LM101A/LM201A/LM301A Operational Amplifiers

Check for Samples: LM101A-N, LM201A-N, LM301A-N

FEATURES

- **Improved Specifications include:**
- **Offset Voltage 3 mV Maximum Over Temperature (LM101A/LM201A)**
- **Input Current 100 nA Maximum Over Temperature (LM101A/LM201A)**
- **Offset Current 20 nA Maximum Over Temperature (LM101A/LM201A)**
- **Specified Drift Characteristics**
- **Offsets Specified Over Entire Common Mode and Supply Voltage Ranges**
- **Slew Rate of 10V/μs as a Summing Amplifier**

DESCRIPTION

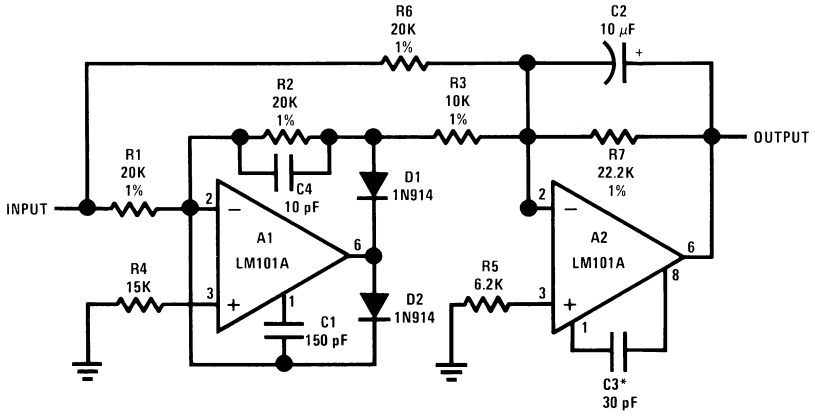
The LM101A series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. Advanced processing techniques make possible an order of magnitude reduction in input currents, and a redesign of the biasing circuitry reduces the temperature drift of input current.

This amplifier offers many features which make its application nearly foolproof: Overload protection on the input and output, no latch-up when the common mode range is exceeded, and freedom from oscillations and compensation with a single 30 pF Capacitor. It has advantages over internally compensated amplifiers in that the frequency compensation can be tailored to the particular application. For example, in low frequency circuits it can be overcompensated for increased stability margin or the compensation can be optimized to give more than a factor of ten improvement in high frequency performance for most applications.

In Addition, the device provides better accuracy and lower noise in high impedance circuitry. The low input currents also make it particularly well suited for long interval integrators or timers, sample and hold circuits and low frequency waveform generators. Further, replacing circuits where matched transistor pairs buffer the inputs of conventional IC op amps, It can give lower offset voltage and a drift at a lower cost.

The LM101A is ensured over a temperature range of −55°C to +125°C, the LM201A from −25°C to +85°C, and the LM301A from 0°C to +70°C.

Fast AC-DC Converter



Feedforward compensation can be used to make a fast full wave rectifier without a filter.

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.

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.

Absolute Maximum Ratings[1][2]

	LM101A/LM201A	LM301A
Supply Voltage	±22V	±18V
Differential Input Voltage	±30V	±30V
Input Voltage[3]	±15V	±15V
Output Short Circuit Duration[4]	Continuous	Continuous
Operating Ambient Temp. Range	−55°C to +125°C (LM101A)	0°C to +70°C
	−25°C to +85°C (LM201A)	
T_J Max		
LMC0008C Package	150°C	100°C
P0008E Package	150°C	100°C
NAB0008A, J0014A Package	150°C	100°C
Power Dissipation at T_A = 25°C		
LMC0008C-Package (Still Air)	500 mW	300 mW
(400 LF/Min Air Flow)	1200 mW	700 mW
P0008E Package	900 mW	500 mW
NAB0008A, J0014A Package	1000 mW	650 mW
Thermal Resistance (Typical) θ_{jA}		
LMC0008C Package (Still Air)	165°C/W	165°C/W
(400 LF/Min Air Flow)	67°C/W	67°C/W
P0008E Package	135°C/W	135°C/W
NAB0008A, J0014A Package	110°C/W	110°CmW
(Typical) θ_{jC}		
LMC0008C Package	25°C/W	25°C/W
Storage Temperature Range	−65°C to +150°C	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)		
LMC0008C or NAB0008A, J0014A, NAD0010A	300°C	300°C
P0008E	260°C	260°C
ESD Tolerance[5]	2000V	2000V

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating ratings indicate for which the device is functional, but do no ensure specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test conditions which ensure specific limits. This assumes that the device is within the Operating Ratings. Specifications are not ensured for parameters where no limit is given, however, the typical value is a good indication of device performance.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(3) For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
(4) Continuous short circuit is allowed for case temperatures to 125°C and ambient temperatures to 75°C for LM101A/LM201A, and 70°C and 55°C respectively for LM301A.
(5) Human body model, 100 pF discharged through 1.5 kΩ.

Electrical Characteristics(1)

$T_A = T_J$

Parameter	Test Conditions		LM101A/LM201A			LM301A			Units
			Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	T_A = 25°C, R_S ≤ 50 kΩ			0.7	2.0		2.0	7.5	mV
Input Offset Current	T_A = 25°C			1.5	10		3.0	50	nA
Input Bias Current	T_A = 25°C			30	75		70	250	nA
Input Resistance	T_A = 25°C		1.5	4.0		0.5	2.0		MΩ
Supply Current	T_A = 25°C	V_S = ±20V		1.8	3.0				mA
		V_S = ±15V					1.8	3.0	mA
Large Signal Voltage Gain	T_A = 25°C, V_S = ±15V		50	160		25	160		V/mV
	V_{OUT} = ±10V, R_L ≥ 2 kΩ								
Input Offset Voltage	R_S ≤ 50 kΩ				3.0			10	mV
Average Temperature Coefficient of Input Offset Voltage	R_S ≤ 50 kΩ			3.0	15		6.0	30	µV/°C
Input Offset Current					20			70	nA
Average Temperature Coefficient of Input Offset Current	25°C ≤ T_A ≤ T_{MAX}			0.01	0.1		0.01	0.3	nA/°C
	T_{MIN} ≤ T_A ≤ 25°C			0.02	0.2		0.02	0.6	nA/°C
Input Bias Current					0.1			0.3	µA
Supply Current	T_A = T_{MAX}, V_S = ±20V			1.2	2.5				mA
Large Signal Voltage Gain	V_S = ±15V, V_{OUT} = ±10V R_L ≥ 2k		25			15			V/mV
Output Voltage Swing	V_S = ±15V	R_L = 10 kΩ	±12	±14		±12	±14		V
		R_L = 2 kΩ	±10	±13		±10	±13		V
Input Voltage Range	V_S = ±20V		±15						V
	V_S = ±15V			+15, −13		±12	+15, −13		V
Common-Mode Rejection Ratio	R_S ≤ 50 kΩ		80	96		70	90		dB
Supply Voltage Rejection Ratio	R_S ≤ 50 kΩ		80	96		70	96		dB

(1) Unless otherwise specified, these specifications apply for C1 = 30 pF, ±5V ≤ V_S ≤ ±20V and −55°C ≤ T_A ≤ +125°C (LM101A), ±5V ≤ V_S ≤ ±20V and −25°C ≤ T_A ≤ +85°C (LM201A), ±5V ≤ V_S ≤ ±15V and 0°C ≤ T_A ≤ +70°C (LM301A).

Typical Performance Characteristics

LM101A/LM201A

Input Voltage Range

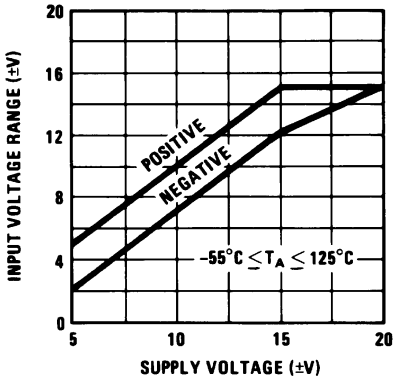


Figure 1.

Output Swing

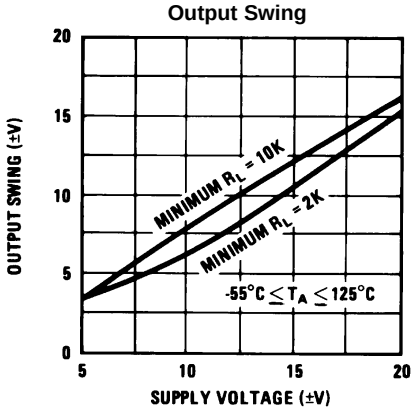


Figure 2.

Voltage Gain

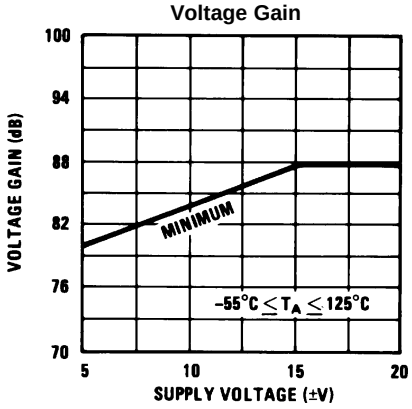


Figure 3.

Performance Characteristics

LM301A

Input Voltage Range

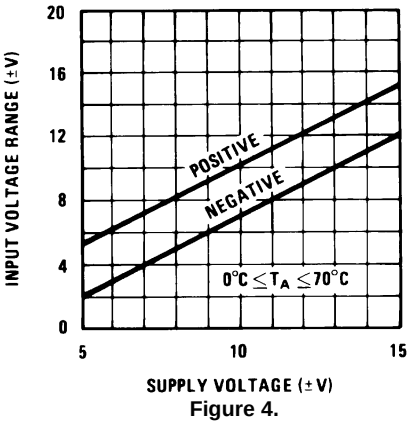


Figure 4.

Output Swing

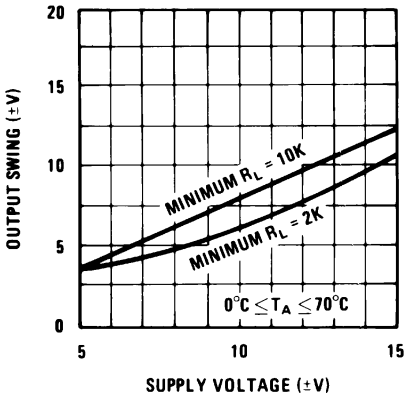


Figure 5.

Performance Characteristics (continued)

LM301A

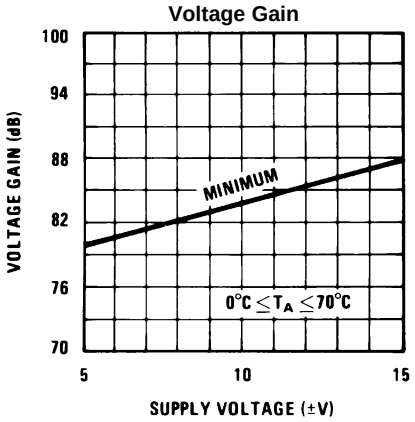


Figure 6.

Typical Performance Characteristics

Supply Current

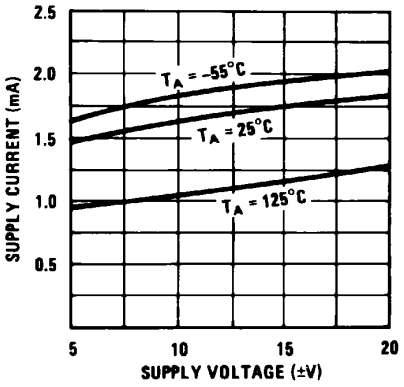


Figure 7.

Voltage Gain

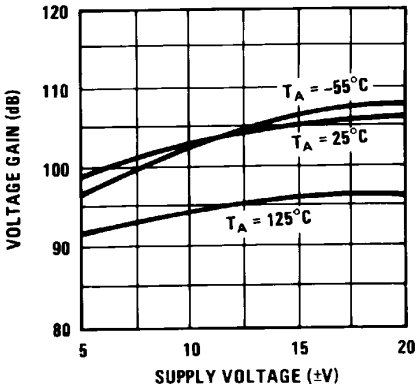


Figure 8.

Maximum Power Dissipation

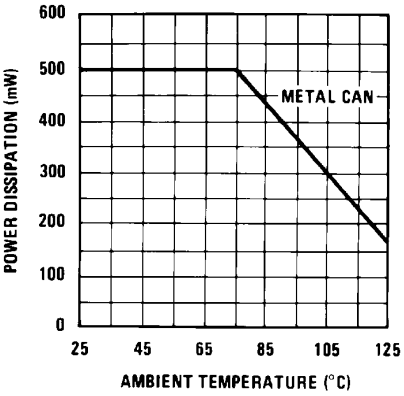


Figure 9.

Input Current, LM101A/LM201A/LM301A

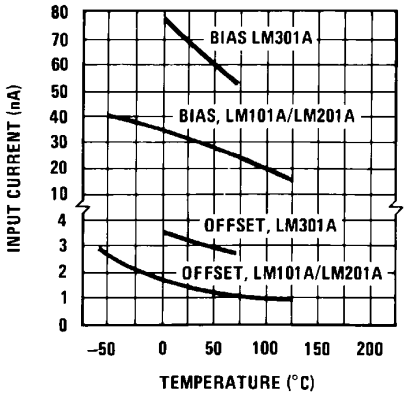


Figure 10.

Current Limiting

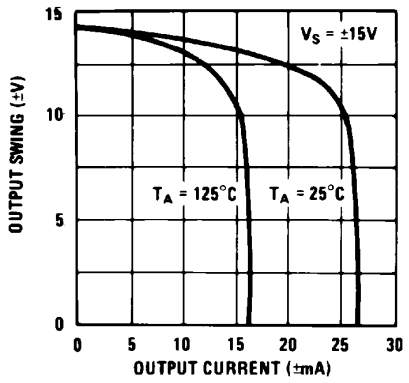


Figure 11.

Input Noise Voltage

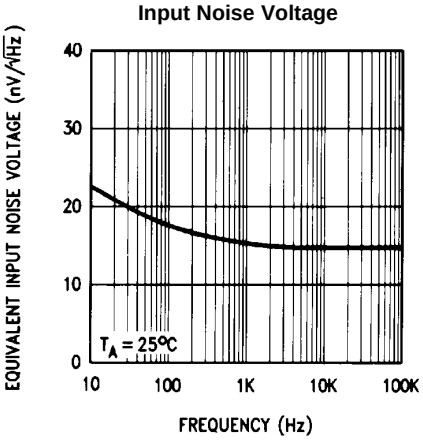


Figure 12.

Typical Performance Characteristics (continued)

Input Noise Current

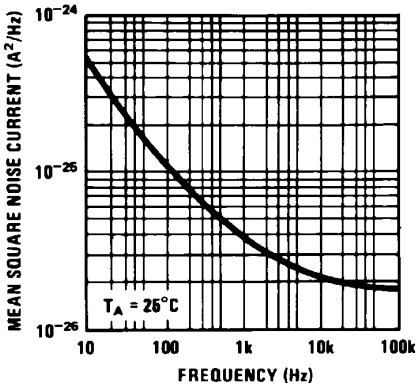


Figure 13.

Common Mode Rejection

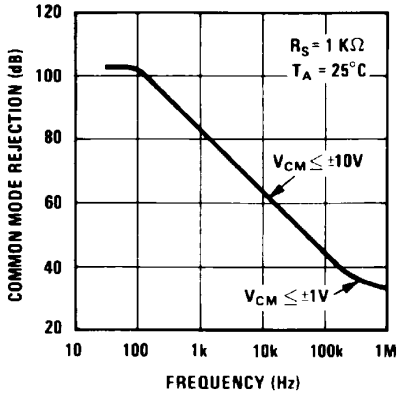


Figure 14.

Power Supply Rejection

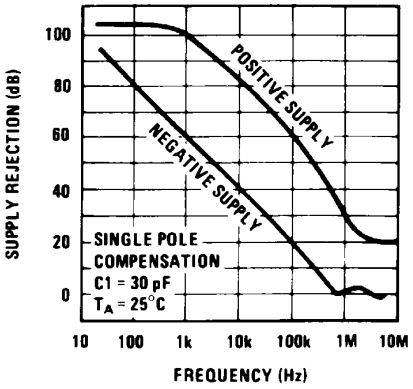


Figure 15.

Closed Loop Output Impedance

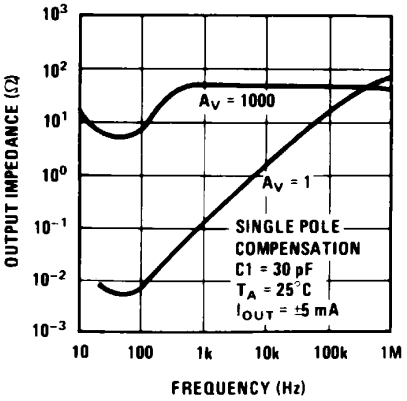
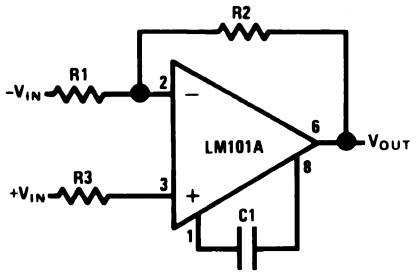


Figure 16.

Typical Performance Characteristics for Various Compensation Circuits

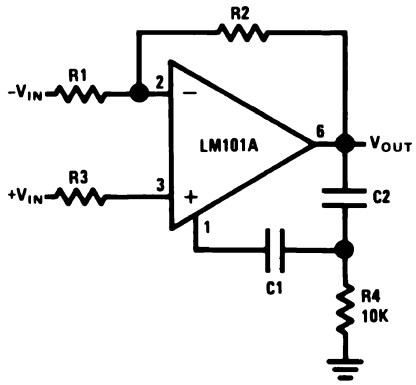
Pin connections shown are for 8-pin packages.



$$C1 \geq \frac{R1\,C_S}{R1 + R2}$$

C_S= 30 pF

Figure 17. Single Pole Compensation

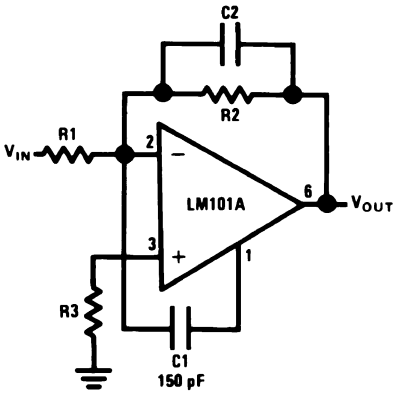


$$C1 \geq \frac{R1\,C_S}{R1 + R2}$$

C_S= 30 pF

C2 = 10 C1

Figure 18. Two Pole Compensation



$$C2 = \frac{1}{2\pi\, f_o\, R2}$$

f_o= 3 MHz

Figure 19. Feedforward Compensation

Open Loop Frequency Response

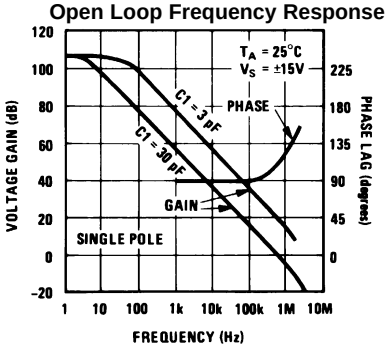


Figure 20.

Open Loop Frequency Response

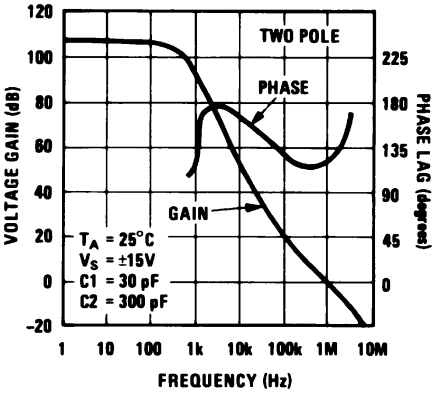


Figure 21.

Open Loop Frequency Response

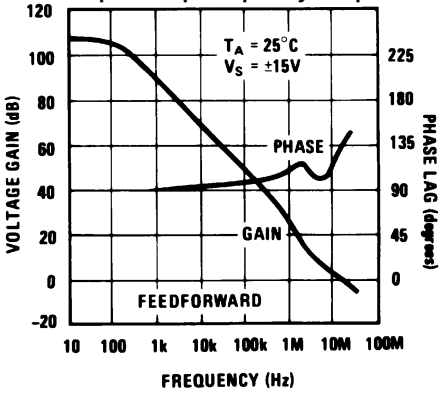


Figure 22.

Typical Performance Characteristics for Various Compensation Circuits (continued)

Large Signal Frequency Response

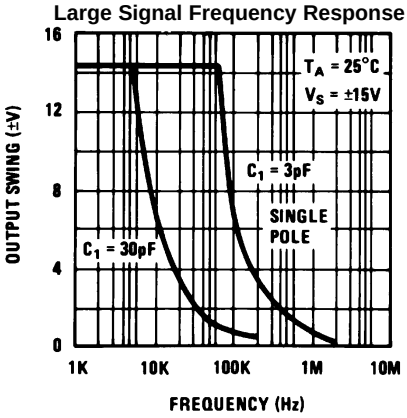


Figure 23.

Large Signal Frequency Response

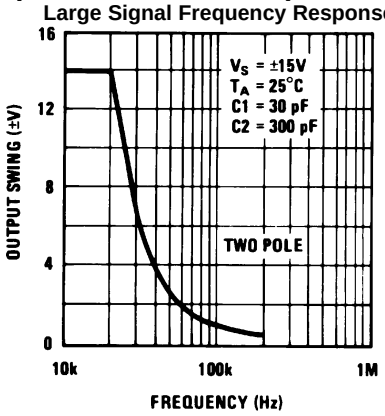


Figure 24.

Large Signal Frequency Response

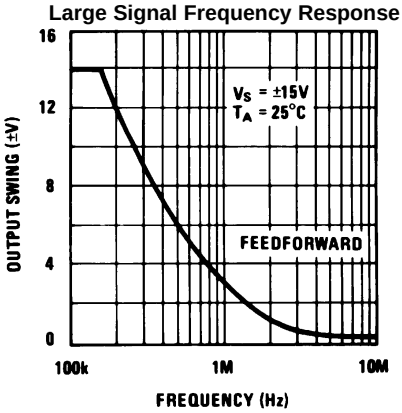


Figure 25.

Voltage Follower Pulse Response

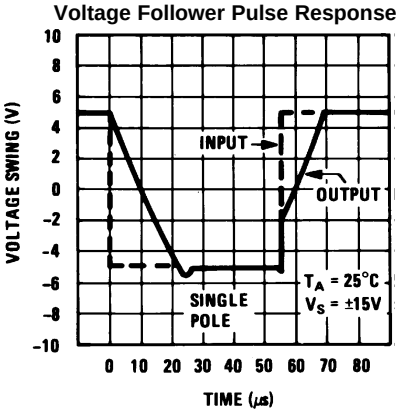


Figure 26.

Voltage Follower Pulse Response

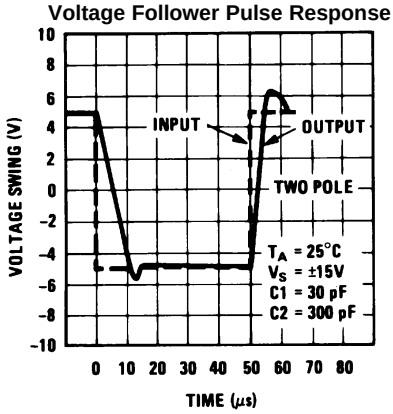


Figure 27.

Inverter Pulse Response

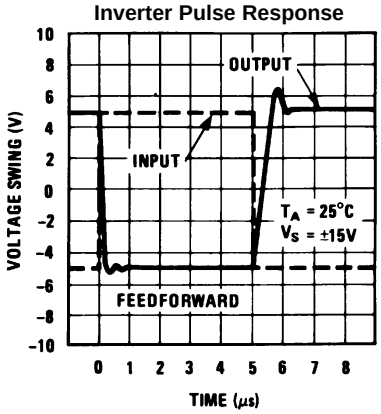


Figure 28.

TYPICAL APPLICATIONS

Pin connections shown are for 8-pin packages

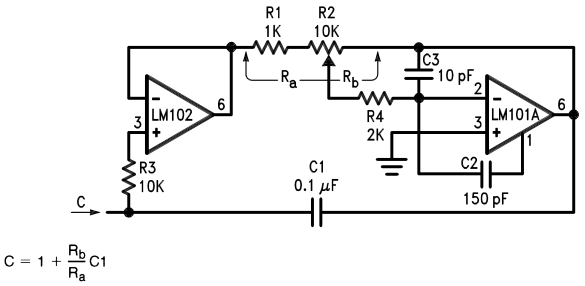
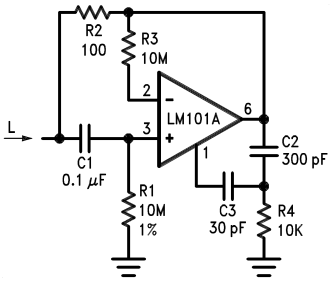


Figure 29. Variable Capacitance Multiplier



L ≈ R1 R2 C1
R_S = R2
R_P = R1

Figure 30. Simulated Inductor

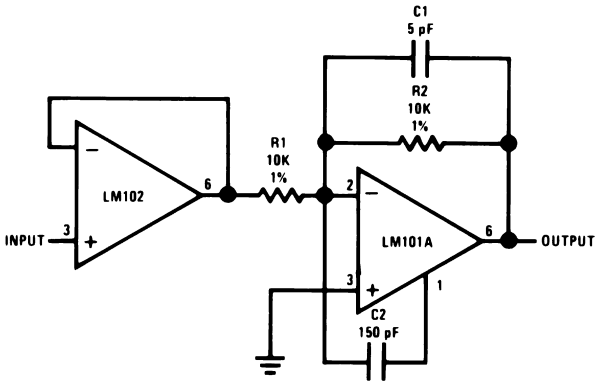
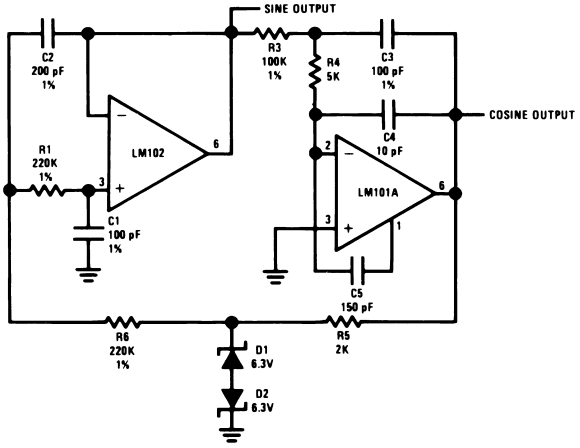
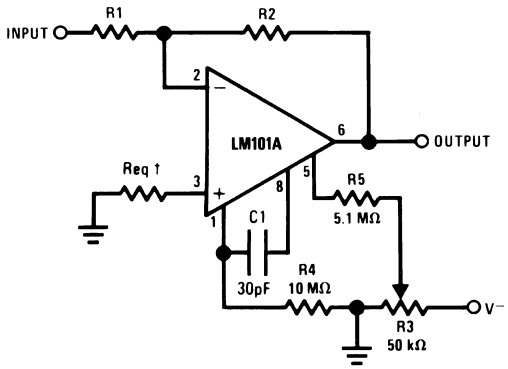


Figure 31. Fast Inverting Amplifier with High Input Impedance



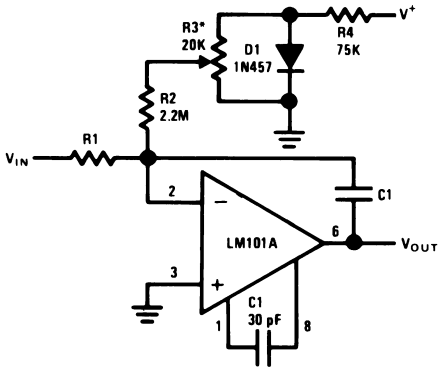
f_o = 10 kHz

Figure 33. Sine Wave Oscillator



†May be zero or equal to parallel combination of R1 and R2 for minimum offset.

Figure 32. Inverting Amplifier with Balancing Circuit

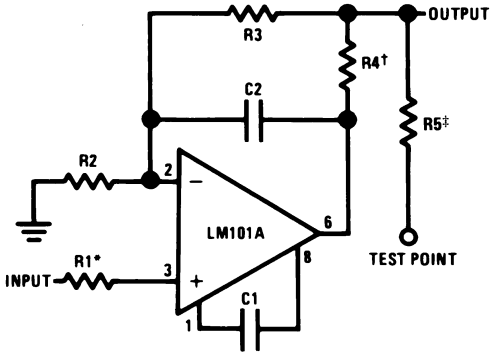


*Adjust for zero integrator drift. Current drift typically 0.1 nA/°C over −55°C to +125°C temperature range.

Figure 34. Integrator with Bias Current Compensation

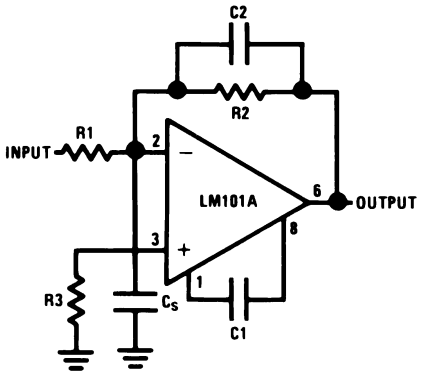
Application Hints

Pin connections shown are for 8-pin packages.



*Protects input
†Protects output
‡Protects output—not needed when R4 is used.

Figure 35. Protecting Against Gross Fault Conditions



$$C2 = \frac{R1\,C_S}{R2}$$

Figure 36. Compensating for Stray Input Capacitances or Large Feedback Resistor

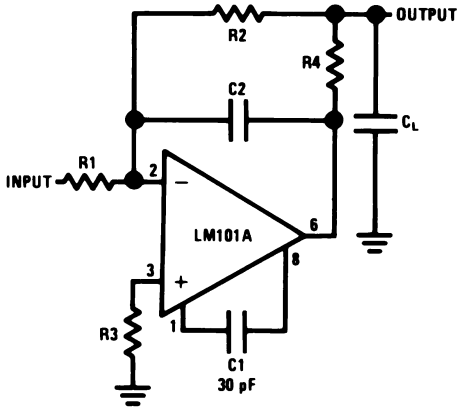


Figure 37. Isolating Large Capacitive Loads

Although the LM101A is designed for trouble free operation, experience has indicated that it is wise to observe certain precautions given below to protect the devices from abnormal operating conditions. It might be pointed out that the advice given here is applicable to practically any IC op amp, although the exact reason why may differ with different devices.

When driving either input from a low-impedance source, a limiting resistor should be placed in series with the input lead to limit the peak instantaneous output current of the source to something less than 100 mA. This is especially important when the inputs go outside a piece of equipment where they could accidentally be connected to high voltage sources. Large capacitors on the input (greater than 0.1 µF) should be treated as a low source impedance and isolated with a resistor. Low impedance sources do not cause a problem unless their output voltage exceeds the supply voltage. However, the supplies go to zero when they are turned off, so the isolation is usually needed.

The output circuitry is protected against damage from shorts to ground. However, when the amplifier output is connected to a test point, it should be isolated by a limiting resistor, as test points frequently get shorted to bad places. Further, when the amplifer drives a load external to the equipment, it is also advisable to use some sort of limiting resistance to preclude mishaps.

Precautions should be taken to insure that the power supplies for the integrated circuit never become reversed—even under transient conditions. With reverse voltages greater than 1V, the IC will conduct excessive current, fusing internal aluminum interconnects. If there is a possibility of this happening, clamp diodes with a high peak current rating should be installed on the supply lines. Reversal of the voltage between V^+ and V^- will always cause a problem, although reversals with respect to ground may also give difficulties in many circuits.

The minimum values given for the frequency compensation capacitor are stable only for source resistances less than 10 kΩ, stray capacitances on the summing junction less than 5 pF and capacitive loads smaller than 100 pF. If any of these conditions are not met, it becomes necessary to overcompensate the amplifier with a larger compensation capacitor. Alternately, lead capacitors can be used in the feedback network to negate the effect of stray capacitance and large feedback resistors or an RC network can be added to isolate capacitive loads.

Although the LM101A is relatively unaffected by supply bypassing, this cannot be ignored altogether. Generally it is necessary to bypass the supplies to ground at least once on every circuit card, and more bypass points may be required if more than five amplifiers are used. When feed-forward compensation is employed, however, it is advisable to bypass the supply leads of each amplifier with low inductance capacitors because of the higher frequencies involved.

Typical Applications

Pin connections shown are for 8-pin packages.

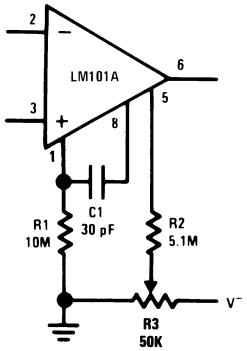
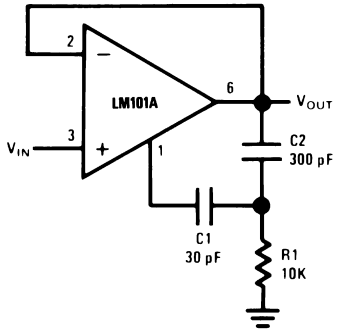
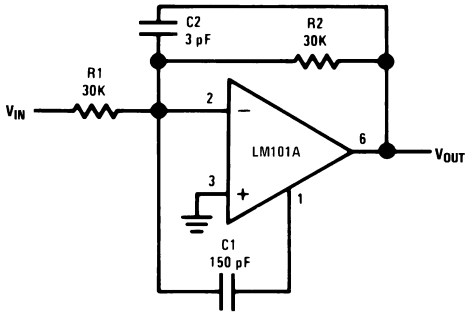


Figure 38. Standard Compensation and Offset Balancing Circuit



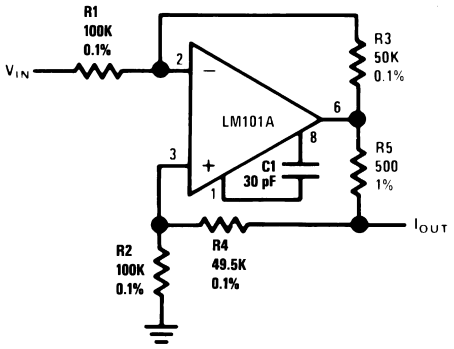
Power Bandwidth: 15 kHz
Slew Rate: 1V/μs

Figure 39. Fast Voltage Follower



Power Bandwidth: 250 kHz
Small Signal Bandwiidth: 3.5 MHz
Slew Rate: 10V/μs

Figure 40. Fast Summing Amplifier



$$I_{OUT} = \frac{R3\ V_{IN}}{R1\ R5}$$

R3 = R4 + R5

R1 = R2

Figure 41. Bilateral Current Source

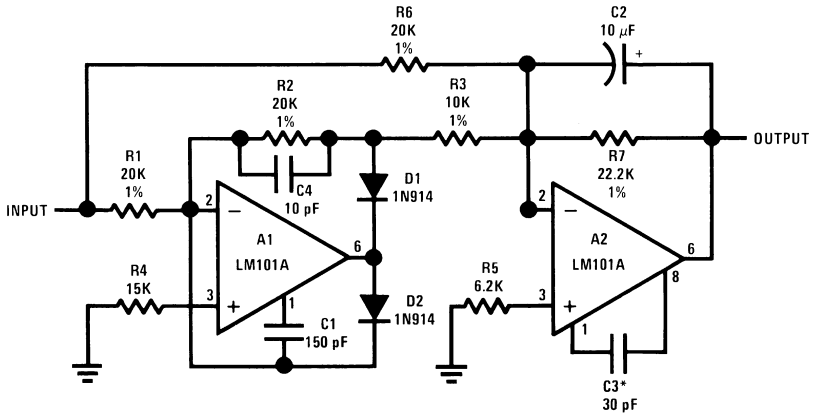
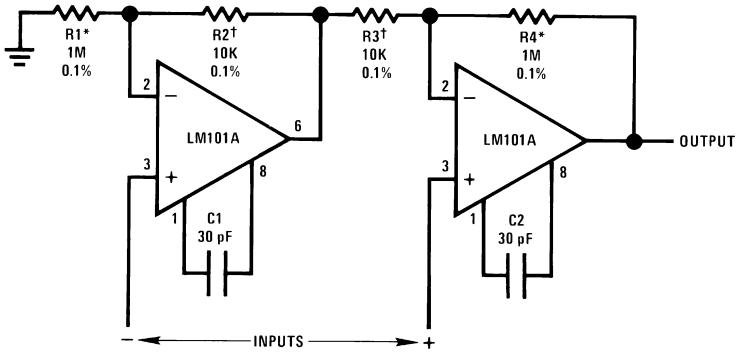


Figure 42. Fast AC/DC Converter(1)



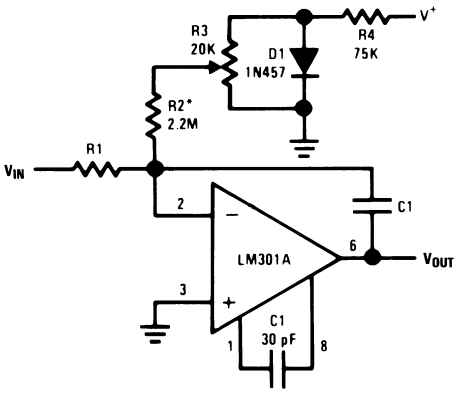
R1 = R4; R2 = R3

$$A_V = 1 + \frac{R1}{R2}$$

*,† Matching determines CMRR.

Figure 43. Instrumentation Amplifier

(1) Feedforward compensation can be used to make a fast full wave rectifier without a filter



*Adjust for zero integrator drift. Current drift typically 0.1 nA/°C over 0°C to +70°C temperature range.

Figure 44. Integrator with Bias Current Compensation

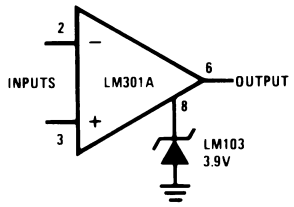


Figure 45. Voltage Comparator for Driving RTL Logic or High Current Driver

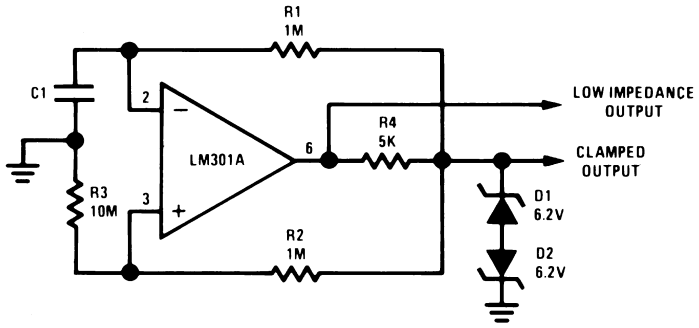
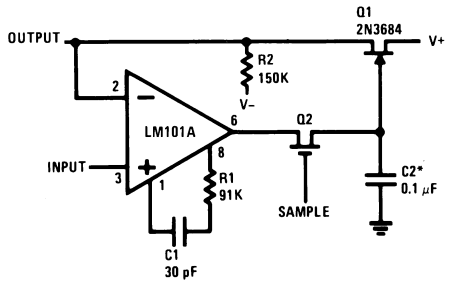


Figure 46. Low Frequency Square Wave Generator



*Polycarbonate-dielectric capacitor

Figure 47. Low Drift Sample and Hold

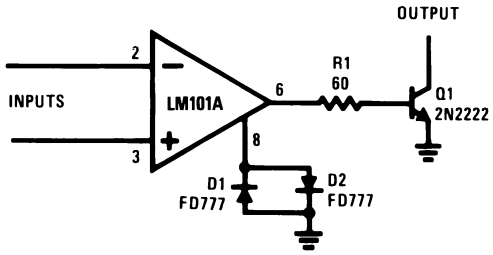
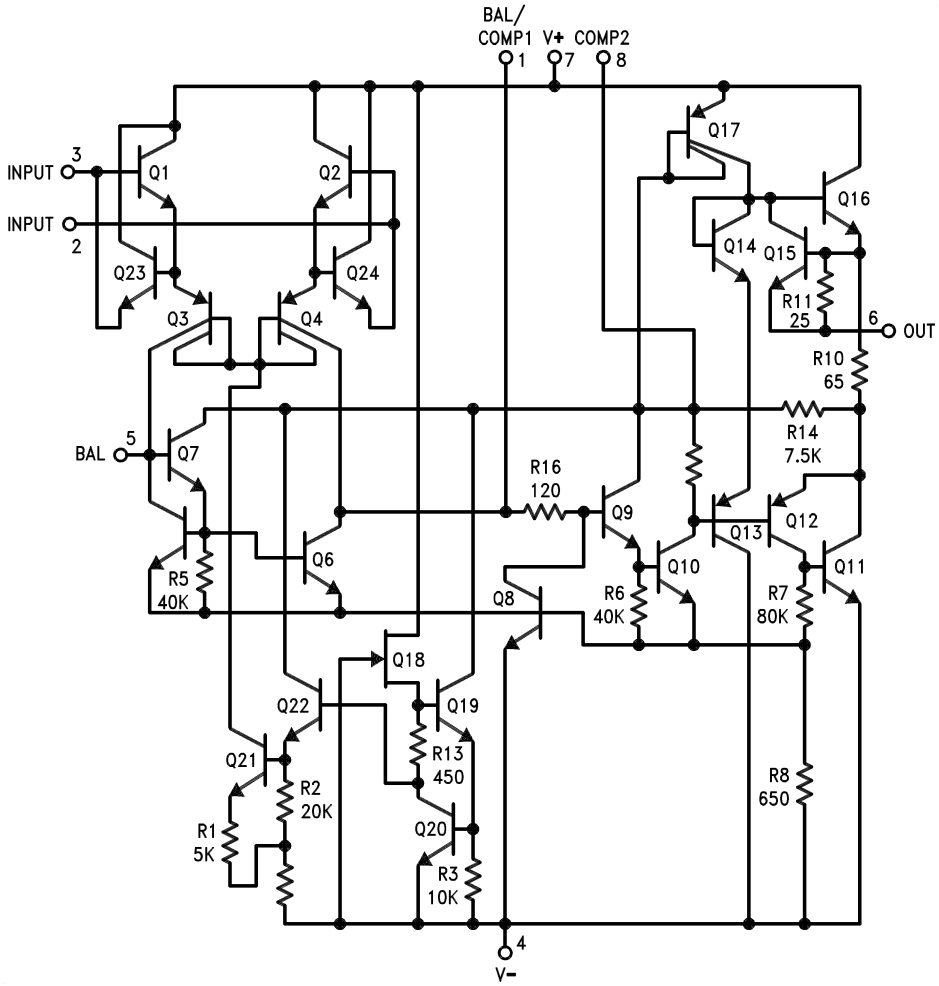


Figure 48. Voltage Comparator for Driving DTL or TTL Integrated Circuits

Schematic



Pin connections shown are for 8-pin packages.

Connection Diagrams

Top View

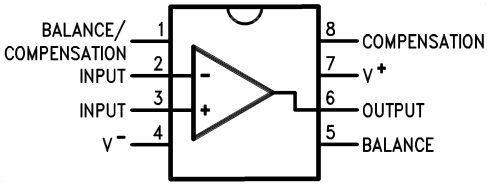


Figure 49. CDIP and PDIP Packages
Package Number NAB0008A or P0008E

Top View

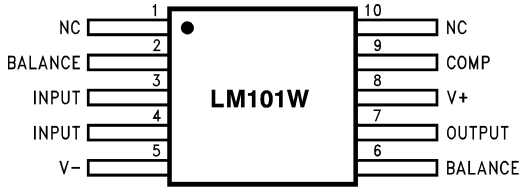


Figure 50. CLGA Package
Package Number NAD0010A

Top View

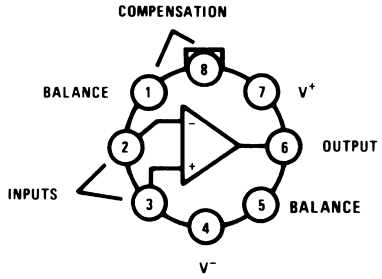


Figure 51. TO-99 Package
See Package Number LMC0008C

Top View

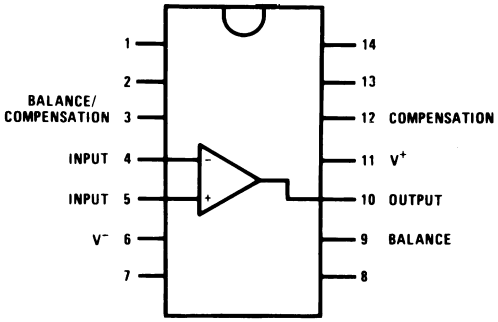


Figure 52. CDIP Package
See Package Number J0014A,

REVISION HISTORY

Changes from Revision C (March 2013) to Revision D	Page
• Changed layout of National Data Sheet to TI format	17

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
LM101AH	ACTIVE	TO-99	LMC	8	500	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	(LM101AH, LM101AH)	Samples
LM101AH/NOPB	ACTIVE	TO-99	LMC	8	500	RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	(LM101AH, LM101AH)	Samples
LM101AJ	ACTIVE	CDIP	NAB	8	40	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-55 to 125	LM101AJ	Samples
LM201AH	ACTIVE	TO-99	LMC	8	500	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	-40 to 85	(LM201AH, LM201AH)	Samples
LM201AH/NOPB	ACTIVE	TO-99	LMC	8	500	RoHS & Green	Call TI	Level-1-NA-UNLIM	-40 to 85	(LM201AH, LM201AH)	Samples
LM301AH	ACTIVE	TO-99	LMC	8	500	Non-RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 70	(LM301AH, LM301AH)	Samples
LM301AH/NOPB	ACTIVE	TO-99	LMC	8	500	RoHS & Green	Call TI	Level-1-NA-UNLIM	0 to 70	(LM301AH, LM301AH)	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.

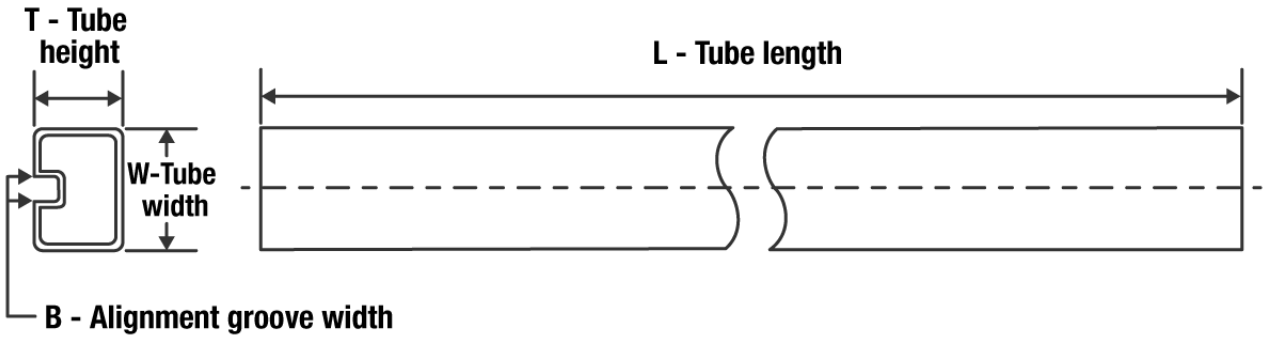
(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(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.

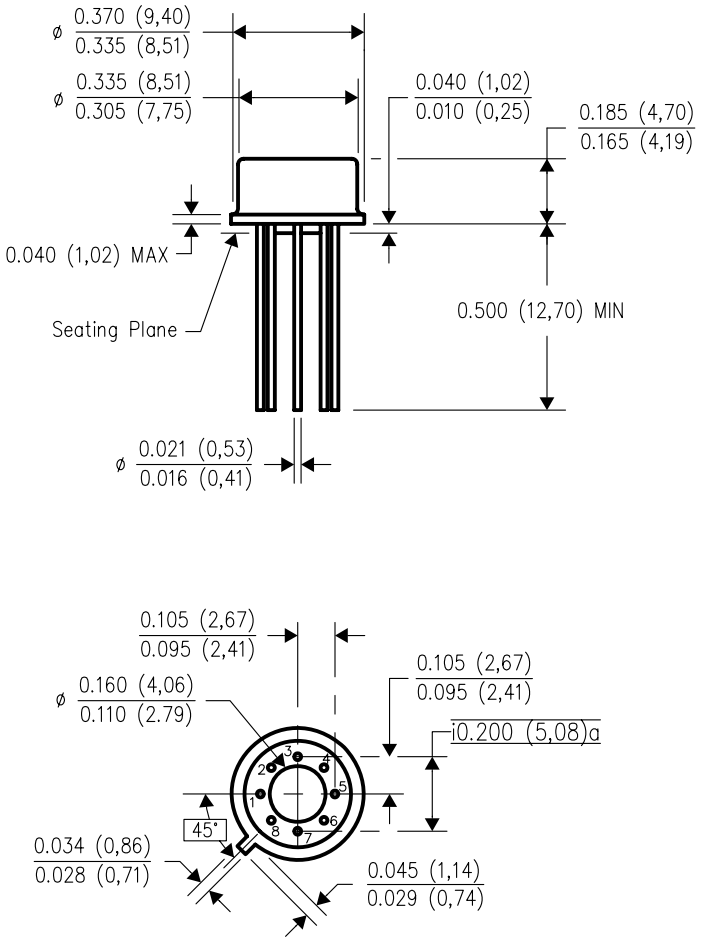
TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
LM101AJ	NAB	CDIP	8	40	502	14	11938	4.32

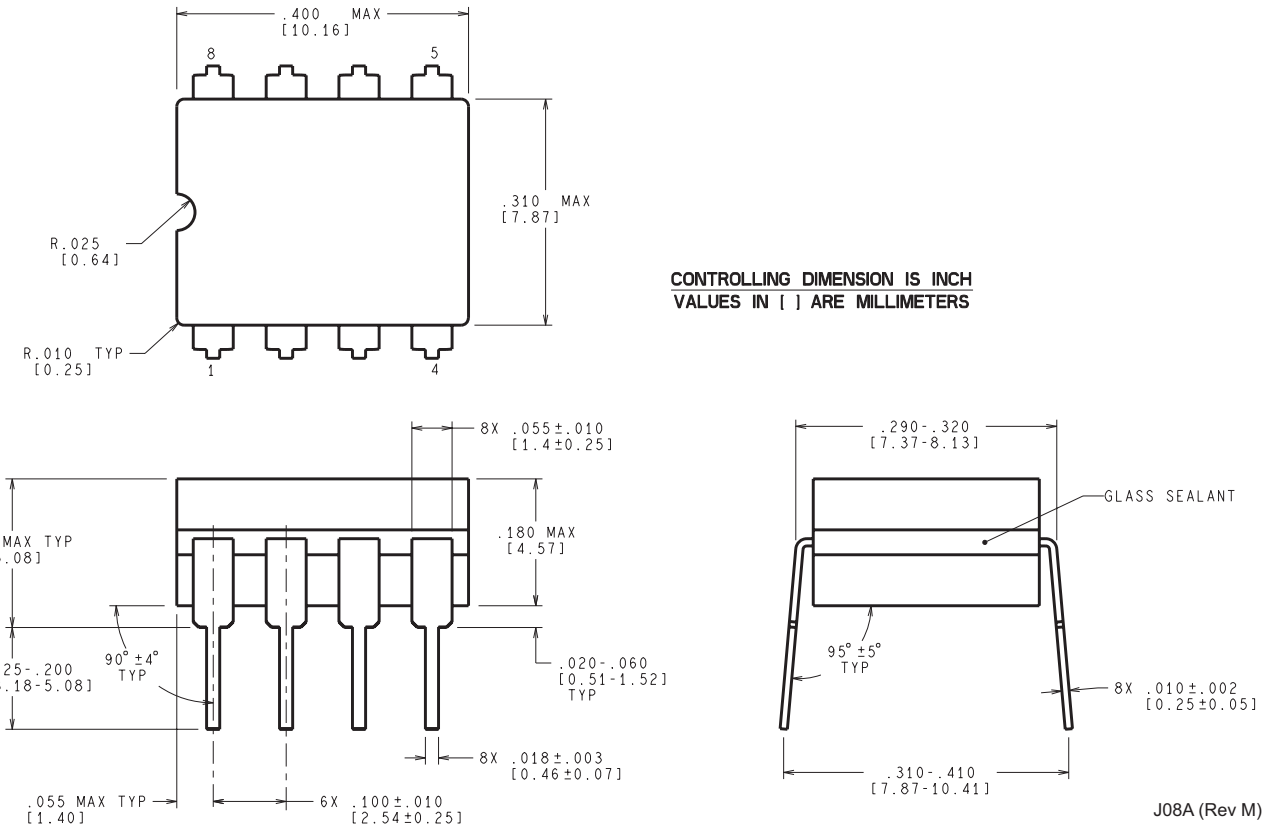
LMC (O–MBCY–W8) METAL CYLINDRICAL PACKAGE



4202483/B 09/07

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Leads in true position within 0.010 (0,25) R @ MMC at seating plane.
D. Pin numbers shown for reference only. Numbers may not be marked on package.
E. Falls within JEDEC MO–002/TO–99.

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)

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