

## 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

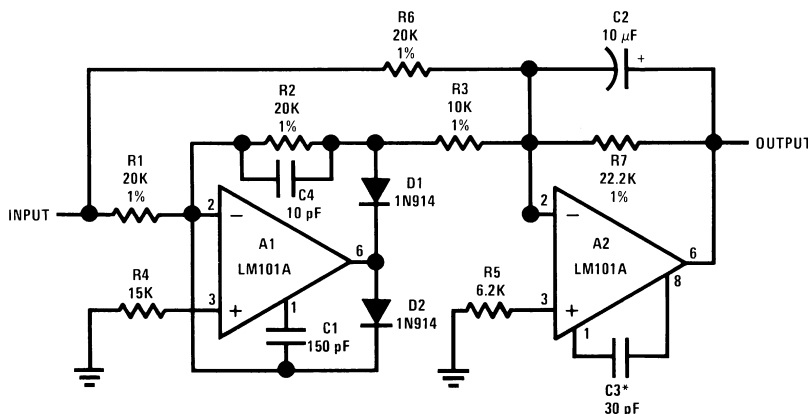
The LM101A series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. Advanced processing techniques make possible an order of magnitude reduction in input currents, and a redesign of the biasing circuitry reduces the temperature drift 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<sup>(1)(2)</sup>

|                                              | LM101A/LM201A            | LM301A          |
|----------------------------------------------|--------------------------|-----------------|
| Supply Voltage                               | ±22V                     | ±18V            |
| Differential Input Voltage                   | ±30V                     | ±30V            |
| Input Voltage <sup>(3)</sup>                 | ±15V                     | ±15V            |
| Output Short Circuit Duration <sup>(4)</sup> | Continuous               | Continuous      |
| Operating Ambient Temp. Range                | –55°C to +125°C (LM101A) | 0°C to +70°C    |
|                                              | –25°C to +85°C (LM201A)  |                 |
| T <sub>J</sub> Max                           |                          |                 |
| LMC0008C Package                             | 150°C                    | 100°C           |
| P0008E Package                               | 150°C                    | 100°C           |
| NAB0008A, J0014A Package                     | 150°C                    | 100°C           |
| Power Dissipation at T <sub>A</sub> = 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 <sub>JA</sub> |                          |                 |
| 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 <sub>JC</sub>                    |                          |                 |
| 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 <sup>(5)</sup>                 | 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 not 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<sup>(1)</sup>**
 $T_A = T_J$ 

| Parameter                                               | Test Conditions                                                                                               |                           | LM101A/LM201A |          |     | LM301A   |          |     | Units                        |
|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------------|---------------|----------|-----|----------|----------|-----|------------------------------|
|                                                         |                                                                                                               |                           | Min           | Typ      | Max | Min      | Typ      | Max |                              |
| Input Offset Voltage                                    | $T_A = 25^\circ\text{C}$ , $R_S \leq 50\text{ k}\Omega$                                                       |                           |               | 0.7      | 2.0 |          | 2.0      | 7.5 | mV                           |
| Input Offset Current                                    | $T_A = 25^\circ\text{C}$                                                                                      |                           |               | 1.5      | 10  |          | 3.0      | 50  | nA                           |
| Input Bias Current                                      | $T_A = 25^\circ\text{C}$                                                                                      |                           |               | 30       | 75  |          | 70       | 250 | nA                           |
| Input Resistance                                        | $T_A = 25^\circ\text{C}$                                                                                      |                           | 1.5           | 4.0      |     | 0.5      | 2.0      |     | M $\Omega$                   |
| Supply Current                                          | $T_A = 25^\circ\text{C}$                                                                                      | $V_S = \pm 20\text{V}$    |               | 1.8      | 3.0 |          |          |     | mA                           |
|                                                         |                                                                                                               | $V_S = \pm 15\text{V}$    |               |          |     |          | 1.8      | 3.0 | mA                           |
| Large Signal Voltage Gain                               | $T_A = 25^\circ\text{C}$ , $V_S = \pm 15\text{V}$<br>$V_{OUT} = \pm 10\text{V}$ , $R_L \geq 2\text{ k}\Omega$ |                           | 50            | 160      |     | 25       | 160      |     | V/mV                         |
|                                                         |                                                                                                               |                           |               |          |     |          |          |     |                              |
| Input Offset Voltage                                    | $R_S \leq 50\text{ k}\Omega$                                                                                  |                           |               |          | 3.0 |          |          | 10  | mV                           |
| Average Temperature Coefficient of Input Offset Voltage | $R_S \leq 50\text{ k}\Omega$                                                                                  |                           |               | 3.0      | 15  |          | 6.0      | 30  | $\mu\text{V}/^\circ\text{C}$ |
| Input Offset Current                                    |                                                                                                               |                           |               |          | 20  |          |          | 70  | nA                           |
| Average Temperature Coefficient of Input Offset Current | $25^\circ\text{C} \leq T_A \leq T_{MAX}$                                                                      |                           |               | 0.01     | 0.1 |          | 0.01     | 0.3 | nA/ $^\circ\text{C}$         |
|                                                         | $T_{MIN} \leq T_A \leq 25^\circ\text{C}$                                                                      |                           |               | 0.02     | 0.2 |          | 0.02     | 0.6 | nA/ $^\circ\text{C}$         |
| Input Bias Current                                      |                                                                                                               |                           |               |          | 0.1 |          |          | 0.3 | $\mu\text{A}$                |
| Supply Current                                          | $T_A = T_{MAX}$ , $V_S = \pm 20\text{V}$                                                                      |                           |               | 1.2      | 2.5 |          |          |     | mA                           |
| Large Signal Voltage Gain                               | $V_S = \pm 15\text{V}$ , $V_{OUT} = \pm 10\text{V}$<br>$R_L \geq 2\text{ k}\Omega$                            |                           | 25            |          |     | 15       |          |     | V/mV                         |
| Output Voltage Swing                                    | $V_S = \pm 15\text{V}$                                                                                        | $R_L = 10\text{ k}\Omega$ | $\pm 12$      | $\pm 14$ |     | $\pm 12$ | $\pm 14$ |     | V                            |
|                                                         |                                                                                                               | $R_L = 2\text{ k}\Omega$  | $\pm 10$      | $\pm 13$ |     | $\pm 10$ | $\pm 13$ |     | V                            |
| Input Voltage Range                                     | $V_S = \pm 20\text{V}$                                                                                        |                           | $\pm 15$      |          |     |          |          |     | V                            |
|                                                         | $V_S = \pm 15\text{V}$                                                                                        |                           |               | +15, -13 |     | $\pm 12$ | +15, -13 |     | V                            |
| Common-Mode Rejection Ratio                             | $R_S \leq 50\text{ k}\Omega$                                                                                  |                           | 80            | 96       |     | 70       | 90       |     | dB                           |
| Supply Voltage Rejection Ratio                          | $R_S \leq 50\text{ k}\Omega$                                                                                  |                           | 80            | 96       |     | 70       | 96       |     | dB                           |

(1) Unless otherwise specified, these specifications apply for  $C_1 = 30\text{ pF}$ ,  $\pm 5\text{V} \leq V_S \leq \pm 20\text{V}$  and  $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$  (LM101A),  $\pm 5\text{V} \leq V_S \leq \pm 20\text{V}$  and  $-25^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$  (LM201A),  $\pm 5\text{V} \leq V_S \leq \pm 15\text{V}$  and  $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$  (LM301A).

## Typical Performance Characteristics

LM101A/LM201A

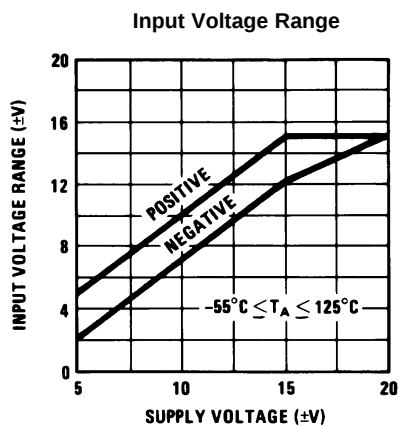


Figure 1.

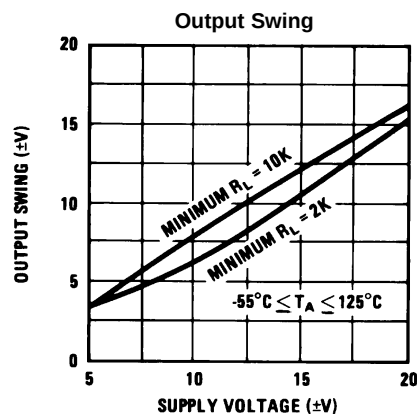


Figure 2.

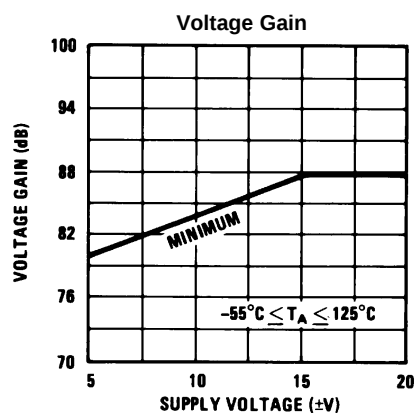


Figure 3.

## Performance Characteristics

LM301A

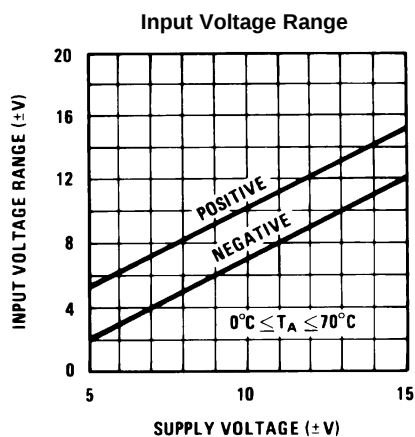


Figure 4.

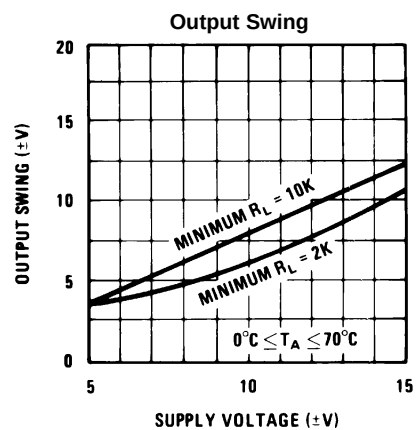
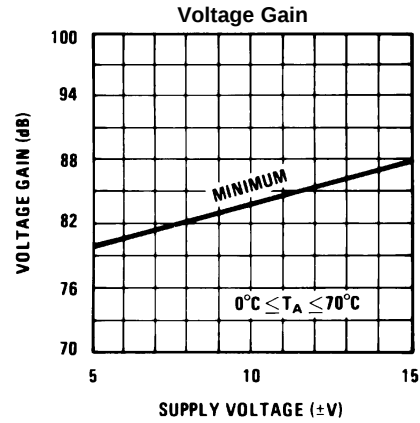


Figure 5.

## Performance Characteristics (continued)

LM301A



## Typical Performance Characteristics

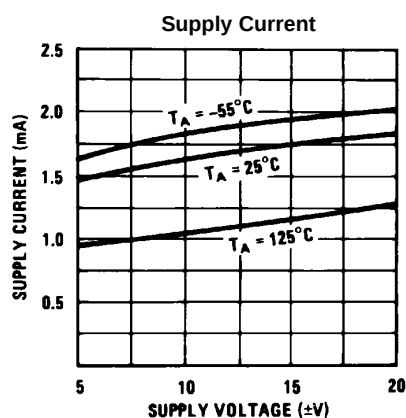


Figure 7.

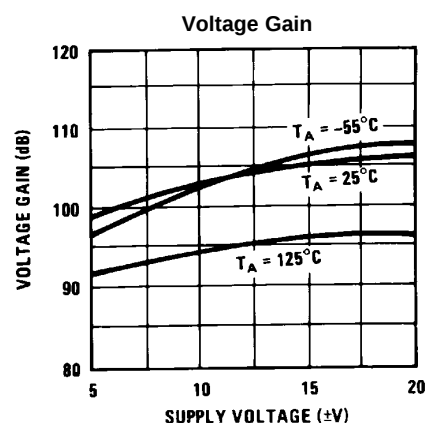


Figure 8.

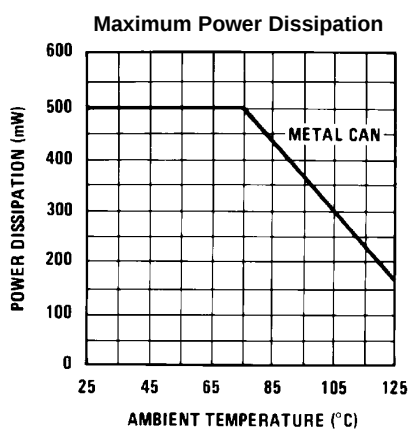


Figure 9.

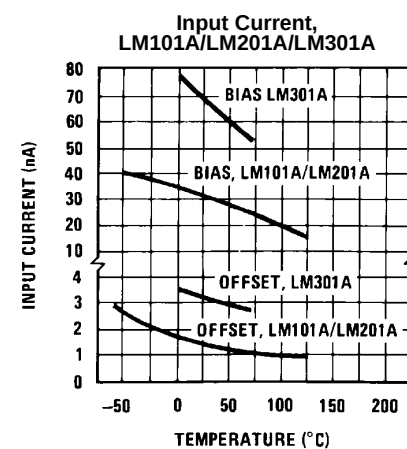


Figure 10.

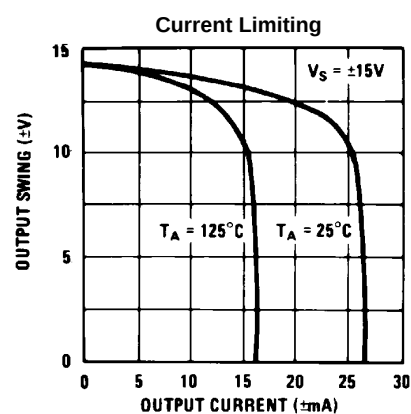


Figure 11.

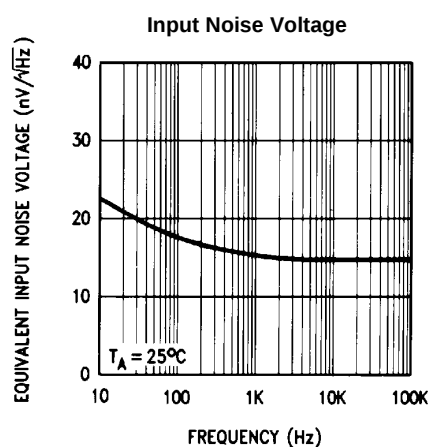


Figure 12.

## Typical Performance Characteristics (continued)

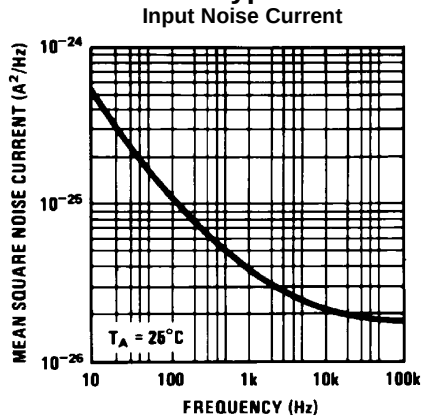


Figure 13.

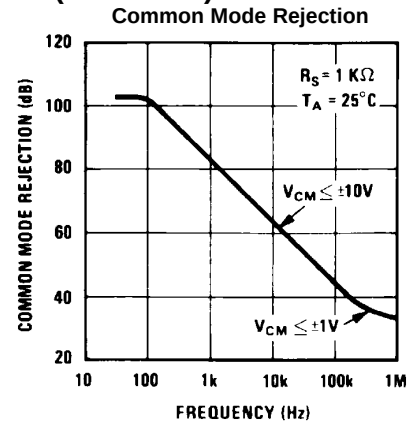


Figure 14.

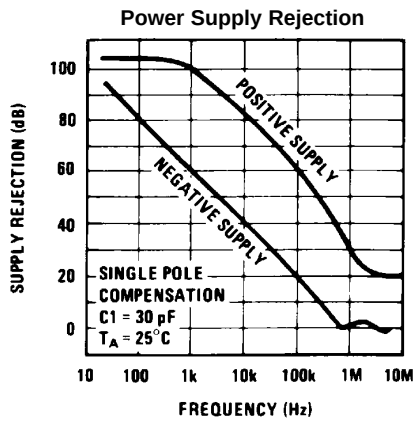


Figure 15.

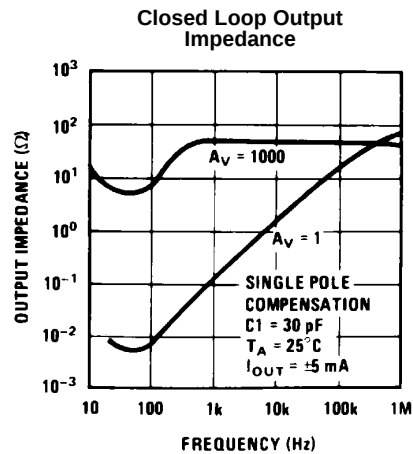
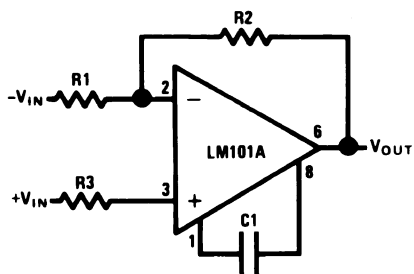


Figure 16.

## Typical Performance Characteristics for Various Compensation Circuits

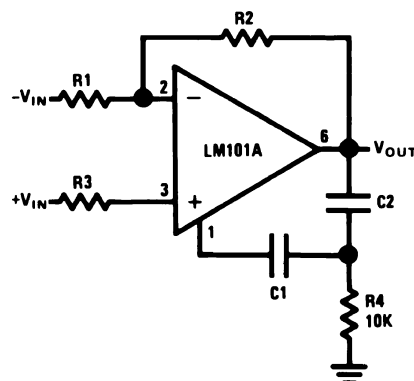
Pin connections shown are for 8-pin packages.



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

$$C_S = 30 \text{ pF}$$

Figure 17. Single Pole Compensation

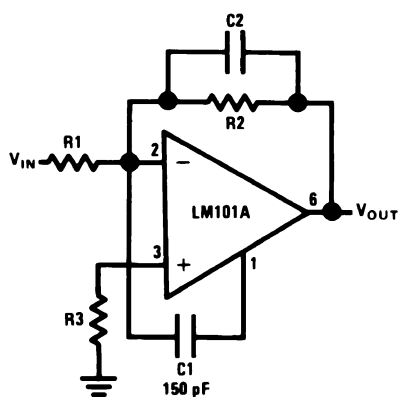


$$C1 \geq \frac{R1 C_S}{R1 + R2}$$

$$C_S = 30 \text{ pF}$$

$$C2 = 10 C1$$

Figure 18. Two Pole Compensation



$$C2 = \frac{1}{2\pi f_0 R2}$$

$$f_0 = 3 \text{ MHz}$$

Figure 19. Feedforward Compensation

### Open Loop Frequency Response

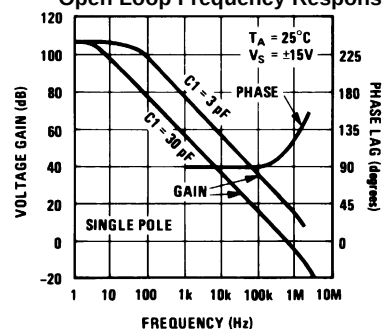


Figure 20.

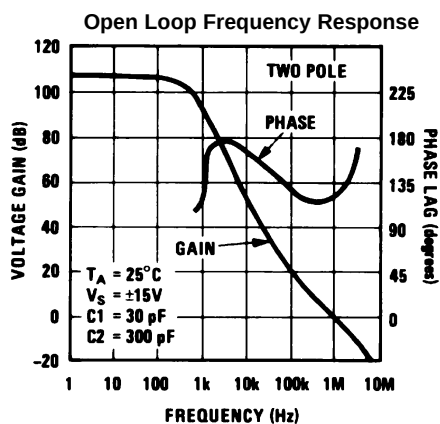


Figure 21.

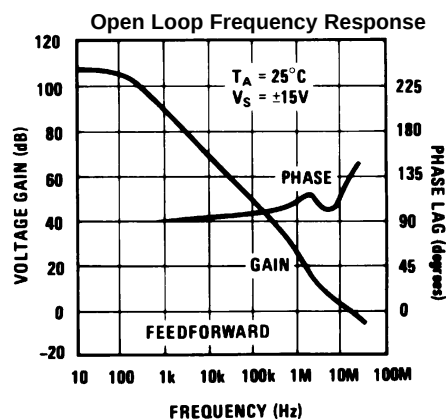
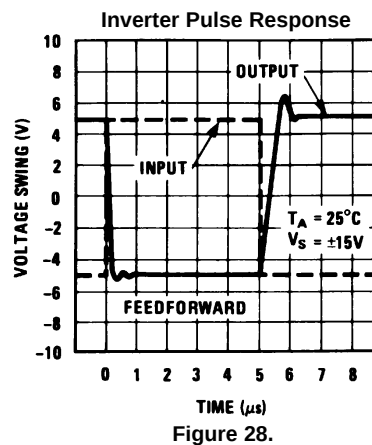
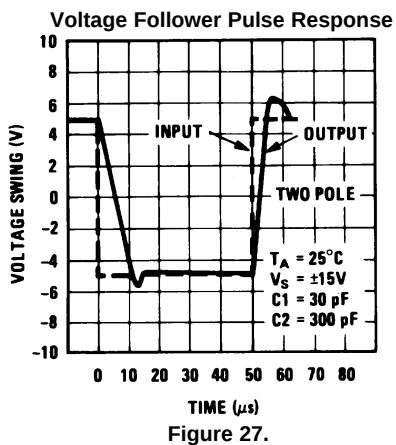
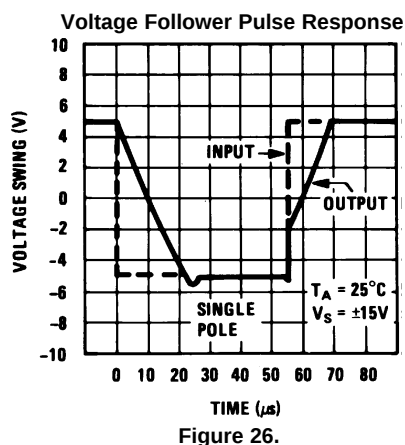
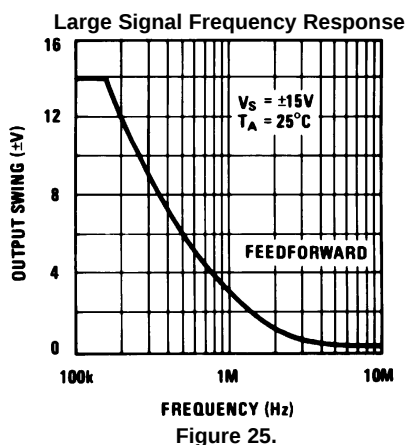
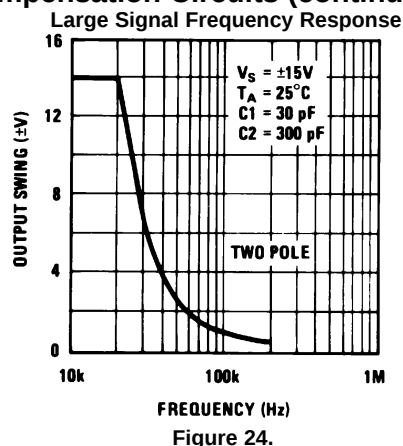
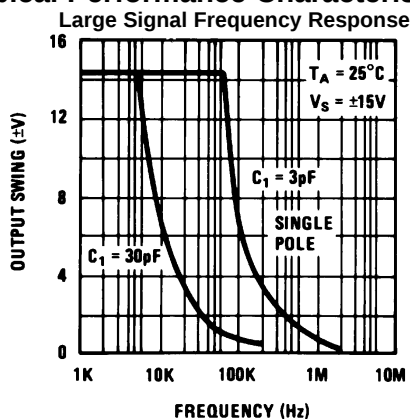


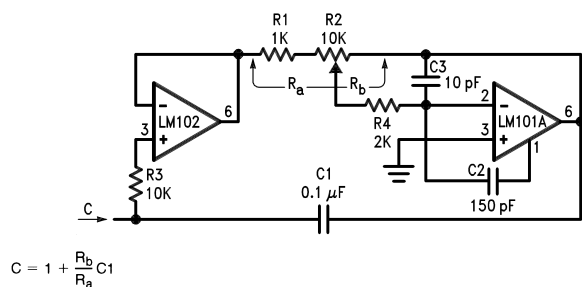
Figure 22.

# Typical Performance Characteristics for Various Compensation Circuits (continued)



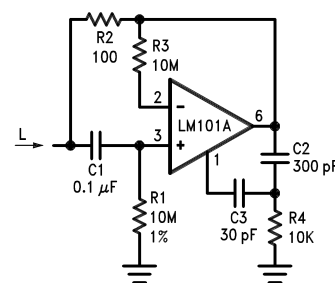
## TYPICAL APPLICATIONS

Pin connections shown are for 8-pin packages



$$C = 1 + \frac{R_b}{R_a} C_1$$

Figure 29. Variable Capacitance Multiplier



$$L \approx R_1 R_2 C_1$$

$$R_S = R_2$$

$$R_P = R_1$$

Figure 30. Simulated Inductor

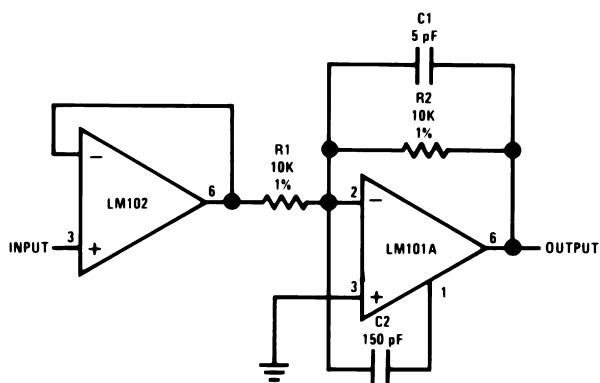
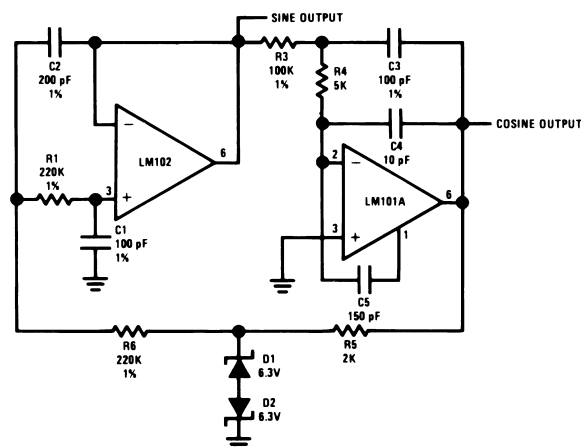
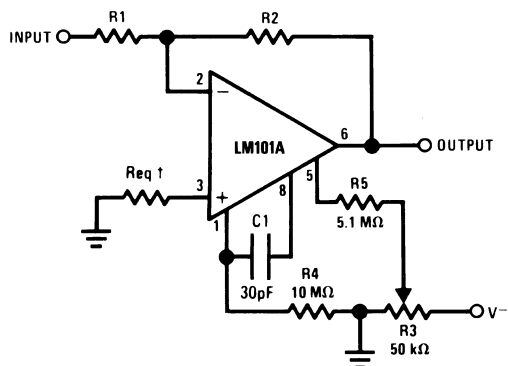


Figure 31. Fast Inverting Amplifier with High Input Impedance



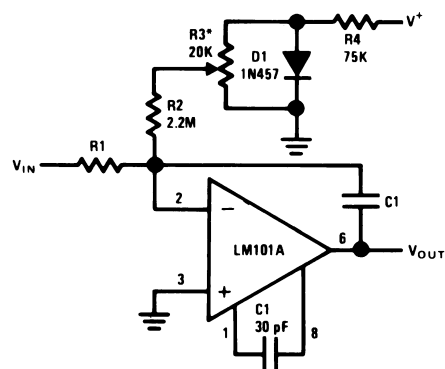
$$f_0 = 10 \text{ kHz}$$

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

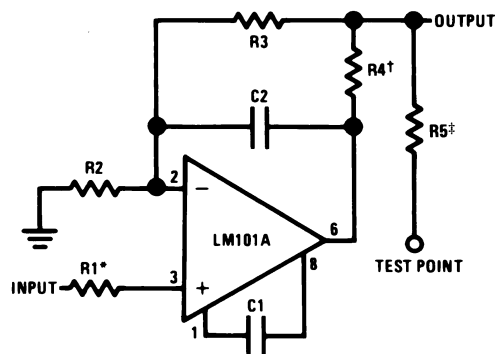


\*Adjust for zero integrator drift. Current drift typically 0.1 nA/°C over -55°C to +125°C temperature range.

Figure 34. Integrator with Bias Current Compensation

## Application Hints

Pin connections shown are for 8-pin packages.

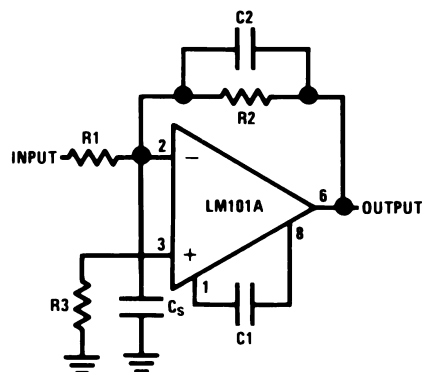


\*Protects input

†Protects output

‡Protects output—not needed when R4 is used.

Figure 35. Protecting Against Gross Fault Conditions



$$C_2 = \frac{R_1 C_s}{R_2}$$

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

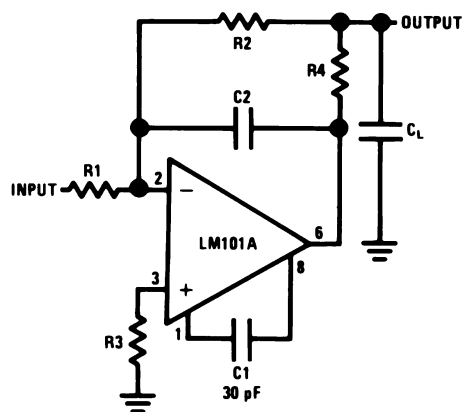


Figure 37. Isolating Large Capacitive Loads

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  $\mu\text{F}$ ) 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 amplifier 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 k $\Omega$ , 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.

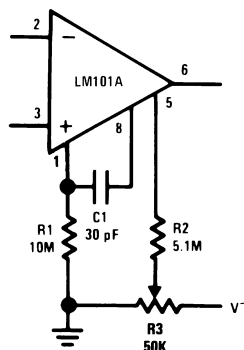
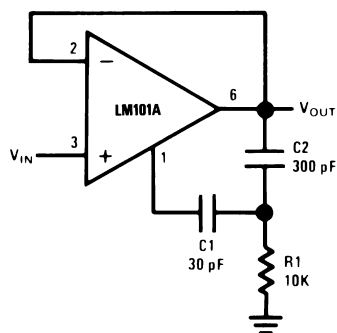
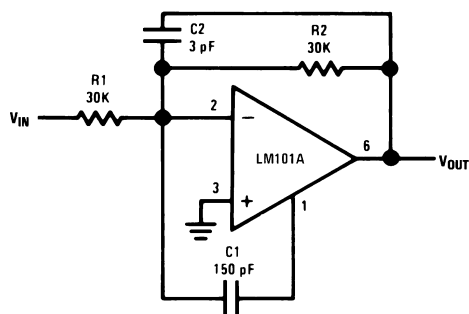


Figure 38. Standard Compensation and Offset Balancing Circuit



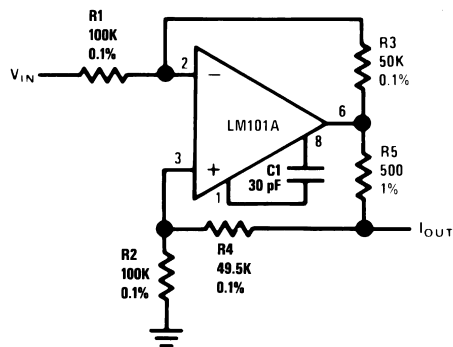
Power Bandwidth: 15 kHz  
Slew Rate: 1V/μs

Figure 39. Fast Voltage Follower



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

Figure 40. Fast Summing Amplifier

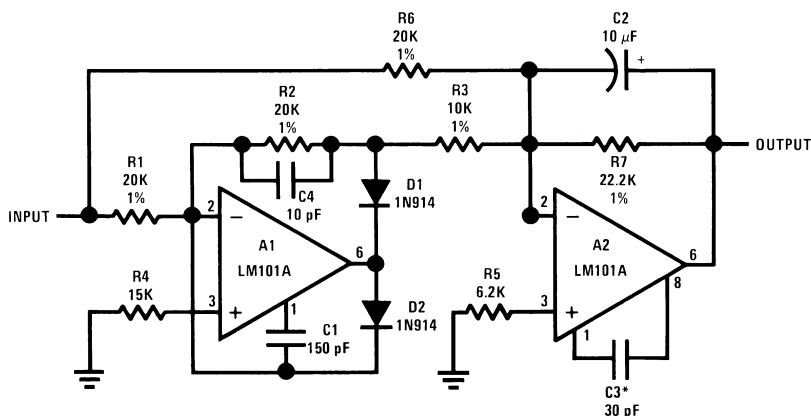
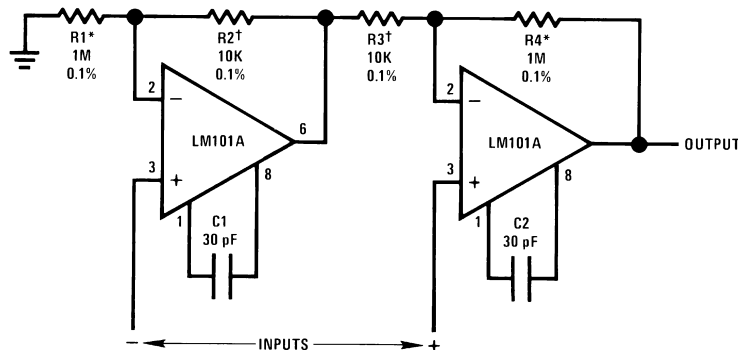


$$I_{OUT} = \frac{R3 V_{IN}}{R1 R5}$$

$$R3 = R4 + R5$$

$$R1 = R2$$

Figure 41. Bilateral Current Source

Figure 42. Fast AC/DC Converter<sup>(1)</sup>

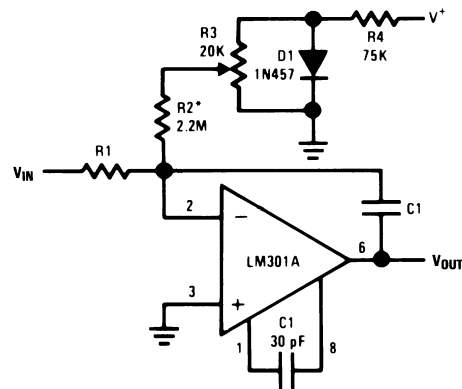
$$R1 = R4; R2 = R3$$

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

\*, † Matching determines CMRR.

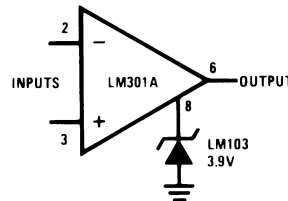
Figure 43. Instrumentation Amplifier

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

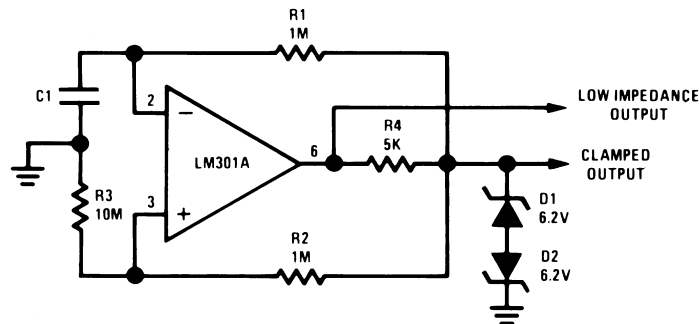


\*Adjust for zero integrator drift. Current drift typically 0.1 nA/°C over 0°C to +70°C temperature range.

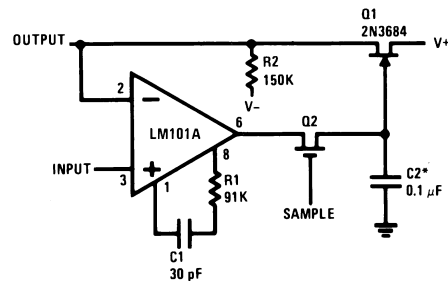
**Figure 44. Integrator with Bias Current Compensation**



**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**

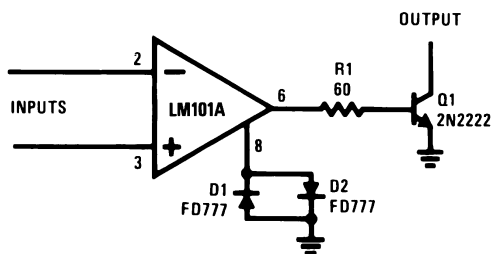
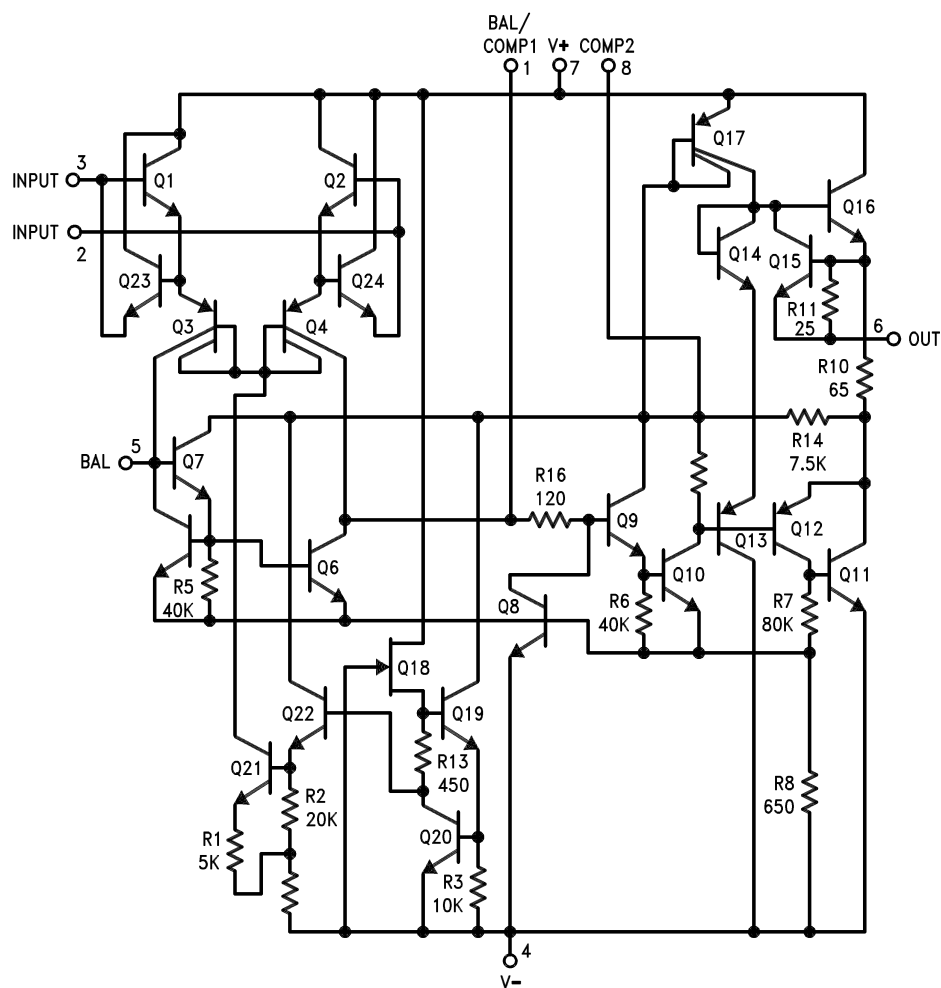


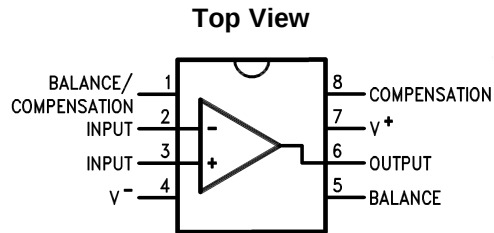
Figure 48. Voltage Comparator for Driving DTL or TTL Integrated Circuits

## Schematic

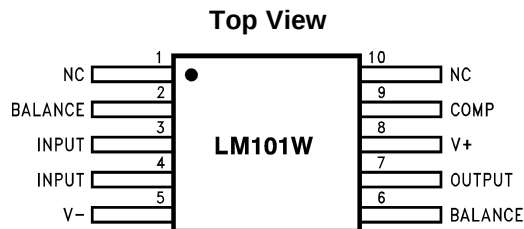


Pin connections shown are for 8-pin packages.

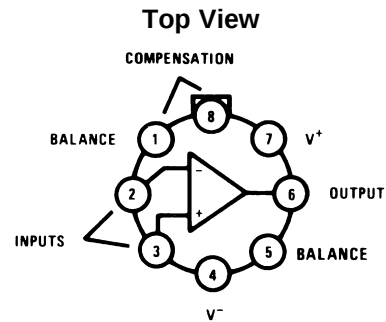
## Connection Diagrams



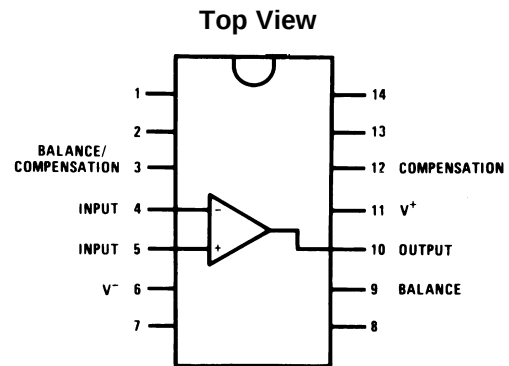
**Figure 49. CDIP and PDIP Packages**  
Package Number NAB0008A or P0008E



**Figure 50. CLGA Package**  
Package Number NAD0010A



**Figure 51. TO-99 Package**  
See Package Number LMC0008C



**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<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM101AH          | ACTIVE        | TO-99        | LMC                | 8    | 500            | TBD                        | Call TI                 | Call TI              | -55 to 125   | ( LM101AH ~<br>LM101AH) | <a href="#">Samples</a> |
| LM101AH/NOPB     | ACTIVE        | TO-99        | LMC                | 8    | 500            | Green (RoHS<br>& no Sb/Br) | Call TI                 | Level-1-NA-UNLIM     | -55 to 125   | ( LM101AH ~<br>LM101AH) | <a href="#">Samples</a> |
| LM101AJ          | ACTIVE        | CDIP         | NAB                | 8    | 40             | TBD                        | Call TI                 | Call TI              | -55 to 125   | LM101AJ                 | <a href="#">Samples</a> |
| LM201AH          | ACTIVE        | TO-99        | LMC                | 8    | 500            | TBD                        | Call TI                 | Call TI              | -40 to 85    | ( LM201AH ~<br>LM201AH) | <a href="#">Samples</a> |
| LM201AH/NOPB     | ACTIVE        | TO-99        | LMC                | 8    | 500            | Green (RoHS<br>& no Sb/Br) | Call TI                 | Level-1-NA-UNLIM     | -40 to 85    | ( LM201AH ~<br>LM201AH) | <a href="#">Samples</a> |
| LM301AH          | ACTIVE        | TO-99        | LMC                | 8    | 500            | TBD                        | Call TI                 | Call TI              | 0 to 70      | ( LM301AH ~<br>LM301AH) | <a href="#">Samples</a> |
| LM301AH/NOPB     | ACTIVE        | TO-99        | LMC                | 8    | 500            | Green (RoHS<br>& no Sb/Br) | Call TI                 | Level-1-NA-UNLIM     | 0 to 70      | ( LM301AH ~<br>LM301AH) | <a href="#">Samples</a> |
| LM301AN/NOPB     | ACTIVE        | PDIP         | P                  | 8    | 40             | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-NA-UNLIM     | 0 to 70      | LM<br>301AN             | <a href="#">Samples</a> |

(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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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

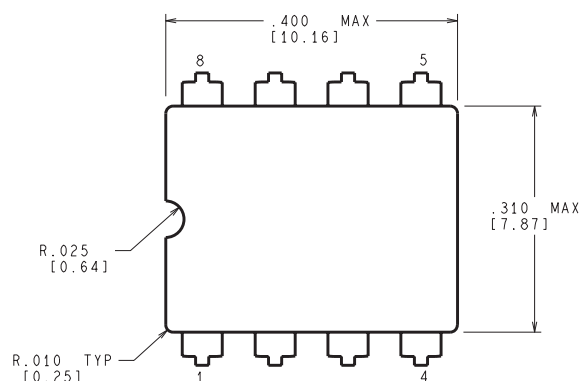
<sup>(5)</sup> Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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

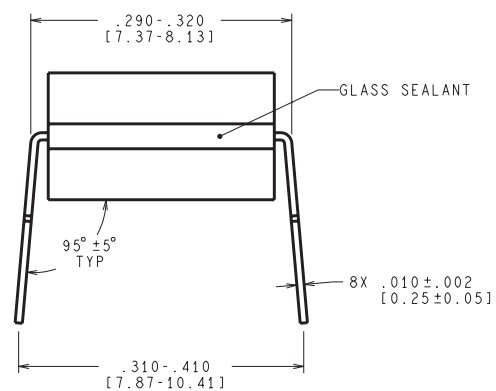
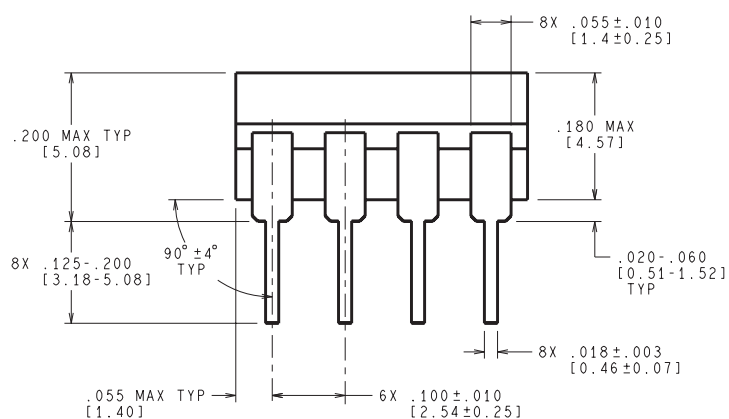
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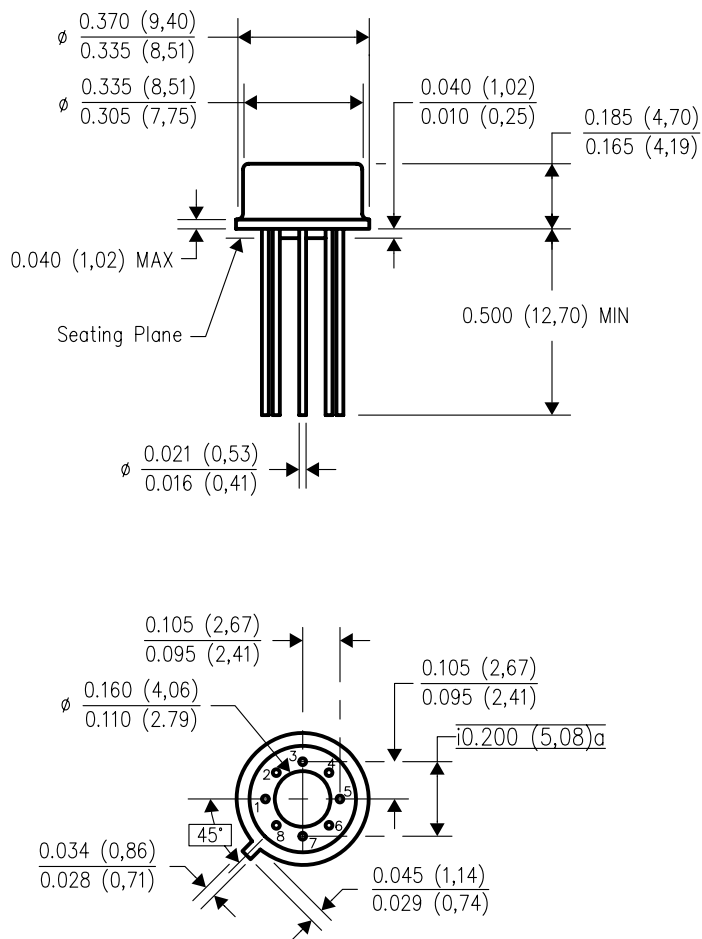
CONTROLLING DIMENSION IS INCH  
VALUES IN [ ] ARE MILLIMETERS



J08A (Rev M)

## LMC (O-MBCY-W8)

## METAL CYLINDRICAL PACKAGE



4202483/B 09/07

- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - Leads in true position within 0.010 (0,25) R @ MMC at seating plane.
  - Pin numbers shown for reference only. Numbers may not be marked on package.
  - Falls within JEDEC MO-002/T0-99.

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Falls within JEDEC MS-001 variation BA.

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