



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

## General Description

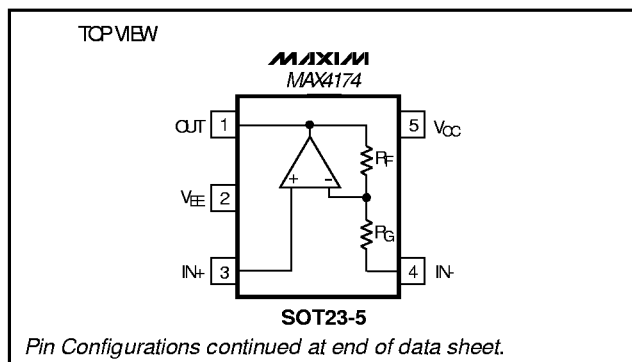
The MAX4174/MAX4175/MAX4274/MAX4275 Gain-Amp™ family combines a low-cost Rail-to-Rail® op amp with precision internal gain-setting resistors and  $V_{CC} / 2$  biasing. Factory-trimmed on-chip resistors decrease design size, cost, and layout, and provide 0.1% gain accuracy. Fixed inverting gains from  $-0.25V/V$  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 only  $300\mu A$ . Gain-Amp amplifiers are optimally compensated for each gain version, achieving exceptional GBW products up to  $23MHz$  ( $A_v = +25V/V$  to  $+101V/V$ ). High-voltage fault protection withstands  $\pm 17V$  at either input without excessive current draw.

Three versions are available in this amplifier family: single/dual/quad open-loop, unity-gain stable (MAX4281/MAX4282/MAX4284); single/dual fixed gain (MAX4174/MAX4274); and single/dual fixed gain plus internal  $V_{CC} / 2$  bias at the noninverting input (MAX4175/MAX4275), which simplifies input biasing in single-supply designs. 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 outputs can swing rail-to-rail and drive a  $1k\Omega$  load while maintaining excellent DC accuracy. The amplifier is stable for capacitive loads up to  $470pF$ .

## Applications

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

## Pin Configurations



† Patent pending

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

## Features

- ♦ Gain-Amp Family Provides Internal Precision Gain-Setting Resistors in SOT23 (MAX4174/5)
- ♦ 0.1% Gain Accuracy ( $R_F/R_G$ ) (MAX4174/5, MAX4274/5)
- ♦ 54 Standard Gains Available (MAX4174/5, MAX4274/5)
- ♦ Open-Loop Unity-Gain-Stable Op Amps (MAX4281/2/4)
- ♦ Rail-to-Rail Outputs Drive  $1k\Omega$  Load
- ♦ Internal  $V_{CC} / 2$  Biasing (MAX4175/MAX4275)
- ♦  $+2.5V$  to  $+5.5V$  Single Supply
- ♦  $300\mu A$  Supply Current
- ♦ Up to  $23MHz$  GBW Product
- ♦ Fault-Protected Inputs Withstand  $\pm 17V$
- ♦ Stable with Capacitive Loads Up to  $470pF$  with No Isolation Resistor

## Ordering Information

| PART*         | TEMP. RANGE                      | PIN-<br>PACKAGE | SOT<br>TOP MARK |
|---------------|----------------------------------|-----------------|-----------------|
| MAX4174_EUK-T | $-40^{\circ}C$ to $+85^{\circ}C$ | 5 SOT23-5       | ††              |
| MAX4175_EUK-T | $-40^{\circ}C$ to $+85^{\circ}C$ | 5 SOT23-5       | ††              |

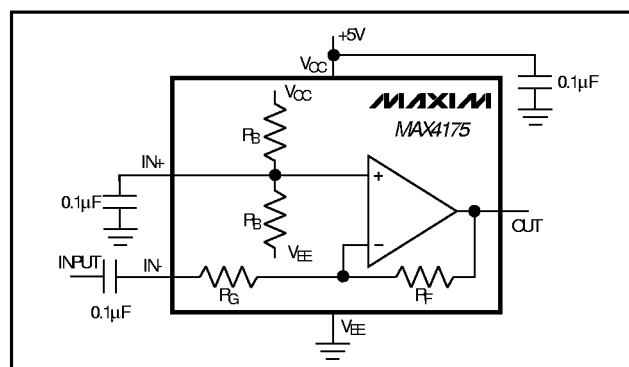
Ordering Information continued at end of data sheet.

\* Insert the desired gain code (from the Gain Selection Guide) in the blank to complete the part number.

†† Refer to the Gain Selection Guide for a list of preferred gains and SOT Top Marks.

Selector Guide appears at end of data sheet.

## Typical Operating Circuit



MAX4174/5, MAX4274/5, MAX4281/2/4†



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For small orders, phone 1-800-835-8769.

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

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ( $V_{CC}$  to  $V_{EE}$ ) .....-0.3V to +6V  
 Voltage Inputs ( $IN_{-}$ )  
   MAX4281/4282/4284.....( $V_{EE} - 0.3V$ ) to ( $V_{CC} + 0.3V$ )  
   MAX4174/4175/4274/4275 (with respect to GND) .....±17V  
 Output Short-Circuit Duration  
 ( $OUT_{-}$ ).....Continuous to Either  $V_{EE}$  or  $V_{CC}$   
 Continuous Power Dissipation ( $T_A = +70^{\circ}C$ )  
   5-Pin SOT23 (derate 7.1mW/ $^{\circ}C$  above +70 $^{\circ}C$ ).....571mW  
   8-Pin SO (derate 5.88mW/ $^{\circ}C$  above +70 $^{\circ}C$ ).....471mW

8-Pin  $\mu$ MAX (derate 4.1mW/ $^{\circ}C$  above +70 $^{\circ}C$ ) .....330mW  
 14-Pin SO (derate 8.3mW/ $^{\circ}C$  above +70 $^{\circ}C$ ).....667mW  
 16-Pin QSOP (derate 8.3mW/ $^{\circ}C$  above +70 $^{\circ}C$ ).....667mW  
 Operating Temperature Range .....-40 $^{\circ}C$  to +85 $^{\circ}C$   
 Maximum Junction Temperature .....+150 $^{\circ}C$   
 Storage Temperature Range .....-65 $^{\circ}C$  to +150 $^{\circ}C$   
 Lead Temperature (soldering, 10sec) .....+300 $^{\circ}C$

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—MAX4174/MAX4175/MAX4274/MAX4275 FIXED-GAIN AMPLIFIERS

( $V_{CC} = +2.5V$  to  $+5.5V$ ,  $V_{EE} = 0$ ,  $V_{IN+} = V_{IN-} = V_{CC} / 2$ ,  $R_L$  to  $V_{CC} / 2$ ,  $R_L = \text{open}$ ,  $T_A = T_{MIN}$  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 tests                                 |                   | 2.5                 |       | 5.5                 | V                 |
| Supply Current<br>(per Amplifier) | $I_{CC}$        | MAX4174/MAX4274                                          | $V_{CC} = 3V$     |                     | 300   | 460                 | $\mu A$           |
|                                   |                 |                                                          | $V_{CC} = 5V$     |                     | 330   | 510                 |                   |
|                                   |                 | MAX4175/MAX4275,<br>includes $V_{CC} / 2$ bias resistors | $V_{CC} = 3V$     |                     | 320   | 480                 |                   |
|                                   |                 |                                                          | $V_{CC} = 5V$     |                     | 355   | 530                 |                   |
| Input Offset Voltage              | $V_{OS}$        | $R_L = 100k\Omega$                                       |                   |                     | ±0.5  | ±2.0                | mV                |
| Input Offset Voltage Drift        |                 |                                                          |                   |                     | ±5    |                     | $\mu V/^{\circ}C$ |
| Input Bias Current                | $I_{BIAS}$      | $IN_{+}$ , MAX4174/MAX4274 (Note 2)                      |                   |                     | ±0.05 | ±10                 | nA                |
| Inverting Input Resistance        |                 | $A_V < 25V/V$                                            |                   |                     | 150   |                     | $k\Omega$         |
|                                   |                 | $A_V > 25V/V$                                            |                   |                     | 40    |                     |                   |
| Noninverting Input Resistance     |                 | MAX4174/MAX4274                                          |                   |                     | 1000  |                     | $M\Omega$         |
|                                   |                 | MAX4175/MAX4275                                          |                   |                     | 75    |                     | $k\Omega$         |
| $IN_{+}$ Bias Voltage             |                 | MAX4175/MAX4275, $V_{IN+} = V_{IN-}$                     |                   | $V_{CC} / 2 - 0.25$ |       | $V_{CC} / 2 + 0.25$ | V                 |
| $IN_{+}$ Input Voltage Range      |                 | Guaranteed by functional test (Note 3)                   |                   | $V_{EE}$            |       | $V_{CC} - 1.2$      | V                 |
| $IN_{-}$ Input Voltage Range      |                 | Guaranteed by functional test                            |                   | $V_{EE}$            |       | $V_{CC}$            | V                 |
| Power-Supply Rejection Ratio      | PSRR            | $V_{CC} = 2.5V$ to $5.5V$                                |                   | 70                  | 90    |                     | dB                |
| Closed-Loop Output Impedance      | $R_{OUT}$       |                                                          |                   |                     | 0.02  |                     | $\Omega$          |
| Short-Circuit Current             |                 | Shorted to $V_{EE}$                                      |                   |                     | 10    |                     | mA                |
|                                   |                 | Shorted to $V_{CC}$                                      |                   |                     | 65    |                     |                   |
| Output Voltage Swing<br>(Note 4)  | $V_{OH}/V_{OL}$ | $R_L = 100k\Omega$                                       | $V_{CC} - V_{OH}$ |                     | 2     | 8                   | mV                |
|                                   |                 |                                                          | $V_{OL} - V_{EE}$ |                     | 2     | 8                   |                   |
|                                   |                 | $R_L = 1k\Omega$                                         | $V_{CC} - V_{OH}$ |                     | 150   | 250                 |                   |
|                                   |                 |                                                          | $V_{OL} - V_{EE}$ |                     | 60    | 150                 |                   |

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

MAX4174/5, MAX4274/5, MAX4281/2/4

## ELECTRICAL CHARACTERISTICS—MAX4174/MAX4175/MAX4274/MAX4275 (continued)

( $V_{CC} = +2.5V$  to  $+5.5V$ ,  $V_{EE} = 0$ ,  $V_{IN+} = V_{IN-} = V_{CC} / 2$ ,  $R_L$  to  $V_{CC} / 2$ ,  $R_L = \text{open}$ ,  $T_A = T_{MIN}$  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%                                                                 |     | 1    |     | ms              |
| Slew Rate                     | SR     | $V_{CC} = 5V$ , $V_{OUT} = 4V$ step                                                   |     | 0.7  |     | V/ $\mu$ s      |
| Settling Time to Within 0.01% |        | $V_{CC} = 5V$ , $V_{OUT} = 4V$ step                                                   |     | 7    |     | $\mu$ s         |
| Input Noise Voltage Density   | $e_n$  | $f = 10kHz$ (Note 5)                                                                  |     | 90   |     | nV/ $\sqrt{Hz}$ |
| Input Noise Current Density   | $i_n$  | $f = 10kHz$                                                                           |     | 4    |     | fA/ $\sqrt{Hz}$ |
| Capacitive Load Stability     | CLOAD  | No sustained oscillations                                                             |     | 470  |     | pF              |
| DC Gain Accuracy              |        | ( $V_{EE} + 25mV$ ) < $V_{OUT}$ < ( $V_{CC} - 25mV$ ),<br>$R_L = 100k\Omega$ (Note 6) |     | 0.1  | 0.5 | %               |
| -3dB Bandwidth                | BW-3dB | Gain = +1.25V/V                                                                       |     | 1700 |     | kHz             |
|                               |        | Gain = +3V/V                                                                          |     | 970  |     |                 |
|                               |        | Gain = +5V/V                                                                          |     | 970  |     |                 |
|                               |        | Gain = +10V/V                                                                         |     | 640  |     |                 |
|                               |        | Gain = +25V/V                                                                         |     | 590  |     |                 |
|                               |        | Gain = +51V/V                                                                         |     | 330  |     |                 |

## ELECTRICAL CHARACTERISTICS—MAX4281/MAX4282/MAX4284 OPEN-LOOP OP AMPS

( $V_{CC} = +2.5V$  to  $+5.5V$ ,  $V_{EE} = 0$ ,  $V_{IN+} = V_{IN-} = V_{CC} / 2$ ,  $R_L$  to  $V_{CC} / 2$ ,  $R_L = \text{open}$ ,  $T_A = T_{MIN}$  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 tests                        | 2.5             |            | 5.5            | V                    |
| Supply Current (per Amplifier)  | $I_{CC}$   | $V_{CC} = 3V$                                   |                 | 290        | 450            | $\mu$ A              |
|                                 |            | $V_{CC} = 5V$                                   |                 | 320        | 500            | $\mu$ A              |
| Input Offset Voltage            | $V_{OS}$   | $R_L = 100k\Omega$                              |                 | $\pm 0.5$  | $\pm 2$        | mV                   |
| Input Offset Voltage Drift      |            |                                                 |                 | $\pm 5$    |                | $\mu$ V/ $^{\circ}C$ |
| Input Bias Current              | $I_{BIAS}$ |                                                 |                 | $\pm 0.05$ | $\pm 10$       | nA                   |
| Input Offset Current            | $I_{OS}$   |                                                 |                 | $\pm 10$   | $\pm 1000$     | pA                   |
| Input Resistance                | $R_{IN}$   | Differential or common mode                     |                 | 1000       |                | $M\Omega$            |
| Input Capacitance               | $C_{IN}$   |                                                 |                 | 2.5        |                | pF                   |
| Common-Mode Input Voltage Range | CMVR       | Guaranteed by CMRR test                         | $V_{EE} - 0.15$ |            | $V_{CC} - 1.2$ | V                    |
| Common-Mode Rejection Ratio     | CMRR       | $V_{EE} - 0.15V \leq V_{CM} \leq V_{CC} - 1.2V$ | 60              | 90         |                | dB                   |
| Power-Supply Rejection Ratio    | PSRR       | $V_{CC} = 2.5V$ to $5.5V$                       | 70              | 90         |                | dB                   |
| Closed-Loop Output Impedance    | $R_{OUT}$  | $A_V = 1$                                       |                 | 0.02       |                | $\Omega$             |

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

## ELECTRICAL CHARACTERISTICS—MAX4281/MAX4282/MAX4284 OPEN-LOOP OP AMPS (continued)

( $V_{CC} = +2.5V$  to  $+5.5V$ ,  $V_{EE} = 0$ ,  $V_{IN+} = V_{IN-} = V_{CC} / 2$ ,  $R_L$  to  $V_{CC} / 2$ ,  $R_L = \text{open}$ ,  $T_A = T_{MIN}$  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           |
|-------------------------------|-----------------|-----------------------------------------------------------------|-------------------|-----|-----|-----------------|
| Short-Circuit Current         |                 | Shorted to $V_{EE}$                                             |                   | 10  |     | mA              |
|                               |                 | Shorted to $V_{CC}$                                             |                   | 65  |     | mA              |
| Large-Signal Voltage Gain     | $A_{VOL}$       | $V_{EE} + 0.05V < V_{OUT} < V_{CC} - 0.1V$ , $R_L = 100k\Omega$ | 90                | 120 |     | dB              |
|                               |                 | $V_{EE} + 0.25V < V_{OUT} < V_{CC} - 0.3V$ , $R_L = 1k\Omega$   | 80                | 100 |     | dB              |
| Output Voltage Swing          | $V_{OH}/V_{OL}$ | $R_L = 100k\Omega$                                              | $V_{CC} - V_{OH}$ |     | 2   | 8               |
|                               |                 |                                                                 | $V_{OL} - V_{EE}$ |     | 2   | 8               |
|                               |                 | $R_L = 1k\Omega$                                                | $V_{CC} - V_{OH}$ |     | 160 | 250             |
|                               |                 |                                                                 | $V_{OL} - V_{EE}$ |     | 60  | 100             |
| Gain Bandwidth Product        | GBW             |                                                                 |                   | 2   |     | MHz             |
| Slew Rate                     | SR              | $V_{CC} = 5V$ , $V_{OUT} = 4V$ step                             |                   | 0.7 |     | V/ $\mu s$      |
| Settling Time to within 0.01% |                 | $V_{CC} = 5V$ , $V_{OUT} = 4V$ step                             |                   | 7   |     | $\mu s$         |
| Input Noise Voltage Density   | $e_n$           | $f = 10kHz$                                                     |                   | 60  |     | nV/ $\sqrt{Hz}$ |
| Input Noise Current Density   | $i_n$           | $f = 10kHz$                                                     |                   | 1.8 |     | fA/ $\sqrt{Hz}$ |
| Capacitive Load Stability     | $C_{LOAD}$      | No sustained oscillations, $A_V = 1$                            |                   | 470 |     | pF              |
| Power-Up Time                 |                 | Output settling to 1%                                           |                   | 1   |     | ms              |

**Note 1:** MAX4174/MAX4175/MAX4281 and MAX4274/MAX4275/MAX4282 and MAX4284 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 Gain-Amp.

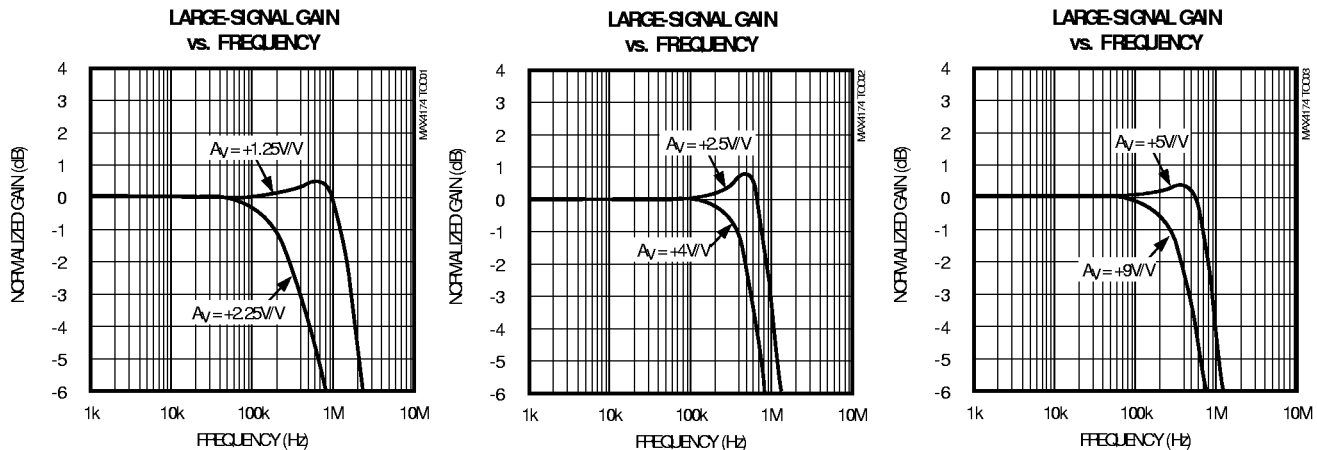
**Note 4:** For  $A_V = -0.5V/V$  and  $A_V = -0.25V/V$ , the output voltage swing is limited by the input voltage range.

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

**Note 6:** The gain accuracy test is performed with the Gain-Amp in 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

( $V_{CC} = +5V$ ,  $R_L = 100k\Omega$  to  $V_{CC} / 2$ , small-signal  $V_{OUT} = 100mV_{p-p}$ , large-signal  $V_{OUT} = 1V_{p-p}$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

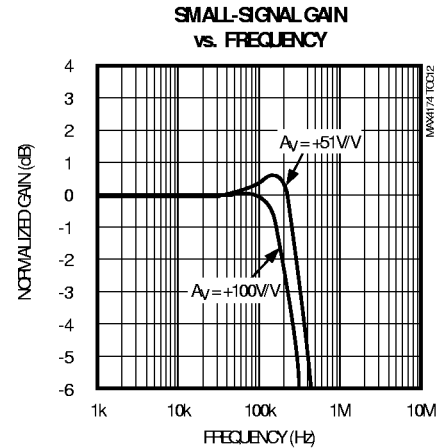
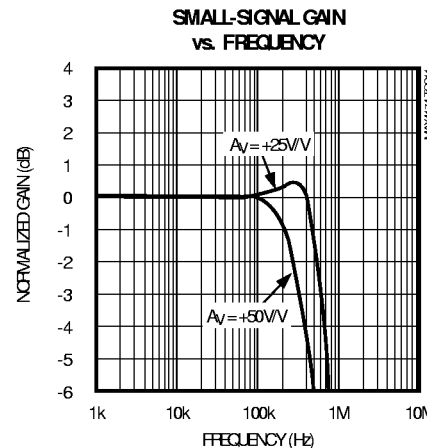
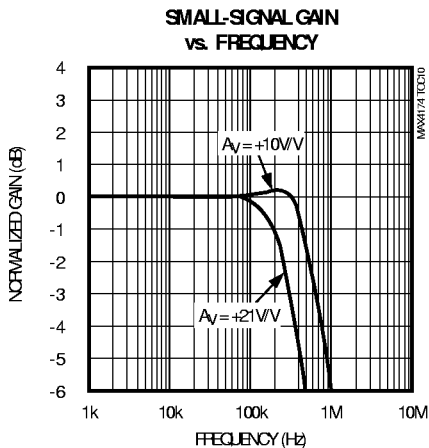
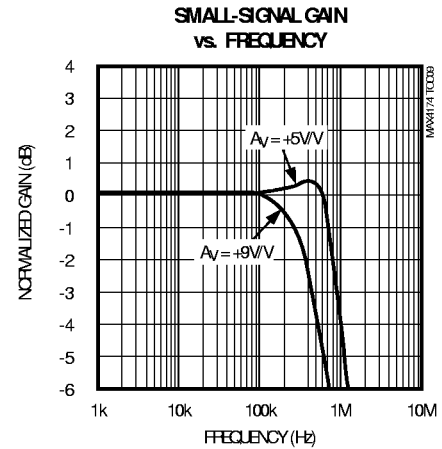
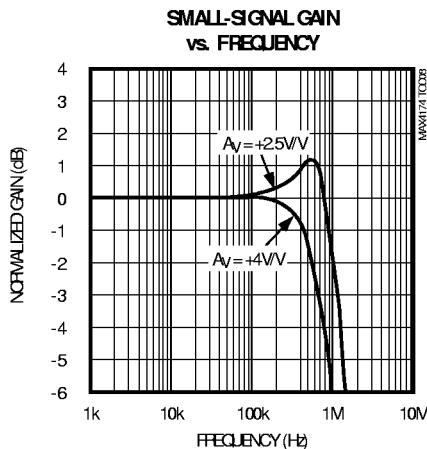
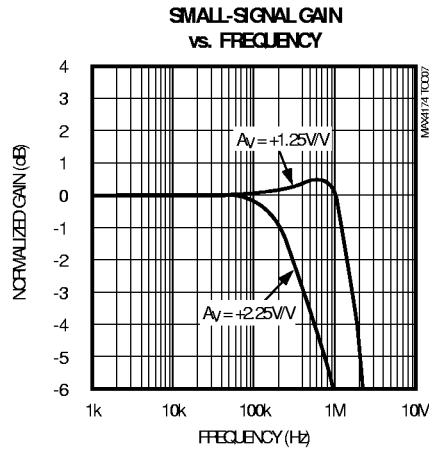
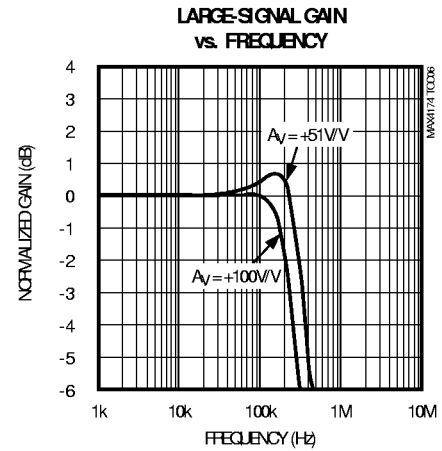
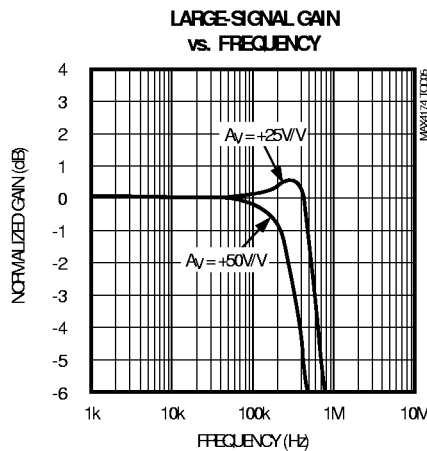
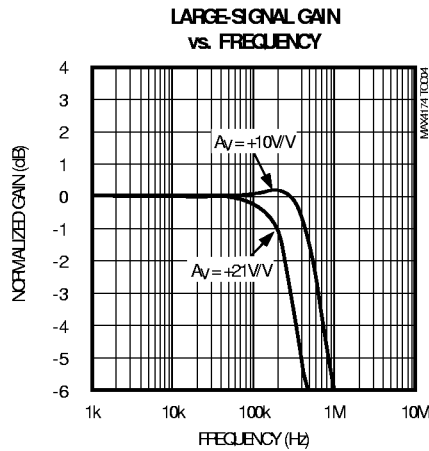


# SOT23, Rail-to-Rail, Fixed-Gain Gain-Amps/Open-Loop Op Amps

## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $R_L = 100k\Omega$  to  $V_{CC} / 2$ , small-signal  $V_{OUT} = 100mVp-p$ , large-signal  $V_{OUT} = 1Vp-p$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

### MAX4174/MAX4175



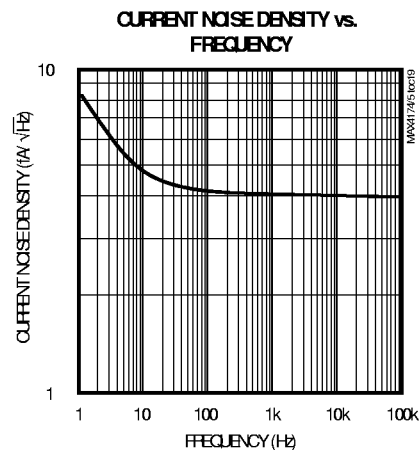
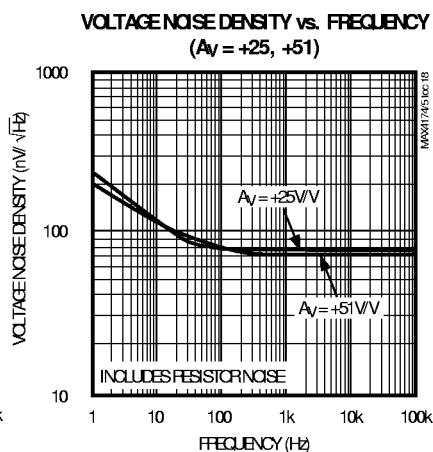
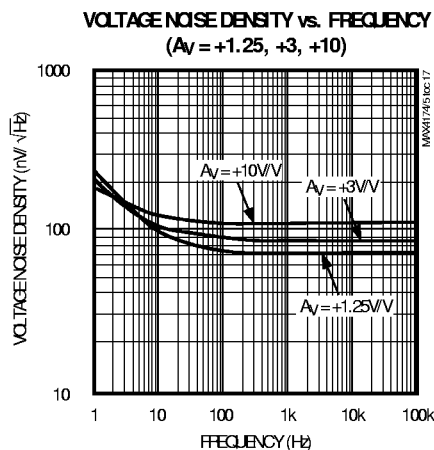
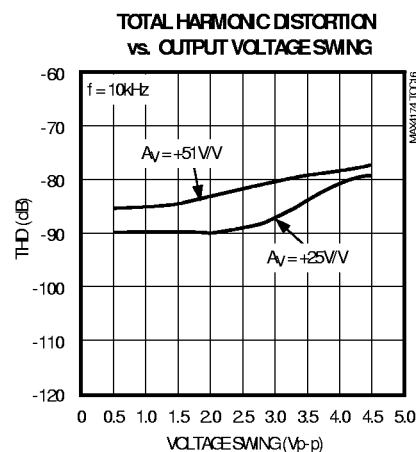
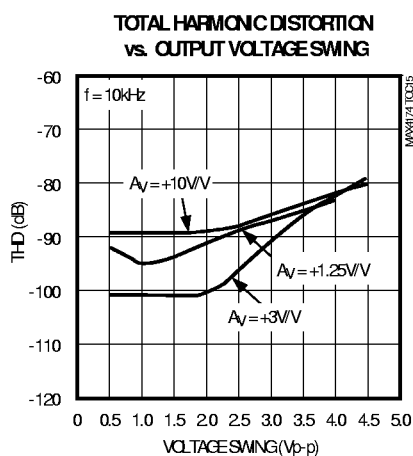
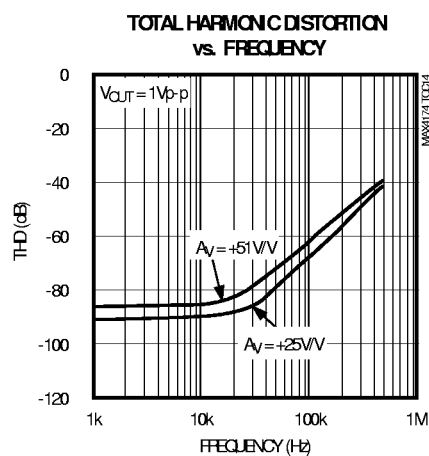
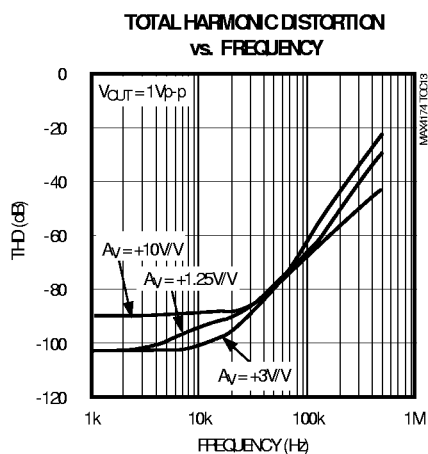
MAX4174/5, MAX4274/5, MAX4281/2/4

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

## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $R_L = 100k\Omega$  to  $V_{CC} / 2$ , small-signal  $V_{OUT} = 100mVp-p$ , large-signal  $V_{OUT} = 1Vp-p$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

### MAX4174/MAX4175



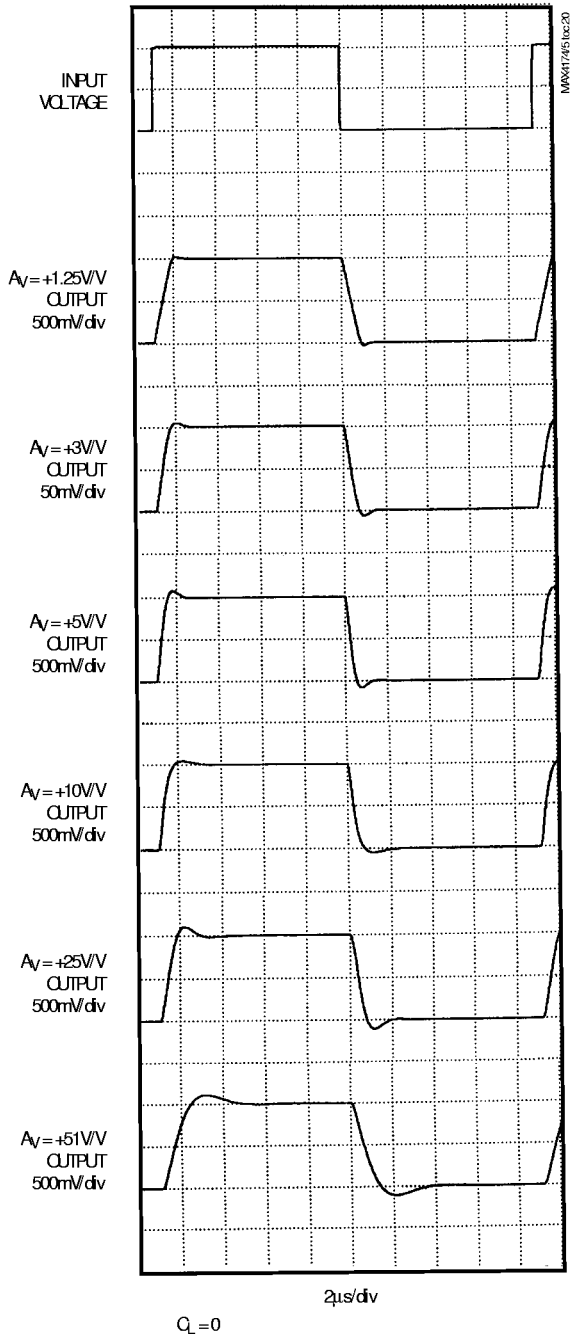
# SOT23, Rail-to-Rail, Fixed-Gain Gain-Amps/Open-Loop Op Amps

## Typical Operating Characteristics (continued)

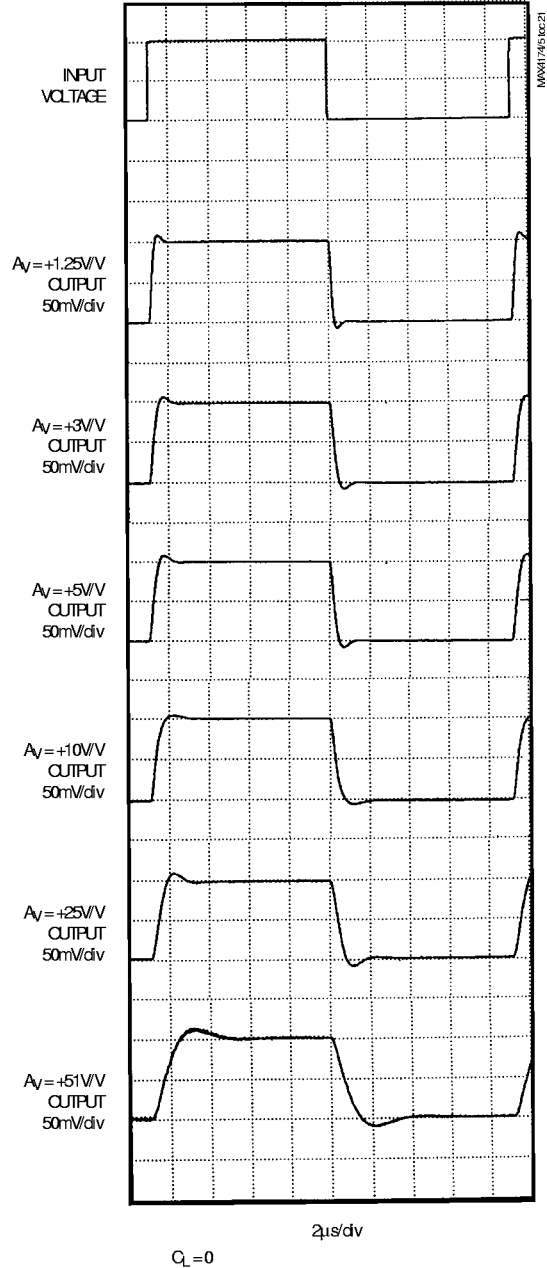
( $V_{CC} = +5V$ ,  $R_L = 100k\Omega$  to  $V_{CC} / 2$ , small-signal  $V_{OUT} = 100mVp-p$ , large-signal  $V_{OUT} = 1Vp-p$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

### MAX4174/MAX4175

#### LARGE-SIGNAL PULSE RESPONSE



#### SMALL-SIGNAL PULSE RESPONSE



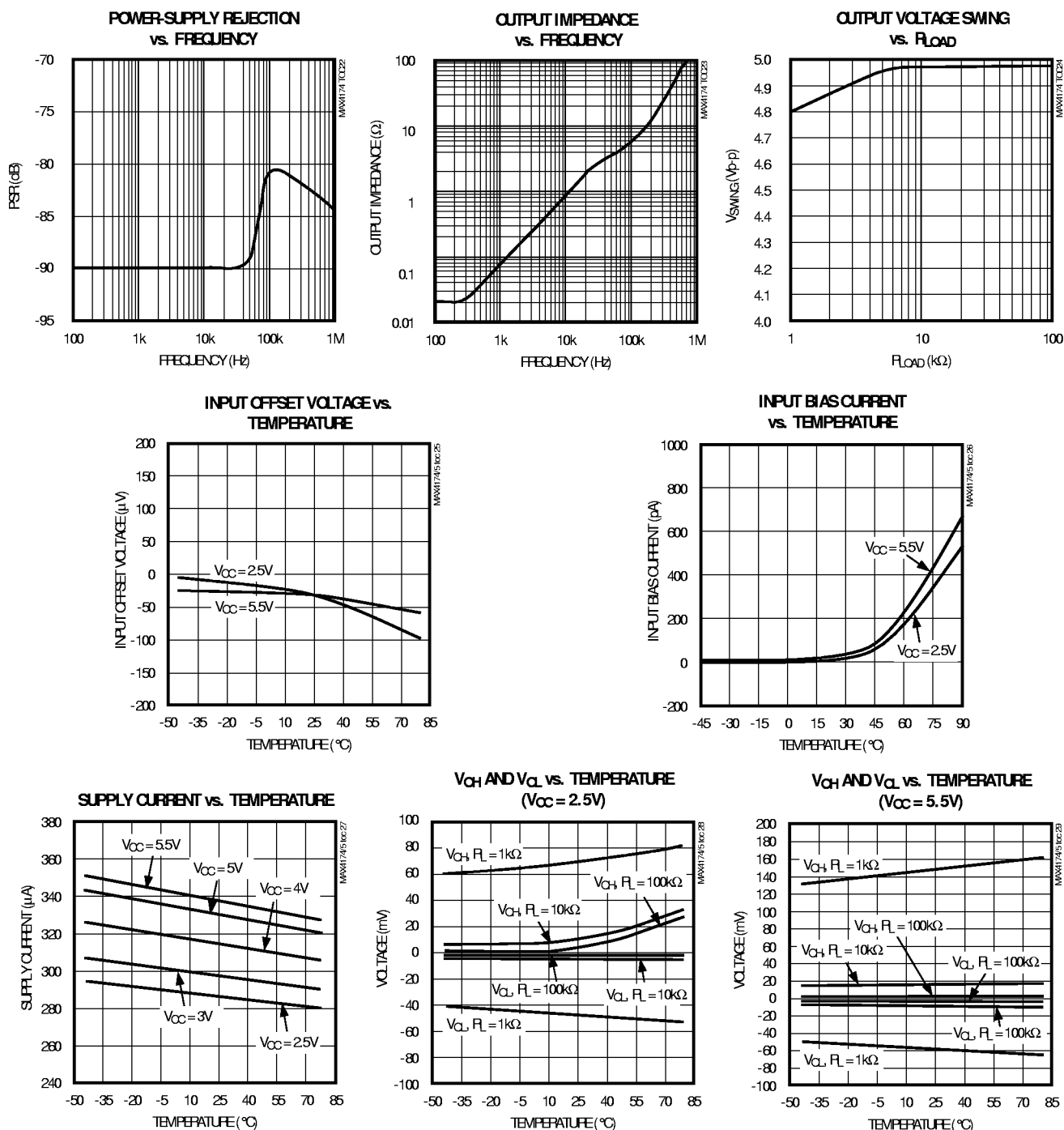
MAX4174/5, MAX4274/5, MAX4281/2/4

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

## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $R_L = 100k\Omega$  to  $V_{CC} / 2$ , small-signal  $V_{OUT} = 100mV_{p-p}$ , large-signal  $V_{OUT} = 1V_{p-p}$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

### MAX4174/MAX4175/MAX4281/MAX4282/MAX4284

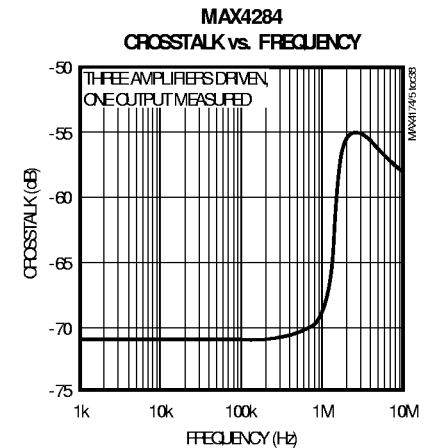
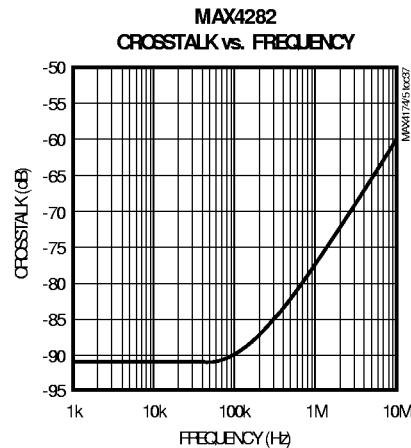
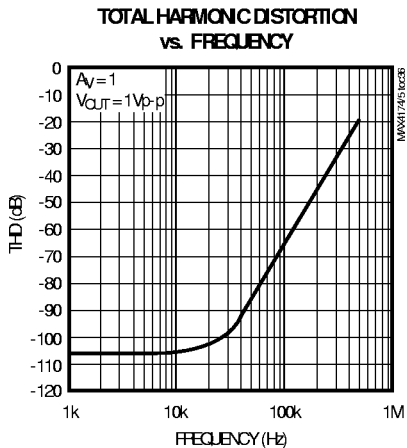
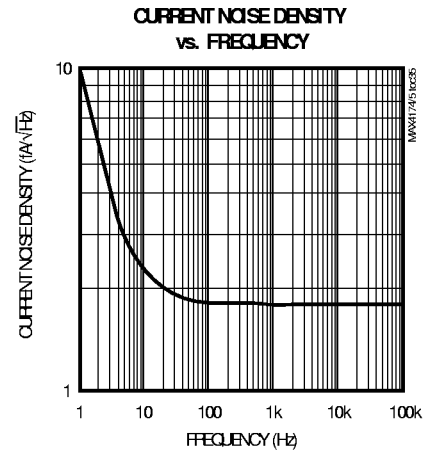
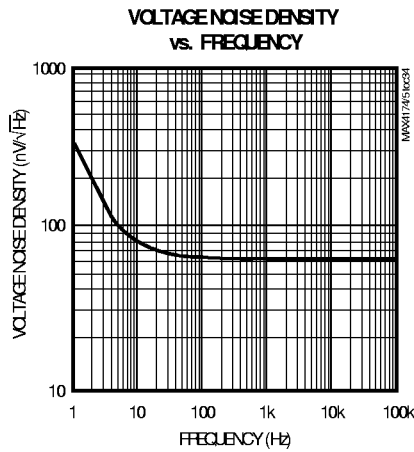
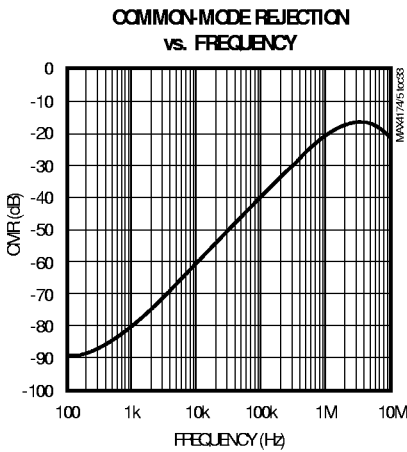
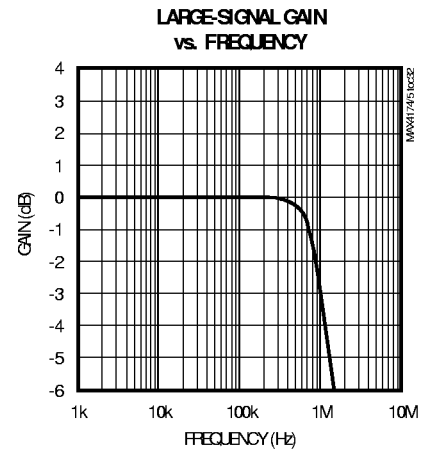
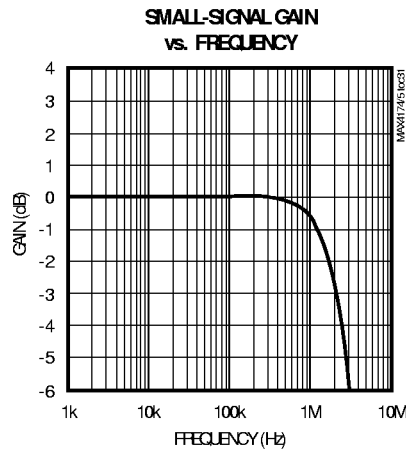
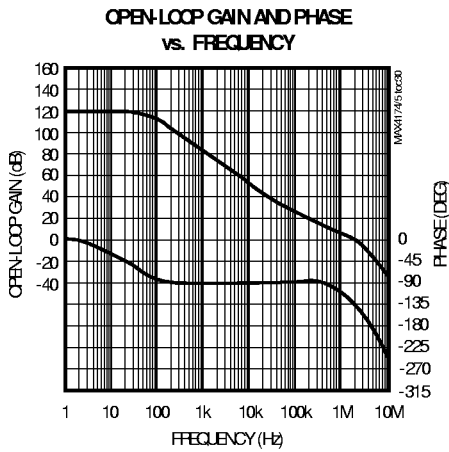


# SOT23, Rail-to-Rail, Fixed-Gain Gain-Amps/Open-Loop Op Amps

## Typical Operating Characteristics

( $V_{CC} = +5V$ ,  $R_L = 100k\Omega$  to  $V_{CC} / 2$ , small-signal  $V_{OUT} = 100mVp-p$ , large-signal  $V_{OUT} = 1Vp-p$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

### MAX4281/MAX4282/MAX4284



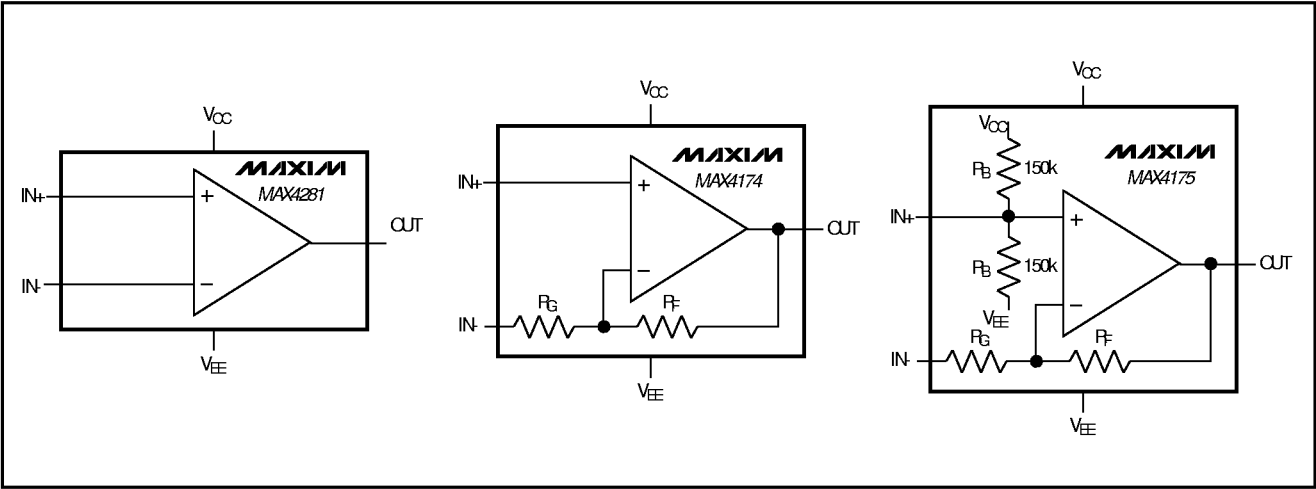
MAX4174/5, MAX4274/5, MAX4281/2/4

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

## Pin Description

| PIN     |            |                     |           |                     |                 |                 | NAME                              | FUNCTION                                                                                                |
|---------|------------|---------------------|-----------|---------------------|-----------------|-----------------|-----------------------------------|---------------------------------------------------------------------------------------------------------|
| MAX4281 |            | MAX4174/<br>MAX4175 | MAX4282   | MAX4274/<br>MAX4275 | MAX4284         |                 |                                   |                                                                                                         |
| 5 SOT23 | 8 SO       | 5 SOT23             | 8 SO/μMAX | 8 SO/μMAX           | 14 SO           | 16 QSOP         |                                   |                                                                                                         |
| 1       | 6          | 1                   | 1, 7      | 1, 7                | 1, 7,<br>8, 14  | 1, 7,<br>10, 16 | OUT, OUTA,<br>OUTB, OUTC,<br>OUTD | Amplifier Output                                                                                        |
| 2       | 4          | 2                   | 4         | 4                   | 11              | 13              | V <sub>EE</sub>                   | Negative Supply or<br>Ground                                                                            |
| 3       | 3          | 3                   | 3, 5      | 3, 5                | 3, 5,<br>10, 12 | 3, 5,<br>12, 14 | IN+, INA+,<br>INB+, INC+,<br>IND+ | Noninverting<br>Amplifier Input.<br>Internally biased to<br>V <sub>CC</sub> / 2 for<br>MAX4175/MAX4275. |
| 4       | 2          | 4                   | 2, 6      | 2, 6                | 2, 6,<br>9, 13  | 2, 6,<br>11, 15 | IN-, INA-, INB-,<br>INC-, IND-    | Inverting Amplifier<br>Input. Connects to<br>R <sub>G</sub> for MAX4174/<br>4175/4274/4275.             |
| 5       | 7          | 5                   | 8         | 8                   | 4               | 4               | V <sub>CC</sub>                   | Positive Supply                                                                                         |
| —       | 1, 5,<br>8 | —                   | —         | —                   | —               | 8, 9            | N.C.                              | No Connection. Not<br>internally connected.                                                             |

## Functional Diagrams



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

## Detailed Description

Maxim's Gain-Amp 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. Three versions are available in this amplifier family: single/dual/quad open-loop, unity-gain-stable devices (MAX4281/MAX4282/MAX4284); single/dual fixed-gain devices (MAX4174/MAX4274); and single/dual devices with fixed gain plus internal  $V_{CC}/2$  bias at the noninverting input (MAX4175/MAX4275). All amplifiers feature rail-to-rail outputs and drive a 1k $\Omega$  load while maintaining excellent DC accuracy.

## Open-Loop Op Amps

The single/dual/quad MAX4281/MAX4282/MAX4284 are high-performance, open-loop op amps with rail-to-rail outputs. These devices are compensated for unity-gain stability, and feature a gain bandwidth (GBW) of 2MHz. The op amps in these ICs feature an input common-mode range that 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 Gain-Amp 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.

## Internal Gain-Setting Resistors

Maxim's proprietary laser trimming techniques produce the necessary  $R_F/R_G$  values (Figure 1), so many gain offerings are easily available. These Gain-Amp 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 Gain-Amp fixed-gain amplifiers to drop in directly to existing board designs, easily replacing op-amp-plus-resistor gain blocks.

## Gain-Amp Bandwidth

Gain-Amp 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 Gain-Amp with a fixed gain of  $A_V = 100$ V/V has a -3dB bandwidth of 230kHz. By comparison, a unity-gain-stable op amp configured for  $A_V = 100$ V/V would yield a -3dB bandwidth of only 20kHz (Figure 2). Decompensation is performed at five intermediate gain sets, as shown in the *Gain Selection Guide*. Low gain decompensation great-

ly increases usable bandwidth, while decompensation above gains of +25V/V offers diminished returns.

## $V_{CC}/2$ Internal Bias

The MAX4175/MAX4275 Gain-Amp fixed-gain amplifiers with the  $V_{CC}/2$  bias option are identical to standard Gain-Amp fixed-gain amplifiers, with the added feature of  $V_{CC}/2$  internal bias at the noninverting inputs. Two 150k $\Omega$  resistors form a voltage-divider for self-biasing the noninverting input, eliminating external bias resistors for AC-coupled applications, and allowing maximum signal swing at the op amp's rail-to-rail output for single-supply systems (see *Typical Operating Circuit*). For DC-coupled applications, use the MAX4174/MAX4274.

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

The MAX4174/MAX4175/MAX4274/MAX4275 include  $\pm 17$ V input fault protection. For normal operation, see the input voltage range specification in the *Electrical Characteristics*. Overdriven inputs up to  $\pm 17$ V will not

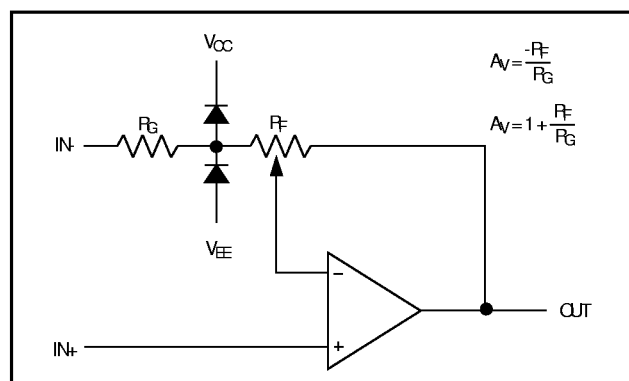


Figure 1. Internal Gain-Setting Resistors

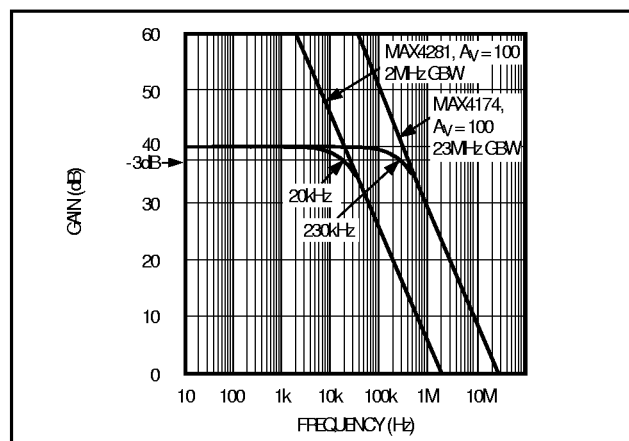


Figure 2. Gain-Bandwidth Comparison

MAX4174/5, MAX4274/5, MAX4281/2/4

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

cause output phase reversal. A back-to-back SCR structure at the input pins allows either input to safely swing  $\pm 17\text{V}$  relative to  $V_{EE}$  (Figure 3). Additionally, the internal op-amp inputs are diode clamped to either supply rail for the protection of sensitive input stage circuitry. Current through the clamp diodes is limited by a  $5\text{k}\Omega$  resistor at the noninverting input, and by  $R_G$  at the inverting input. An  $\text{IN}_+$  or  $\text{IN}_-$  fault voltage as high as  $\pm 17\text{V}$  will cause less than  $3.5\text{mA}$  of current to flow through the input pin, protecting both the Gain-Amp and the signal source from damage.

### Applications Information

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

### Gain-Amp Input Voltage Range

The MAX4174/MAX4175/MAX4274/MAX4275 combine both an op amp and gain-setting feedback resistors on the same chip. Because the inverting input pin is actually tied to the  $R_G$  input series resistor, the inverting input voltage range is different from the noninverting input voltage range. Just as with a discrete design, care must be taken not to saturate the inputs/output of the core op amp, to avoid signal distortions or clipping.

The inverting inputs ( $\text{IN}_-$ ) of the MAX4174/MAX4175/MAX4274/MAX4275 must be within the supply rails or signal distortion may result. The Gain-Amp's inverting input structure includes diodes to both supplies, such that driving the inverting input beyond the rails may cause signal distortions (Figure 1). For applications that require sensing voltages beyond the rails, use the MAX4281/MAX4282/MAX4284 open-loop op amps (Figure 4).

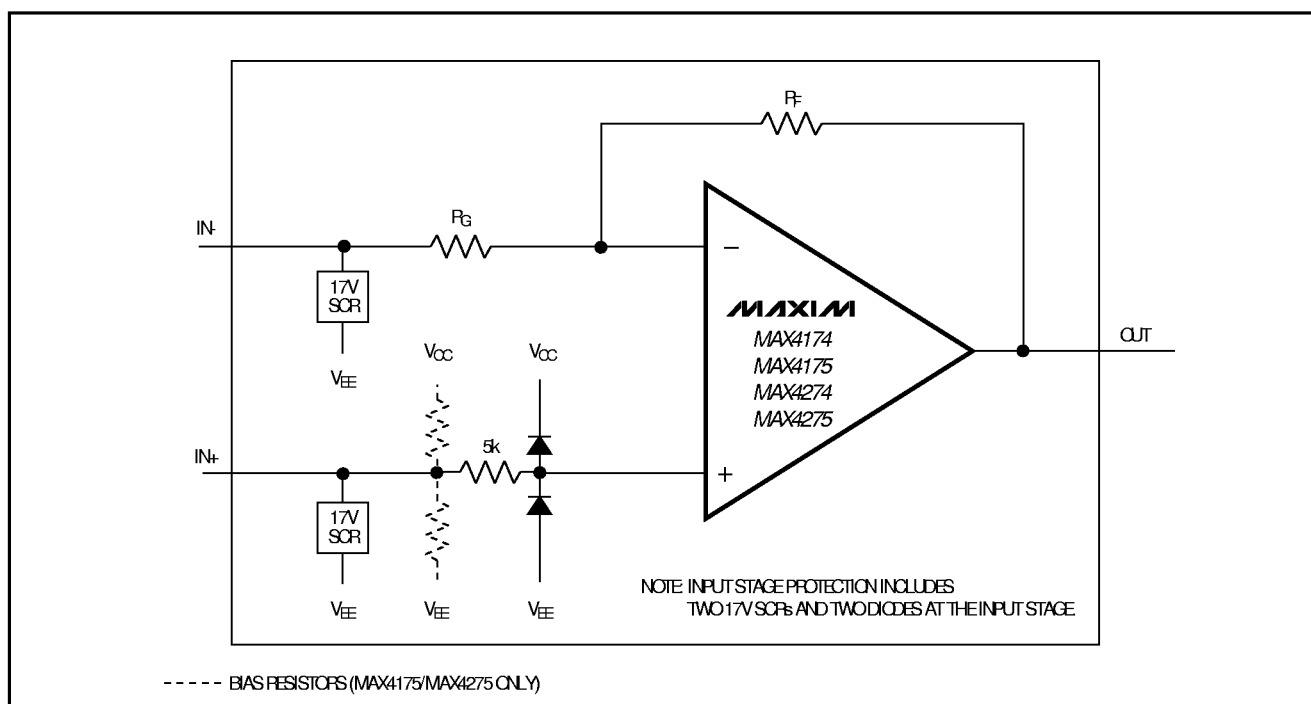


Figure 3. Input Protection

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

MAX4174/5, MAX4274/5, MAX4281/2/4

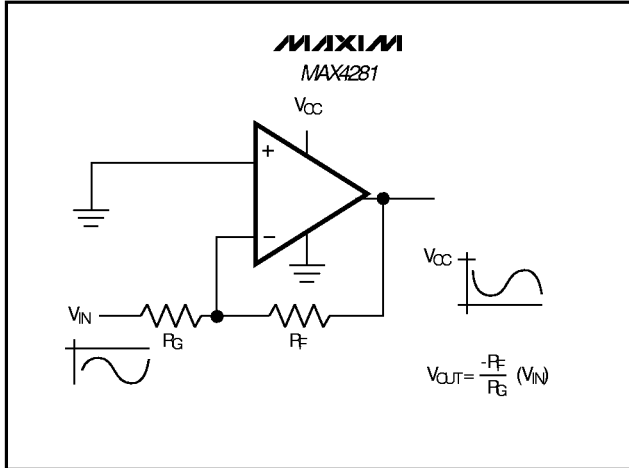


Figure 4. Single-Supply, DC-Coupled Inverting Amplifier with Negative Input Voltage

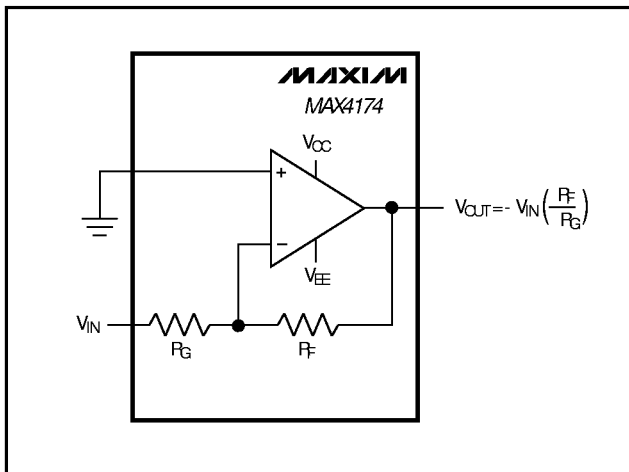


Figure 5. Dual-Supply, DC-Coupled Inverting Amplifier

## Gain-Amp Signal Coupling and Configurations

Common op-amp configurations include both noninverting and inverting amplifiers. Figures 5–8 show various single and dual-supply circuit configurations. Single-supply systems benefit from a midsupply bias on the noninverting input (provided internally on MAX4175/MAX4275), as this produces a quiescent DC level at the center of the rail-to-rail output stage signal swing. For dual-supply systems, ground-referenced signals may be DC-coupled into the inverting or noninverting inputs.

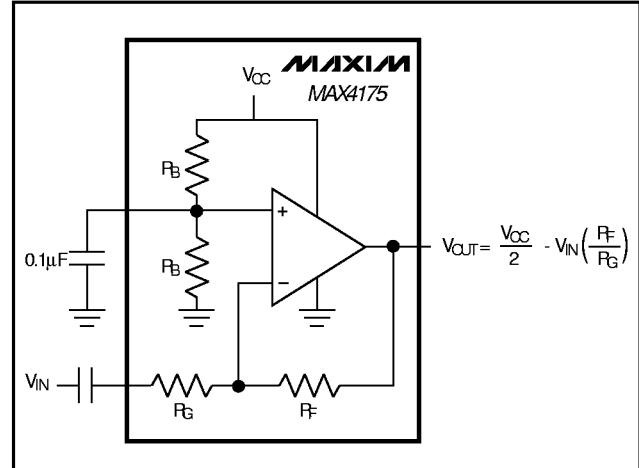


Figure 6. Single-Supply, AC-Coupled Inverting Amplifier

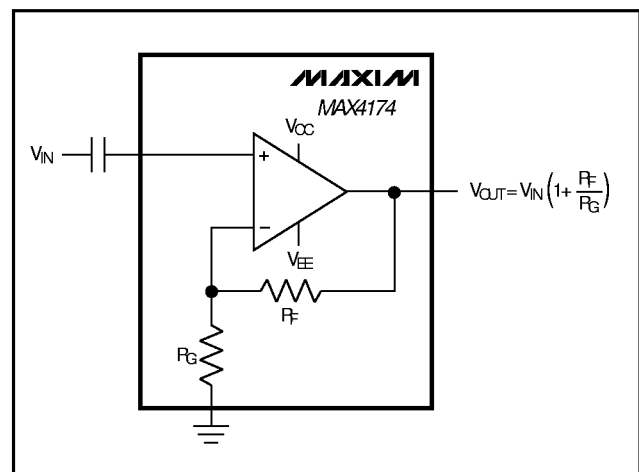


Figure 7. Dual-Supply, AC-Coupled Noninverting Amplifier

## IN<sub>+</sub> + Filter on MAX4175/MAX4275

Internal resistor biasing of the  $V_{CC} / 2$  bias options couples power-supply noise directly to the op amp's noninverting input. To minimize high-frequency power-supply noise coupling, add a  $1\mu\text{F}$  to  $0.1\mu\text{F}$  capacitor from  $\text{IN}_+$  to ground to create a lowpass filter (Figure 6). The low-pass filter resulting from the internal bias resistors and added capacitor can help eliminate higher frequency power-supply noise coupling through the noninverting input.

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

## Supply Bypassing and Board Layout

All devices in the Gain-Amp family operate from a +2.5V to +5.5V single supply or from  $\pm 1.25\text{V}$  to  $\pm 2.75\text{V}$  dual supplies. For single-supply operation, bypass the power supply with a  $0.1\mu\text{F}$  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 Gain-Amp family are stable with capacitive loads up to  $470\text{pF}$ . Stability with higher capacitive loads can be improved by adding an isolation resistor in series with the op-amp output, as shown in Figure 9. This resistor improves the circuit's phase margin by isolating the load capacitor from the amplifier's output. In Figure 10, a  $1000\text{pF}$  capacitor is driven with a  $100\Omega$  isolation resistor exhibiting some overshoot but no oscillation. Figures 11 and 12 show the typical small-signal pulse responses of Gain-Amp fixed-gain amplifiers with  $250\text{pF}$  and  $470\text{pF}$  capacitive loads and no isolation resistor.

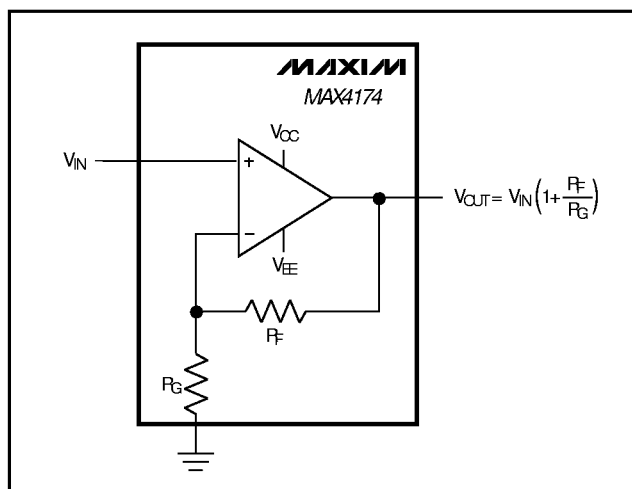


Figure 8. Dual-Supply, DC-Coupled Noninverting Amplifier

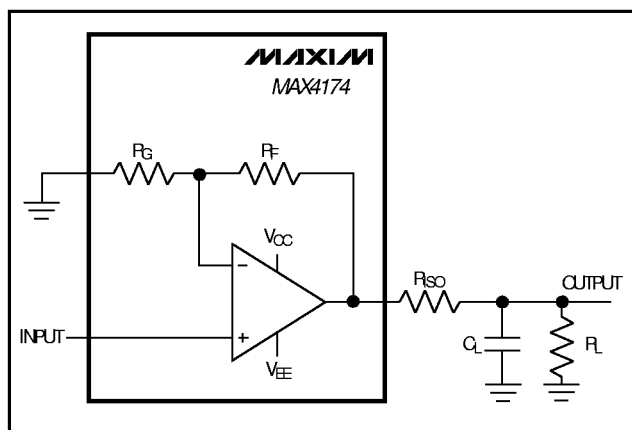


Figure 9. Dual-Supply, Capacitive-Load Driving Circuit

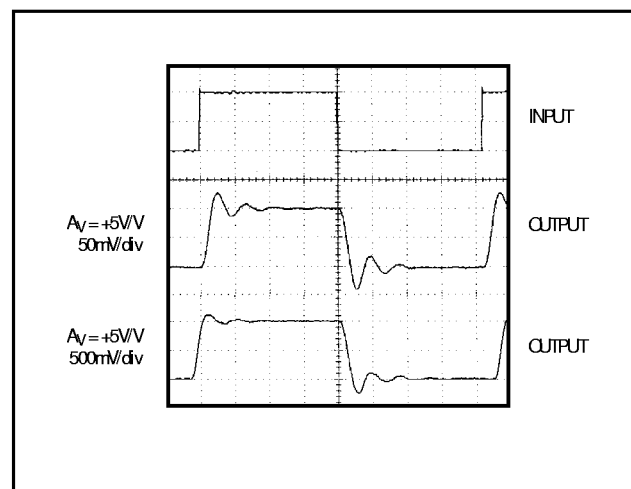


Figure 10. Small-Signal/Large-Signal Transient Response with Excessive Capacitive Load with Isolation Resistor

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

MAX4174/5, MAX4274/5, MAX4281/2/4

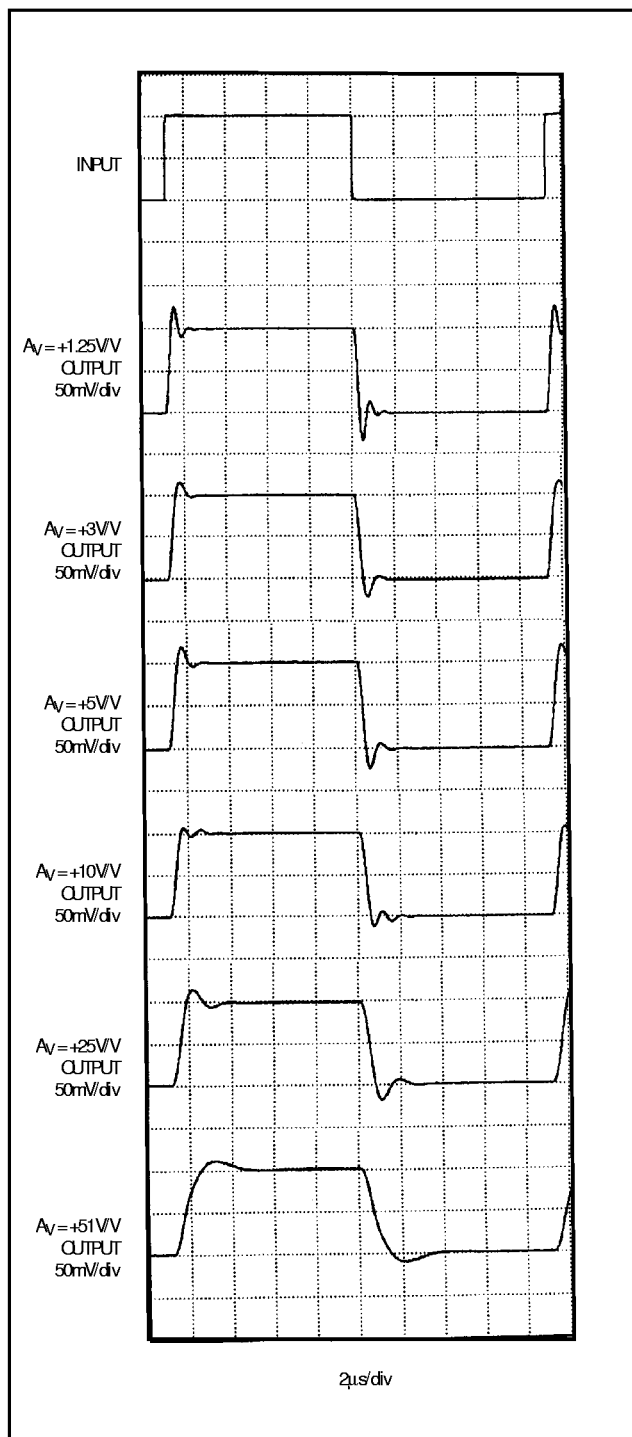


Figure 11. MAX4174/MAX4175 Small-Signal Pulse Response ( $C_L = 250\text{pF}$ ,  $R_L = 100\text{k}\Omega$ )

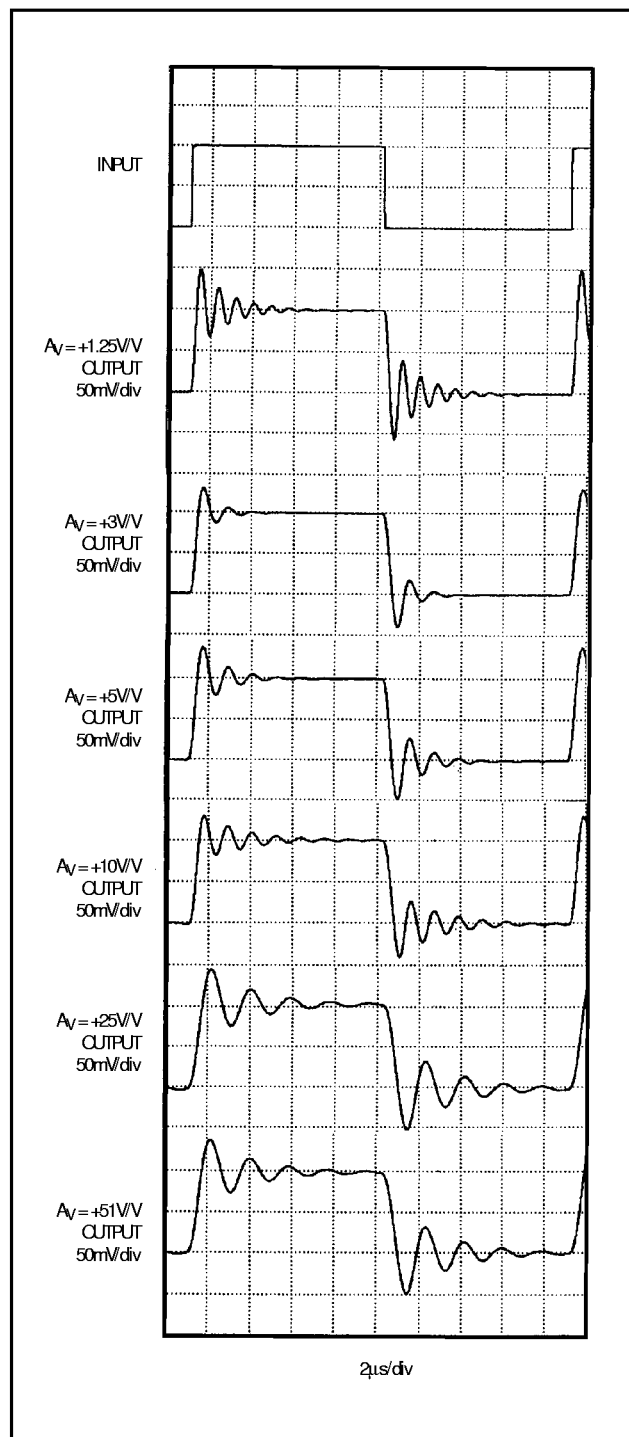


Figure 12. MAX4174/MAX4175 Small-Signal Pulse Response ( $C_L = 470\text{pF}$ ,  $R_L = 100\text{k}\Omega$ )

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

## Gain Selection Guide

| GAIN CODE | R <sub>F</sub> /R <sub>G</sub><br>INVERTING GAIN | 1+ (R <sub>F</sub> /R <sub>G</sub> )<br>NONINVERTING GAIN | -3dB BW (kHz) <sup>†</sup> | SOT TOP MARK |         |
|-----------|--------------------------------------------------|-----------------------------------------------------------|----------------------------|--------------|---------|
|           |                                                  |                                                           |                            | MAX4174      | MAX4175 |
| AB*       | 0.25                                             | 1.25                                                      | 1700                       | ACDS         | ACET    |
| AC        | 0.5                                              | 1.5                                                       | 1280                       | ACDT         | ACEU    |
| AD*       | 1                                                | 2                                                         | 590                        | ACDU         | ACEV    |
| AE        | 1.25                                             | 2.25                                                      | 450                        | ACDV         | ACEW    |
| AF        | 1.5                                              | 2.5                                                       | 1180                       | ACDW         | ACEX    |
| AG*       | 2                                                | 3                                                         | 970                        | ACDX         | ACEY    |
| AH        | 2.5                                              | 3.5                                                       | 820                        | ACDY         | ACEZ    |
| AJ        | 3                                                | 4                                                         | 690                        | ACDZ         | ACFA    |
| AK*       | 4                                                | 5                                                         | 970                        | ACEA         | ACFB    |
| AL        | 5                                                | 6                                                         | 790                        | ACEB         | ACFC    |
| AM        | 6                                                | 7                                                         | 640                        | ACEC         | ACFD    |
| AN        | 8                                                | 9                                                         | 480                        | ACED         | ACFE    |
| AO*       | 9                                                | 10                                                        | 640                        | ACEE         | ACFF    |
| BA*       | 10                                               | 11                                                        | 560                        | ACEF         | ACFG    |
| BB        | 12.5                                             | 13.5                                                      | 460                        | ACEG         | ACFH    |
| BC        | 15                                               | 16                                                        | 390                        | ACEH         | ACFI    |
| BD        | 20                                               | 21                                                        | 300                        | ACEI         | ACFJ    |
| BE*       | 24                                               | 25                                                        | 590                        | ACEJ         | ACFK    |
| BF        | 25                                               | 26                                                        | 580                        | ACEK         | ACFL    |
| BG        | 30                                               | 31                                                        | 510                        | ACEL         | ACFM    |
| BH        | 40                                               | 41                                                        | 390                        | ACEM         | ACFN    |
| BJ*       | 49                                               | 50                                                        | 310                        | ACEN         | ACFO    |
| BK*       | 50                                               | 51                                                        | 330                        | ACEO         | ACFP    |
| BL        | 60                                               | 61                                                        | 310                        | ACEP         | ACFQ    |
| BM        | 80                                               | 81                                                        | 260                        | ACEQ         | ACFR    |
| BN*       | 99                                               | 100                                                       | 230                        | ACER         | ACFS    |
| CA*       | 100                                              | 101                                                       | 230                        | ACES         | ACFT    |

**Note:** Gains in the noninverting configuration are 1+ (R<sub>F</sub>/R<sub>G</sub>) and range from +1.25V/V to +101V/V. For a +1V/V gain, use the MAX4281/MAX4282/MAX4284.

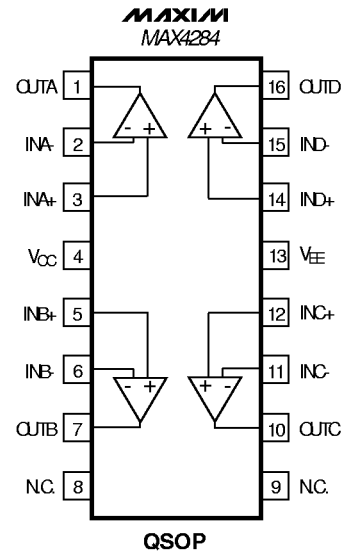
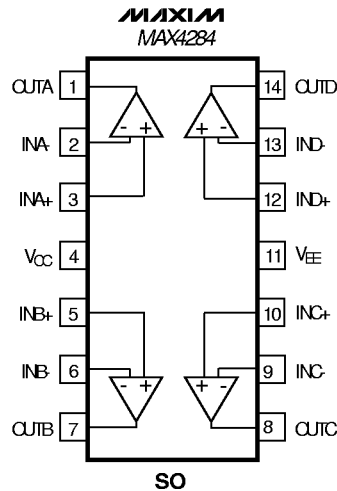
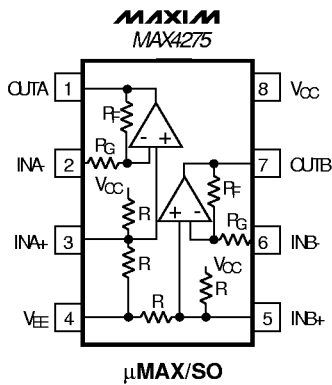
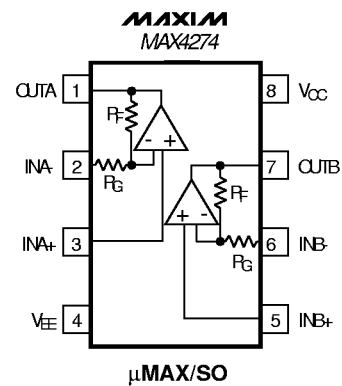
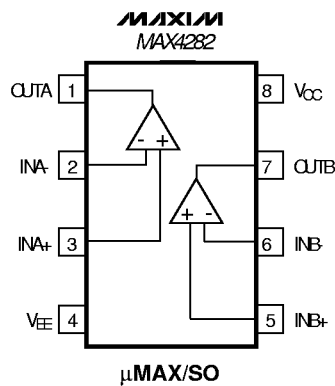
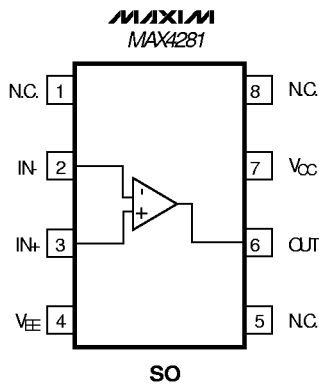
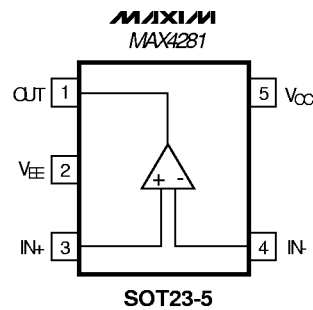
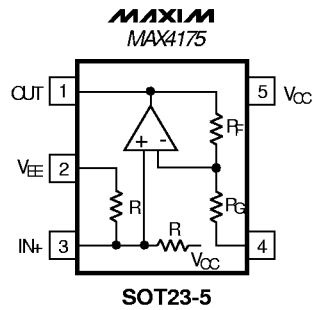
\* Preferred Gains. These gain versions are available as samples and in small quantities.

† The -3dB bandwidth is the same for inverting and noninverting configurations.

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

Pin Configurations (continued)

TOP VIEW



MAX4174/5, MAX4274/5, MAX4281/2/4

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

## Ordering Information (continued)

| PART*         | TEMP. RANGE    | PIN-PACKAGE | SOT TOP MARK |
|---------------|----------------|-------------|--------------|
| MAX4274_EUA** | -40°C to +85°C | 8 $\mu$ MAX |              |
| MAX4274_ESA** | -40°C to +85°C | 8 SO        |              |
| MAX4275_EUA** | -40°C to +85°C | 8 $\mu$ MAX |              |
| MAX4275_ESA** | -40°C to +85°C | 8 SO        |              |
| MAX4281EUK-T  | -40°C to +85°C | 5 SOT23-5   | ACDR         |
| MAX4281ESA    | -40°C to +85°C | 8 SO        |              |
| MAX4282EUA    | -40°C to +85°C | 8 $\mu$ MAX |              |
| MAX4282ESA    | -40°C to +85°C | 8 SO        |              |
| MAX4284ESD    | -40°C to +85°C | 14 SO       |              |
| MAX4284EEE    | -40°C to +85°C | 16 QSOP     |              |

**Note:** Refer to Gain Selection Guide for SOT top marks.

\* Insert the desired gain code (from the Gain Selection Guide) in the blank to complete the part number. Refer to Gain Selection Guide for a list of preferred gains.

\*\* Future product—contact factory for availability.

## Chip Information

### TRANSISTOR COUNTS:

MAX4174: 178

MAX4175: 178

MAX4274: 332

MAX4275: 332

MAX4281: 178

MAX4282: 332

MAX4284: 328

SUBSTRATE CONNECTED TO VEE

## Selector Guide

| PART*      | INVERTING GAINS AVAILABLE (V/V) (INVERTING, $R_F/R_G$ ) | NONINVERTING GAIN (V/V) | INTERNAL RESISTORS | INTERNAL $V_{CC} / 2$ BIAS | NO. OF AMPS PER PACKAGE | PIN-PACKAGE            |
|------------|---------------------------------------------------------|-------------------------|--------------------|----------------------------|-------------------------|------------------------|
| MAX4174_   | -0.25 to -100                                           | +1.25 to +101           | Yes                | No                         | 1                       | 5-pin SOT23            |
| MAX4175_   | -0.25 to -100                                           | +1.25 to +101           | Yes                | Yes                        | 1                       | 5-pin SOT23            |
| MAX4274_** | -0.25 to -100                                           | +1.25 to +101           | Yes                | No                         | 2                       | 8-pin $\mu$ MAX/SO     |
| MAX4275_** | -0.25 to -100                                           | +1.25 to +101           | Yes                | Yes                        | 2                       | 8-pin $\mu$ MAX/SO     |
| MAX4281    | Open Loop, Unity-Gain Stable                            |                         | No                 | No                         | 1                       | 5-pin SOT23, 8-pin SO  |
| MAX4282    | Open Loop, Unity-Gain Stable                            |                         | No                 | No                         | 2                       | 8-pin $\mu$ MAX/SO     |
| MAX4284    | Open Loop, Unity-Gain Stable                            |                         | No                 | No                         | 4                       | 14-pin SO, 16-pin QSOP |

\* Insert the desired gain code (from the Gain Selection Guide) in the blank to complete the part number.

\*\* Future product—contact factory for availability.