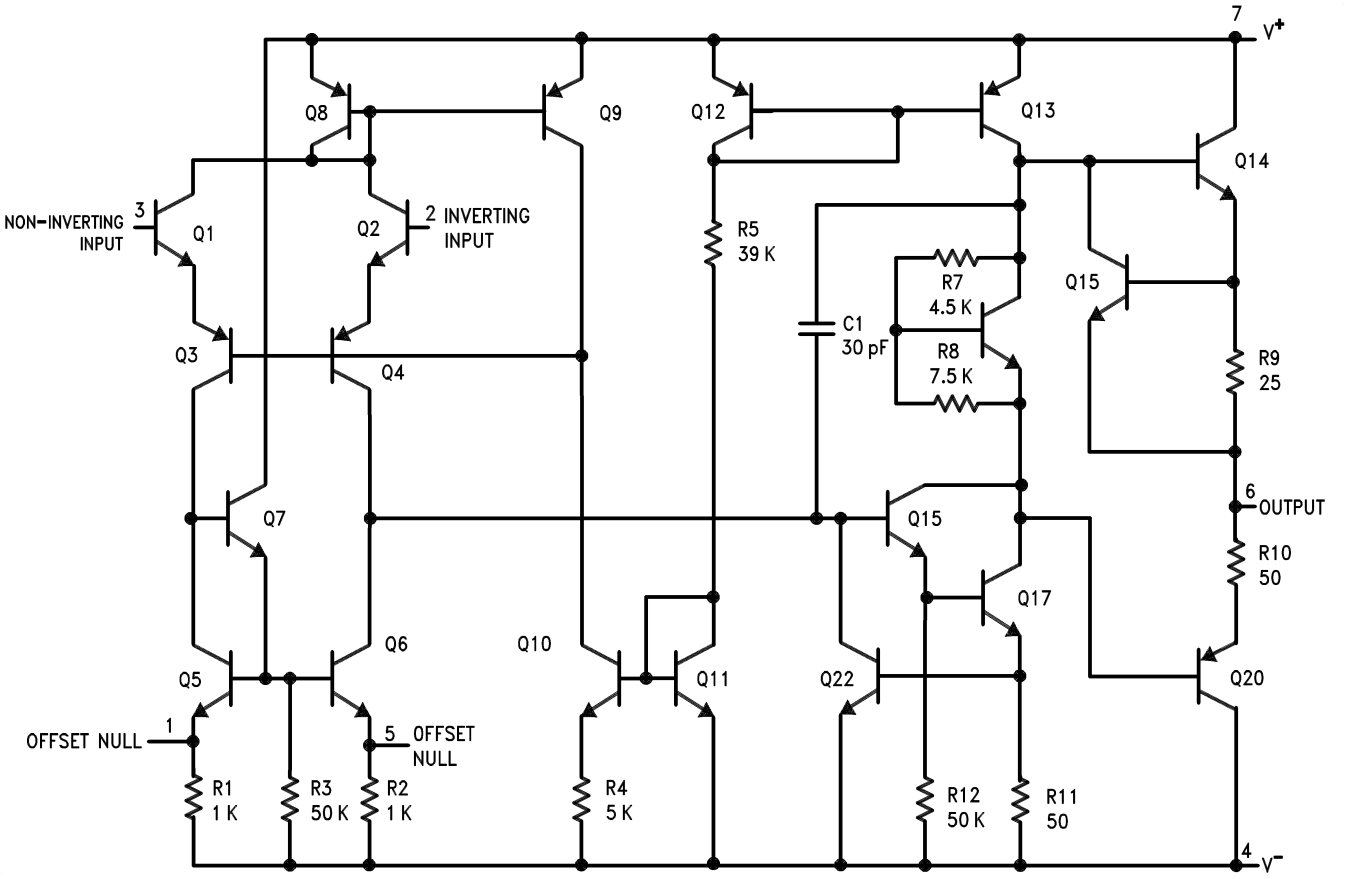
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
Input offset voltage		R_S ≤ 10 kΩ	T_A = 25°C		1	5	mV
						6	mV
Input offset voltage adjustment range		T_A = 25°C, V_S = ±20 V			±15		mV
Input offset current		T_A = 25°C			20	200	nA
					85	500	
Input bias current		T_A = 25°C			80	500	nA
						1.5	μA
Input resistance		T_A = 25°C, V_S = ±20 V		0.3	2		MΩ
Input voltage range				±12	±13		V
Large signal voltage gain		V_S = ±15 V, V_O = ±10 V, R_L ≥ 2 kΩ	T_A = 25°C	50	200		V/mV
				25			
Output voltage swing		V_S = ±15 V	R_L ≥ 10 kΩ	±12	±14		V
			R_L ≥ 2 kΩ	±10	±13		
Output short circuit current		T_A = 25°C			25		mA
Common-mode rejection ratio		R_S ≤ 10 Ω, V_{CM} = ±12 V		80	95		dB
Supply voltage rejection ratio		V_S = ±20 V to V_S = ±5 V, R_S ≤ 10 Ω		86	96		dB
Transient response	Rise time	T_A = 25°C, unity gain			0.3		μs
	Overshoot				5%		
Slew rate		T_A = 25°C, unity gain			0.5		V/μs
Supply current		T_A = 25°C			1.7	2.8	mA
Power consumption		V_S = ±15 V	T_A = 25°C		50	85	mW
			T_A = $T_{A(min)}$		60	100	
			T_A = $T_{A(min)}$		45	75	

7 Detailed Description

7.1 Overview

The LM741-MIL device is a general-purpose operational amplifier which features improved performance over industry standards such as the LM709. It is intended for a wide range of analog applications. The high gain and wide range of operating voltage provide superior performance in integrator, summing amplifier, and general feedback applications. The LM741-MIL operates with either a single or dual power supply voltage. The LM741-MIL device is a direct, plug-in replacement for the 709C, LM201, MC1439, and 748 in most applications.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Overload Protection

The LM741-MIL features overload protection circuitry on the input and output. This prevents possible circuit damage to the device.

7.3.2 Latch-up Prevention

The LM741-MIL is designed so that there is no latch-up occurrence when the common-mode range is exceeded. This allows the device to function properly without having to power cycle the device.

7.3.3 Pin-to-Pin Capability

The LM741-MIL is a pin-to-pin direct replacement for the LM709C, LM201, MC1439, and LM748 in most applications. Direct replacement capabilities allows flexibility in design for replacing obsolete parts.

7.4 Device Functional Modes

7.4.1 Open-Loop Amplifier

The LM741-MIL can be operated in an open-loop configuration. The magnitude of the open-loop gain is typically large thus for a small difference between the non-inverting input terminals and the inverting input terminals, the amplifier output is driven near the supply voltage. Without negative feedback, the LM741-MIL can act as a comparator. If the inverting input is held at 0 V, and the input voltage applied to the non-inverting input is positive, the output will be positive. If the input voltage applied to the non-inverting input is negative, the output is negative.

7.4.2 Closed-Loop Amplifier

In a closed-loop configuration, negative feedback is used by applying a portion of the output voltage to the inverting input. Unlike the open-loop configuration, closed loop feedback reduces the gain of the circuit. The overall gain and response of the circuit is determined by the feedback network rather than the operational amplifier characteristics. The response of the operational amplifier circuit is characterized by the transfer function.

8 Application and Implementation

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. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The LM741-MIL is a general-purpose amplifier than can be used in a variety of applications and configurations. One common configuration is in a non-inverting amplifier configuration. In this configuration, the output signal is in phase with the input (not inverted as in the inverting amplifier configuration), the input impedance of the amplifier is high, and the output impedance is low. The characteristics of the input and output impedance is beneficial for applications that require isolation between the input and output. No significant loading will occur from the previous stage before the amplifier. The gain of the system is set accordingly so the output signal is a factor larger than the input signal.

8.2 Typical Application

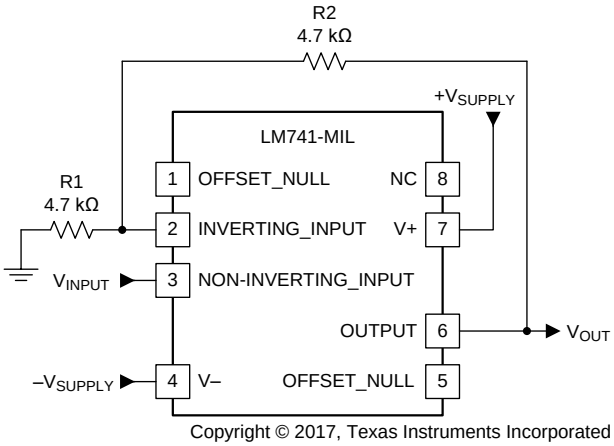


Figure 1. LM741-MIL Noninverting Amplifier Circuit

8.2.1 Design Requirements

As shown in Figure 1, the signal is applied to the noninverting input of the LM741-MIL. The gain of the system is determined by the feedback resistor and input resistor connected to the inverting input. The gain can be calculated by Equation 1:

$$\text{Gain} = 1 + (R2/R1) \quad (1)$$

The gain is set to 2 for this application. R1 and R2 are 4.7-kΩ resistors with 5% tolerance.

8.2.2 Detailed Design Procedure

The LM741-MIL can be operated in either single supply or dual supply. This application is configured for dual supply with the supply rails at ±15 V. The input signal is connected to a function generator. A 1-V_{PP}, 10-kHz sine wave was used as the signal input. 5% tolerance resistors were used, but if the application requires an accurate gain response, use 1% tolerance resistors.

8.2.3 Application Curve

The waveforms in Figure 2 show the input and output signals of the LM741-MIL non-inverting amplifier circuit. The blue waveform (top) shows the input signal, while the red waveform (bottom) shows the output signal. The input signal is 1.06 V_{P-P} and the output signal is 1.94 V_{P-P}. With the 4.7-kΩ resistors, the theoretical gain of the system is 2. Due to the 5% tolerance, the gain of the system including the tolerance is 1.992. The gain of the system when measured from the mean amplitude values on the oscilloscope was 1.83.

Typical Application (continued)

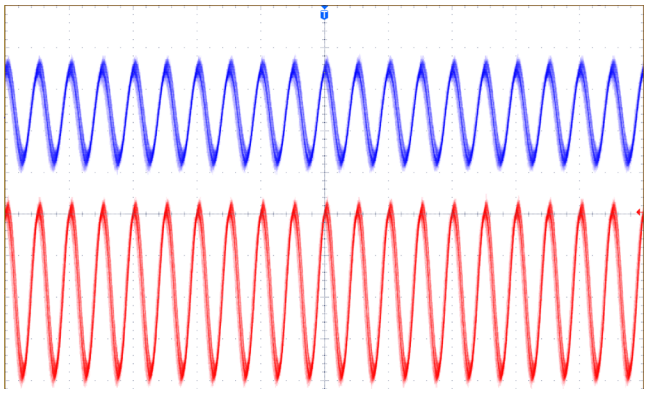


Figure 2. Waveforms for LM741-MIL Non-inverting Amplifier Circuit

9 Power Supply Recommendations

For proper operation, the power supplies must be properly decoupled. For decoupling the supply lines, a 0.1-µF capacitor is recommended and should be placed as close as possible to the LM741-MIL power supply pins.

10 Layout

10.1 Layout Guidelines

As with most amplifiers, take care with lead dress, component placement, and supply decoupling in order to ensure stability. For example, resistors from the output to an input should be placed with the body close to the input to minimize pick-up and maximize the frequency of the feedback pole by minimizing the capacitance from the input to ground. As shown in Figure 3, the feedback resistors and the decoupling capacitors are located close to the device to ensure maximum stability and noise performance of the system.

10.2 Layout Example

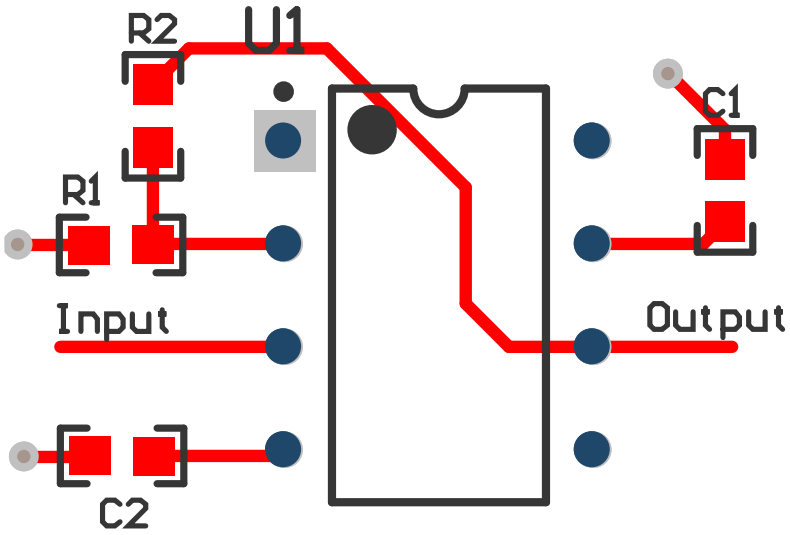


Figure 3. LM741-MIL Layout

11 Device and Documentation Support

11.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* 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.

11.2 Community Resources

The following links connect to TI community resources. Linked contents are 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.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.3 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.4 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.5 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 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 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
LM741CH	ACTIVE	TO-99	LMC	8	500	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 70	(LM741CH, LM741CH)	Samples
LM741CH/NOPB	ACTIVE	TO-99	LMC	8	500	RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 70	(LM741CH, LM741CH)	Samples
LM741H	ACTIVE	TO-99	LMC	8	500	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	(LM741H, LM741H)	Samples
LM741H/NOPB	ACTIVE	TO-99	LMC	8	500	RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	(LM741H, LM741H)	Samples
LM741J	ACTIVE	CDIP	NAB	8	40	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	LM741J	Samples
U5B7741312	ACTIVE	TO-99	LMC	8	500	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	(LM741H, LM741H)	Samples
U5B7741393	ACTIVE	TO-99	LMC	8	500	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 70	(LM741CH, LM741CH)	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.

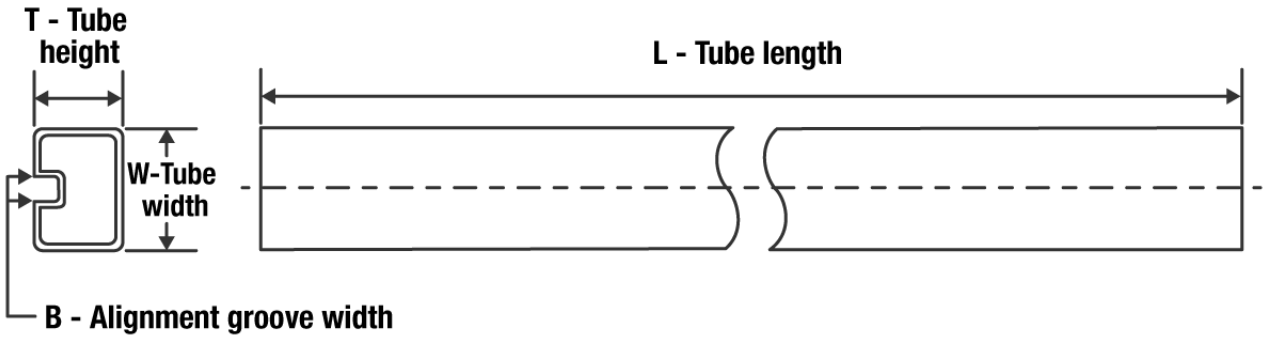
(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(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.

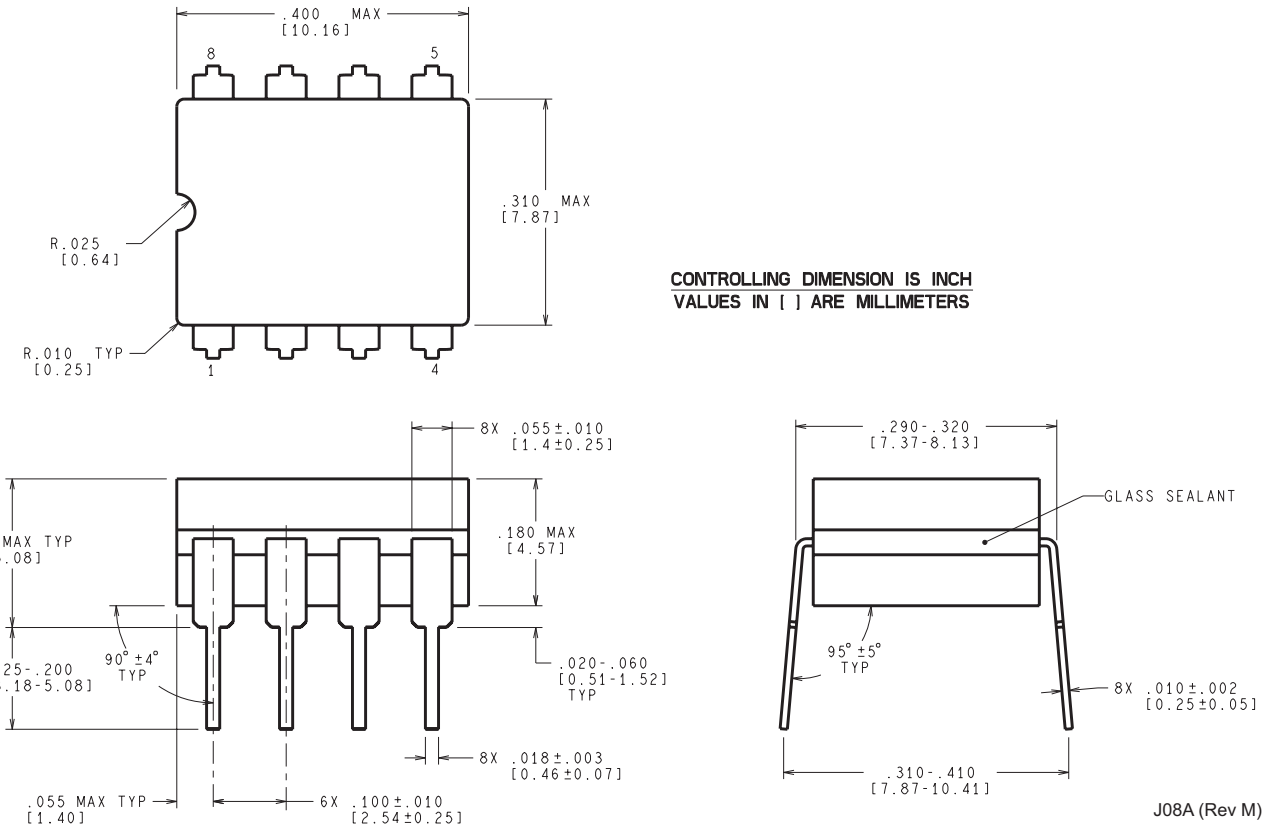
TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
LM741J	NAB	CDIP	8	40	502	14	11938	4.32

NAB0008A

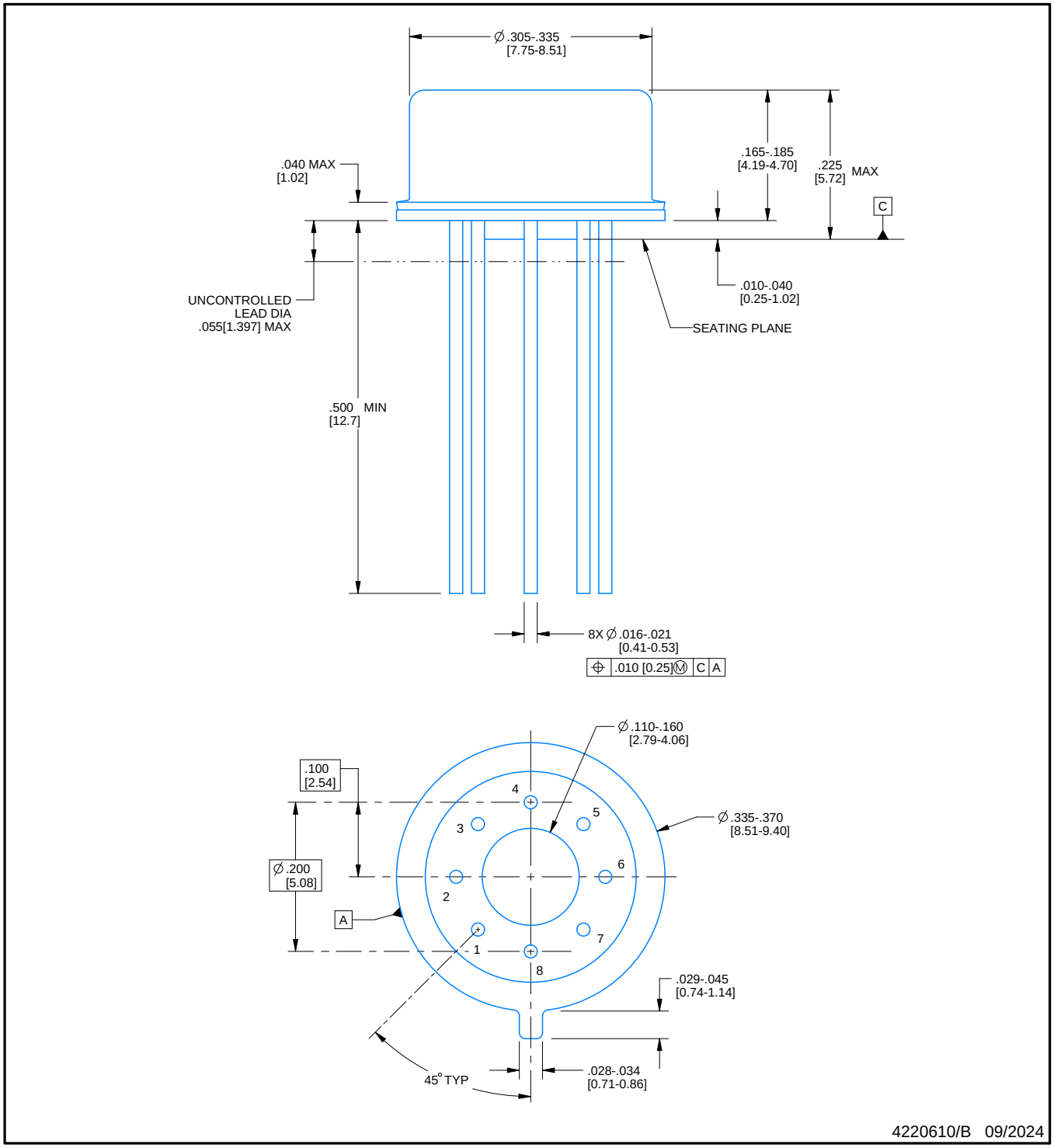

.400 MAX
[10.16]
8
5
.310 MAX
[7.87]
R.025
[0.64]
R.010 TYP
[0.25]
1
4
CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS
8X .055±.010
[1.4±0.25]
.200 MAX TYP
[5.08]
.180 MAX
[4.57]
8X .125-.200
[3.18-5.08]
90° ±4°
TYP
.020-.060
[0.51-1.52]
TYP
8X .018±.003
[0.46±0.07]
.055 MAX TYP
[1.40]
6X .100±.010
[2.54±0.25]
.290-.320
[7.37-8.13]
GLASS SEALANT
95° ±5°
TYP
8X .010±.002
[0.25±0.05]
.310-.410
[7.87-10.41]
J08A (Rev M)

PACKAGE OUTLINE

LMC0008A

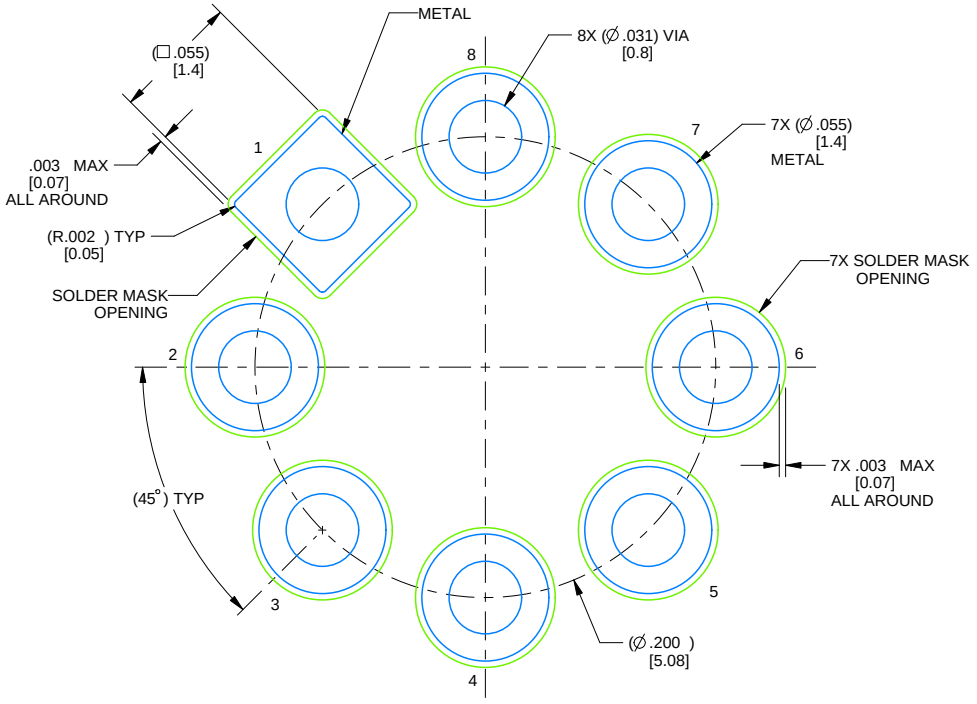
TO-CAN - 5.72 mm max height

TRANSISTOR OUTLINE



NOTES:

1. All linear dimensions are in inches [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. Pin numbers shown for reference only. Numbers may not be marked on package.
4. Reference JEDEC registration MO-002/TO-99.



LAND PATTERN EXAMPLE
NON-SOLDER MASK DEFINED
SCALE: 12X

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