



# THE DATASHEET OF MAX4076ESA





# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## General Description

The MAX4074–MAX4078 GainAmp™ op amp family combines low-cost Rail-to-Rail® op amps with precision internal gain-setting resistors. Factory-trimmed on-chip resistors decrease design size, cost, and layout, and provide 0.1% gain accuracy. Fixed inverting gains from -0.25V/V to -100V/V or noninverting gains from +1.25V/V to +101V/V are available. These devices operate from a single +2.5V to +5.5V supply and consume just 34μA. GainAmp amplifiers are optimally compensated for each gain version, achieving gain bandwidth (GBW) products up to 4MHz ( $A_v = +25V/V$  to +101V/V). High-voltage fault protection withstands  $\pm 17V$  at either input without damage or excessive current draw (MAX4074/MAX4075 only).

Two versions are available in this amplifier family. The MAX4076/MAX4077/MAX4078 are single/dual/quad open-loop, unity-gain-stable op amps, and the MAX4074/MAX4075 are single/dual fixed-gain op amps. The input common-mode voltage range of the open-loop amplifiers extends from 150mV below the negative supply to within 1.2V of the positive supply. The GainAmp outputs can swing rail-to-rail and drive a 1kΩ load while maintaining excellent DC accuracy (MAX4074/MAX4075 only). The amplifiers are stable for capacitive loads up to 100pF.

For space-critical applications, the MAX4074/MAX4076 are available in space-saving SOT23-5 packages.

## Applications

Portable Battery-Powered Equipment  
Instruments, Terminals, and Bar-Code Readers  
Keyless Entry  
Photodiode Preamps  
Smart-Card Readers  
Infrared Receivers for Remote Controls  
Low-Side Current-Sense Amplifiers

**Gain Selector Guide appears at end of data sheet.**  
**Typical Operating Circuit appears at end of data sheet.**

GainAmp is a trademark of Maxim Integrated Products.  
Rail-to-Rail is a registered trademark of Nippon Motorola, Ltd.

## Features

- ◆ Internal Gain-Setting Resistors in SOT23 Packages (MAX4074)
- ◆ 0.1% Gain Accuracy ( $R_F/R_G$ ) (MAX4074/75)
- ◆ 54 Standard Gains Available (MAX4074/75)
- ◆ Open-Loop, Unity-Gain-Stable Op Amps (MAX4076/77/78)
- ◆ Rail-to-Rail Outputs Drive 1kΩ Load (MAX4074/75)
- ◆ +2.5V to +5.5V Single Supply
- ◆ 34μA Supply Current (MAX4074/75)
- ◆ Up to 4MHz GBW Product
- ◆ Fault-Protected Inputs Withstand  $\pm 17V$  (MAX4074/75)
- ◆ 200pA max Input Bias Current (MAX4076/77/78)
- ◆ Stable with Capacitive Loads up to 100pF with No Isolation Resistor

## Ordering Information

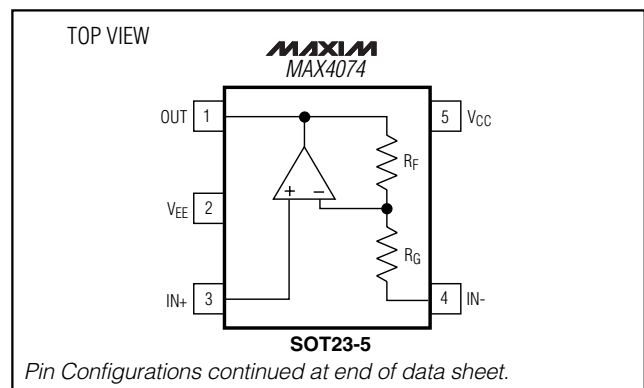
| PART           | TEMP. RANGE    | PIN-PACKAGE | TOP MARK |
|----------------|----------------|-------------|----------|
| MAX4074__EUK-T | -40°C to +70°C | 5 SOT23-5   | **       |
| MAX4074__ESA   | -40°C to +70°C | 8 SO        | —        |

Ordering Information continued at end of data sheet.

**Note:** Insert the desired gain code in the blank to complete the part number (see the Gain Selector Guide).

\*\*See the Gain Selector Guide for a list of preferred gains and top marks.

## Pin Configurations/ Functional Diagrams



# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## ABSOLUTE MAXIMUM RATINGS

|  |   |  |                      |
|--|---|--|----------------------|
| Supply Voltages (V <sub>CC</sub> to V <sub>EE</sub> )              | .....-0.3V to +6V   | 8-Pin μMAX (derate 4.1mW/°C above +70°C) | .....330mW           |
| Voltage Inputs (IN <sub>-</sub> )                                  |   | 8-Pin SO (derate 5.88mW/°C above +70°C)  | .....471mW           |
| MAX4076/MAX4077/MAX4078  | .....(V <sub>CC</sub> + 0.3V) to (V <sub>EE</sub> - 0.3V) | 14-Pin SO (derate 8.33mW/°C above +70°C) | .....667mW           |
| MAX4074/MAX4075  | .....±17V   | Operating Temperature Range              | .....-40°C to +85°C  |
| Output Short-Circuit Duration to Either Supply (OUT <sub>-</sub> ) | .... Continuous   | Junction Temperature                     | .....+150°C          |
| Continuous Power Dissipation (T <sub>A</sub> = +70°C)              |   | Storage Temperature Range                | .....-65°C to +150°C |
| 5-Pin SOT23 (derate 7.1mW/°C above +70°C)                          | .....571mW  | Lead Temperature (soldering, 10sec)      | .....+300°C          |
| 14-Pin TSSOP (derate 6.3mW/°C above +70°C)                         | .....500mW  |  |                      |

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS—MAX4074/MAX4075

(V<sub>CC</sub> = +2.5V to +5.5V, V<sub>EE</sub> = 0, V<sub>IN+</sub> = V<sub>IN-</sub> = V<sub>CC</sub>/2, R<sub>L</sub> = ∞ to V<sub>CC</sub>/2, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at V<sub>CC</sub> = +5V and T<sub>A</sub> = +25°C.) (Note 1)

| PARAMETER                      | SYMBOL           | CONDITIONS                             | MIN                               | TYP  | MAX                   | UNITS |
|--------------------------------|------------------|--|-----------------------------------|------|-----------------------|-------|
| Supply Voltage Range           | V <sub>CC</sub>  | Guaranteed by PSRR test                | 2.5                               |      | 5.5                   | V     |
| Supply Current (per amplifier) | I <sub>CC</sub>  | V <sub>CC</sub> = 5V                   |                                   | 37   | 55                    | μA    |
|                                |                  | V <sub>CC</sub> = 3V                   |                                   | 34   | 50                    |       |
| Input Offset Voltage           | V <sub>OS</sub>  | R <sub>L</sub> = 1MΩ                   |                                   | 0.2  | 3.5                   | mV    |
| Input Offset Voltage Drift     |                  |  |                                   | 0.3  |                       | μV/°C |
| Input Bias Current (Note 2)    | I <sub>IN+</sub> |  |                                   | 0.8  | 1000                  | pA    |
| Inverting Input Resistance     | R <sub>IN-</sub> | A <sub>V</sub> < +25V/V                |                                   | 300  |                       | kΩ    |
|                                |                  | A <sub>V</sub> ≥ +25V/V                |                                   | 80   |                       |       |
| Noninverting Input Resistance  | R <sub>IN+</sub> |  |                                   | 1000 |                       | MΩ    |
| Positive Input Voltage Range   | IN <sub>+</sub>  | Guaranteed by functional test (Note 3) | V <sub>EE</sub> - 0.15            |      | V <sub>CC</sub> - 1.2 | V     |
| Negative Input Voltage Range   | IN <sub>-</sub>  | Guaranteed by functional test (Note 3) |                                   | ±15  |                       | V     |
| Power-Supply Rejection Ratio   | PSRR             | V <sub>CC</sub> = 2.5V to 5.5V         | 70                                | 96   |                       | dB    |
| Closed-Loop Output Impedance   | R <sub>OUT</sub> |  |                                   | 0.2  |                       | Ω     |
| Output Short-Circuit Current   |                  | Shorted to V <sub>CC</sub>             |                                   | 5    |                       | mA    |
|                                |                  | Shorted to V <sub>EE</sub>             |                                   | -22  |                       |       |
| Output Voltage Swing (Note 4)  |                  | R <sub>L</sub> = 1MΩ                   | V <sub>CC</sub> - V <sub>OH</sub> | 0.5  | 2.5                   | mV    |
|                                |                  |  | V <sub>OL</sub> - V <sub>EE</sub> | 0.4  | 2.5                   |       |
|                                |                  | R <sub>L</sub> = 10kΩ                  | V <sub>CC</sub> - V <sub>OH</sub> | 25   | 150                   |       |
|                                |                  |  | V <sub>OL</sub> - V <sub>EE</sub> | 11   | 80                    |       |
|                                |                  | R <sub>L</sub> = 1kΩ                   | V <sub>CC</sub> - V <sub>OH</sub> | 300  | 1000                  |       |
|                                |                  |  | V <sub>OL</sub> - V <sub>EE</sub> | 100  | 600                   |       |

# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

MAX4074-MAX4078

## ELECTRICAL CHARACTERISTICS—MAX4074/MAX4075 (continued)

( $V_{CC} = +2.5V$  to  $+5.5V$ ,  $V_{EE} = 0$ ,  $V_{IN+} = V_{IN-} = V_{CC}/2$ ,  $R_L = \infty$  to  $V_{CC}/2$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = +5V$  and  $T_A = +25^{\circ}C$ .) (Note 1)

| PARAMETER                   | SYMBOL     | CONDITIONS   | MIN                          | TYP | MAX  | UNITS          |   |
|-----------------------------|------------|--|------------------------------|-----|------|----------------|---|
| Power-Up Time               |            | Output settling to 1%  |                              | 9   |      | ms             |   |
| Slew Rate                   | SR         | $V_{OUT} = 4V$ step  |                              | 100 |      | V/ms           |   |
| Settling Time (to 0.01%)    |            | $V_{OUT} = 4V$ step  |                              | 60  |      | $\mu s$        |   |
| Input Voltage Noise Density | $e_n$      | $f = 5kHz$ (Note 5)  |                              | 150 |      | $nV/\sqrt{Hz}$ |   |
| Input Noise Current Density |            | $f = 5kHz$   |                              | 500 |      | $fA/\sqrt{Hz}$ |   |
| Capacitive Load Stability   | $C_{LOAD}$ | No sustained oscillations  |                              | 500 |      | pF             |   |
| DC Gain Accuracy            |            | $(V_{EE} + 25mV) < V_{OUT} < (V_{CC} - 25mV)$ ,<br>$R_L = 1M\Omega$ (Note 6) | $T_A = +25^{\circ}C$         |     | 0.01 | 1.0            | % |
|                             |            |  | $T_A = T_{MIN}$ to $T_{MAX}$ |     |      | 1.2            |   |
| -3dB Bandwidth              | BW (-3dB)  | $A_V = +1.25V/V$   |                              | 200 |      | kHz            |   |
|                             |            | $A_V = +3V/V$  |                              | 90  |      |                |   |
|                             |            | $A_V = +5V/V$  |                              | 80  |      |                |   |
|                             |            | $A_V = +10V/V$   |                              | 90  |      |                |   |
|                             |            | $A_V = +25V/V$   |                              | 120 |      |                |   |

## ELECTRICAL CHARACTERISTICS—MAX4076/MAX4077/MAX4078

( $V_{CC} = +2.5V$  to  $+5.5V$ ,  $V_{EE} = 0$ ,  $V_{IN+} = V_{IN-} = V_{CC}/2$ ,  $R_L = \infty$  to  $V_{CC}/2$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = +5V$  and  $T_A = +25^{\circ}C$ .) (Note 1)

| PARAMETER                       | SYMBOL     | CONDITIONS  | MIN  | TYP         | MAX            | UNITS             |
|---------------------------------|------------|---|------|-------------|----------------|-------------------|
| Supply Voltage Range            | $V_{CC}$   | Guaranteed by PSRR test                                 | 2.5  |             | 5.5            | V                 |
| Supply Current (per amplifier)  | $I_{CC}$   | $V_{CC} = 5V$   |      | 45          | 60             | $\mu A$           |
|                                 |            | $V_{CC} = 3V$   |      | 40          | 55             |                   |
| Input Offset Voltage            | $V_{OS}$   | $R_L = 1M\Omega$  |      | 1.2         | 3.5mV          | mV                |
| Input Offset Voltage Drift      |            |   |      | 1.5 $\mu V$ |                | $\mu V/^{\circ}C$ |
| Input Bias Current (Note 2)     | $I_{BIAS}$ |   |      | 1           | 200            | pA                |
| Input Offset Current            | $I_{OS}$   |   |      | $\pm 0.4$   |                | pA                |
| Common-Mode Input Voltage Range | $I_{VR}$   | Guaranteed by CMRR                                      | 0.15 |             | $V_{CC} - 1.2$ | V                 |
| Common-Mode Rejection Ratio     | CMRR       | $(V_{CC} - 1.2V) \geq V_{CM} \geq -0.15V$               | 70   | 95          |                | dB                |
| Power-Supply Rejection Ratio    | PSRR       | $V_{CC} = 2.5V$ to $5.5V$                               | 70   | 95          |                | dB                |
| Closed-Loop Output Impedance    | $R_{OUT}$  | $A_V = +1V/V$   |      | 0.2         |                | $\Omega$          |
| Output Short-Circuit Current    |            | Shorted to $V_{CC}$                                     |      | 4.5         |                | mA                |
|                                 |            | Shorted to $V_{EE}$                                     |      | 20          |                |                   |
| Large-Signal Voltage Gain       | $A_{VOL}$  | $0.05V < V_{OUT} < (V_{CC} - 0.1V)$ , $R_L = 1M\Omega$  | 80   | 117         |                | dB                |
|                                 |            | $0.25V < V_{OUT} < (V_{CC} - 0.3V)$ , $R_L = 10k\Omega$ | 80   | 95          |                |                   |
|                                 |            | $0.25V < V_{OUT} < (V_{CC} - 0.3V)$ , $R_L = 5k\Omega$  | 80   | 93          |                |                   |

# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## ELECTRICAL CHARACTERISTICS—MAX4076/MAX4077/MAX4078 (continued)

( $V_{CC} = +2.5V$  to  $+5.5V$ ,  $V_{EE} = 0$ ,  $V_{IN+} = V_{IN-} = V_{CC}/2$ ,  $R_L = \infty$  to  $V_{CC}/2$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $V_{CC} = +5V$  and  $T_A = +25^\circ C$ .) (Note 1)

| PARAMETER                   | SYMBOL          | CONDITIONS                               |                   | MIN  | TYP | MAX            | UNITS |
|-----------------------------|-----------------|--|-------------------|------|-----|----------------|-------|
| Output Voltage Swing        | $V_{OH}/V_{OL}$ | $R_L = 1M\Omega$                         | $V_{CC} - V_{OH}$ | 0.23 | 2.5 | mV             |       |
|                             |                 |  | $V_{OL} - V_{EE}$ | 0.22 | 2.5 |                |       |
|                             |                 | $R_L = 10k\Omega$                        | $V_{CC} - V_{OH}$ | 12   | 50  |                |       |
|                             |                 |  | $V_{OL} - V_{EE}$ | 7    | 50  |                |       |
|                             |                 | $R_L = 5k\Omega$                         | $V_{CC} - V_{OH}$ | 100  | 100 |                |       |
|                             |                 |  | $V_{OL} - V_{EE}$ | 100  | 100 |                |       |
| Gain-Bandwidth Product      | GBW             |  |                   | 230  |     | kHz            |       |
| Slew Rate                   | SR              | $V_{OUT} = 4V$ step                      |                   | 90   |     | V/ms           |       |
| Settling Time (to 0.01%)    |                 | $V_{OUT} = 4V$ step                      |                   | 69   |     | $\mu s$        |       |
| Input Voltage Noise Density | $e_n$           | $f = 5kHz$                               |                   | 110  |     | $nV/\sqrt{Hz}$ |       |
| Input Noise Current Density |                 | $f = 5kHz$                               |                   | 1.1  |     | $fA/\sqrt{Hz}$ |       |
| Capacitive Load Stability   | $C_{LOAD}$      | No sustained oscillations, $A_V = +1V/V$ |                   | 100  |     | pF             |       |
| Power-Up Time               |                 | Output settling to 1%                    |                   | 10   |     | ms             |       |

**Note 1:** All devices are 100% production tested at  $T_A = +25^\circ C$ . All temperature limits are guaranteed by design.

**Note 2:** Guaranteed by design.

**Note 3:** The input common-mode range for  $IN_+$  is guaranteed by a functional test. A similar test is done on the  $IN_-$  input. See the *Applications Information* section for more information on the input voltage range of the GainAmps.

**Note 4:** For  $A_V = -0.5V/V$  and  $A_V = -0.25V/V$ , the output voltage swing may be limited by the input voltage range.

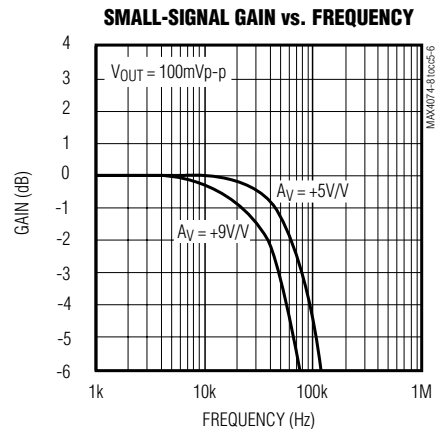
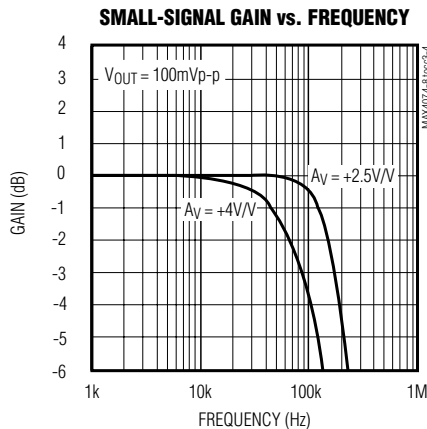
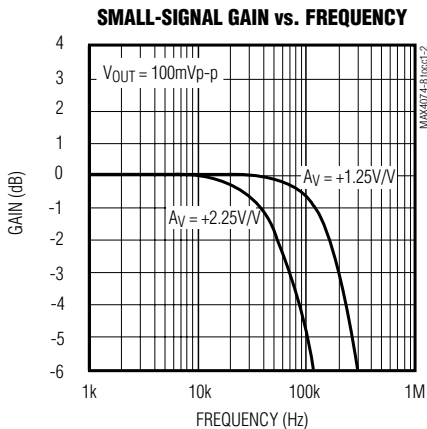
**Note 5:** Includes noise from on-chip resistors.

**Note 6:** The gain accuracy test is performed with the GainAmps in the noninverting configuration. The output voltage swing is limited by the input voltage range for certain gains and supply voltage conditions. For situations where the output voltage swing is limited by the valid input range, the output limits are adjusted accordingly.

## Typical Operating Characteristics

( $V_{CC} = +5.0V$ ,  $R_L = 100k\Omega$  to  $V_{CC}/2$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

### MAX4074/MAX4075



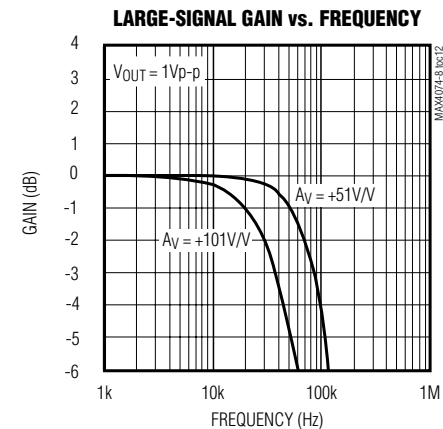
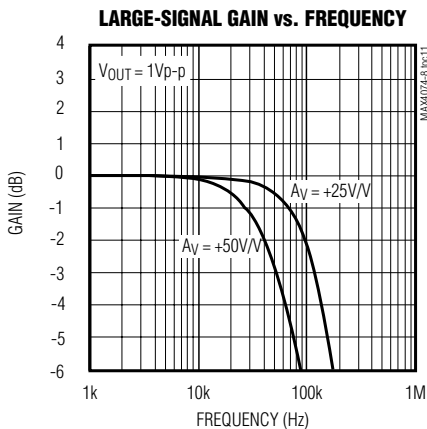
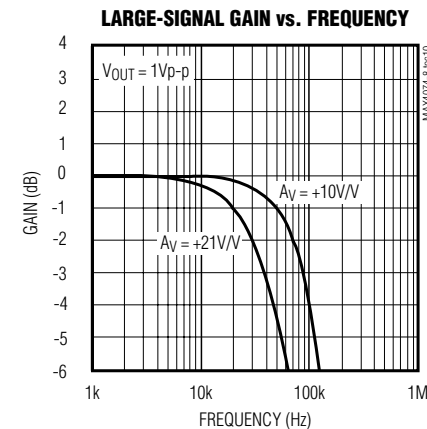
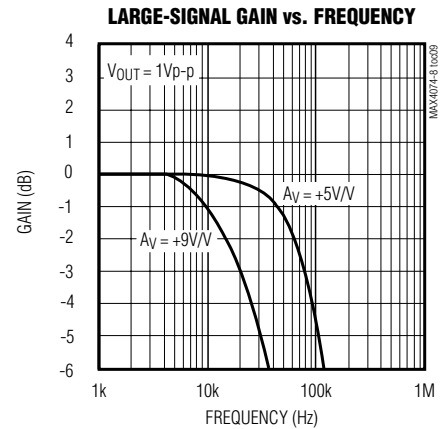
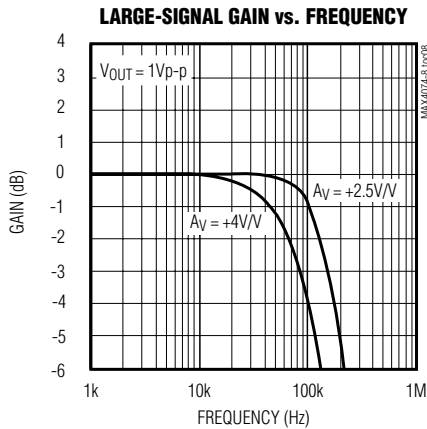
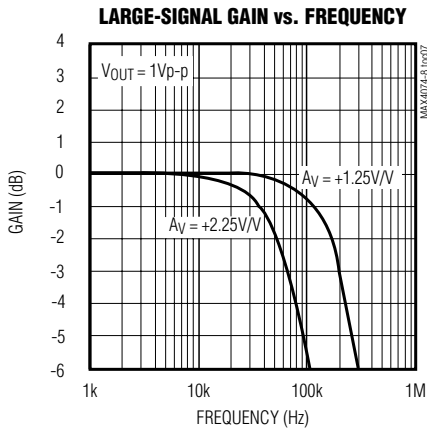
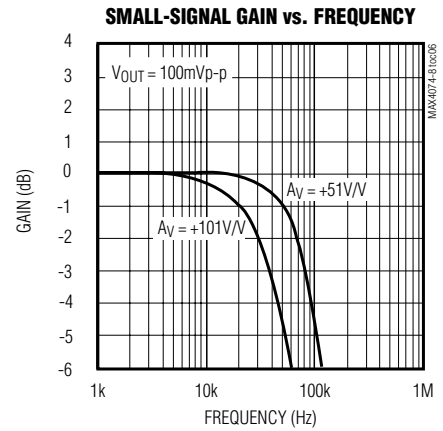
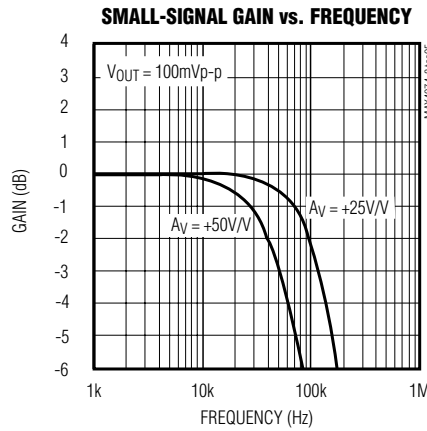
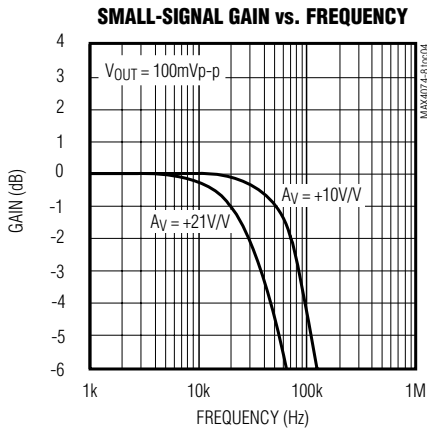
# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## Typical Operating Characteristics

( $V_{CC} = +5.0V$ ,  $R_L = 100k\Omega$  to  $V_{CC}/2$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

MAX4074-MAX4078

### MAX4074/MAX4075

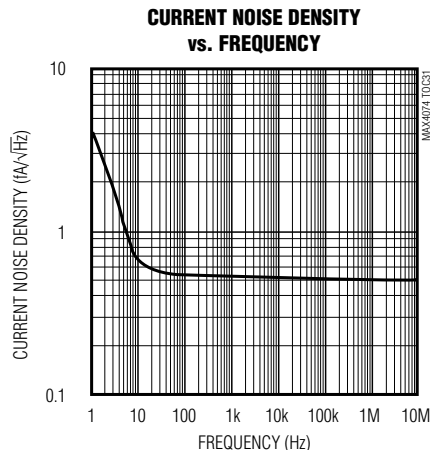
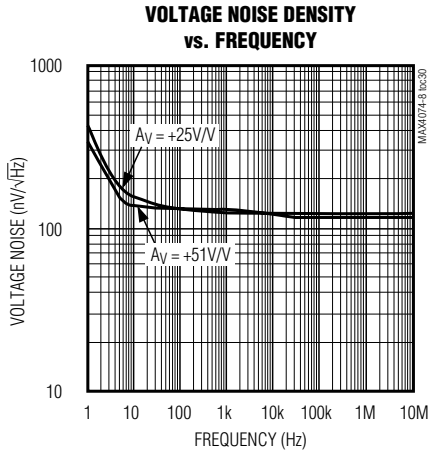
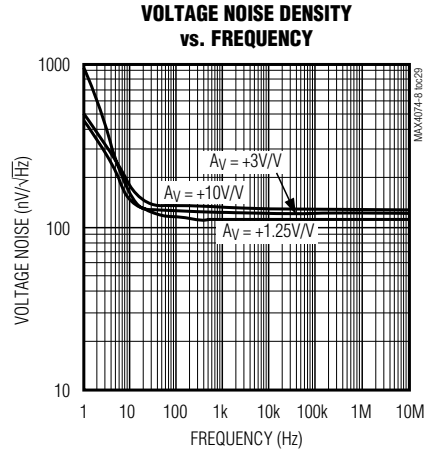
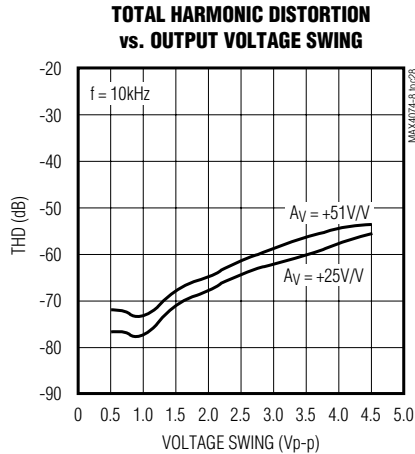
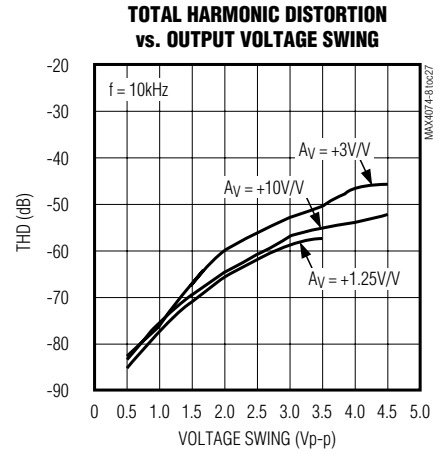
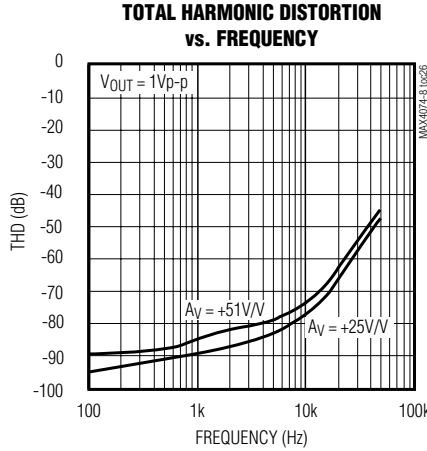
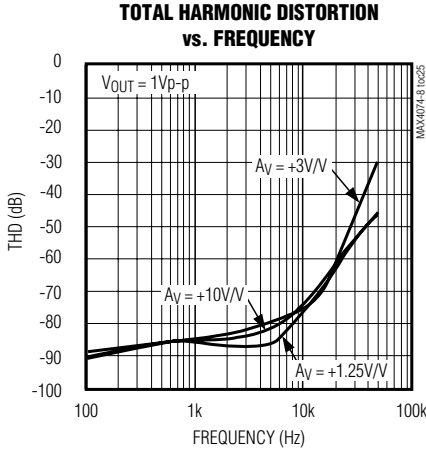


# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## Typical Operating Characteristics (continued)

( $V_{CC} = +5.0V$ ,  $R_L = 100k\Omega$  to  $V_{CC}/2$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

MAX4074/MAX4075



# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

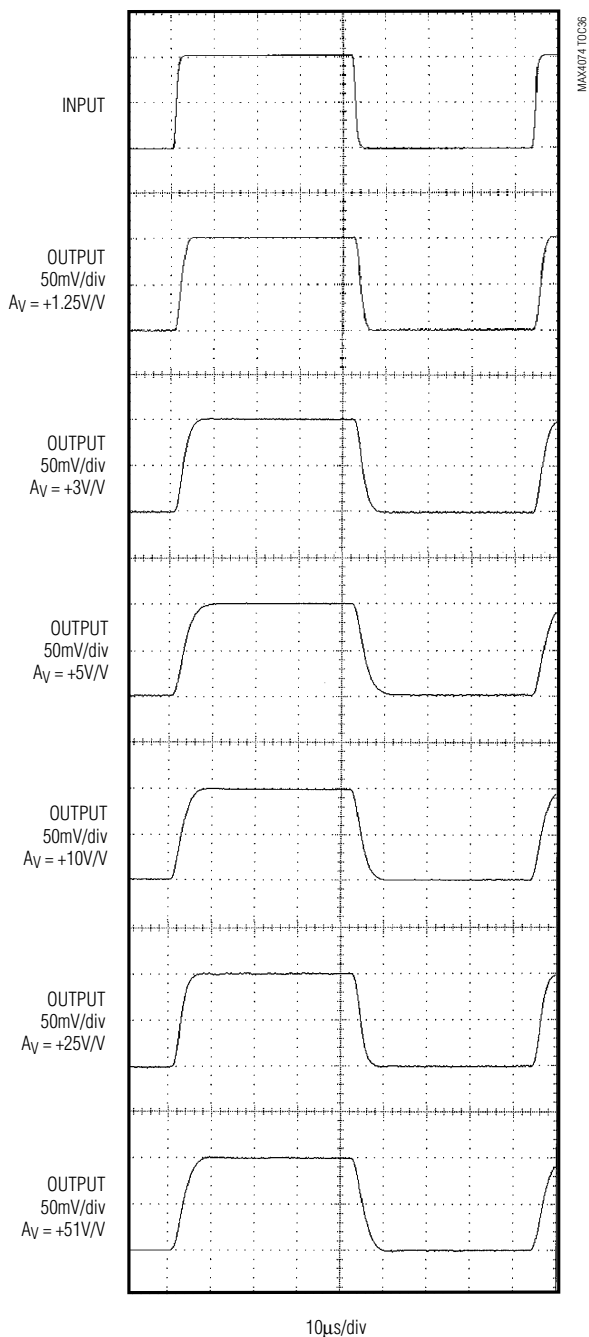
## Typical Operating Characteristics (continued)

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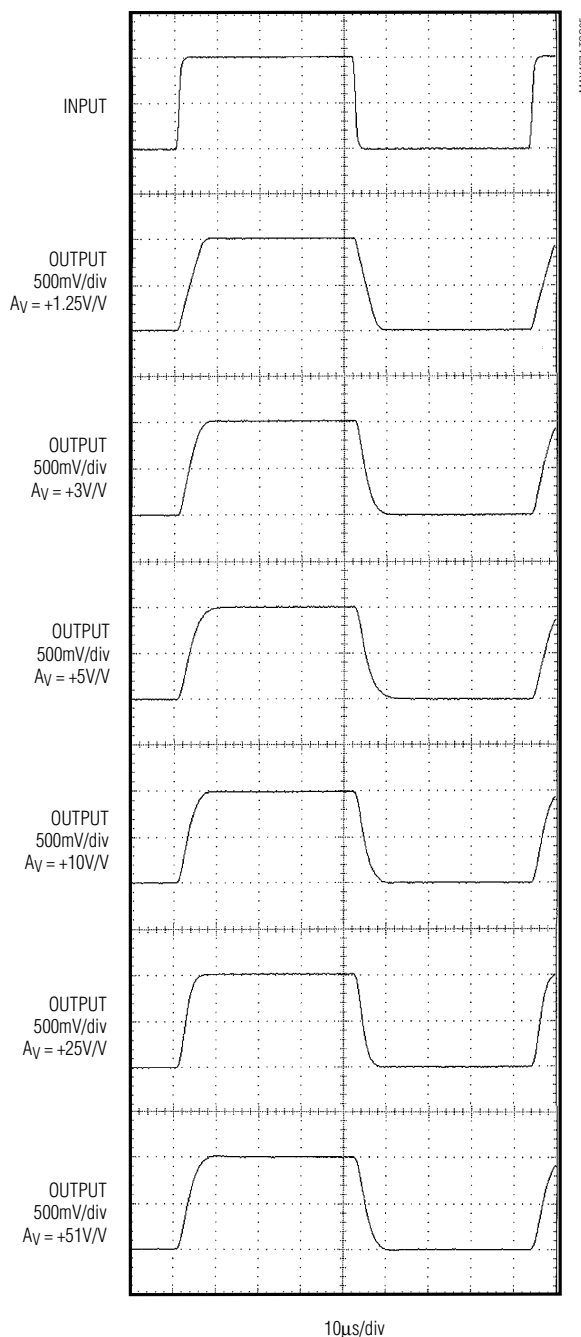
MAX4074/MAX4075

MAX4074-MAX4078

SMALL-SIGNAL PULSE RESPONSE



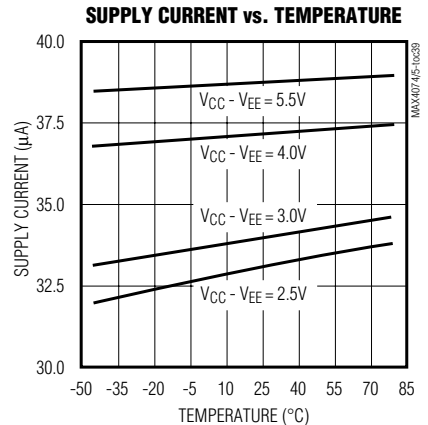
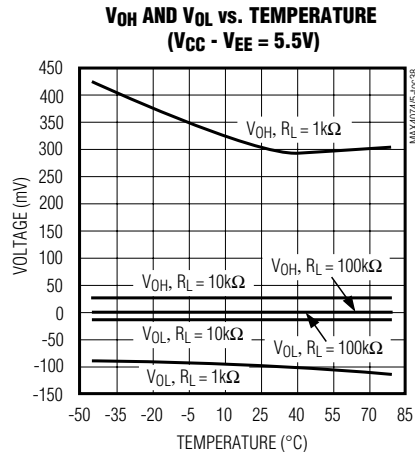
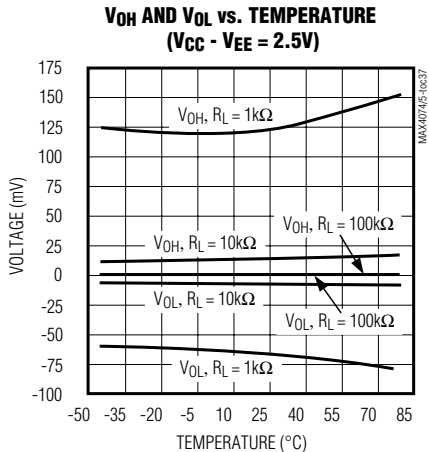
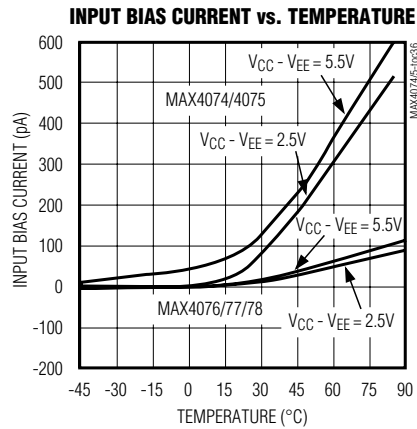
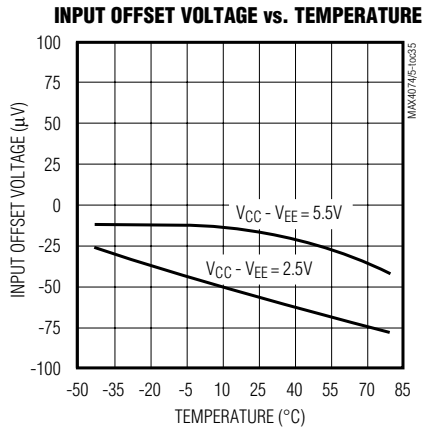
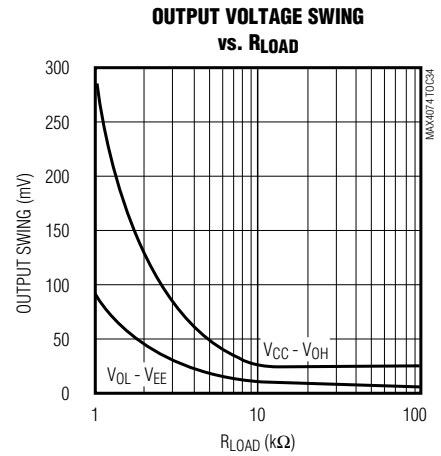
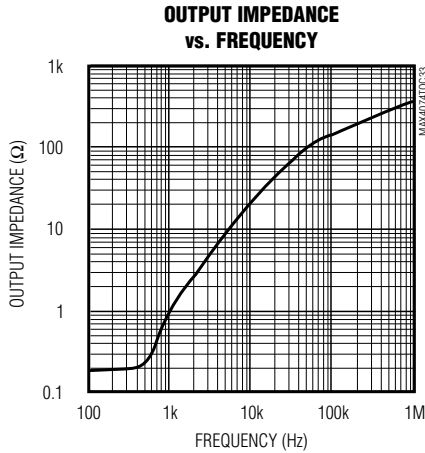
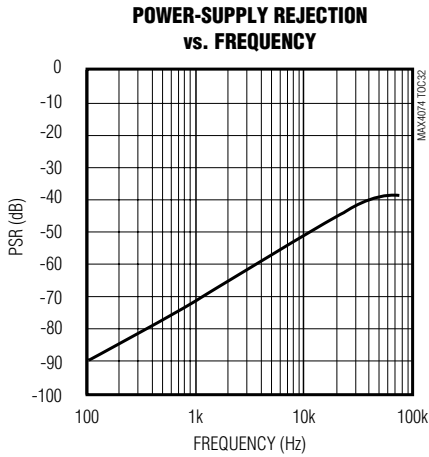
LARGE-SIGNAL PULSE RESPONSE



# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## Typical Operating Characteristics (continued)

( $V_{CC} = +5.0V$ ,  $R_L = 100k\Omega$  to  $V_{CC}/2$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

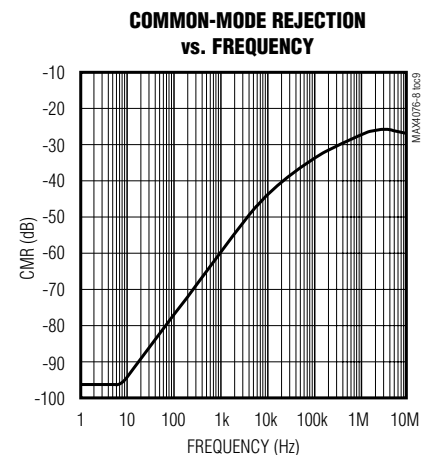
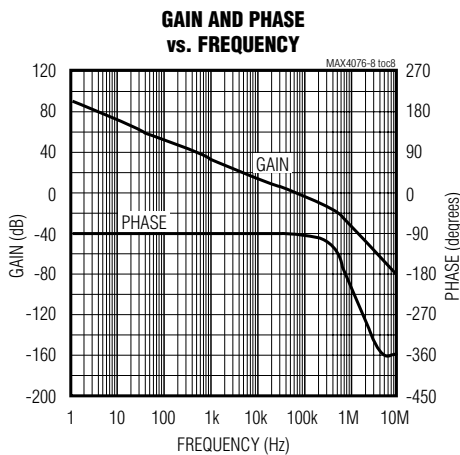
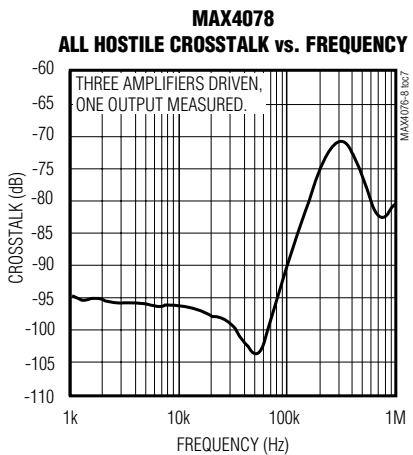
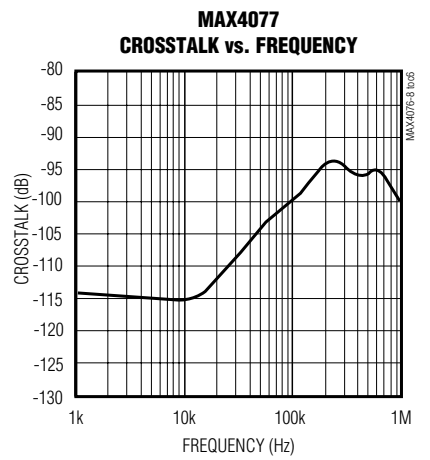
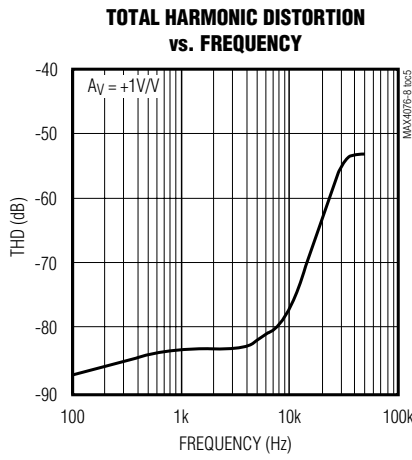
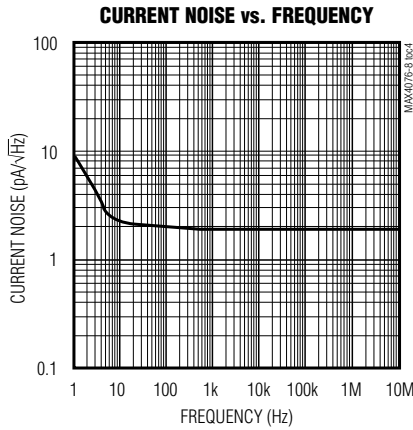
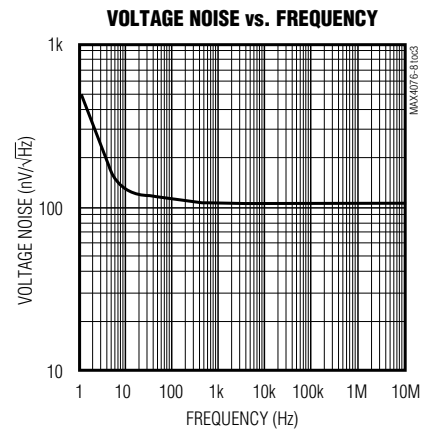
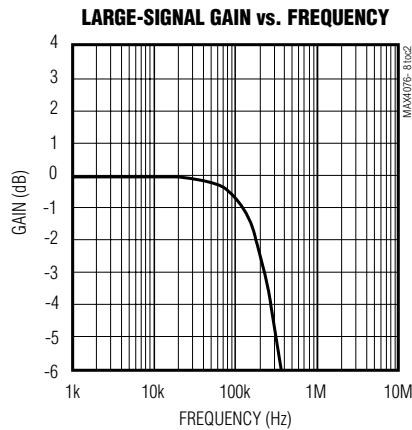
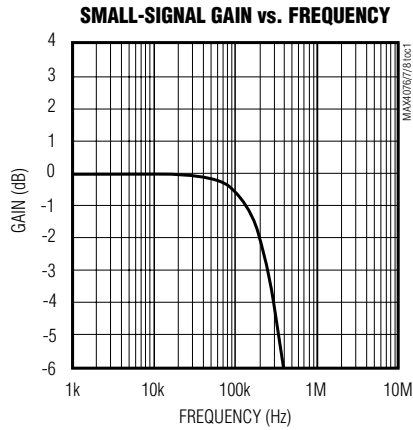


# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## Typical Operating Characteristics (continued)

( $V_{CC} = +5.0V$ ,  $R_L = 100k\Omega$  to  $V_{CC}/2$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

### MAX4076/MAX4077/MAX4078



MAX4074-MAX4078

# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## Pin Description

| PIN             |         |                    |              | NAME | FUNCTION                                 |
|-----------------|---------|--------------------|--------------|------|--|
| MAX4074/MAX4076 |         | MAX4075<br>MAX4077 | MAX4078      |      |  |
| SOT23           | SO      | $\mu$ MAX/SO       | SO/TSSOP     |      |  |
| 1               | 6       | 1, 7               | 1, 7, 8, 14  | OUT_ | Amplifier Output                         |
| 2               | 4       | 4                  | 11           | VEE  | Negative Supply or Ground                |
| 3               | 3       | 3, 5               | 3, 5, 10, 12 | IN_+ | Noninverting Amplifier Input             |
| 4               | 2       | 2, 6               | 2, 6, 9, 13  | IN_- | Inverting Amplifier Input                |
| 5               | 7       | 8                  | 4            | VCC  | Positive Supply                          |
| —               | 1, 5, 8 | —                  | —            | N.C. | No Connection. Not internally connected. |

## Detailed Description

Maxim's GainAmp fixed-gain amplifiers combine a low-cost rail-to-rail op amp with internal gain-setting resistors. Factory-trimmed on-chip resistors provide 0.1% gain accuracy while decreasing design size, cost, and layout. There are two versions in this amplifier family: single/dual/quad open-loop, unity-gain-stable devices (MAX4076/MAX4077/MAX4078), and single/dual fixed-gain devices (MAX4074/MAX4075). All amplifiers feature rail-to-rail outputs and drive a 10k $\Omega$  load while maintaining excellent DC accuracy.

### Open-Loop Op Amps

The single/dual/quad MAX4076/MAX4077/MAX4078 are low-power, open-loop op amps with rail-to-rail outputs. These devices are compensated for unity-gain stability and feature a GBW product of 230kHz. The common-mode range extends from 150mV below the negative rail to within 1.2V of the positive rail. These high-performance op amps serve as the core for this family of GainAmp fixed-gain amplifiers. Although the -3dB bandwidth will not correspond to that of a fixed-gain amplifier in higher gain configurations, these open-loop op amps can be used to prototype designs.

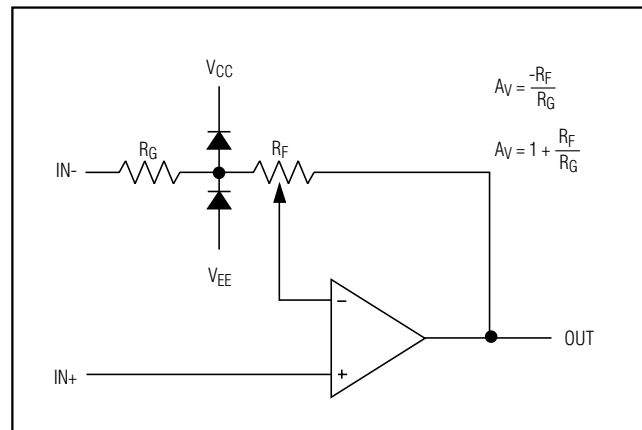


Figure 1. Internal Gain-Setting Resistors

### Internal Gain-Setting Resistors

Maxim's proprietary laser trimming techniques allow  $R_F/R_G$  values (Figure 1) that produce many different gain configurations. These GainAmp fixed-gain amplifiers feature a negative-feedback resistor network that is laser trimmed to provide a gain-setting feedback ratio ( $R_F/R_G$ ) with 0.1% typical accuracy. The standard op amp pinouts allow the GainAmp fixed-gain amplifiers to plug directly into existing board designs, easily replacing op amps-plus-resistor gain blocks.

# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## GainAmp Bandwidth

GainAmp fixed-gain amplifiers feature factory-trimmed precision resistors to provide fixed inverting gains from  $-0.25V/V$  to  $-100V/V$  or noninverting gains from  $+1.25V/V$  to  $+101V/V$ . The op amp core is decompensated strategically over the gain-set options to maximize bandwidth. Open-loop decompensation increases GBW product, ensuring that usable bandwidth is maintained with increasing closed-loop gains. A GainAmp with a fixed gain of  $A_V = +25V/V$  has a  $-3dB$  bandwidth of  $120kHz$ . By comparison, a unity-gain-stable op amp configured for  $A_V = +25V/V$  would yield a  $-3dB$  bandwidth of only  $8kHz$ . Decompensation is performed at five intermediate gain sets, as shown in the *Gain Selector Guide*.

## High-Voltage ( $\pm 17V$ ) Input Fault Protection

The MAX4074/MAX4075 family includes  $\pm 17V$  input fault protection. For normal operation, see the input voltage range specification in the *Electrical Characteristics*. Overdriven inputs up to  $\pm 17V$  will not cause output phase reversal. A back-to-back SCR structure at the input pins allows either input to safely swing  $\pm 17V$  relative to  $V_{EE}$  (Figure 2). Additionally, the internal op amp inputs are diode clamped to both supply rails for

the protection of sensitive input stage circuitry. Current through the clamp diodes is limited by a  $5k\Omega$  resistor at the noninverting input, and by  $R_G$  at the inverting input. An  $IN+$  or  $IN-$  fault voltage as high as  $\pm 17V$  causes less than  $3.5mA$  to flow through the input pin, protecting both the GainAmp and the signal source from damage.

## Applications Information

GainAmp fixed-gain amplifiers offer a precision, fixed-gain amplifier in a small package that can be used in a variety of circuit board designs. GainAmp fixed-gain amplifiers can be used in many op amp circuits that use resistive negative feedback to set gain, and do not require other connections to the op amp inverting input. Both inverting and noninverting op amp configurations can be implemented easily using a GainAmp.

## GainAmp Input Voltage Range

The MAX4074/MAX4075 combine both an op amp and gain-setting feedback resistors on the same IC. The inverting input voltage range is different from the noninverting input voltage range because the inverting input pin is connected to the  $R_G$  input series resistor. Just as with a discrete design, take care not to saturate the inputs/output of the core op amp to avoid signal distortions or clipping.

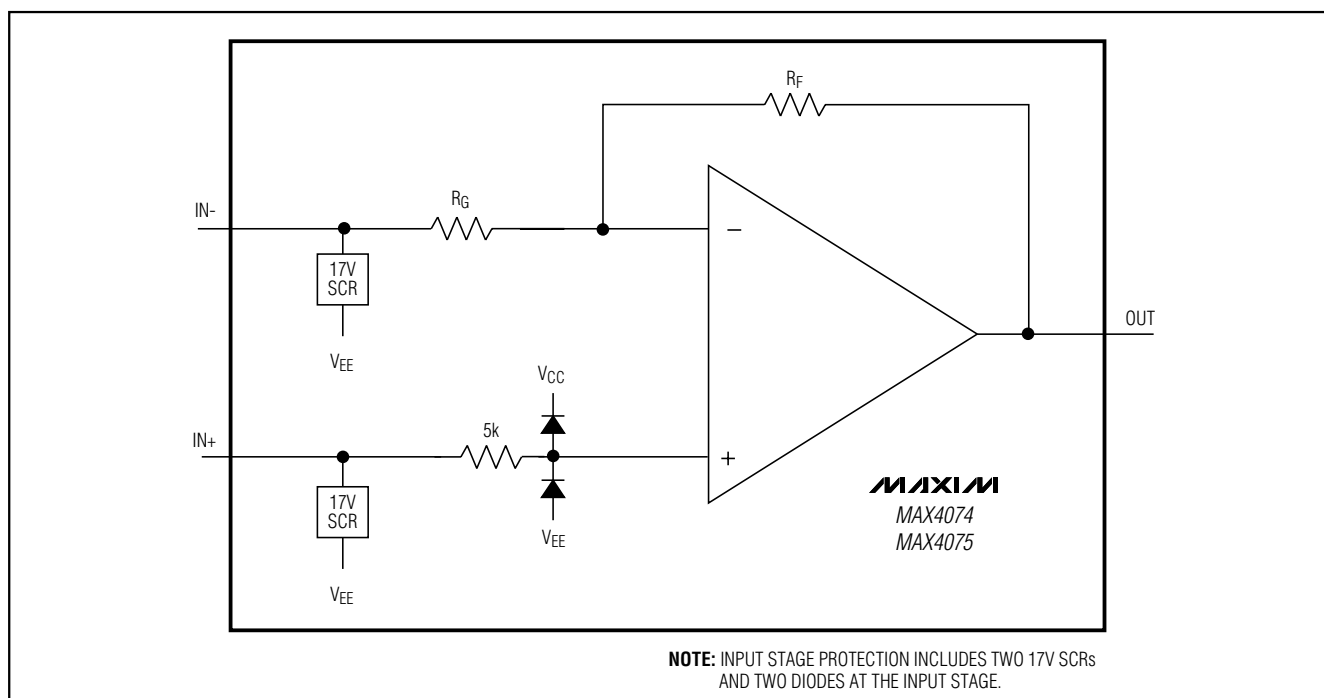


Figure 2. Input Protection

# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## GainAmp Signal Coupling and Configurations

Common op amp configurations include both noninverting and inverting amplifiers. Figures 3–6 show various single- and dual-supply circuit configurations. In single-supply systems, use a resistor-divider to bias the noninverting input. A lowpass filter capacitor from the op amp input to ground (Figure 5) prevents high-frequency power-supply noise from coupling into the op amp input. Dual-supply systems can have ground-referenced signals DC-coupled into the inverting or noninverting inputs.

## Supply Bypassing and Board Layout

All devices in this GainAmp family operate from a +2.5V to +5.5V single supply or from ±1.25V to ±2.75V dual supplies. For single-supply operation, bypass the power supply with a 0.1µF capacitor to ground. For dual supplies, bypass each supply to ground. Bypass with capacitors as close to the device as possible to minimize lead inductance and noise. A printed circuit board with a low-inductance ground plane is recommended.

## Capacitive-Load Stability

Driving large capacitive loads can cause instability in most low-power, rail-to-rail output amplifiers. The fixed-gain amplifiers of this GainAmp family are stable with capacitive loads up to 100pF. Stability with higher capacitive loads can be improved by adding an isolation resistor in series with the op amp output, as shown in Figure 7. This resistor improves the circuit's phase margin by isolating the load capacitor from the amplifier's output. In Figure 8, a 220pF capacitor is driven with a 100Ω isolation resistor exhibiting some overshoot but no oscillation. Figures 9 and 10 show the typical small-signal pulse responses of GainAmp fixed-gain amplifiers with 47pF and 100pF capacitive loads and no isolation resistor

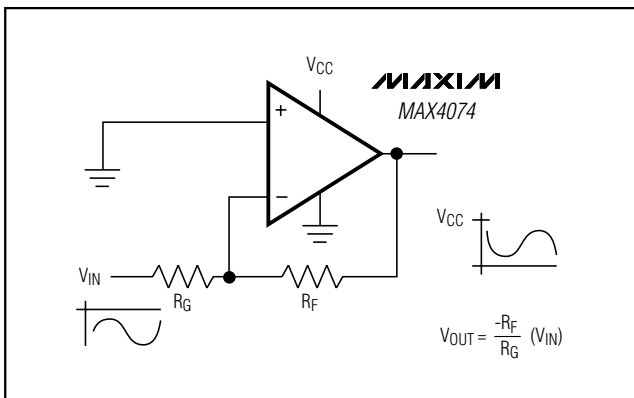


Figure 3. Single-Supply, DC-Coupled Inverting Amplifier with Negative Input Voltage

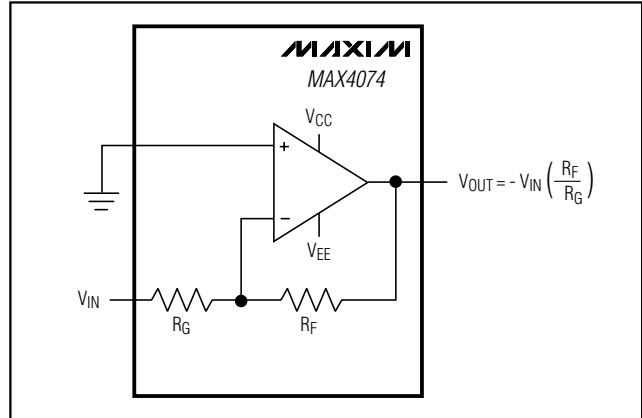


Figure 4. Dual-Supply, DC-Coupled Inverting Amplifier

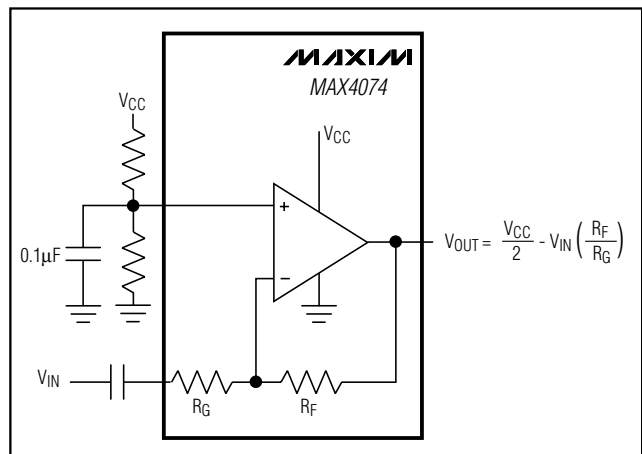


Figure 5. Single-Supply, AC-Coupled Inverting Amplifier

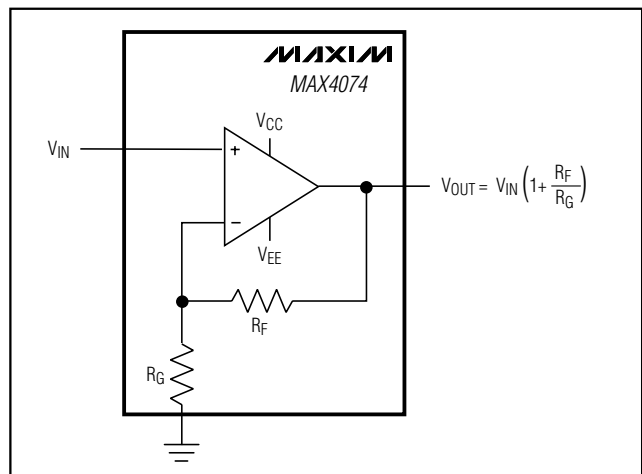


Figure 6. Dual-Supply, DC-Coupled Noninverting Amplifier

# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

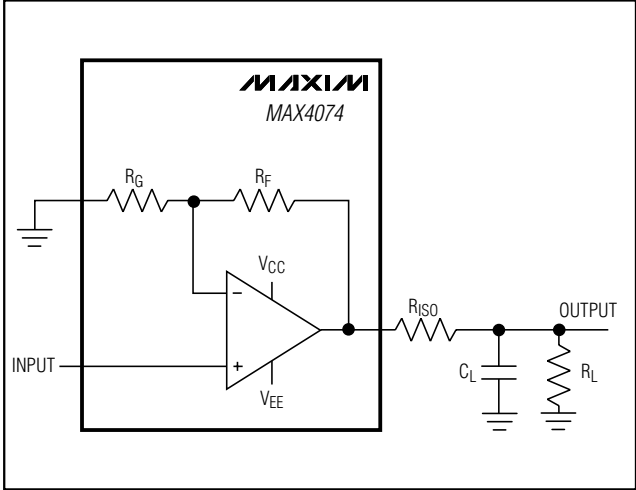


Figure 7. Dual-Supply, Capacitive-Load-Driving Circuit

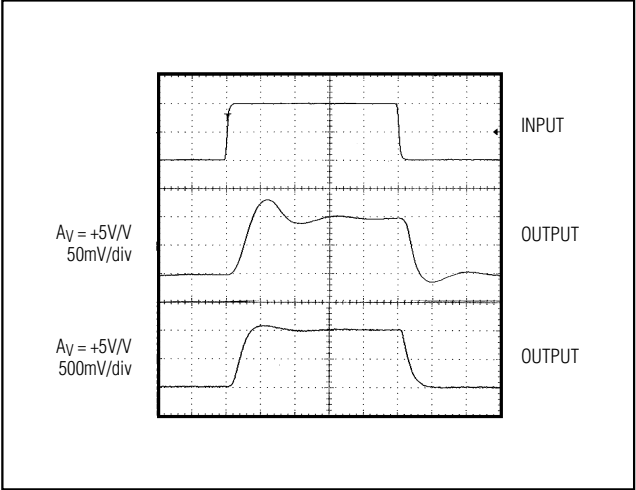


Figure 8. Small-Signal/Large-Signal Transient Response with Excessive Capacitive Load and Isolation Resistor

**MAX4074-MAX4078**

# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

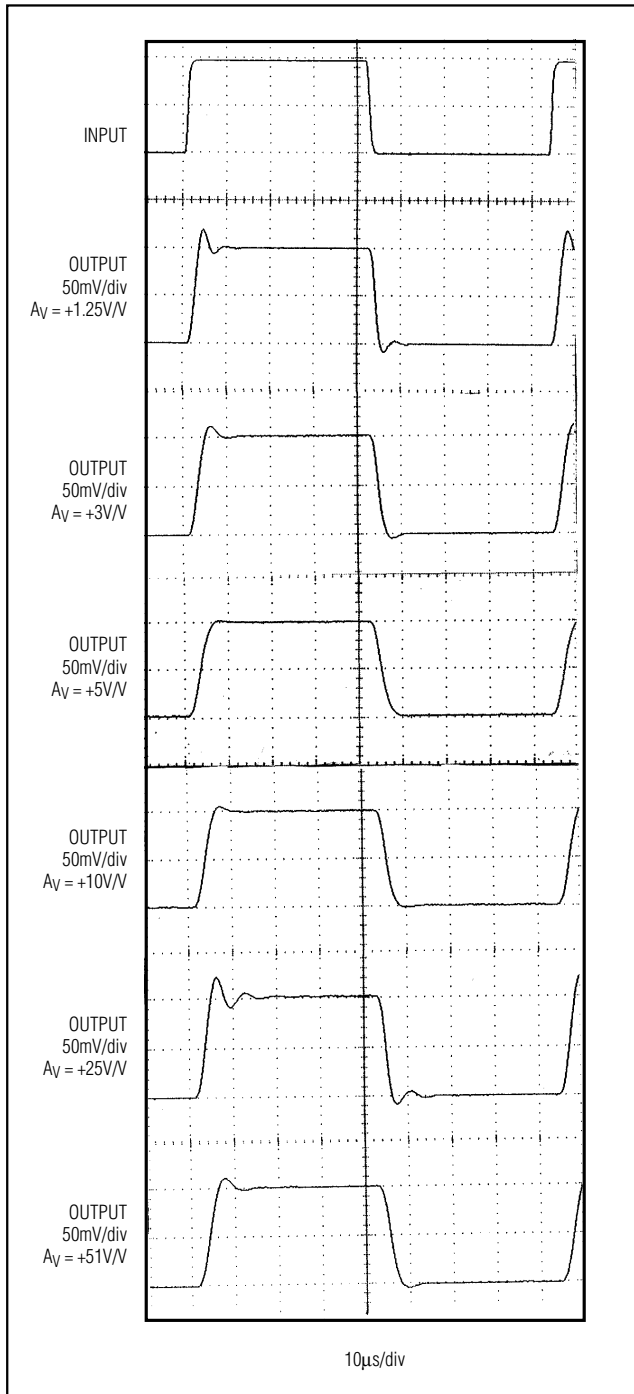


Figure 9. GainAmp Small-Signal Pulse Response ( $C_L = 340\text{pF}$ ,  $R_L = 100\text{k}\Omega$ )

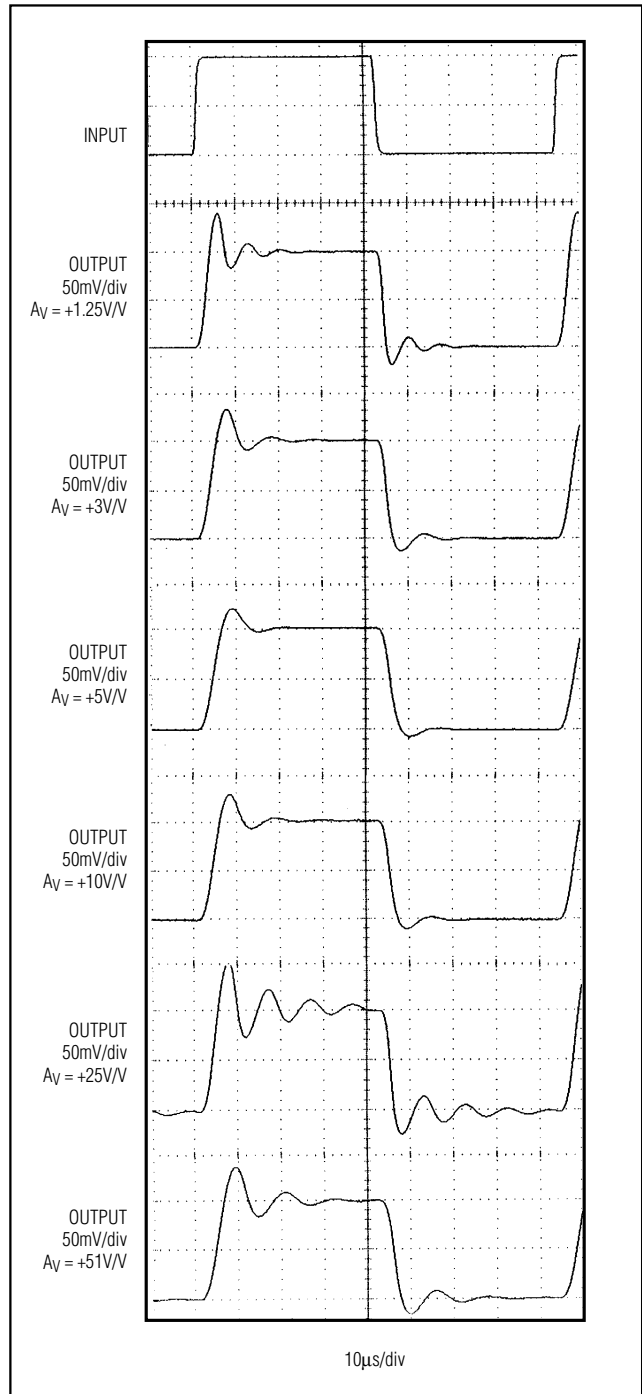


Figure 10. GainAmp Small-Signal Pulse Response ( $C_L = 940\text{pF}$ ,  $R_L = 100\text{k}\Omega$ )

# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## Gain Selector Guide

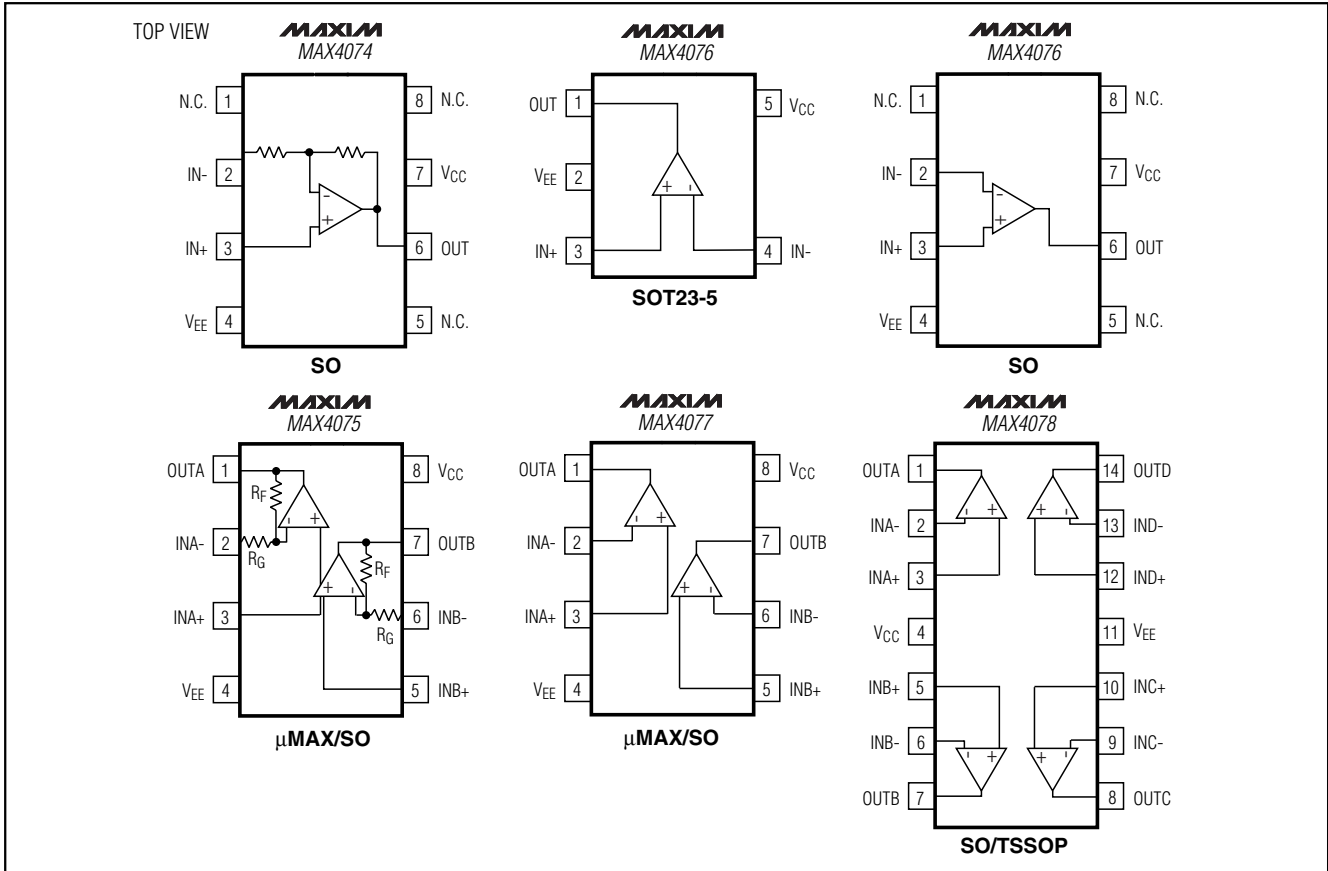
MAX4074-MAX4078

| GAIN CODE | INVERTING GAIN (V/V) | NONINVERTING GAIN (V/V) | -3dB BW (kHz) | TOP MARK |
|-----------|----------------------|-------------------------|---------------|----------|
| AB        | 0.25                 | 1.25                    | 200           | ADJB     |
| AC        | 0.5                  | 1.5                     | 136           | ADJC     |
| <b>AD</b> | 1                    | 2                       | 102           | ADJD     |
| AE        | 1.25                 | 2.25                    | 70            | ADJE     |
| AF        | 1.5                  | 2.5                     | 180           | ADJF     |
| <b>AG</b> | 2                    | 3                       | 135           | ADJG     |
| AH        | 2.5                  | 3.5                     | 116           | ADJH     |
| AJ        | 3                    | 4                       | 90            | ADJI     |
| <b>AK</b> | 4                    | 5                       | 80            | ADJJ     |
| AL        | 5                    | 6                       | 71            | ADJK     |
| AM        | 6                    | 7                       | 61            | ADJL     |
| AN        | 8                    | 9                       | 50            | ADJM     |
| <b>AO</b> | 9                    | 10                      | 90            | ADJN     |
| <b>BA</b> | 10                   | 11                      | 79            | ADJO     |
| BB        | 12.5                 | 13.5                    | 64            | ADJP     |
| BC        | 15                   | 16                      | 54            | ADJQ     |
| BD        | 20                   | 21                      | 40            | ADJR     |
| <b>BE</b> | 24                   | 25                      | 120           | ADJS     |
| BF        | 25                   | 26                      | 106           | ADJT     |
| BG        | 30                   | 31                      | 89            | ADJU     |
| BH        | 40                   | 41                      | 67            | ADJV     |
| <b>BJ</b> | 49                   | 50                      | 50            | ADJW     |
| <b>BK</b> | 50                   | 51                      | 82            | ADJX     |
| BL        | 60                   | 61                      | 66            | ADJY     |
| BM        | 79                   | 80                      | 50            | ADJZ     |
| <b>BN</b> | 99                   | 100                     | 40            | ADKA     |
| <b>CA</b> | 100                  | 101                     | 38            | ADKB     |

**Note:** **Bold** indicates preferred gains. These gain versions are available as samples and in small quantities.

# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## Pin Configurations/Functional Diagrams



# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## Ordering Information (continued)

| PART                 | TEMP. RANGE    | PIN-PACKAGE | TOP MARK |
|----------------------|----------------|-------------|----------|
| <b>MAX4075</b> __EUA | -40°C to +70°C | 8 $\mu$ MAX | —        |
| MAX4075__ESA         | -40°C to +70°C | 8 SO        | —        |
| <b>MAX4076</b> EUK-T | -40°C to +70°C | 5 SOT23-5   | **       |
| MAX4076ESA           | -40°C to +70°C | 8 SO        | —        |
| <b>MAX4077</b> EUA   | -40°C to +70°C | 8 $\mu$ MAX | —        |
| MAX4077ESA           | -40°C to +70°C | 8 SO        | —        |
| <b>MAX4078</b> EUD   | -40°C to +70°C | 14 TSSOP    | —        |
| MAX4078ESD           | -40°C to +70°C | 14 SO       | —        |

**Note:** Insert the desired gain code in the blank to complete the part number (see the Gain Selector Guide).

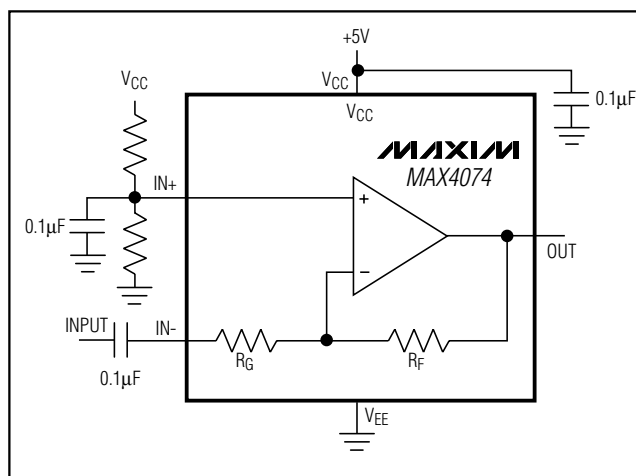
\*\*See the Gain Selector Guide for a list of preferred gains and top marks.

## Chip Information

### TRANSISTOR COUNTS

|              |              |
|--------------|--------------|
| MAX4074: 180 | MAX4077: 340 |
| MAX4075: 360 | MAX4078: 332 |
| MAX4076: 180 |              |

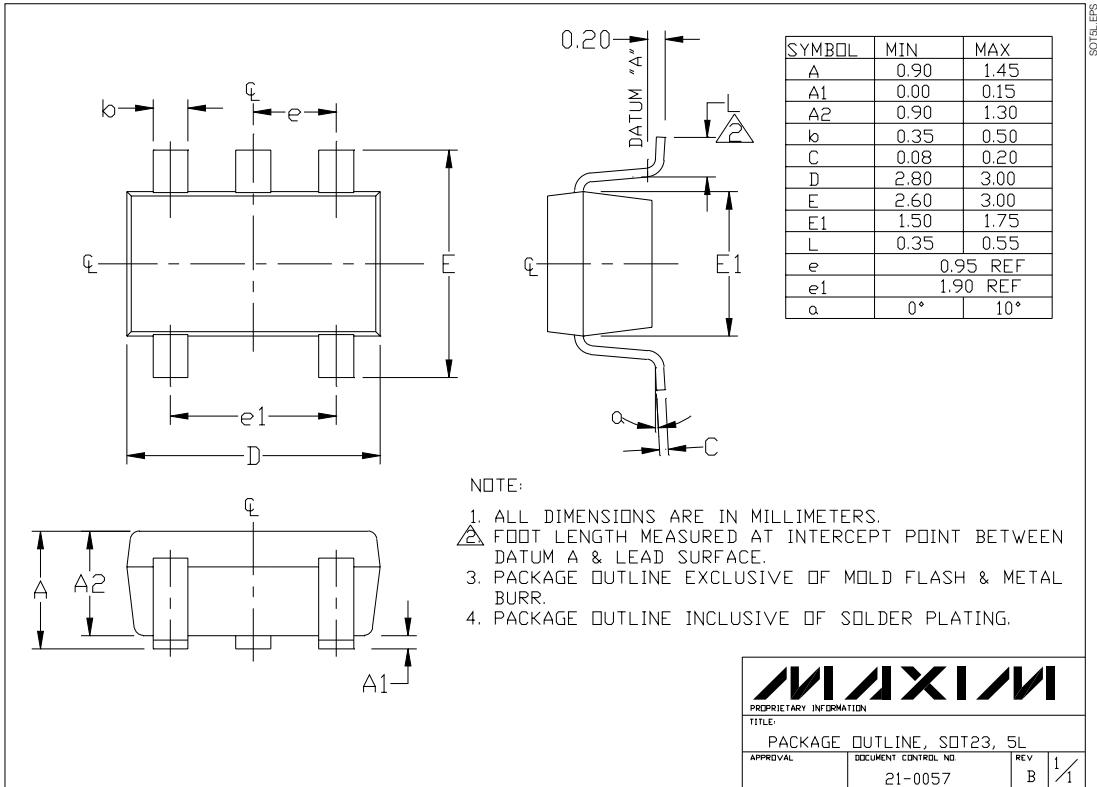
## Typical Operating Circuit



**MAX4074-MAX4078**

# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## Package Information



SOT23LEPS

|  |                                     |                    |
|--|-------------------------------------|--------------------|
| <b>MAXIM</b>                           |                                     |                    |
| <small>PROPRIETARY INFORMATION</small> |                                     |                    |
| <small>TITLE:</small>                  |                                     |                    |
| PACKAGE OUTLINE, SOT23, 5L             |                                     |                    |
| <small>APPROVAL</small>                | <small>DOCUMENT CONTROL NO.</small> | <small>REV</small> |
|  | 21-0057                             | B 1/1              |

# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## Package Information (continued)

MAX4074-MAX4078

| COMMON DIMENSIONS |                |       |                |       |  |
|-------------------|----------------|-------|----------------|-------|--|
| DIMENSION         | MILLIMETERS    |       | INCHES         |       |  |
|                   | MIN.           | MAX.  | MIN.           | MAX.  |  |
| A                 | 0.05           | 0.15  | .002           | .006  |  |
| A <sub>1</sub>    | 0.85           | 0.95  | .033           | .037  |  |
| A <sub>2</sub>    | 0.19           | 0.30  | .007           | .012  |  |
| b                 | 0.19           | 0.25  | .007           | .010  |  |
| bl                | 0.090          | 0.20  | .0035          | .008  |  |
| c                 | 0.090          | 0.135 | .0035          | .0053 |  |
| cl                | 0.090          | 0.135 | .0035          | .0053 |  |
| D                 | SEE VARIATIONS |       | SEE VARIATIONS |       |  |
| E                 | 4.30           | 4.50  | .169           | .177  |  |
| e                 | 0.65 BSC       |       | .026 BSC       |       |  |
| H                 | 6.25           | 6.50  | .246           | .256  |  |
| L                 | 0.50           | 0.70  | .020           | .028  |  |
| N                 | SEE VARIATIONS |       | SEE VARIATIONS |       |  |
| Y                 | 2.85           | 3.15  | .112           | .124  |  |
| α                 | 0°             | 8°    | 0°             | 8°    |  |

| JEDEC | N  | VARIATIONS  |      |        |      |
|-------|----|-------------|------|--------|------|
|       |    | MILLIMETERS |      | INCHES |      |
|       |    | MIN.        | MAX. | MIN.   | MAX. |
| AB    | 14 | 4.90        | 5.10 | .193   | .201 |
| AC    | 16 | 4.90        | 5.10 | .193   | .201 |
| AC-EP | 16 | 4.90        | 5.10 | .193   | .201 |
|       | X  | 2.85        | 3.15 | .112   | .124 |
| AD    | 20 | 6.40        | 6.60 | .252   | .260 |
| AD-EP | 20 | 6.40        | 6.60 | .252   | .260 |
|       | X  | 4.00        | 4.34 | .157   | .171 |
| AE    | 24 | 7.70        | 7.90 | .303   | .311 |
| AF    | 28 | 9.60        | 9.80 | .378   | .386 |
| AF-EP | D  | 9.60        | 9.80 | .378   | .386 |
|       | X  | 5.35        | 5.65 | .211   | .222 |

**NOTES:**

- DIMENSIONS D AND E DO NOT INCLUDE FLASH.
- MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15 mm PER SIDE.
- CONTROLLING DIMENSION: MILLIMETER.
- MEETS JEDEC OUTLINE MD-153 VARIATIONS AB, AC, AD, AE, AF.
- DIMENSIONS X AND Y APPLY TO EXPOSED PAD (EP) VERSIONS ONLY.
- EXPOSED PAD FLUSH WITH BOTTOM OF PACKAGE WITHIN .002".

**MAXIM**

PROPRIETARY INFORMATION

TITLE:  
PACKAGE OUTLINE, TSSOP, 4.40mm BODY, 0.65mm PITCH

|          |                                 |              |
|----------|---------------------------------|--------------|
| APPROVAL | DOCUMENT CONTROL NO.<br>21-0066 | REV<br>C 1/1 |
|----------|---------------------------------|--------------|

# Micropower, SOT23, Rail-to-Rail, Fixed-Gain, GainAmp/Open-Loop Op Amps

## Package Information (continued)

|    | INCHES |       | MILLIMETERS |       | JEDEC  |       |      |      |
|----|--------|-------|-------------|-------|--------|-------|------|------|
|    | MIN    | MAX   | MIN         | MAX   | MIN    | MAX   | MIN  | MAX  |
| A  | 0.037  | 0.043 | 0.94        | 1.10  | ---    | 0.043 | ---  | 1.10 |
| A1 | 0.002  | 0.006 | 0.05        | 0.15  | 0.002  | 0.006 | 0.05 | 0.15 |
| B  | 0.010  | 0.014 | 0.25        | 0.36  | 0.010  | 0.016 | 0.25 | 0.40 |
| C  | 0.005  | 0.007 | 0.13        | 0.18  | 0.005  | 0.009 | 0.13 | 0.23 |
| D  | 0.116  | 0.120 | 2.95        | 3.05  | 0.114  | 0.122 | 2.9  | 3.1  |
| e  | 0.0256 | BSC   | 0.65        | BSC   | 0.0256 | BSC   | 0.64 | BSC  |
| E  | 0.116  | 0.120 | 2.95        | 3.05  | 0.114  | 0.122 | 2.9  | 3.1  |
| H  | 0.188  | 0.198 | 4.78        | 5.03  | 0.193  | BSC   | 4.9  | BSC  |
| L  | 0.016  | 0.026 | 0.41        | 0.66  | 0.016  | 0.027 | 0.40 | 0.70 |
| α  | 0°     | 6°    | 0°          | 6°    | 0°     | 6°    | 0°   | 6°   |
| *X | 0.087  | 0.059 | 2.210       | 2.515 |        |       |      |      |
| *Y | 0.062  | 0.074 | 1.575       | 1.880 |        |       |      |      |

\* EXPOSED PAD (Note 5)

NOTES:  
 1. D&E DO NOT INCLUDE MOLD FLASH.  
 2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15 MM (.006").  
 3. CONTROLLING DIMENSION: MILLIMETERS.  
 4. MEETS JEDEC MO-187.  
 5. DIMENSIONS X & Y APPLY TO EXPOSED PAD (EP) VERSIONS ONLY. SEE INDIVIDUAL PRODUCT DATASHEET TO DETERMINE IF A PRODUCT USES EXPOSED PAD PACKAGE.  
 6. EXPOSED PAD FLUSH WITH BOTTOM OF PACKAGE WITHIN .002".

MAXIM  
 PROPRIETARY INFORMATION  
 TITLE: PACKAGE OUTLINE, BL UMAX WITH EP OPTION  
 APPROVAL: DOCUMENT CONTROL: NS 21-0036 REV: H 1/1

|    | INCHES |       | MILLIMETERS |      | N | MS012 |
|----|--------|-------|-------------|------|---|-------|
|    | MIN    | MAX   | MIN         | MAX  |   |       |
| A  | 0.053  | 0.069 | 1.35        | 1.75 | 8 | A     |
| A1 | 0.004  | 0.010 | 0.10        | 0.25 |   |       |
| B  | 0.014  | 0.019 | 0.35        | 0.49 |   |       |
| C  | 0.007  | 0.010 | 0.19        | 0.25 |   |       |
| e  | 0.050  |       | 1.27        |      |   |       |
| E  | 0.150  | 0.157 | 3.80        | 4.00 |   |       |
| H  | 0.228  | 0.244 | 5.80        | 6.20 |   |       |
| h  | 0.010  | 0.020 | 0.25        | 0.50 |   |       |
| L  | 0.016  | 0.050 | 0.40        | 1.27 |   |       |

|   | INCHES |       | MILLIMETERS |       | N  | MS012 |
|---|--------|-------|-------------|-------|----|-------|
|   | MIN    | MAX   | MIN         | MAX   |    |       |
| D | 0.189  | 0.197 | 4.80        | 5.00  | 8  | A     |
| D | 0.337  | 0.344 | 8.55        | 8.75  | 14 | B     |
| D | 0.386  | 0.394 | 9.80        | 10.00 | 16 | C     |

NOTES:  
 1. D&E DO NOT INCLUDE MOLD FLASH.  
 2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006").  
 3. LEADS TO BE COPLANAR WITHIN .102mm (.004").  
 4. CONTROLLING DIMENSION: MILLIMETER.  
 5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE.  
 6. N = NUMBER OF PINS.

MAXIM  
 PROPRIETARY INFORMATION  
 TITLE: PACKAGE FAMILY OUTLINE: SOIC .150  
 APPROVAL: DOCUMENT CONTROL: NS 21-0041 A REV: H 1/1

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