

# MAXIM

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

### General Description

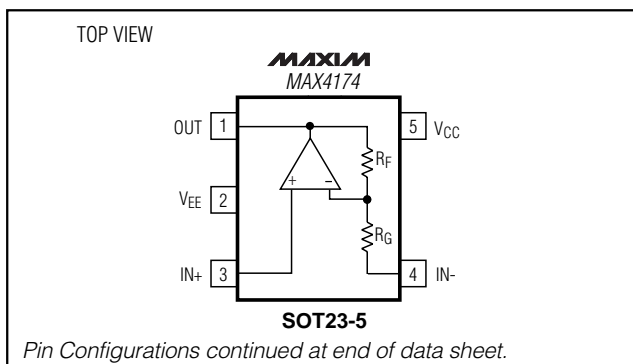
The MAX4174/MAX4175/MAX4274/MAX4275 GainAmp™ family combines a low-cost Rail-to-Rail® op amp with precision internal gain-setting resistors and  $V_{CC} / 2$  biasing. Factory-trimmed on-chip resistors decrease design size, cost, and layout, and provide 0.1% gain accuracy. Fixed inverting gains from  $-0.25V/V$  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  $300\mu A$ . GainAmp 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

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

### Features

- ◆ GainAmp 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-PACKAGE	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	††

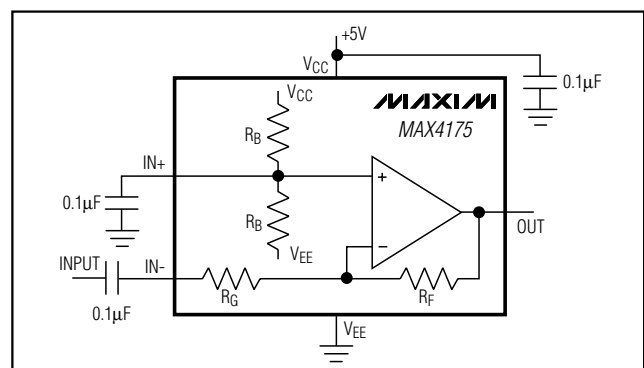
Ordering Information continued at end of data sheet.

\* 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 GainAmps/Open-Loop Op Amps

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V <sub>CC</sub> to V <sub>EE</sub> )	.....-0.3V to +6V	8-Pin $\mu$ MAX (derate 4.1mW/°C above +70°C)	.....330mW
Voltage Inputs (IN <sub>-</sub> )		14-Pin SO (derate 8.3mW/°C above +70°C)	.....667mW
MAX4281/4282/4284	.....(V <sub>EE</sub> - 0.3V) to (V <sub>CC</sub> + 0.3V)	16-Pin QSOP (derate 8.3mW/°C above +70°C)	.....667mW
MAX4174/4175/4274/4275 (with respect to GND)	..... $\pm$ 17V	Operating Temperature Range	.....-40°C to +85°C
Output Short-Circuit Duration (OUT <sub>-</sub> )	.....Continuous to Either V <sub>EE</sub> or V <sub>CC</sub>	Maximum 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
8-Pin SO (derate 5.88mW/°C above +70°C)	.....471mW		

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

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

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

## ELECTRICAL CHARACTERISTICS—MAX4174/MAX4175/MAX4274/MAX4275 Fixed-Gain Amplifiers (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  $T_A = +25^{\circ}C$ .)

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		$(V_{EE} + 25mV) < V_{OUT} < (V_{CC} - 25mV)$ , $R_L = 100k\Omega$ (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	$R_{OUT}$	$A_V = 1V/V$		0.02		$\Omega$

# SOT23, Rail-to-Rail, Fixed-Gain GainAmps/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	mV
			$V_{OL} - V_{EE}$	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, $A_V = 1V/V$		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 GainAmp.

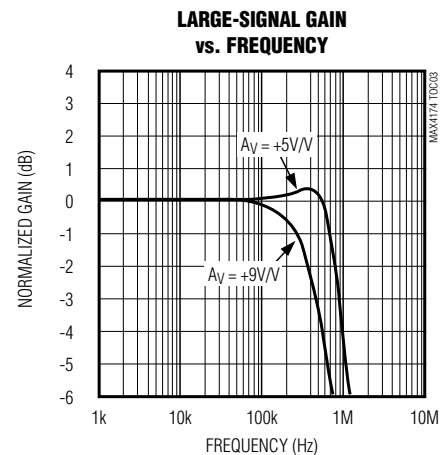
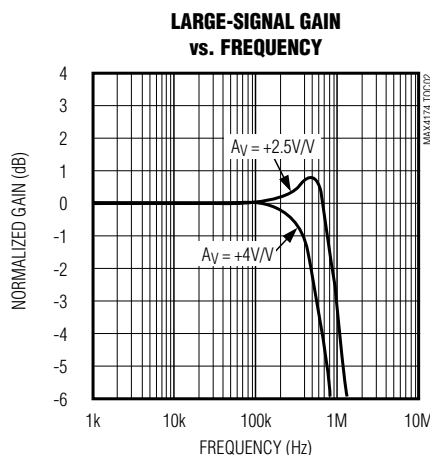
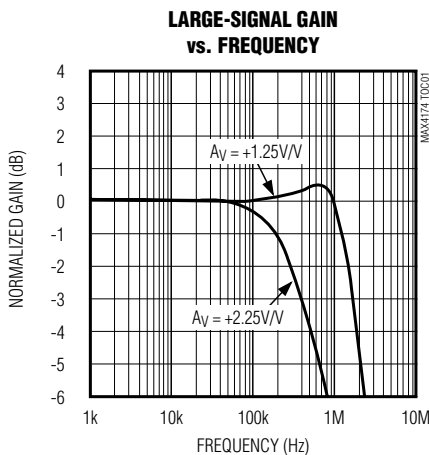
**Note 4:** For  $A_V = -0.5V/V$  and  $A_V = -0.25V/V$ , the output voltage swing is limited by the input voltage range.

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

**Note 6:** The gain accuracy test is performed with the GainAmp 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  $V_{OUT} = 100mVp-p$ , large-signal  $V_{OUT} = 1Vp-p$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



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

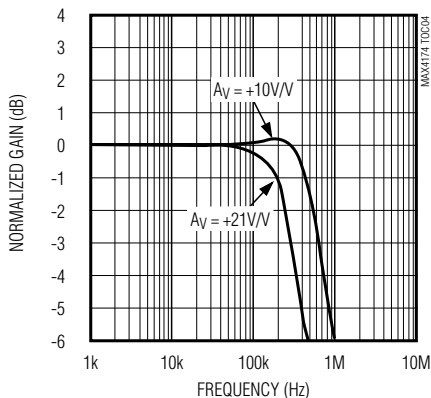
## Typical Operating Characteristics (continued)

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

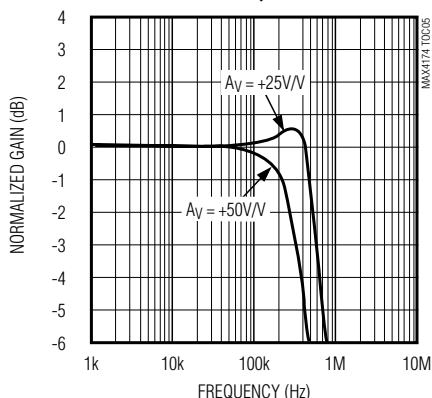
MAX4174/5, MAX4274/5, MAX4281/2/4

### MAX4174/MAX4175

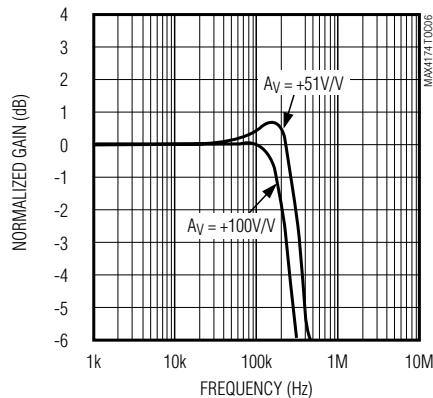
**LARGE-SIGNAL GAIN vs. FREQUENCY**



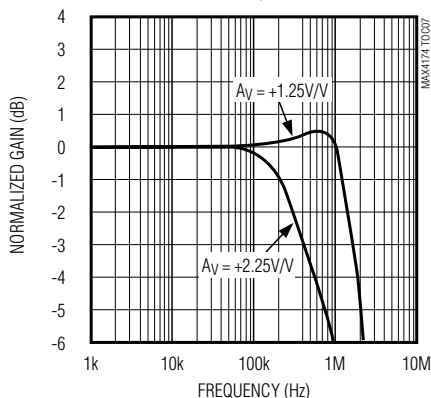
**LARGE-SIGNAL GAIN vs. FREQUENCY**



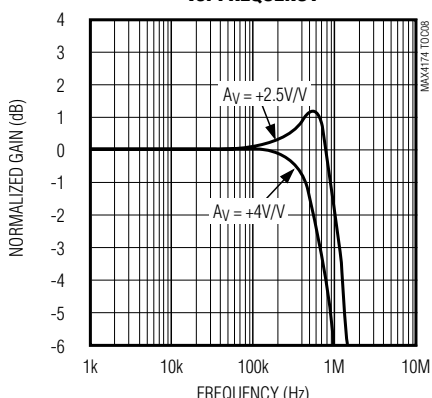
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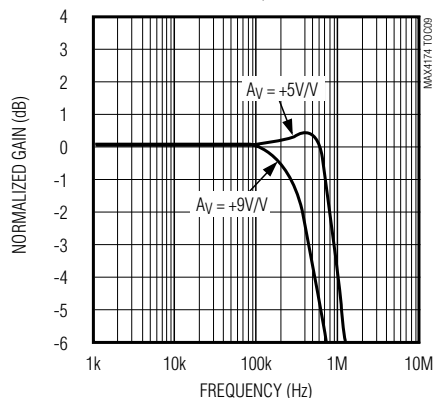
**SMALL-SIGNAL GAIN vs. FREQUENCY**



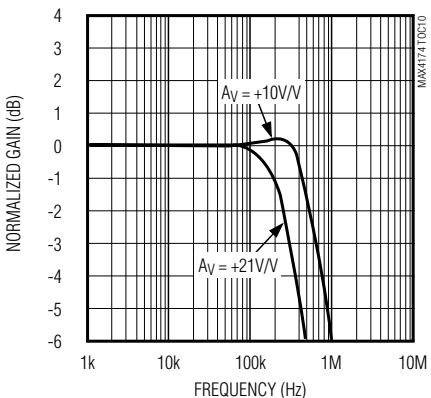
**SMALL-SIGNAL GAIN vs. FREQUENCY**



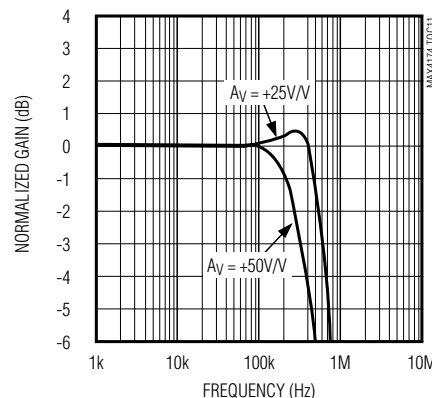
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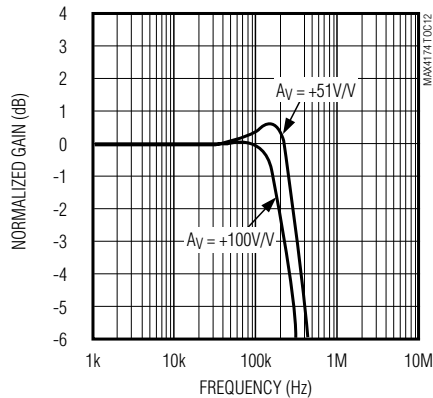
**SMALL-SIGNAL GAIN vs. FREQUENCY**



**SMALL-SIGNAL GAIN vs. FREQUENCY**



**SMALL-SIGNAL GAIN vs. FREQUENCY**

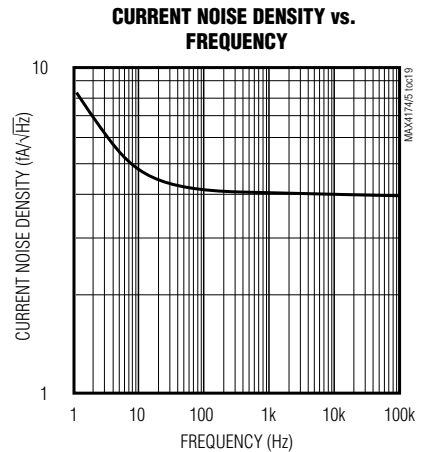
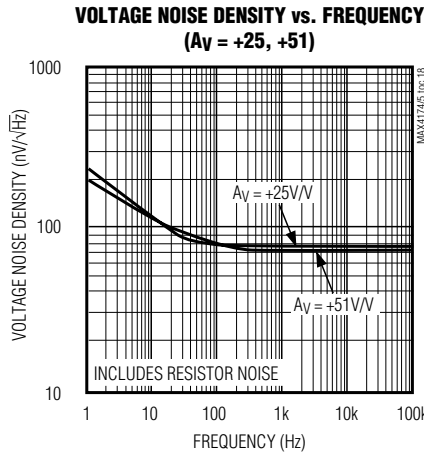
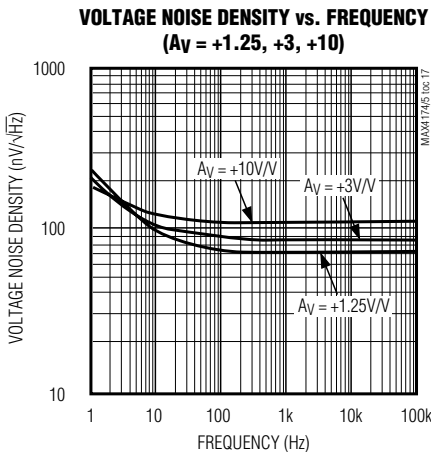
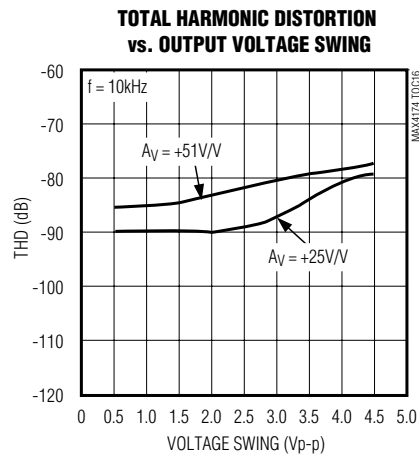
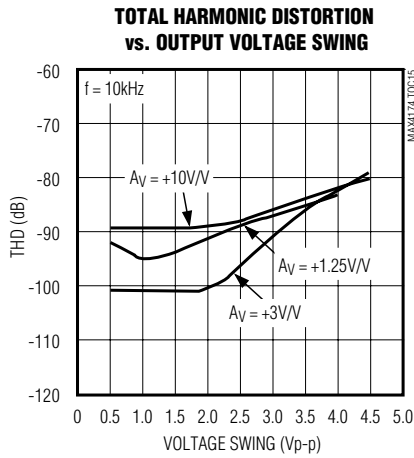
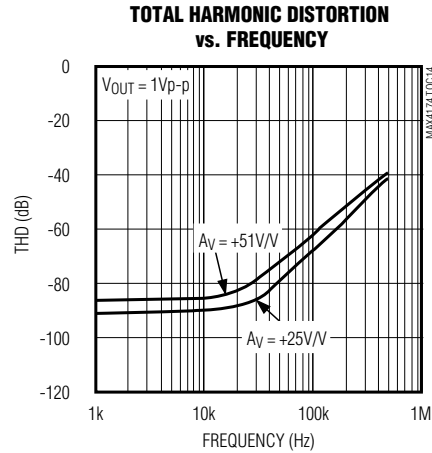
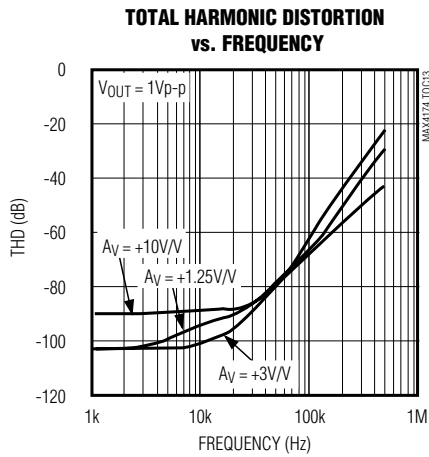


# SOT23, Rail-to-Rail, Fixed-Gain GainAmps/Open-Loop Op Amps

## 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



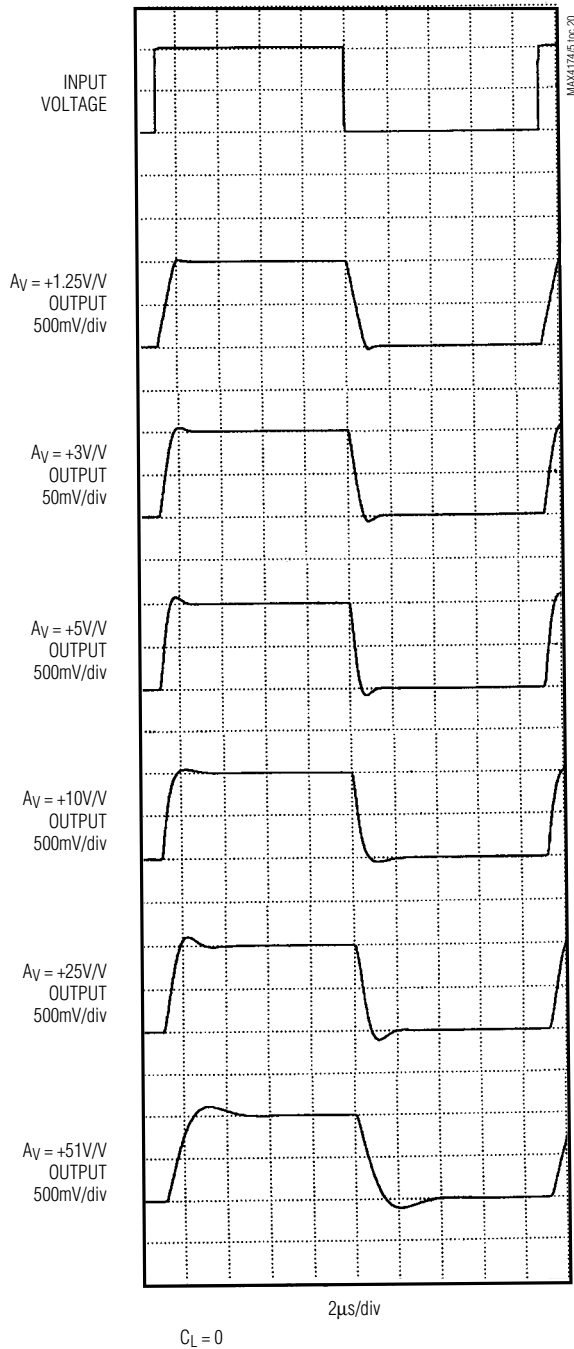
# SOT23, Rail-to-Rail, Fixed-Gain GainAmps/Open-Loop Op Amps

## Typical Operating Characteristics (continued)

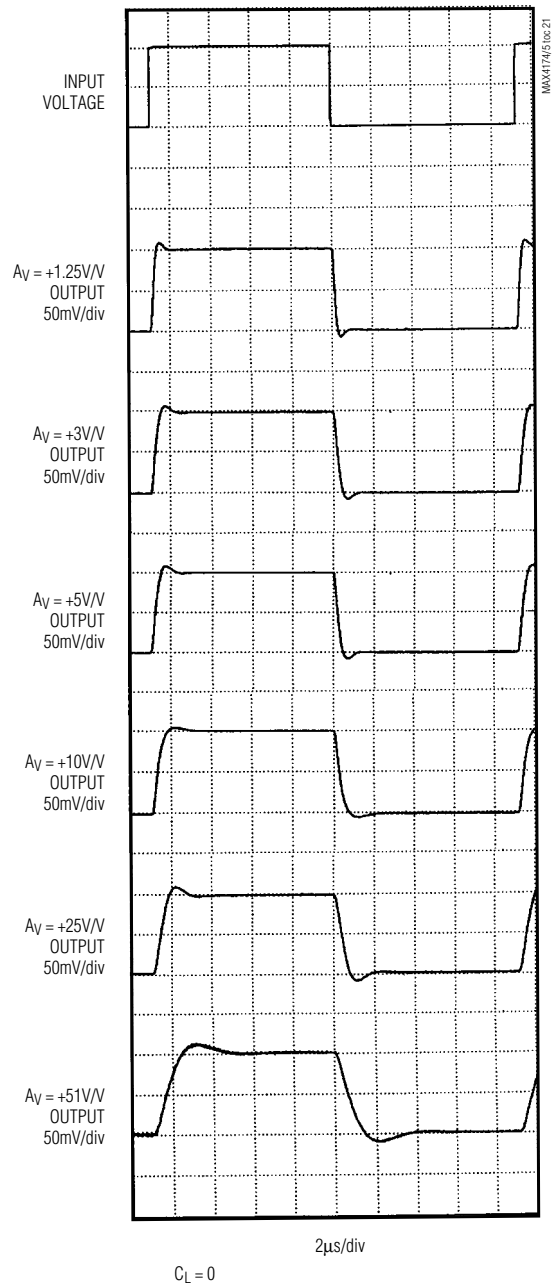
( $V_{CC} = +5V$ ,  $R_L = 100k\Omega$  to  $V_{CC} / 2$ , small-signal  $V_{OUT} = 100mVp-p$ , large-signal  $V_{OUT} = 1Vp-p$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

### MAX4174/MAX4175

#### LARGE-SIGNAL PULSE RESPONSE



#### SMALL-SIGNAL PULSE RESPONSE



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

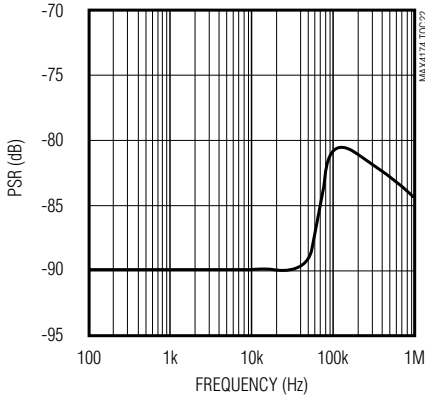
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## Typical Operating Characteristics (continued)

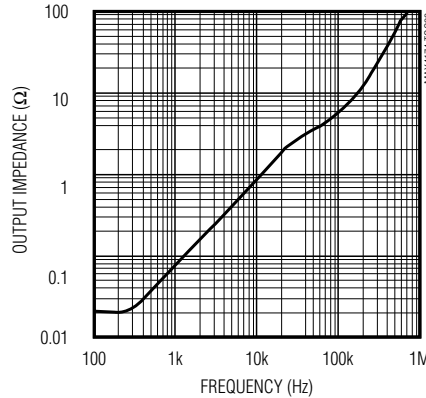
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### MAX4174/MAX4175/MAX4281/MAX4282/MAX4284

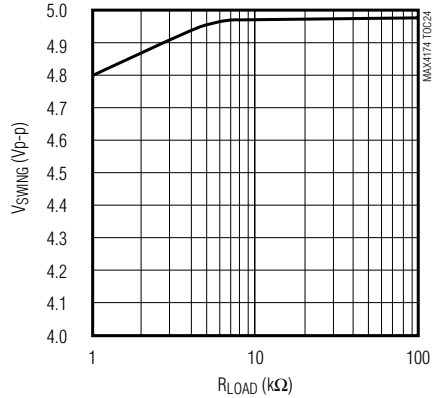
**POWER-SUPPLY REJECTION vs. FREQUENCY**



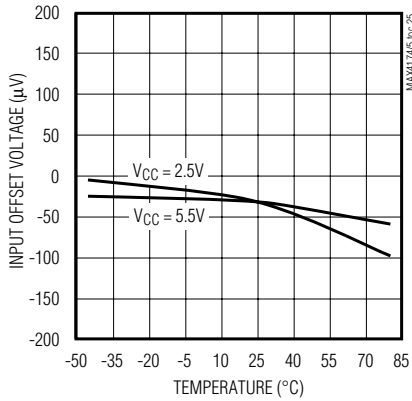
**OUTPUT IMPEDANCE vs. FREQUENCY**



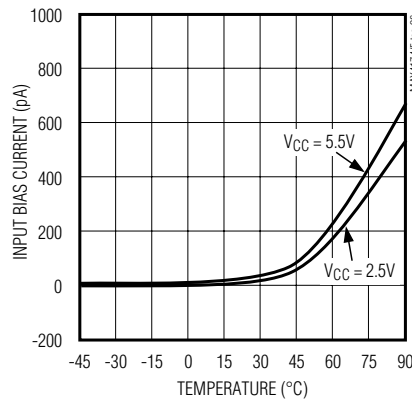
**OUTPUT VOLTAGE SWING vs. RLOAD**



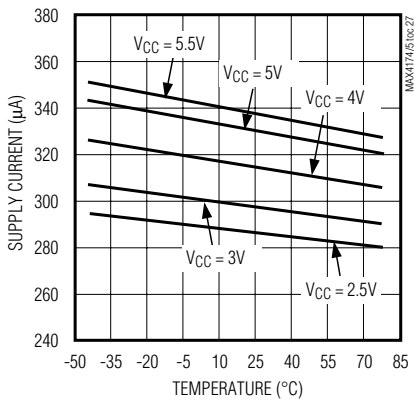
**INPUT OFFSET VOLTAGE vs. TEMPERATURE**



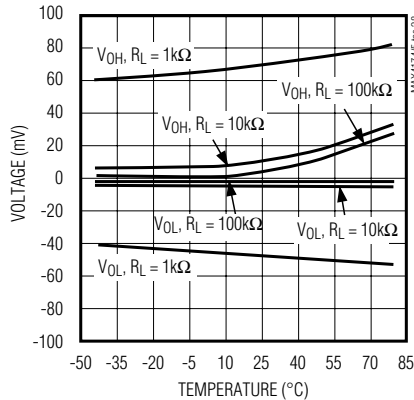
**INPUT BIAS CURRENT vs. TEMPERATURE**



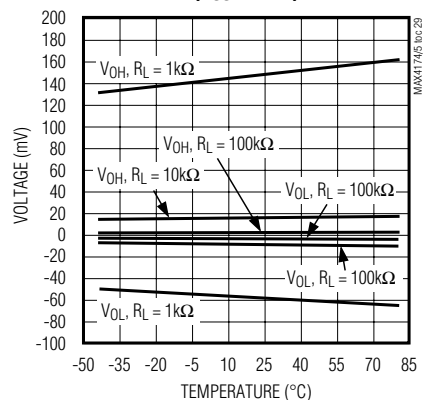
**SUPPLY CURRENT vs. TEMPERATURE**



**VOH AND VOL vs. TEMPERATURE (VCC = 2.5V)**



**VOH AND VOL vs. TEMPERATURE (VCC = 5.5V)**





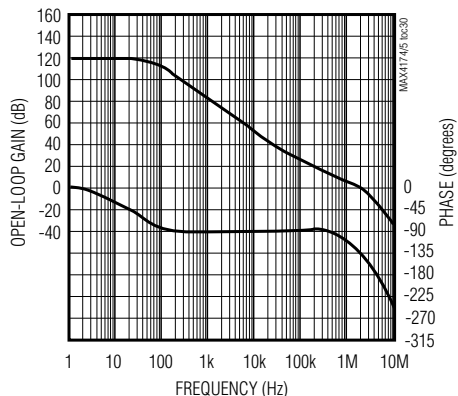
# SOT23, Rail-to-Rail, Fixed-Gain GainAmps/Open-Loop Op Amps

## Typical Operating Characteristics

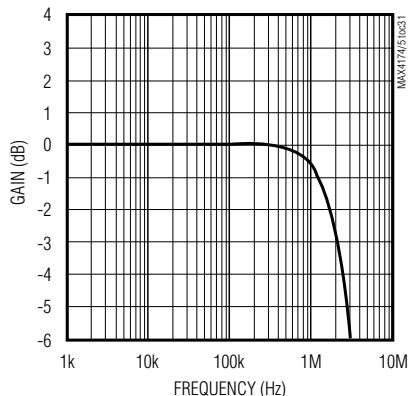
( $V_{CC} = +5V$ ,  $R_L = 100k\Omega$  to  $V_{CC} / 2$ , small-signal  $V_{OUT} = 100mV_{p-p}$ , large-signal  $V_{OUT} = 1V_{p-p}$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

### MAX4281/MAX4282/MAX4284

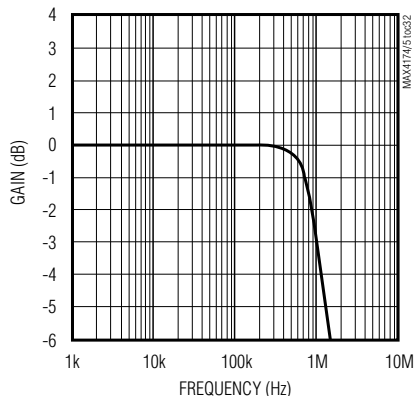
**OPEN-LOOP GAIN AND PHASE vs. FREQUENCY**



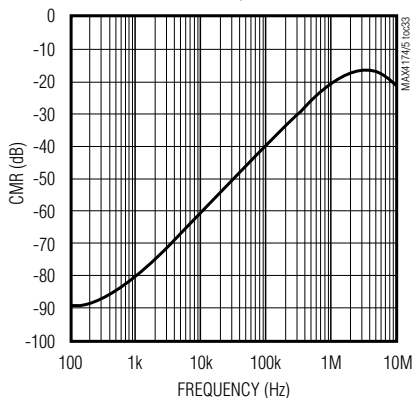
**SMALL-SIGNAL GAIN vs. FREQUENCY**



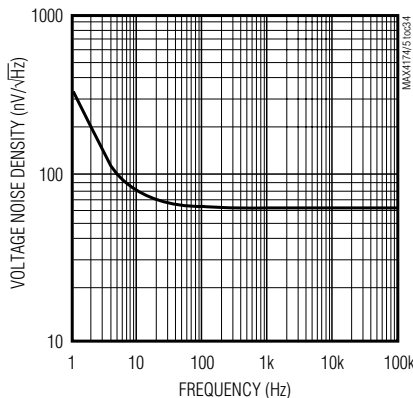
**LARGE-SIGNAL GAIN vs. FREQUENCY**



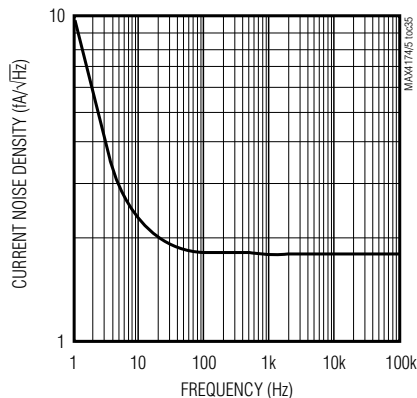
**COMMON-MODE REJECTION vs. FREQUENCY**



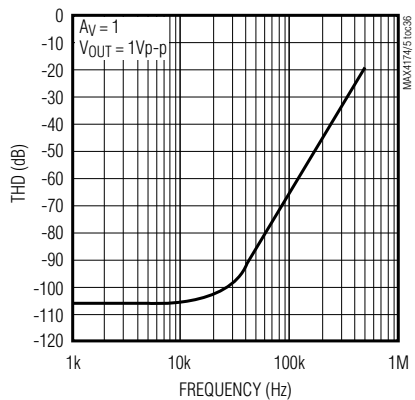
**VOLTAGE NOISE DENSITY vs. FREQUENCY**



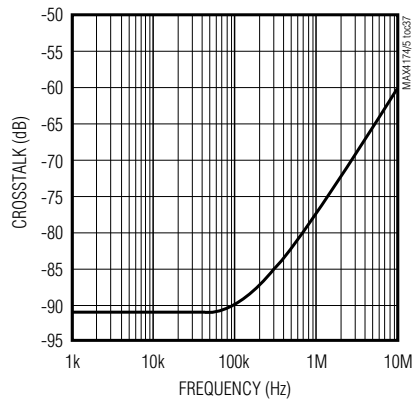
**CURRENT NOISE DENSITY vs. FREQUENCY**



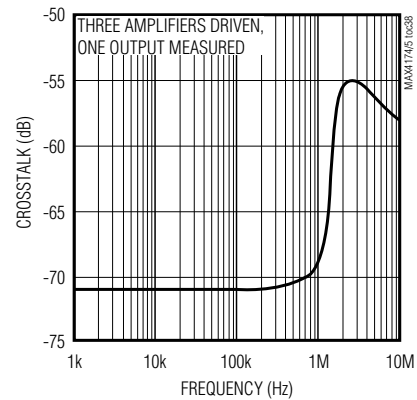
**TOTAL HARMONIC DISTORTION vs. FREQUENCY**



**MAX4282 CROSSTALK vs. FREQUENCY**



**MAX4284 CROSSTALK vs. FREQUENCY**



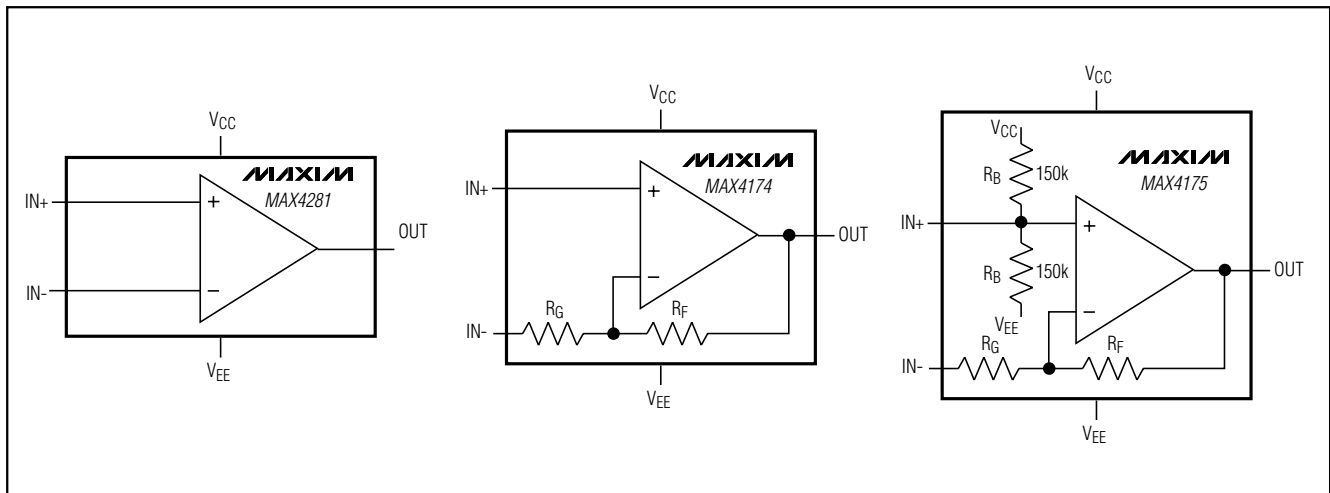
MAX4174/5, MAX4274/5, MAX4281/2/4

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

## Pin Description

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

## Functional Diagrams



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

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

## 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. 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 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.

### 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 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 drop in directly to existing board designs, easily replacing op-amp-plus-resistor gain blocks.

### 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  $A_V = 100V/V$  has a -3dB bandwidth of 230kHz. By comparison, a unity-gain-stable op amp configured for  $A_V = 100V/V$  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 GainAmp fixed-gain amplifiers with the  $V_{CC} / 2$  bias option are identical to standard GainAmp 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 ( $\pm 17V$ ) Input Fault Protection

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

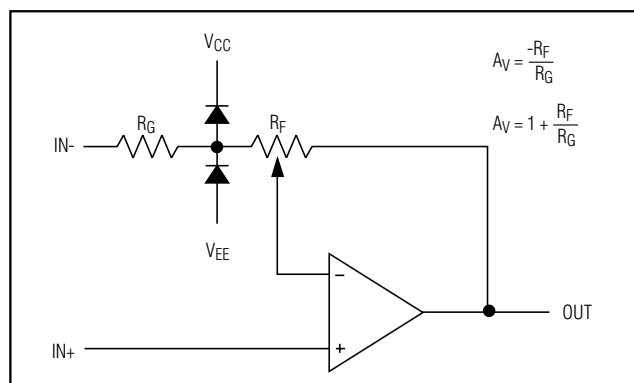


Figure 1. Internal Gain-Setting Resistors

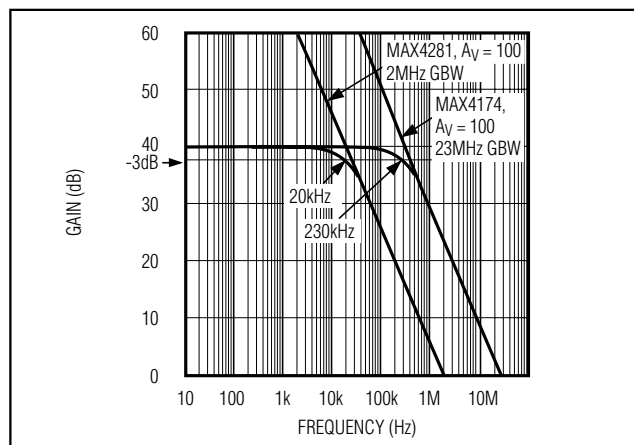


Figure 2. Gain-Bandwidth Comparison

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

cause output phase reversal. A back-to-back SCR structure at the input pins allows either input to safely swing  $\pm 17V$  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  $5k\Omega$  resistor at the noninverting input, and by  $R_G$  at the inverting input. An  $IN+$  or  $IN-$  fault voltage as high as  $\pm 17V$  will cause less than  $3.5mA$  of current 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 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 GainAmp.

## GainAmp 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 ( $IN_-$ ) of the MAX4174/MAX4175/MAX4274/MAX4275 must be within the supply rails or signal distortion may result. The GainAmp'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).

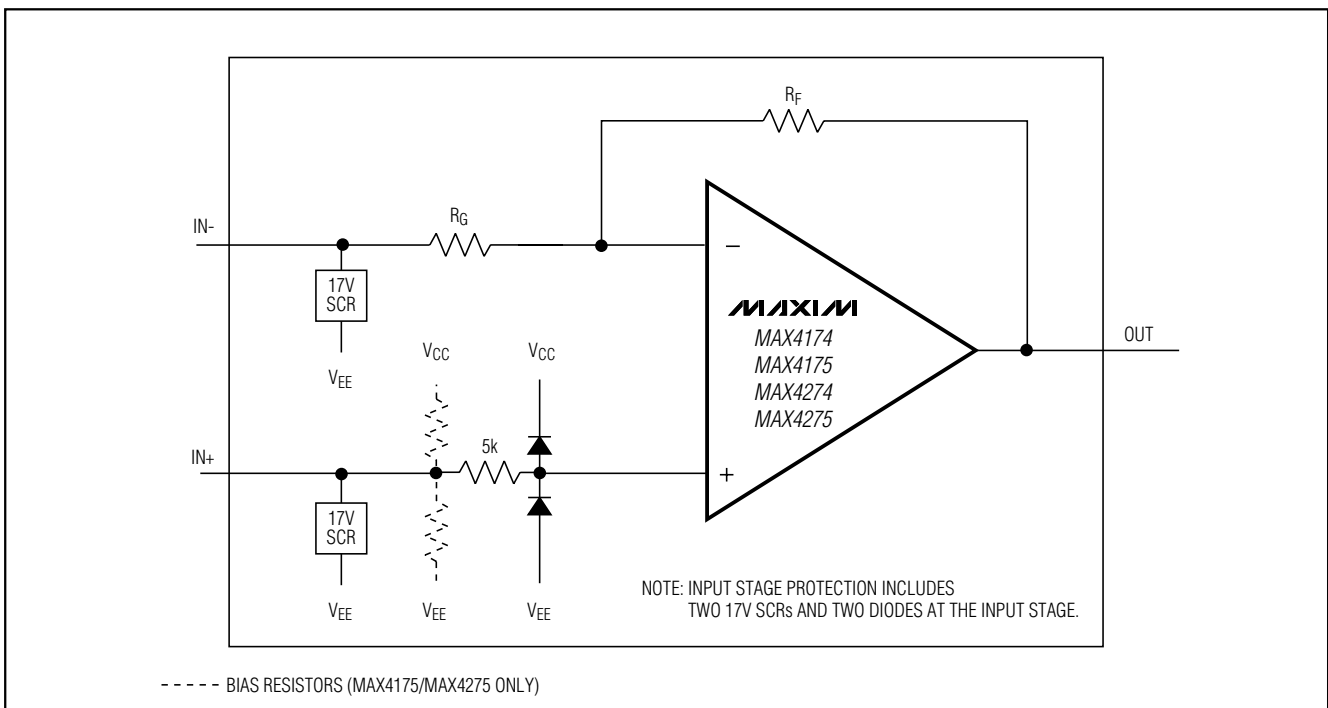


Figure 3. Input Protection

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

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

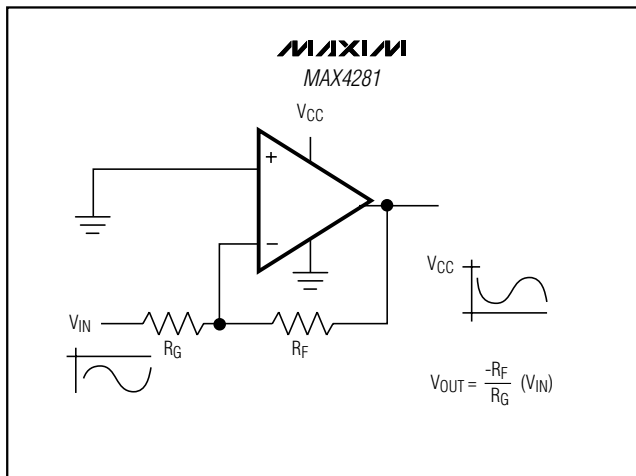


Figure 4. Single-Supply, DC-Coupled Inverting Amplifier with Negative Input Voltage

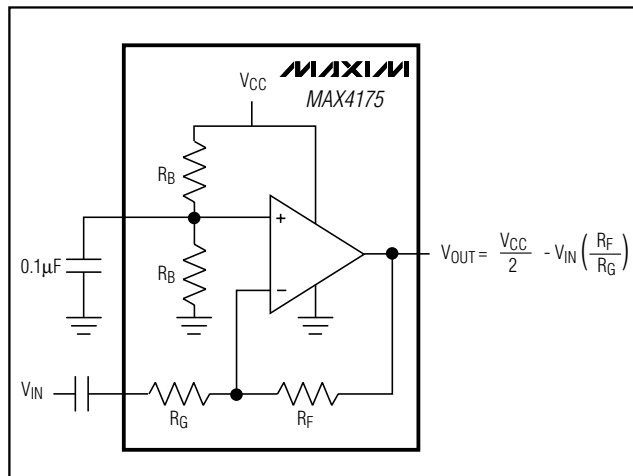


Figure 6. Single-Supply, AC-Coupled Inverting Amplifier

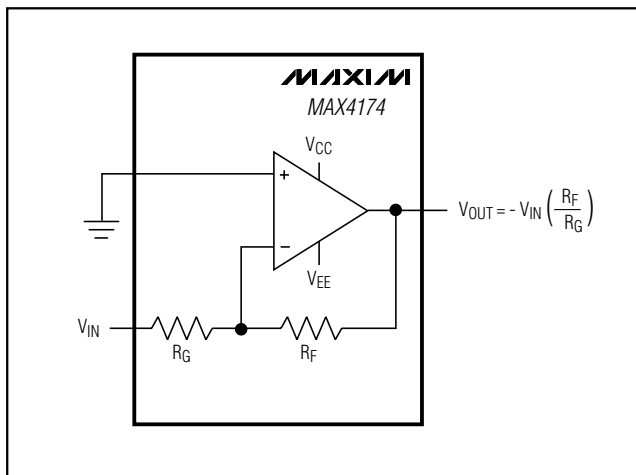


Figure 5. Dual-Supply, DC-Coupled Inverting Amplifier

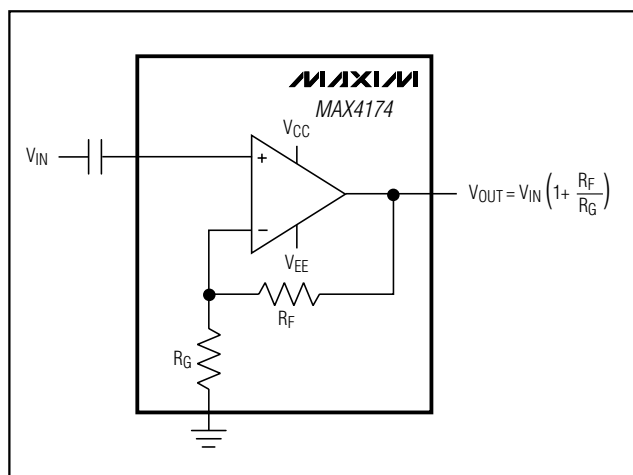


Figure 7. Dual-Supply, AC-Coupled Noninverting Amplifier

## GainAmp 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.

## 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 IN<sub>+</sub> to ground to create a lowpass filter (Figure 6). The lowpass 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 GainAmps/Open-Loop Op Amps

## Supply Bypassing and Board Layout

All devices in the 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 470pF. 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 1000pF capacitor is driven with a 100Ω isolation resistor exhibiting some overshoot but no oscillation. Figures 11 and 12 show the typical small-signal pulse responses of GainAmp fixed-gain amplifiers with 250pF and 470pF capacitive loads and no isolation resistor.

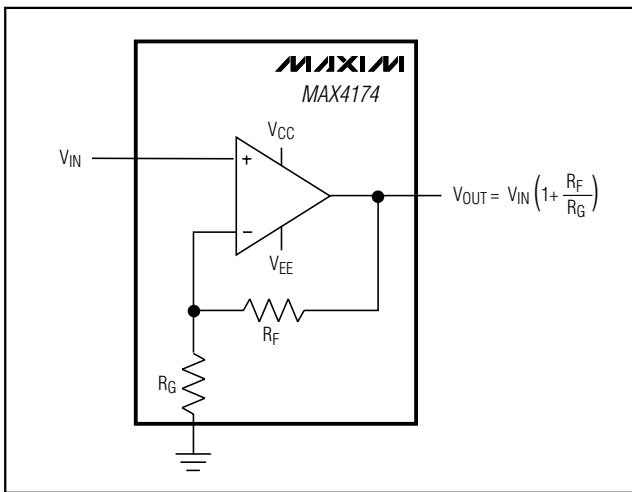


Figure 8. Dual-Supply, DC-Coupled Noninverting Amplifier

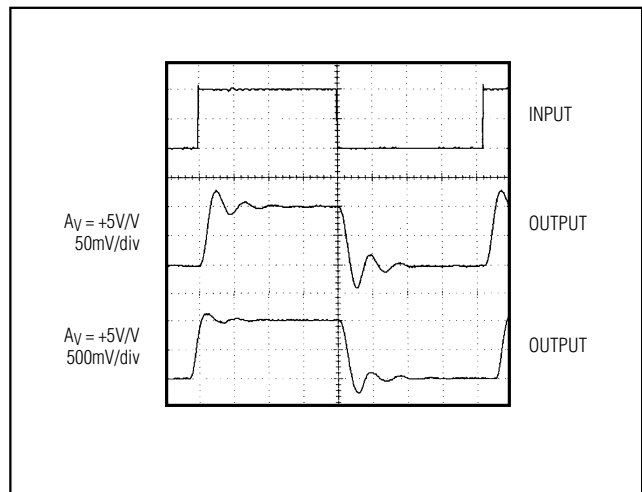


Figure 10. Small-Signal/Large-Signal Transient Response with Excessive Capacitive Load with Isolation Resistor

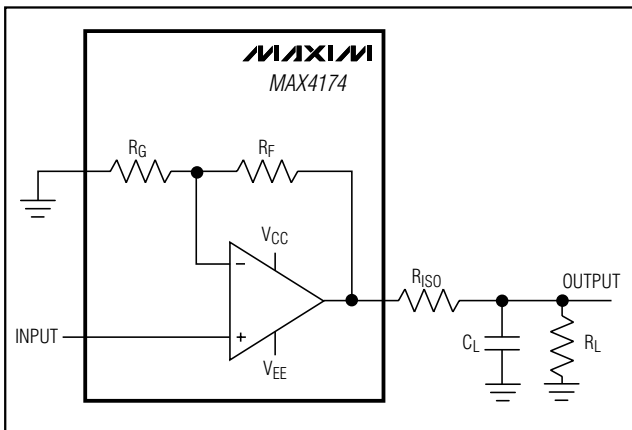


Figure 9. Dual-Supply, Capacitive-Load Driving Circuit

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

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

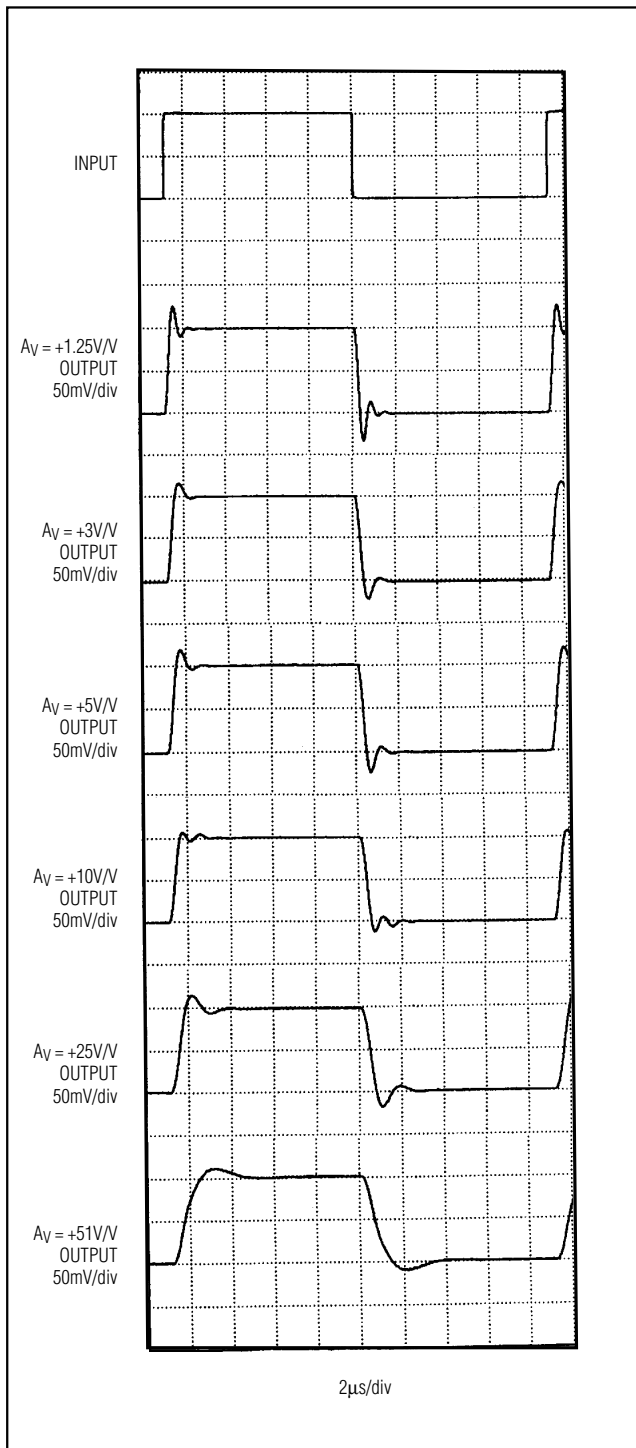


Figure 11. MAX4174/MAX4175 Small-Signal Pulse Response ( $C_L = 250\text{pF}$ ,  $R_L = 100\text{k}\Omega$ )

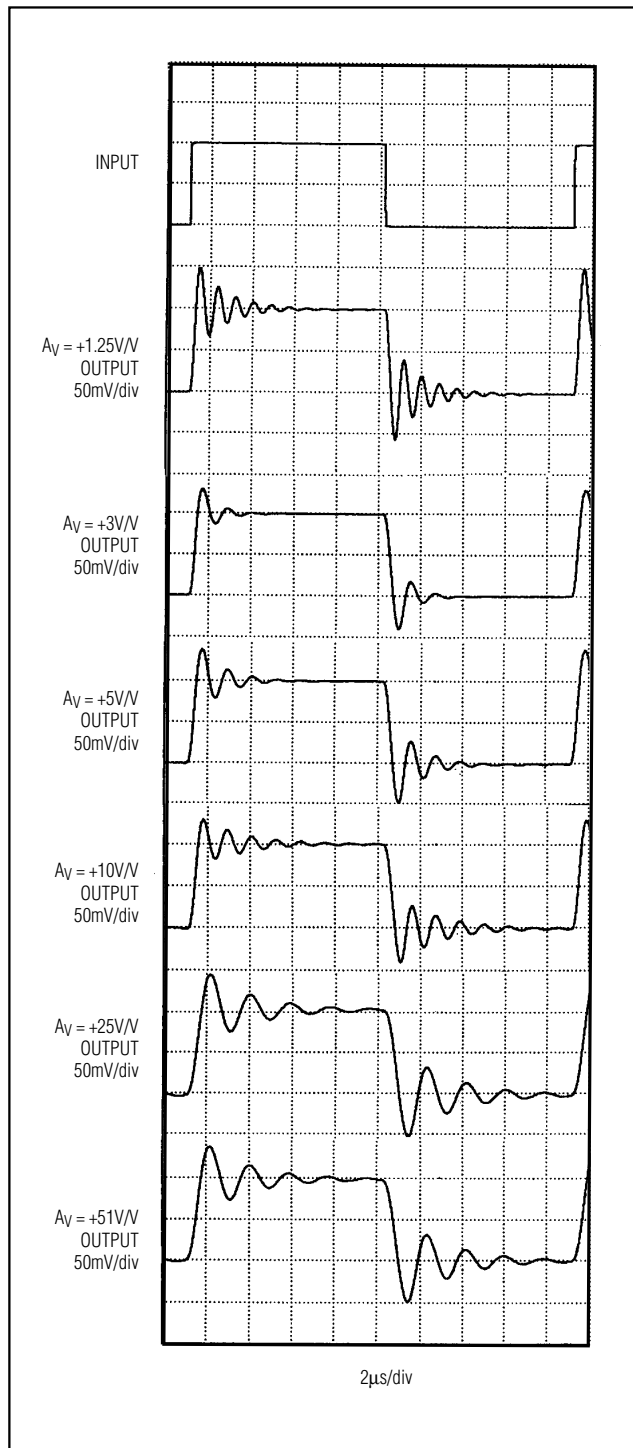


Figure 12. MAX4174/MAX4175 Small-Signal Pulse Response ( $C_L = 470\text{pF}$ ,  $R_L = 100\text{k}\Omega$ )

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

## Gain Selection Guide

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

GAIN CODE	R <sub>F</sub> /R <sub>G</sub> INVERTING GAIN	1+ (R <sub>F</sub> /R <sub>G</sub> ) NONINVERTING GAIN	-3dB BW (kHz) <sup>†</sup>	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  $1 + (R_F/R_G)$  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.

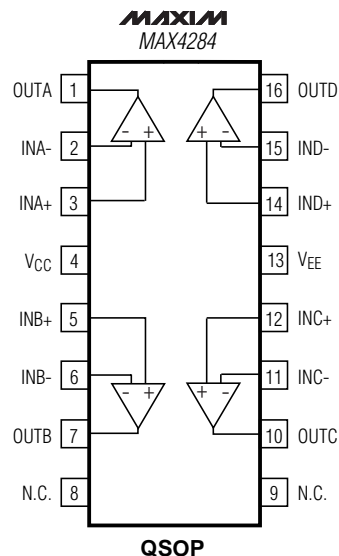
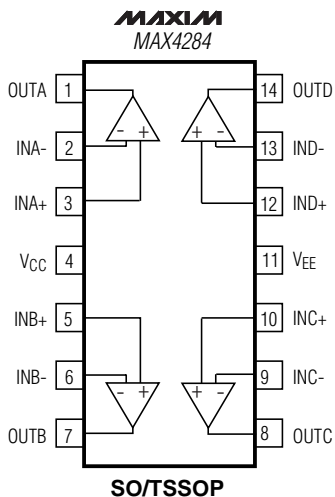
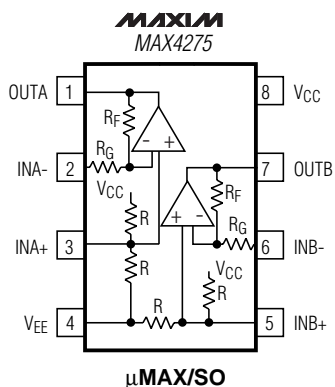
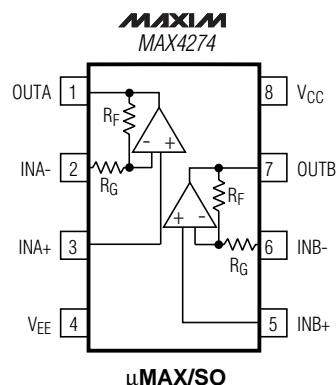
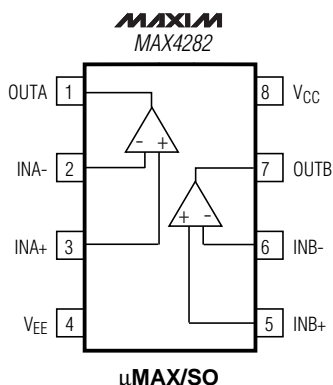
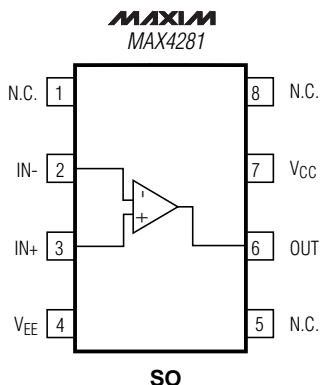
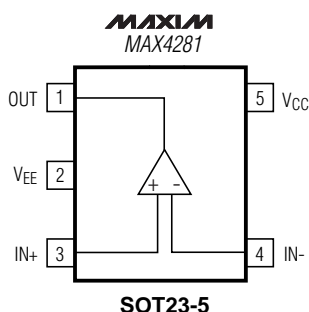
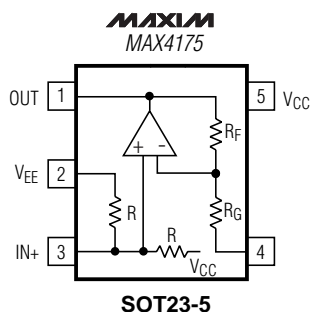


# SOT23, Rail-to-Rail, Fixed-Gain GainAmps/Open-Loop Op Amps

Pin Configurations (continued)

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

TOP VIEW



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

## Ordering Information (continued)

## Chip Information

PART*	TEMP. RANGE	PIN-PACKAGE	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	—
MAX4284EUD	-40°C to +85°C	14 TSSOP	—
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.

TRANSISTOR COUNTS:

MAX4174: 178

MAX4175: 178

MAX4274: 332

MAX4275: 332

MAX4281: 178

MAX4282: 332

MAX4284: 328

SUBSTRATE CONNECTED TO V<sub>EE</sub>

## Selector Guide

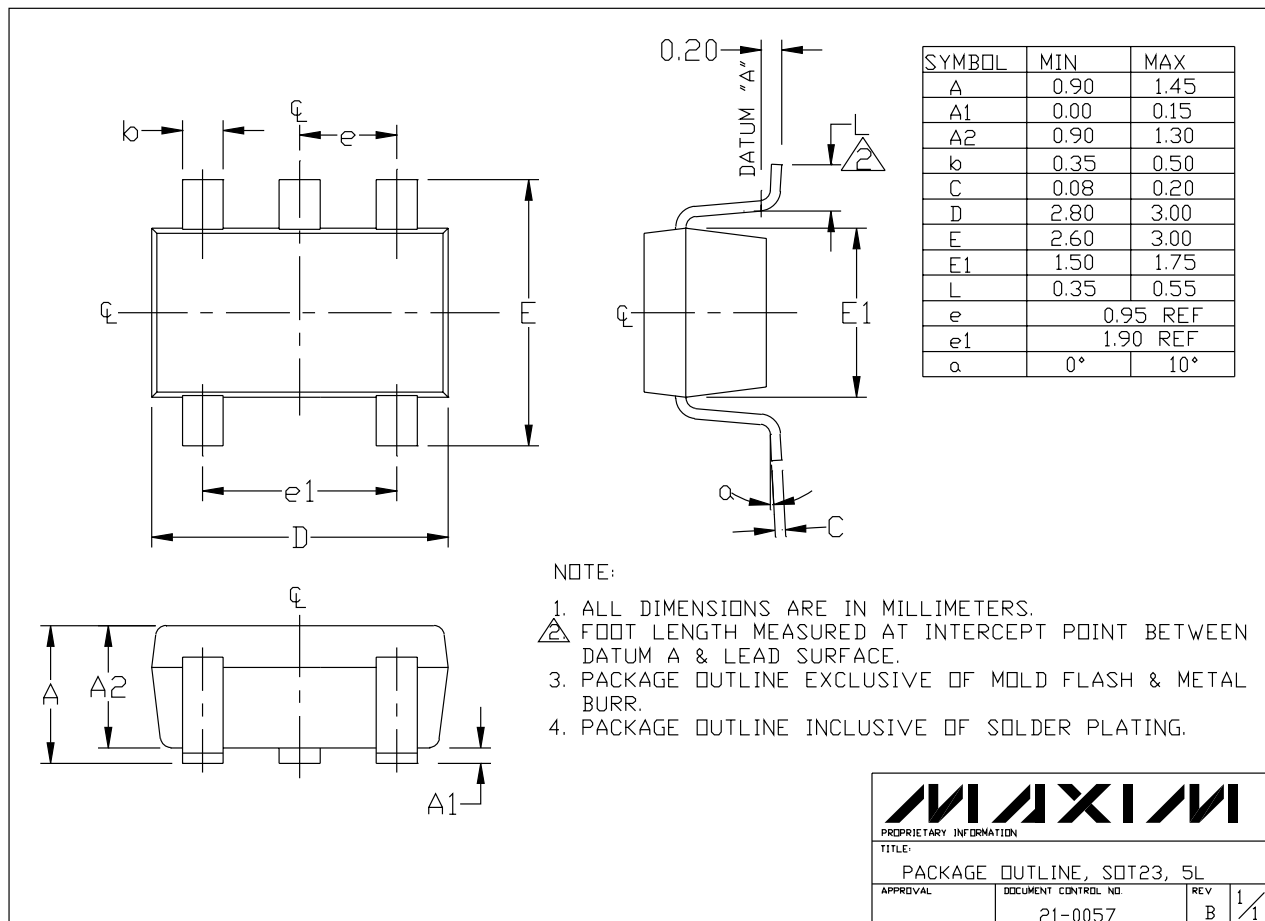
PART*	INVERTING GAINS AVAILABLE (V/V) (INVERTING, R <sub>F</sub> /R <sub>G</sub> )	NONINVERTING GAIN (V/V)	INTERNAL RESISTORS	INTERNAL V <sub>CC</sub> /2 BIAS	NO. OF AMPS PER PACKAGE	PIN-PACKAGE
MAX4174_	-0.25 to -100	+1.25 to +101	Yes	No	1	5-pin SOT23
MAX4175_	-0.25 to -100	+1.25 to +101	Yes	Yes	1	5-pin 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/TSSOP, 16-pin QSOP

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

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

## Package Information

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



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

## Package Information

8LUMAXDLEPS

	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	0.099	2.210	2.515				
*Y	0.062	0.074	1.575	1.880				

\* EXPOSED PAD

**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 VERSIONS ONLY.  
 6. EXPOSED PAD FLUSH WITH BOTTOM OF PACKAGE WITHIN .002".

MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, 8L uMAX

APPROVAL	DOCUMENT CONTROL NO.	REV	1/1
	21-0036	G	

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