



The Infinite Bandwidth Company™

MIC7122

Rail-to-Rail Dual Op Amp

Final Information

General Description

The MIC7122 is a dual high-performance CMOS operational amplifier featuring rail-to-rail inputs and outputs.

The input common-mode range extends beyond the rails by 300mV, and the output voltage swings to within 150µV of both rails when driving a 100kΩ load.

The amplifiers operate from 2.2V to 15V and are fully specified at 2.2V, 5V, and 15V. Gain bandwidth and slew rate are 750kHz and 0.7V/µs, respectively at 2.2V supply.

The MIC7122 is available in the MM8™ 8-lead MSOP package.

Features

- Small footprint MSOP-8 package
- 350µA supply current per op amp at 2.2V supply
- Guaranteed 2.2V, 5V, and 15V performance
- 750kHz gain-bandwidth product at 2.2V supply
- 0.01% total harmonic distortion at 1kHz (15V, 2kΩ)
- Drives 200pF at 5V and greater supply voltages

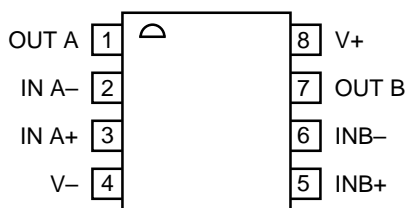
Applications

- Battery-powered instrumentation
- PCMCIA, USB peripherals
- Portable computers and PDAs

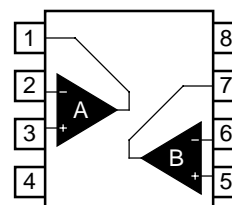
Ordering Information

| Part Number | Temperature Range | Package |
|-------------|-------------------|---------|
| MIC7122BMM | -40°C to +85°C | MSOP-8 |

Pin Configuration



MSOP-8 (MM)



Pin Description

| Pin Number | Pin Name | Pin Function |
|------------|-------------|---|
| 1 / 7 | OUTA / OUTB | Amplifier Outputs |
| 2 / 6 | INA- / INB- | Inverting Inputs |
| 3 / 5 | INA+ / INB+ | Noninverting Inputs |
| 4 | V- | Negative Supply: Negative supply for split supply application or ground for single supply applications. |
| 8 | V+ | Positive Supply |

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Absolute Maximum Ratings (Note 1)

| | |
|--|------------------------------------|
| Supply Voltage ($V_{V+} - V_{V-}$) | 16.5V |
| Differential Input Voltage ($V_{IN+} - V_{IN-}$) | $\pm 10V$ |
| I/O Pin Voltage (V_{IN}, V_{OUT}), Note 3 | $V_{V+} + 0.3V$ to $V_{V-} - 0.3V$ |
| Junction Temperature (T_J) | +150°C |
| Storage Temperature | -65°C to +150°C |
| Lead Temperature (soldering, 10 sec.) | 260°C |
| ESD, Note 6 | 1000V |

Operating Ratings (Note 2)

| | |
|---|----------------|
| Supply Voltage ($V_{V+} - V_{V-}$) | 2.2V to 15V |
| Junction Temperature (T_J) | -40°C to +85°C |
| Max. Junction Temperature ($T_{J(max)}$), Note 4 | +125°C |
| Max. Power Dissipation | Note 4 |
| Package Thermal Resistance, Note 5 | |
| MSOP-8 (θ_{JA}) | 200°C/W |

DC Electrical Characteristics (2.2V)

$V_{V+} = +2.2V$, $V_{V-} = 0V$, $V_{CM} = V_{OUT} = V_{V+}/2$; $R_L = 1M\Omega$; $T_J = 25^\circ C$, **bold** values indicate $-40^\circ C \leq T_J \leq +85^\circ C$; **Note 7**; unless noted

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|------------|------------------------------------|---|-----|------------------|-------------------|------------------|
| V_{OS} | Input Offset Voltage | | | 0.5 | 9 | mV |
| TCV_{OS} | Input Offset Voltage Average Drift | | | 3.0 | | $\mu V/^\circ C$ |
| I_B | Input Bias Current | | | 1.0 64 | 10 500 | pA pA |
| I_{OS} | Input Offset Current | | | 0.5 32 | 5 250 | pA pA |
| R_{IN} | Input Resistance | | | >1 | | T Ω |
| CMRR | Common-Mode Rejection Ratio | $-0.3V \leq V_{CM} \leq 2.5V$, Note 9 | 45 | 65 | | dB |
| $\pm PSRR$ | Power Supply Rejection Ratio | $V_{V+} = V_{V-} = 1.1V$ to $2.5V$, $V_{OUT} = V_{CM} = 0$ | 60 | 85 | | dB |
| C_{IN} | Common-Mode Input Capacitance | | | 3 | | pF |
| V_O | Output Swing | output high, $R_L = 100k$, specified as $V_{V+} - V_{OUT}$ | | 0.15 | 1 1 | mV mV |
| | | output low, $R_L = 100k$ | | 0.15 | 1 1 | mV mV |
| | | output high, $R_L = 2k$ specified as $V_{V+} - V_{OUT}$ | | 8 | 33 50 | mV mV |
| | | output low, $R_L = 2k$ | | 8 | 33 50 | mV mV |
| | | output high, $R_L = 600\Omega$ specified as $V_{V+} - V_{OUT}$ | | 26 | 110 165 | mV mV |
| | | output low, $R_L = 600\Omega$ | | 26 | 110 165 | mV mV |
| I_{SC} | Output Short Circuit Current | sinking or sourcing, Note 8 | 20 | 50 | | mA |
| I_S | Supply Current | both amplifiers | | 0.7 | 1.6 | mA |

AC Electrical Characteristics (2.2V)

$V_{V+} = 2.2V$, $V_{V-} = 0V$, $V_{CM} = V_{OUT} = V_{V+}/2$; $R_L = 1M\Omega$; $T_J = 25^\circ C$, **bold** values indicate $-40^\circ C \leq T_J \leq +85^\circ C$; **Note 7**; unless noted

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|----------|--------------------------|----------------|-----|-----|-----|------------|
| SR | Slew Rate | | | 0.7 | | V/ μs |
| GBW | Gain-Bandwidth Product | | | 750 | | kHz |
| ϕ_m | Phase Margin | $C_L = 0pF$ | | 80 | | $^\circ$ |
| | | $C_L = 200pF$ | | 40 | | $^\circ$ |
| G_m | Gain Margin | | | 10 | | dB |
| | Interamplifier Isolation | Note 12 | | 90 | | dB |

DC Electrical Characteristics (5V)

$V_{V+} = +5.0V$, $V_{V-} = 0V$, $V_{CM} = 1.5V$, $V_{OUT} = V_{V+}/2$; $R_L = 1M\Omega$; $T_J = 25^\circ C$, **bold** values indicate $-40^\circ C \leq T_J \leq +85^\circ C$; **Note 7**; unless noted

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|------------|------------------------------------|---|-----|------------------|-------------------|------------------|
| V_{OS} | Input Offset Voltage | | | 0.5 | 9 | mV |
| TCV_{OS} | Input Offset Voltage Average Drift | | | 3.0 | | $\mu V/^\circ C$ |
| I_B | Input Bias Current | | | 1.0 64 | 10 500 | pA pA |
| I_{OS} | Input Offset Current | | | 0.5 32 | 5 250 | pA pA |
| R_{IN} | Input Resistance | | | >1 | | $T\Omega$ |
| CMRR | Common-Mode Rejection Ratio | $-0.3V \leq V_{CM} \leq 5.3V$, Note 9 | 55 | 75 | | dB |
| $\pm PSRR$ | Power Supply Rejection Ratio | $V_{V+} = V_{V-} = 2.5V$ to $7.5V$, $V_{OUT} = V_{CM} = 0$ | 55 | 100 | | dB |
| C_{IN} | Common-Mode Input Capacitance | | | 3 | | pF |
| V_{OUT} | Output Swing | output high, $R_L = 100k$ specified as $V_{V+} - V_{OUT}$ | | 0.3 | 1.0 1.5 | mV mV |
| | | output low, $R_L = 100k$ | | 0.3 | 1.0 1.5 | mV mV |
| | | output high, $R_L = 2k$ specified as $V_{V+} - V_{OUT}$ | | 13 | 50 75 | mV mV |
| | | output low, $R_L = 2k$ | | 13 | 50 75 | mV mV |
| | | output high, $R_L = 600\Omega$ specified as $V_{V+} - V_{OUT}$ | | 40 | 165 250 | mV mV |
| | | output low, $R_L = 600\Omega$ | | 40 | 165 250 | mV mV |
| I_{SC} | Output Short Circuit Current | sinking or sourcing, Note 8 | 40 | 140 | | mA |
| I_S | Supply Current | both amplifiers | | 0.8 | 1.8 | mA |

AC Electrical Characteristics (5V)

$V_{V+} = 5V$, $V_{V-} = 0V$, $V_{CM} = 1.5V$, $V_{OUT} = V_{V+}/2$; $R_L = 1M\Omega$; $T_J = 25^\circ C$, **bold** values indicate $-40^\circ C \leq T_J \leq +85^\circ C$; **Note 7**; unless noted

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|----------|---------------------------|--|-----|------|-----|-----------|
| THD | Total Harmonic Distortion | $f = 1kHz$, $A_V = -2$, $R_L = 2k\Omega$, $V_{OUT} = 4.0 V_{PP}$ | | 0.05 | | % |
| SR | Slew Rate | | | 0.6 | | $V/\mu s$ |
| GBW | Gain-Bandwidth Product | | | 465 | | kHz |
| ϕ_m | Phase Margin | $C_L = 0pF$ | | 85 | | $^\circ$ |
| | | $C_L = 200pF$ | | 40 | | $^\circ$ |
| G_m | Gain Margin | | | 10 | | dB |
| | Interamplifier Isolation | Note 12 | | 90 | | dB |

DC Electrical Characteristics (15V)

$V_{V+} = +15V$, $V_{V-} = 0V$, $V_{CM} = 1.5V$, $V_{OUT} = V_{V+}/2$; $R_L = 1M\Omega$; $T_J = 25^\circ C$, **bold** values indicate $-40^\circ C \leq T_J \leq +85^\circ C$; **Note 7**; unless noted

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|------------|------------------------------------|---|-----|------------------|-------------------|------------------|
| V_{OS} | Input Offset Voltage | | | 0.5 | 9 | mV |
| TCV_{OS} | Input Offset Voltage Average Drift | | | 3.0 | | $\mu V/^\circ C$ |
| I_B | Input Bias Current | | | 1.0 64 | 10 500 | pA pA |
| I_{OS} | Input Offset Current | | | 0.5 32 | 5 250 | pA pA |
| R_{IN} | Input Resistance | | | >1 | | $T\Omega$ |
| CMRR | Common-Mode Rejection Ratio | $-0.3V \leq V_{CM} \leq 15.3V$, Note 9 | 60 | 85 | | dB |
| $\pm PSRR$ | Power Supply Rejection Ratio | $V_{V+} = V_{V-} = 2.5V$ to $7.5V$, $V_{OUT} = V_{CM} = 0$ | 55 | 100 | | dB |
| A_V | Large Signal Voltage Gain | sourcing or sinking, $R_L = 2k$, Note 10 | | 340 | | V/mV |
| | | sourcing or sinking, $R_L = 600\Omega$, Note 10 | | 300 | | V/mV |
| C_{IN} | Common-Mode Input Capacitance | | | 3 | | pF |
| V_{OUT} | Output Swing | output high, $R_L = 100k$ specified as $V_{V+} - V_{OUT}$ | | 0.8 | 2 3 | mV mV |
| | | output low, $R_L = 100k$ | | 0.8 | 2 3 | mV mV |
| | | output high, $R_L = 2k$ specified as $V_{V+} - V_{OUT}$ | | 40 | 80 120 | mV mV |
| | | output low, $R_L = 2k$ | | 40 | 80 120 | mV mV |
| | | output high, $R_L = 600\Omega$ specified as $V_{V+} - V_{OUT}$ | | 130 | 270 400 | mV mV |
| | | output low, $R_L = 600\Omega$ | | 130 | 270 400 | mV mV |
| I_{SC} | Output Short Circuit Current | sinking or sourcing, Notes 8 | 50 | 250 | | mA |
| I_S | Supply Current | both amplifiers | | 0.9 | 2.0 | mA |

AC Electrical Characteristics (15V)

$V_{V+} = 15V$, $V_{V-} = 0V$, $V_{CM} = 1.5V$, $V_{OUT} = V_{V+}/2$; $R_L = 1M\Omega$; $T_J = 25^\circ C$, **bold** values indicate $-40^\circ C \leq T_J \leq +85^\circ C$; **Note 7**; unless noted

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|----------|------------------------------|--|-----|------|-----|----------------|
| THD | Total Harmonic Distortion | $f = 1kHz$, $A_V = -2$, $R_L = 2k$, $V_{OUT} = 8.5 V_{PP}$ | | 0.01 | | % |
| SR | Slew Rate | $V+ = 15V$, Note 11 | | 0.5 | | V/ μs |
| GBW | Gain-Bandwidth Product | | | 420 | | kHz |
| ϕ_m | Phase Margin | $C_L = 0pF$ | | 85 | | $^\circ$ |
| | | $C_L = 500pF$ | | 40 | | $^\circ$ |
| G_m | Gain Margin | | | 10 | | dB |
| e_n | Input-Referred Voltage Noise | $f = 1kHz$, $V_{CM} = 1V$ | | 37 | | nV/\sqrt{Hz} |
| i_n | Input-Referred Current Noise | $f = 1kHz$ | | 1.5 | | fA/\sqrt{Hz} |
| | Interamplifier Isolation | Note 12 | | 90 | | dB |

- Note 1.** Exceeding the absolute maximum rating may damage the device.
- Note 2.** The device is not guaranteed to function outside its operating rating.
- Note 3.** I/O Pin Voltage is any external voltage to which an input or output is referenced.
- Note 4.** The maximum allowable power dissipation is a function of the maximum junction temperature, $T_{J(max)}$; the junction-to-ambient thermal resistance, θ_{JA} ; and the ambient temperature, T_A . The maximum allowable power dissipation at any ambient temperature is calculated using: $P_D = (T_{J(max)} - T_A) / \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature.
- Note 5.** Thermal resistance, θ_{JA} , applies to a part soldered on a printed-circuit board.
- Note 6.** Devices are ESD protected; however, handling precautions are recommended. Human body model, 1.5k Ω in series with 100pF.
- Note 7.** All limits guaranteed by testing or statistical analysis.
- Note 8.** Continuous short circuit may exceed absolute maximum T_J under some conditions.
- Note 9.** CMRR is determined as follows: The maximum ΔV_{OS} over the V_{CM} range is divided by the magnitude of the V_{CM} range. The measurement points are: $V_{CM} = V_{V-} - 0.3V$, $(V_{V+} - V_{V-})/2$, and $V_{V+} + 0.3V$.
- Note 10.** R_L connected to 7.5V. Sourcing: $7.5V \leq V_{OUT} \leq 12.5V$. Sinking: $2.5V \leq V_{OUT} \leq 7.5V$.
- Note 11.** Device connected as a voltage follower with a 10V step input. The value is the positive or negative slew rate, whichever is slower.
- Note 12.** Referenced to input.

Application Information

Input Common-Mode Voltage

The MIC7122 tolerates input overdrive by at least 300mV beyond either rail without producing phase inversion.

If the absolute maximum input voltage is exceeded, the input current should be limited to $\pm 5\text{mA}$ maximum to prevent reducing reliability. A $10\text{k}\Omega$ series input resistor, used as a current limiter, will protect the input structure from voltages as large as 50V above the supply or below ground. See Figure 1.

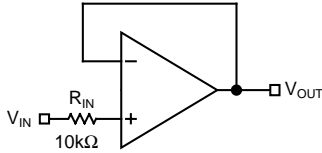


Figure 1. Input Current-Limit Protection

Output Voltage Swing

Sink and source output resistances of the MIC7122 are equal. Maximum output voltage swing is determined by the load and the approximate output resistance. The output resistance is:

$$R_{\text{OUT}} = \frac{V_{\text{DROP}}}{I_{\text{LOAD}}}$$

V_{DROP} is the voltage dropped within the amplifier output stage. V_{DROP} and I_{LOAD} can be determined from the V_{O} (output swing) portion of the appropriate Electrical Characteristics table. I_{LOAD} is equal to the typical output high voltage minus $V_{+}/2$ and divided by R_{LOAD} . For example, using the Electrical Characteristics DC (5V) table, the typical output high voltage drops 13mV using a $2\text{k}\Omega$ load (connected to $V_{+}/2$), which produces an I_{LOAD} of:

$$\frac{5.0\text{V} - 0.013\text{V} - 2.5\text{V}}{2\text{k}\Omega} = 1.244\text{mA}$$

Because of output stage symmetry, the corresponding typical output low voltage (13mV) also equals V_{DROP} . Then:

$$R_{\text{OUT}} = \frac{0.013\text{V}}{0.001244\text{A}} = 10.5\Omega$$

Power Dissipation

The MIC7122 output drive capability requires considering power dissipation. If the load impedance is low, it is possible to damage the device by exceeding the 125°C junction temperature rating.

On-chip power consists of two components: supply power and output stage power. Supply power (P_{S}) is the product of the supply voltage ($V_{\text{S}} = V_{\text{V}+} - V_{\text{V}-}$) and supply current (I_{S}). Output stage power (P_{O}) is the product of the output stage

voltage drop (V_{DROP}) and the output (load) current (I_{OUT}). Total on-chip power dissipation is:

$$P_{\text{D}} = P_{\text{S}} + P_{\text{O}}$$

$$P_{\text{D}} = V_{\text{S}} I_{\text{S}} + V_{\text{DROP}} I_{\text{OUT}}$$

where:

P_{D} = total on-chip power

P_{S} = supply power dissipation

P_{O} = output power dissipation

$$V_{\text{S}} = V_{\text{V}+} - V_{\text{V}-}$$

I_{S} = power supply current

$$V_{\text{DROP}} = V_{\text{V}+} - V_{\text{OUT}} \quad (\text{sourcing current})$$

$$V_{\text{DROP}} = V_{\text{OUT}} - V_{\text{V}-} \quad (\text{sinking current})$$

The above addresses only steady state (dc) conditions. For non-dc conditions the user must estimate power dissipation based on rms value of the signal.

The task is one of determining the allowable on-chip power dissipation for operation at a given ambient temperature and power supply voltage. From this determination, one may calculate the maximum allowable power dissipation and, after subtracting P_{S} , determine the maximum allowable load current, which in turn can be used to determine the minimum load impedance that may safely be driven. The calculation is summarized below.

$$P_{\text{D}(\text{max})} = \frac{T_{\text{J}(\text{max})} - T_{\text{A}}}{\theta_{\text{JA}}}$$

$$\theta_{\text{JA}(\text{MSOP-8})} = 200^{\circ}\text{C}/\text{W}$$

Driving Capacitive Loads

Driving a capacitive load introduces phase-lag into the output signal, and this in turn reduces op-amp system phase margin. The application that is least forgiving of reduced phase margin is a unity gain amplifier. The MIC7122 can typically drive a 200pF capacitive load connected directly to the output when configured as a unity-gain amplifier and powered with a 2.2V supply. At 15V operation the circuit typically drives 500pF .

Using Large-Value Feedback Resistors

A large-value feedback resistor ($> 500\text{k}\Omega$) can reduce the phase margin of a system. This occurs when the feedback resistor acts in conjunction with input capacitance to create phase lag in the feedback signal. Input capacitance is usually a combination of input circuit components and other parasitic capacitance, such as amplifier input capacitance and stray printed circuit board capacitance.

Figure 2 illustrates a method of compensating phase lag caused by using a large-value feedback resistor. Feedback capacitor C_{FB} introduces sufficient phase lead to overcome the phase lag caused by feedback resistor R_{FB} and input

capacitance C_{IN} . The value of C_{FB} is determined by first estimating C_{IN} and then applying the following formula:

$$R_{IN} \times C_{IN} \leq R_{FB} \times C_{FB}$$

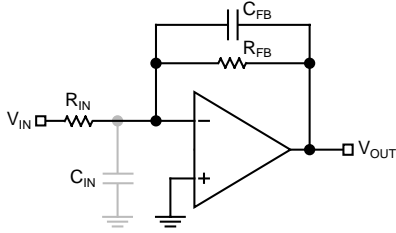


Figure 2. Cancelling Feedback Phase Lag

Since a significant percentage of C_{IN} may be caused by board layout, it is important to note that the correct value of C_{FB} may change when changing from a breadboard to the final circuit layout.

Typical Circuits

Some single-supply, rail-to-rail applications for which the MIC7122 is well suited are shown in the circuit diagrams of Figures 3 through 7.

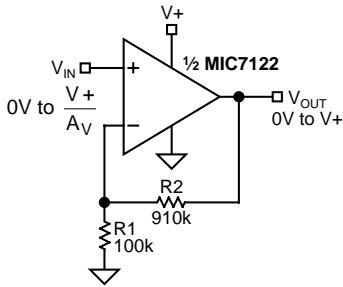


Figure 3a. Noninverting Amplifier

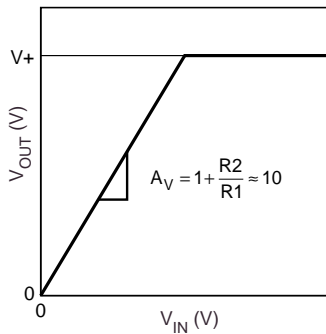


Figure 3b. Noninverting Amplifier Behavior

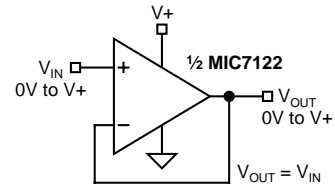


Figure 4. Voltage Follower/Buffer

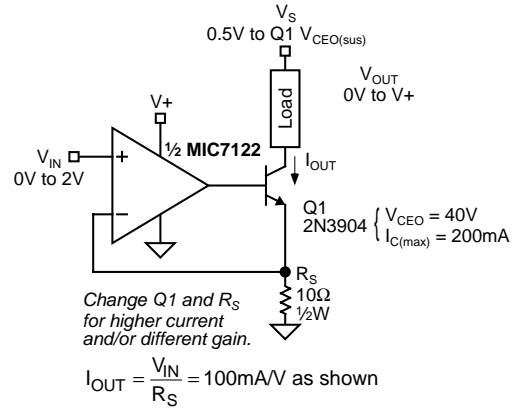


Figure 5. Voltage-Controlled Current Sink

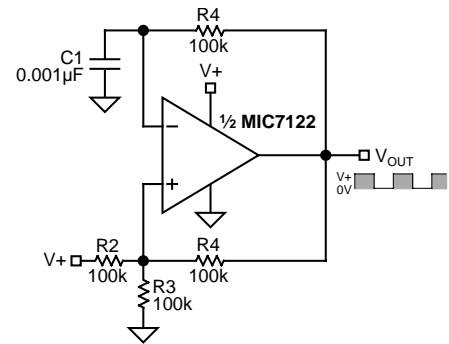


Figure 6. Square Wave Oscillator

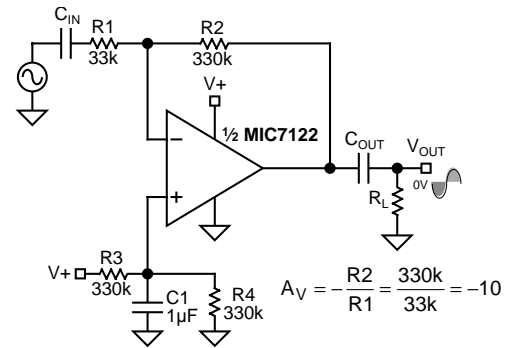
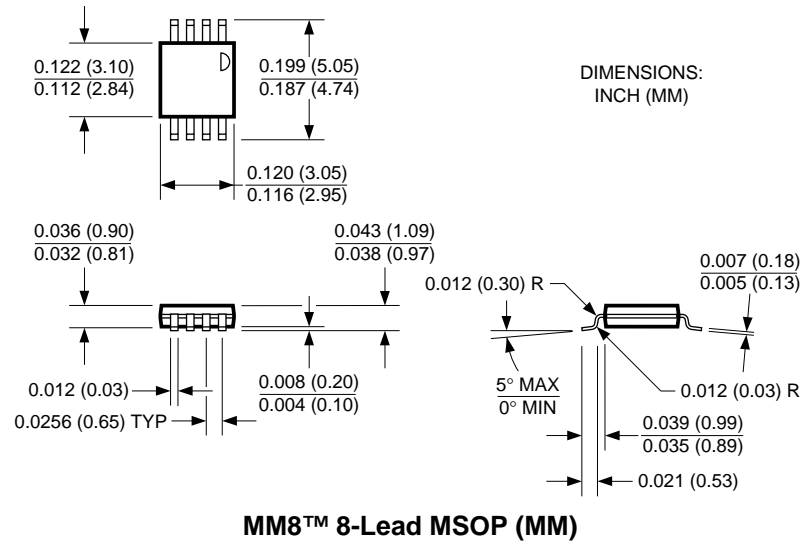


Figure 7. AC-Coupled Inverting Amplifier

Package Information



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