



# Low-Cost, +3V/+5V, 620 $\mu$ A, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs

## General Description

The MAX4452/MAX4352 single, MAX4453/MAX4353 dual, and MAX4454/MAX4354 quad amplifiers combine high-speed performance with ultra-low power consumption. The MAX4452/MAX4453/MAX4454 are unity-gain stable and achieve a -3dB bandwidth of 200MHz, while the MAX4352/MAX4353/MAX4354 are compensated for a minimum closed-loop gain of +5V/V and achieve a 80MHz -3dB bandwidth. These devices consume only 620 $\mu$ A of supply current per amplifier.

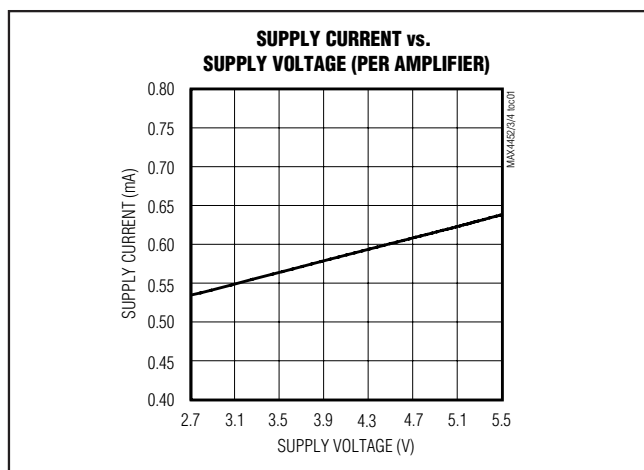
These amplifiers operate from a +2.7V to +5.25V single supply and feature rail-to-rail outputs. Along with an excellent speed/power ratio of 323MHz/mA, these devices feature a slew rate of 95V/ $\mu$ s and fast 20ns rise and fall times. These devices are ideal for low-power/low-voltage systems that require wide bandwidth such as cell phones and keyless entry systems.

The MAX4452/MAX4352 are available in miniature 5-pin SC70 and SOT23 packages, while the MAX4453/MAX4353 are available in tiny 8-pin SOT23, Thin SOT23, and SO packages. The MAX4454/MAX4354 are available in space-saving 14-pin TSSOP and SO packages.

## Applications

Battery-Powered Instruments  
Cellular Telephones  
Portable Communications  
Keyless Entry  
Baseband Applications

## Typical Operating Characteristic



## Features

- ◆ Ultra-Low 620 $\mu$ A Supply Current
- ◆ High Speed (MAX4452/MAX4453/MAX4454)  
200MHz -3dB Bandwidth  
30MHz 0.1dB Gain Flatness  
95V/ $\mu$ s Slew Rate
- ◆ High Speed (MAX4352/MAX4353/MAX4354)  
80MHz -3dB Bandwidth  
4MHz 0.1dB Gain Flatness  
240V/ $\mu$ s Slew Rate
- ◆ Single +3V/+5V Operation
- ◆ Rail-to-Rail Outputs
- ◆ Ultra-Small SC70-5, SOT23-5, SOT23-8 and Thin SOT23-8 Packages

## Ordering Information

| PART         | TEMP RANGE     | PIN-PACKAGE    | TOP MARK |
|--------------|----------------|----------------|----------|
| MAX4452EXK-T | -40°C to +85°C | 5 SC70-5       | ABI      |
| MAX4452EUK-T | -40°C to +85°C | 5 SOT23-5      | ADOV     |
| MAX4453EKA-T | -40°C to +85°C | 8 SOT23-8      | AADS     |
| MAX4453EZA-T | -40°C to +85°C | 8 Thin SOT23-8 | AAAB     |
| MAX4453ESA   | -40°C to +85°C | 8 SO           | —        |
| MAX4454EUD   | -40°C to +85°C | 14 TSSOP       | —        |
| MAX4454ESD   | -40°C to +85°C | 14 SO          | —        |
| MAX4352EXK-T | -40°C to +85°C | 5 SC70-5       | ABJ      |
| MAX4352EUK-T | -40°C to +85°C | 5 SOT23-5      | ADOW     |
| MAX4353EKA-T | -40°C to +85°C | 8 SOT23-8      | AADT     |
| MAX4353ESA   | -40°C to +85°C | 8 SO           | —        |
| MAX4354EUD   | -40°C to +85°C | 14 TSSOP       | —        |
| MAX4354ESD   | -40°C to +85°C | 14 SO          | —        |

Pin Configurations appear at end of data sheet.

## Selector Guide

| PART    | NO. OF AMPS | MIN GAIN | GAIN BANDWIDTH (MHz) | SLEW RATE (V/ $\mu$ s) |
|---------|-------------|----------|----------------------|------------------------|
| MAX4452 | 1           | 1        | 200                  | 95                     |
| MAX4352 | 1           | 5        | 400                  | 240                    |
| MAX4453 | 2           | 1        | 200                  | 95                     |
| MAX4353 | 2           | 5        | 400                  | 240                    |
| MAX4454 | 4           | 1        | 200                  | 95                     |
| MAX4354 | 4           | 5        | 400                  | 240                    |



Maxim Integrated Products 1

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at [www.maxim-ic.com](http://www.maxim-ic.com).

MAX4452/MAX4453/MAX4454/MAX4352/MAX4353/MAX4354

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## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ( $V_{CC}$  to  $V_{EE}$ ).....+6V  
 Differential Input Voltage .....2.5V  
 $IN_-$ ,  $IN_+$ ,  $OUT_-$ .....( $V_{CC} + 0.3V$ ) to ( $V_{EE} - 0.3V$ )  
 Current into Input Pins ( $IN_+$ ,  $IN_-$ ) ..... $\pm 20mA$   
 Output Short-Circuit Duration to  $V_{CC}$ ,  $V_{EE}$  .....Continuous  
 Continuous Power Dissipation ( $T_A = +70^\circ C$ )  
   5-Pin SC70 (derate 3.1mW/ $^\circ C$  above  $+70^\circ C$ ).....247mW  
   5 Pin SOT23 (derate 7.1mW/ $^\circ C$  above  $+70^\circ C$ ).....571mW  
   8-Pin SOT23 (derate 8.9mW/ $^\circ C$  above  $+70^\circ C$ ).....741mW

8-Pin Thin SOT23 (derate 6.3mW/ $^\circ C$  above  $+70^\circ C$ ).....500mW  
 8-Pin SO (derate 5.9mW/ $^\circ C$  above  $+70^\circ C$ ).....471mW  
 14-Pin TSSOP (derate 6.3mW/ $^\circ C$  above  $+70^\circ C$ ) .....500mW  
 14-Pin SO (derate 8mW/ $^\circ C$  above  $+70^\circ C$ ).....640mW  
 Operating Temperature Range ..... $-40^\circ C$  to  $+85^\circ C$   
 Junction Temperature ..... $+150^\circ C$   
 Storage Temperature Range ..... $-65^\circ C$  to  $+150^\circ C$   
 Lead Temperature (soldering, 10s) ..... $+300^\circ C$

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.

## DC ELECTRICAL CHARACTERISTICS

( $V_{CC} = +5V$ ,  $V_{CM} = V_{CC}/2 - 0.75V$ ,  $V_{EE} = 0$ ,  $R_L = \infty$  to  $V_{CC}/2$ ,  $V_{OUT} = V_{CC}/2$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ C$ .) (Note 1)

| PARAMETER                                    | SYMBOL     | CONDITIONS                                                          | MIN               | TYP     | MAX            | UNITS            |
|----------------------------------------------|------------|---------------------------------------------------------------------|-------------------|---------|----------------|------------------|
| Operating Supply Voltage Range               | $V_S$      | Guaranteed by PSRR test                                             | 2.7               |         | 5.25           | V                |
| Quiescent Supply Current (Per Amplifier)     | $I_S$      | $V_{CC} = +5V$                                                      |                   | 620     | 1200           | $\mu A$          |
|                                              |            | $V_{CC} = +3V$                                                      |                   | 530     |                |                  |
| Input Common-Mode Voltage Range              | $V_{CM}$   | Guaranteed by CMRR test                                             | $V_{EE} - 0.1$    |         | $V_{CC} - 1.5$ | V                |
| Input Offset Voltage                         | $V_{OS}$   |                                                                     |                   | 0.4     | 12             | mV               |
| Input Offset Voltage Temperature Coefficient | $TC_{VOS}$ |                                                                     |                   | 7       |                | $\mu V/^\circ C$ |
| Input Offset Voltage Matching                |            | MAX4453/MAX4454/MAX4353/MAX4354                                     |                   | $\pm 1$ |                | mV               |
| Input Bias Current                           | $I_B$      |                                                                     |                   | 0.8     | 3              | $\mu A$          |
| Input Offset Current                         | $I_{OS}$   |                                                                     |                   | 0.1     |                | $\mu A$          |
| Input Resistance                             | $R_{IN}$   | Differential mode,<br>$-0.04V \leq (V_{IN+} - V_{IN-}) \leq +0.04V$ |                   | 120     |                | k $\Omega$       |
|                                              |            | Common mode,<br>$V_{EE} - 0.1V \leq V_{CM} \leq V_{CC} - 1.5V$      |                   | 30      |                | M $\Omega$       |
| Common-Mode Rejection Ratio                  | CMRR       | $V_{EE} - 0.1V \leq V_{CM} \leq V_{CC} - 1.5V$                      | 60                | 100     |                | dB               |
| Open-Loop Gain                               | $A_{VOL}$  | $+0.5V \leq V_{OUT} \leq +4.5V$ ,<br>$R_L = 1k\Omega$               | 60                | 80      |                | dB               |
| Output Current                               | $I_{OUT}$  | $R_L = 20\Omega$ connected to $V_{CC}$ or $V_{EE}$                  | Sourcing          | 15      |                | mA               |
|                                              |            |                                                                     | Sinking           | 22      |                |                  |
| Output Voltage Swing                         | $V_{OUT}$  | $R_L = 1k\Omega$                                                    | $V_{CC} - V_{OH}$ | 180     | 400            | mV               |
|                                              |            |                                                                     | $V_{OL} - V_{EE}$ | 75      | 350            |                  |
| Output Short-Circuit Current                 | $I_{SC}$   | Sourcing                                                            |                   | 17      |                | mA               |
|                                              |            | Sinking                                                             |                   | 24      |                |                  |
| Power-Supply Rejection Ratio                 | PSRR       | $V_{CC} = +2.7V$ to $+5.25V$ , $V_{CM} = 0$ ,<br>$V_{OUT} = 2V$     | 60                | 70      |                | dB               |

# Low-Cost, +3V/+5V, 620 $\mu$ A, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs

## AC ELECTRICAL CHARACTERISTICS

( $V_{CC} = +5V$ ,  $V_{EE} = 0$ ,  $V_{CM} = +1.75V$ ,  $R_L = 1k\Omega$  to  $V_{CC}/2$ ,  $A_{VCL} = +1V/V$  (MAX4452/MAX4453/MAX4454),  $A_{VCL} = +5V/V$  (MAX4352/MAX4353/MAX4354),  $T_A = +25^\circ C$ , unless otherwise noted.)

| PARAMETER                    | SYMBOL       | CONDITIONS                        |                             | MIN | TYP | MAX | UNITS      |
|------------------------------|--------------|-----------------------------------|-----------------------------|-----|-----|-----|------------|
| Small Signal -3dB Bandwidth  | $BW_{SS}$    | $V_{OUT} = 100mV_{p-p}$           | MAX4452/MAX4453/<br>MAX4454 |     | 200 |     | MHz        |
|                              |              |                                   | MAX4352/MAX4353/<br>MAX4354 |     | 80  |     |            |
| Large Signal -3dB Bandwidth  | $BW_{LS}$    | $V_{OUT} = 2V_{p-p}$              | MAX4452/MAX4453/<br>MAX4454 |     | 15  |     | MHz        |
|                              |              |                                   | MAX4352/MAX4353/<br>MAX4354 |     | 38  |     |            |
| Bandwidth for 0.1dB Flatness | $BW_{0.1dB}$ | $V_{OUT} = 100mV_{p-p}$           | MAX4452/MAX4453/<br>MAX4454 |     | 30  |     | MHz        |
|                              |              |                                   | MAX4352/MAX4353/<br>MAX4354 |     | 4   |     |            |
| Slew Rate                    | SR           | $V_{OUT} = 2V$ step               | MAX4452/MAX4453/<br>MAX4454 |     | 95  |     | V/ $\mu s$ |
|                              |              |                                   | MAX4352/MAX4353/<br>MAX4354 |     | 240 |     |            |
| Rise/Fall Time               | $t_R, t_F$   | $V_{OUT} = 2V$ step<br>10% to 90% | MAX4452/MAX4453/<br>MAX4454 |     | 20  |     | ns         |
|                              |              |                                   | MAX4352/MAX4353/<br>MAX4354 |     | 8   |     |            |
| Settling Time                | $t_s$ 1%     | $V_{OUT} = 2V$ step               | MAX4452/MAX4453/<br>MAX4454 |     | 40  |     | ns         |
|                              |              |                                   | MAX4352/MAX4353/<br>MAX4354 |     | 50  |     |            |
|                              | $t_s$ 0.1%   | $V_{OUT} = 2V$ step               | MAX4452/MAX4453/<br>MAX4454 |     | 50  |     |            |
|                              |              |                                   | MAX4352/MAX4353/<br>MAX4354 |     | 60  |     |            |

# **Low-Cost, +3V/+5V, 620μA, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs**

## **AC ELECTRICAL CHARACTERISTICS (continued)**

(V<sub>CC</sub> = +5V, V<sub>EE</sub> = 0, V<sub>CM</sub> = +1.75V, R<sub>L</sub> = 1kΩ to V<sub>CC</sub>/2, A<sub>VCL</sub> = +1V/V (MAX4452/MAX4453/MAX4454), A<sub>VCL</sub> = +5V/V (MAX4352/MAX4353/MAX4354), T<sub>A</sub> = +25°C, unless otherwise noted.)

| PARAMETER                   | SYMBOL | CONDITIONS                                                                  |                             | MIN | TYP | MAX | UNITS |
|-----------------------------|--------|-----------------------------------------------------------------------------|-----------------------------|-----|-----|-----|-------|
| Spurious-Free Dynamic Range | SFDR   | V <sub>CC</sub> = 5V,<br>V <sub>OUT</sub> = 2Vp-p,<br>f <sub>C</sub> = 1MHz | MAX4452/MAX4453/<br>MAX4454 |     | -83 |     | dBc   |
|                             |        |                                                                             | MAX4352/MAX4353/<br>MAX4354 |     | -74 |     |       |
|                             |        | V <sub>CC</sub> = 3V,<br>V <sub>OUT</sub> = 2Vp-p,<br>f <sub>C</sub> = 1MHz | MAX4452/MAX4453/<br>MAX4454 |     | -79 |     |       |
|                             |        |                                                                             | MAX4352/MAX4353/<br>MAX4354 |     | -70 |     |       |
| 2nd-Harmonic Distortion     |        | V <sub>CC</sub> = 5V,<br>V <sub>OUT</sub> = 2Vp-p,<br>f <sub>C</sub> = 1MHz | MAX4452/MAX4453/<br>MAX4454 |     | -83 |     | dBc   |
|                             |        |                                                                             | MAX4352/MAX4353/<br>MAX4354 |     | -74 |     |       |
|                             |        | V <sub>CC</sub> = 3V,<br>V <sub>OUT</sub> = 1Vp-p,<br>f <sub>C</sub> = 1MHz | MAX4452/MAX4453/<br>MAX4454 |     | -79 |     |       |
|                             |        |                                                                             | MAX4352/MAX4353/<br>MAX4354 |     | -70 |     |       |
| 3rd-Harmonic Distortion     |        | V <sub>CC</sub> = 5V,<br>V <sub>OUT</sub> = 2Vp-p,<br>f <sub>C</sub> = 1MHz | MAX4452/MAX4453/<br>MAX4454 |     | -87 |     | dBc   |
|                             |        |                                                                             | MAX4352/MAX4353/<br>MAX4354 |     | -74 |     |       |
|                             |        | V <sub>CC</sub> = 3V,<br>V <sub>OUT</sub> = 1Vp-p,<br>f <sub>C</sub> = 1MHz | MAX4452/MAX4453/<br>MAX4454 |     | -80 |     |       |
|                             |        |                                                                             | MAX4352/MAX4353/<br>MAX4354 |     | -72 |     |       |
| Total Harmonic Distortion   | THD    | V <sub>CC</sub> = 5V,<br>V <sub>OUT</sub> = 2Vp-p,<br>f <sub>C</sub> = 1MHz | MAX4452/MAX4453/<br>MAX4454 |     | -82 |     | dB    |
|                             |        |                                                                             | MAX4352/MAX4353/<br>MAX4354 |     | -71 |     |       |
|                             |        | V <sub>CC</sub> = 3V,<br>V <sub>OUT</sub> = 1Vp-p,<br>f <sub>C</sub> = 1MHz | MAX4452/MAX4453/<br>MAX4454 |     | -77 |     |       |
|                             |        |                                                                             | MAX4352/MAX4353/<br>MAX4354 |     | -68 |     |       |

# **Low-Cost, +3V/+5V, 620μA, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs**

## **AC ELECTRICAL CHARACTERISTICS (continued)**

( $V_{CC} = +5V$ ,  $V_{EE} = 0$ ,  $V_{CM} = +1.75V$ ,  $R_L = 1k\Omega$  to  $V_{CC}/2$ ,  $A_{VCL} = +1V/V$  (MAX4452/MAX4453/MAX4454),  $A_{VCL} = +5V/V$  (MAX4352/MAX4353/MAX4354),  $T_A = +25^\circ C$ , unless otherwise noted.)

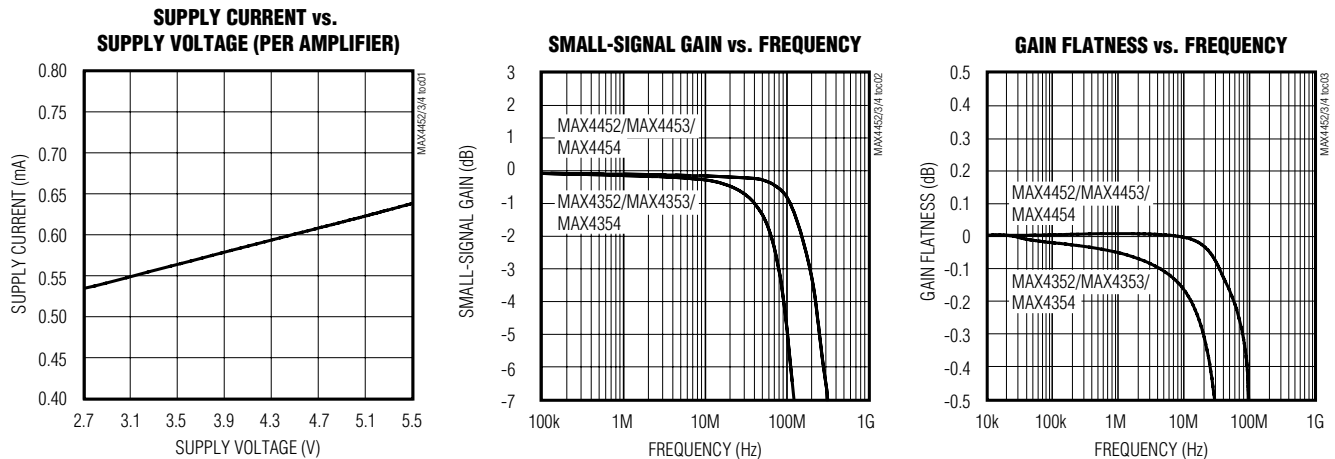
| PARAMETER                                        | SYMBOL     | CONDITIONS                                                           | MIN | TYP | MAX | UNITS           |
|--------------------------------------------------|------------|----------------------------------------------------------------------|-----|-----|-----|-----------------|
| Two-Tone, Third-Order Intermodulation Distortion |            | $f_1 = 2MHz$ , $f_2 = 2.1MHz$                                        |     | -65 |     | dBc             |
| Input Noise-Voltage Density                      | $e_n$      | $f = 10kHz$                                                          |     | 15  |     | nV/ $\sqrt{Hz}$ |
| Input Noise-Current Density                      | $i_n$      | $f = 10kHz$                                                          |     | 0.5 |     | pA/ $\sqrt{Hz}$ |
| Input Capacitance                                | $C_{IN}$   |                                                                      |     | 2   |     | pF              |
| Output Impedance                                 | $Z_{OUT}$  | $f = 1MHz$                                                           |     | 0.8 |     | $\Omega$        |
| Capacitive Load Drive                            |            |                                                                      |     | 22  |     | pF              |
| Crosstalk                                        | $X_{TALK}$ | MAX4453/MAX4454/MAX4353/MAX4354<br>$V_{OUT} = 100mVp-p$ , $f = 1MHz$ |     | -74 |     | dB              |
| Power-Up 1% Settling Time (Note 2)               |            |                                                                      |     | 1   | 100 | $\mu s$         |

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

**Note 2:** Guaranteed by design.

## **Typical Operating Characteristics**

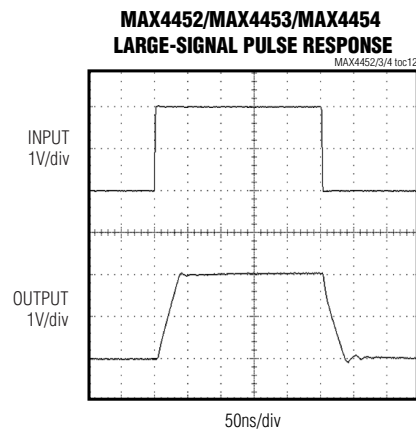
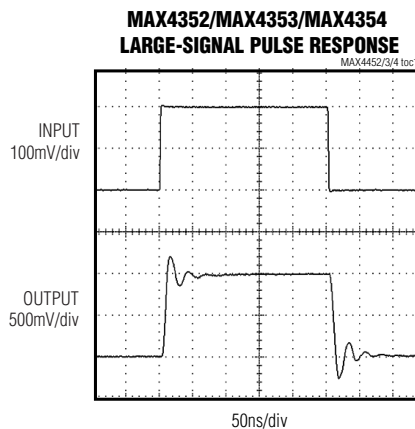
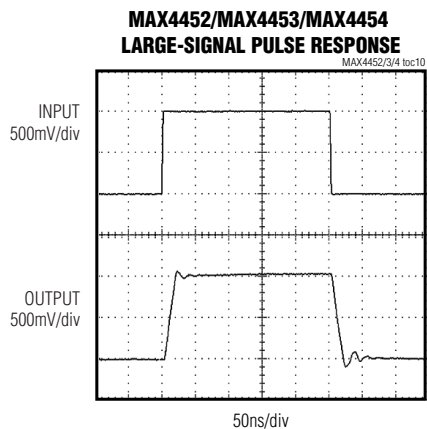
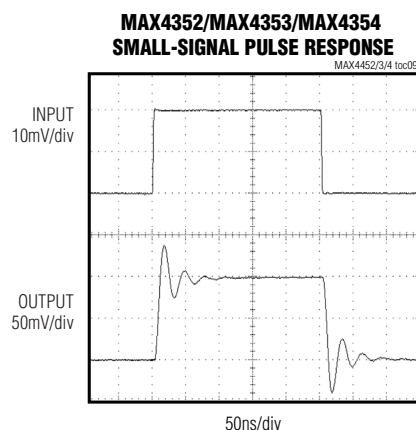
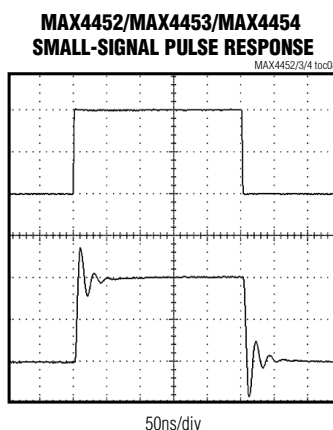
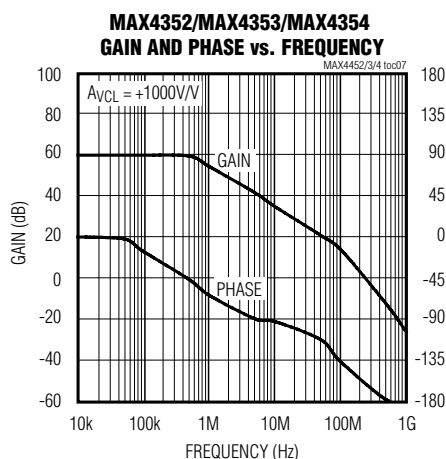
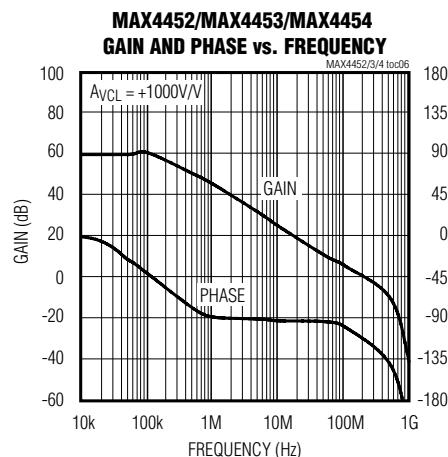
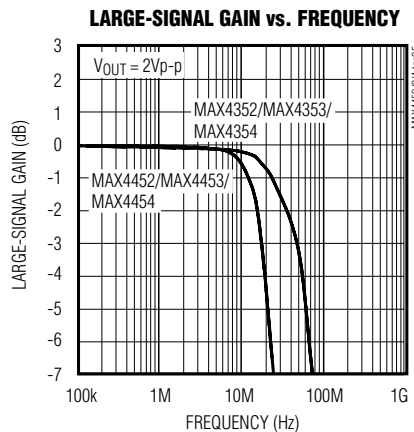
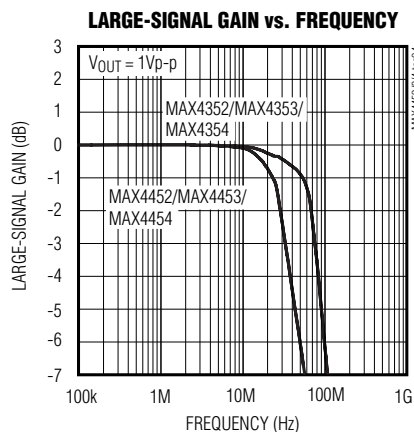
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## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $V_{EE} = 0$ ,  $V_{CM} = +1.75V$ ,  $A_{VCL} = +1V/V$  (MAX4452/MAX4453/MAX4454),  $A_{VCL} = +5V/V$  (MAX4352/MAX4353/MAX4354),  $R_L = 1k\Omega$  to  $V_{CC}/2$ ,  $C_L = 5pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

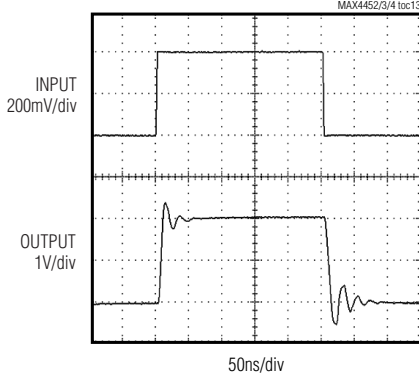


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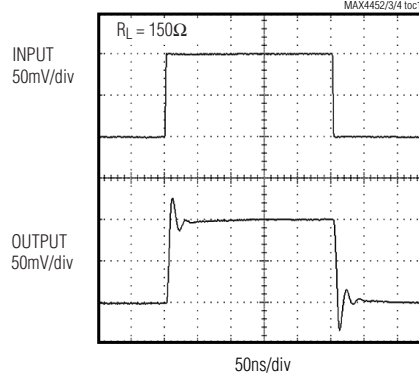
## Typical Operating Characteristics (continued)

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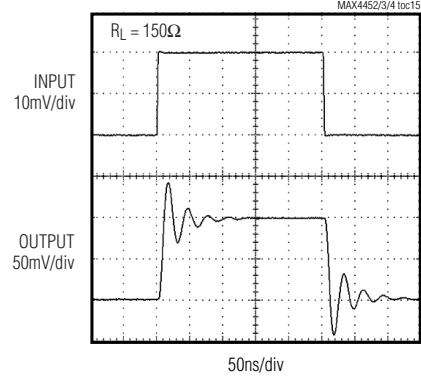
**MAX4352/MAX4353/MAX4354  
LARGE-SIGNAL PULSE RESPONSE**



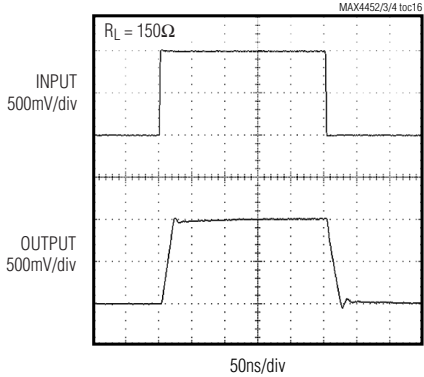
**MAX4452/MAX4453/MAX4454  
SMALL-SIGNAL PULSE RESPONSE**



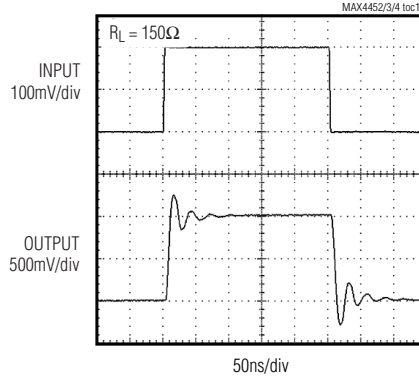
**MAX4352/MAX4353/MAX4354  
SMALL-SIGNAL PULSE RESPONSE**



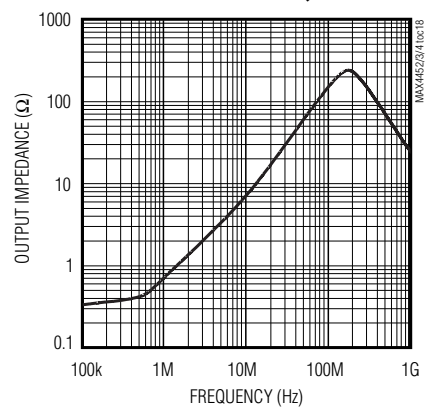
**MAX4452/MAX4453/MAX4454  
LARGE-SIGNAL PULSE RESPONSE**



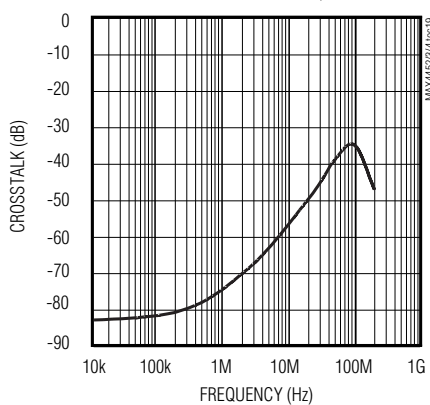
**MAX4352/MAX4353/MAX4354  
LARGE-SIGNAL PULSE RESPONSE**



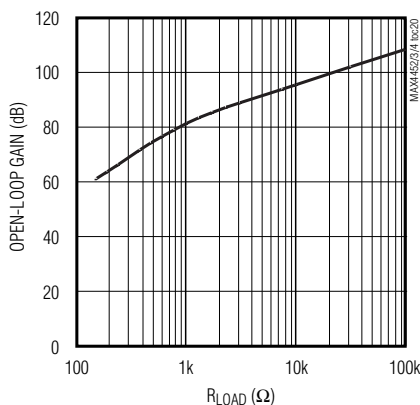
**CLOSED-LOOP OUTPUT  
IMPEDANCE vs. FREQUENCY**



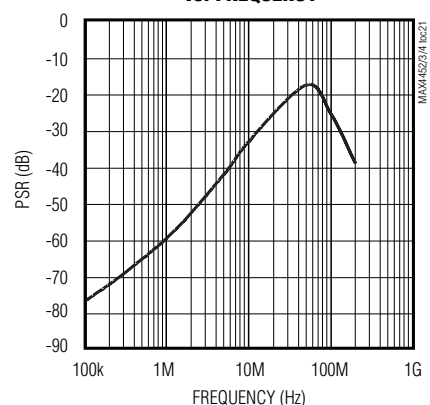
**CROSSTALK vs. FREQUENCY**



**OPEN-LOOP GAIN  
vs. LOAD RESISTANCE**



**POWER-SUPPLY REJECTION  
vs. FREQUENCY**

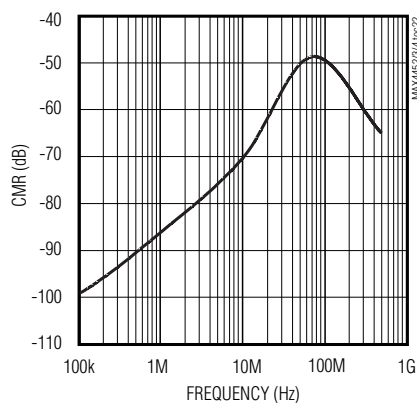


# Low-Cost, +3V/+5V, 620 $\mu$ A, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs

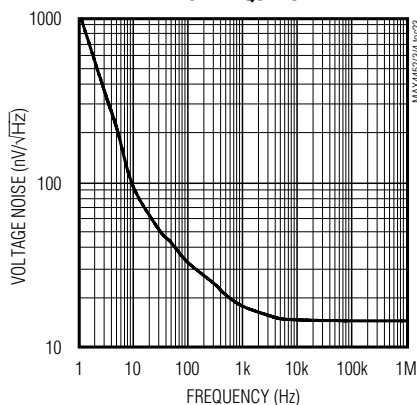
## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $V_{EE} = 0$ ,  $V_{CM} = +1.75V$ ,  $A_{VCL} = +1V/V$  (MAX4452/MAX4453/MAX4454),  $A_{VCL} = +5V/V$  (MAX4352/MAX4353/MAX4354),  $R_L = 1k\Omega$  to  $V_{CC}/2$ ,  $C_L = 5pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

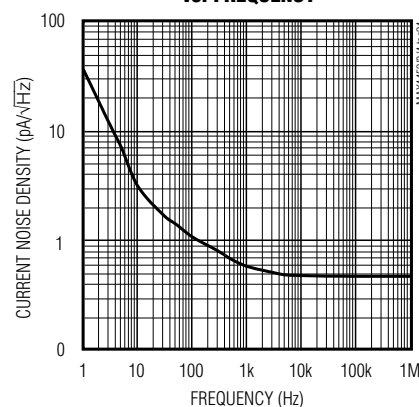
**COMMON-MODE REJECTION vs. FREQUENCY**



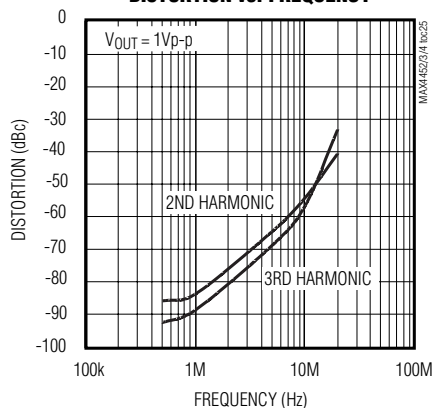
**VOLTAGE NOISE DENSITY vs. FREQUENCY**



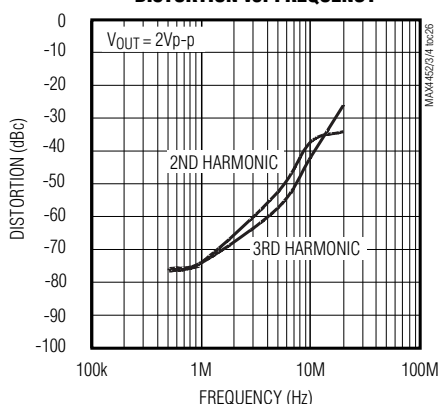
**CURRENT NOISE DENSITY vs. FREQUENCY**



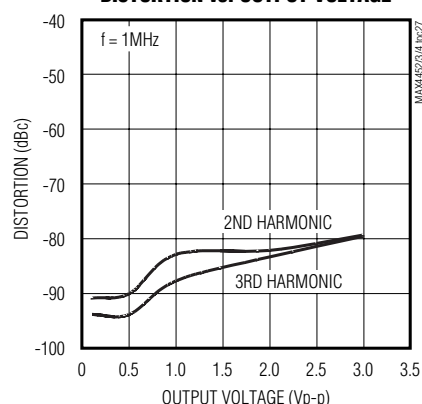
**MAX4452/MAX4453/MAX4454 DISTORTION vs. FREQUENCY**



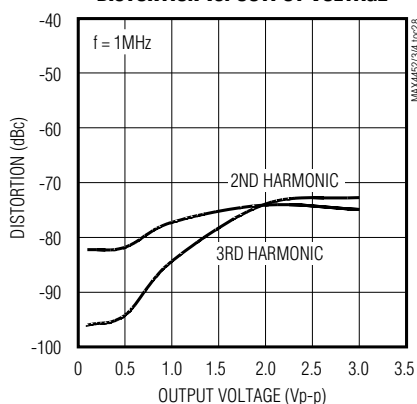
**MAX4352/MAX4353/MAX4354 DISTORTION vs. FREQUENCY**



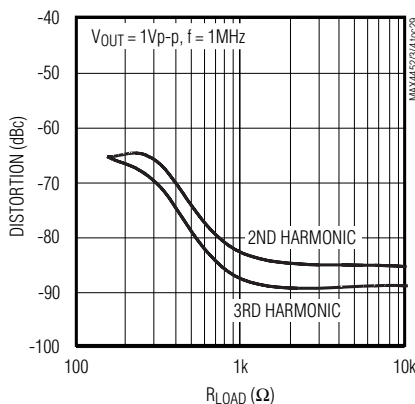
**MAX4452/MAX4453/MAX4454 DISTORTION vs. OUTPUT VOLTAGE**



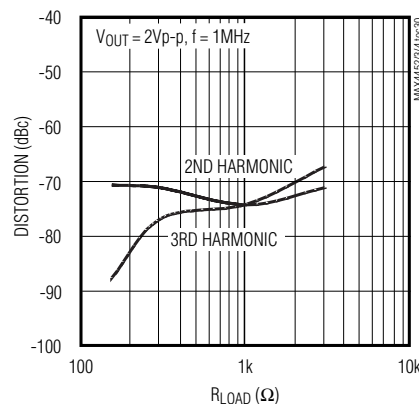
**MAX4352/MAX4353/MAX4354 DISTORTION vs. OUTPUT VOLTAGE**



**MAX4452/MAX4453/MAX4454 DISTORTION vs. OUTPUT RESISTANCE**



**MAX4352/MAX4353/MAX4354 DISTORTION vs. OUTPUT RESISTANCE**

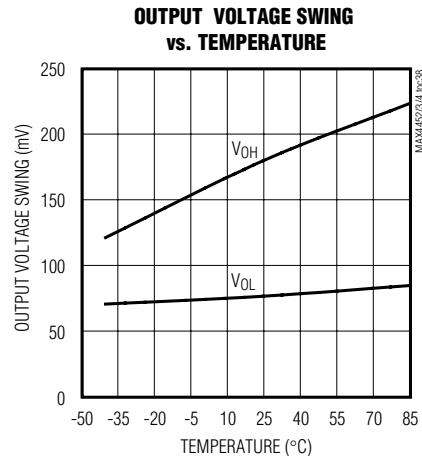
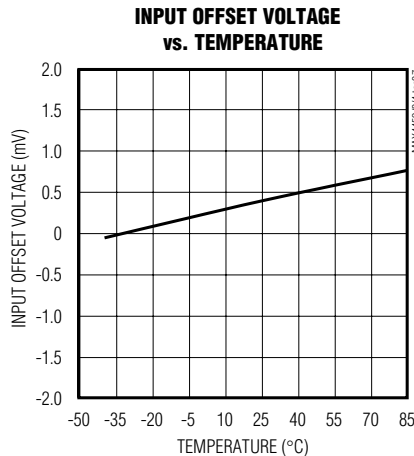
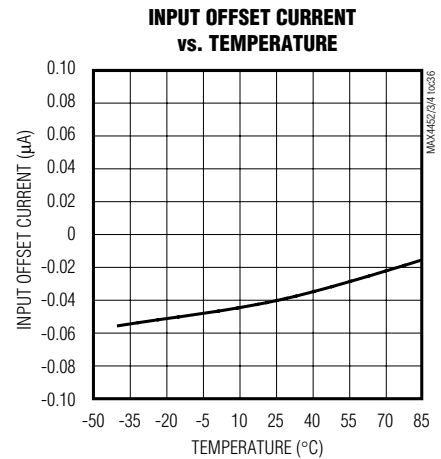
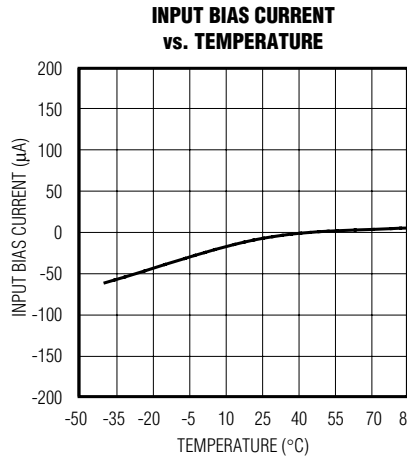
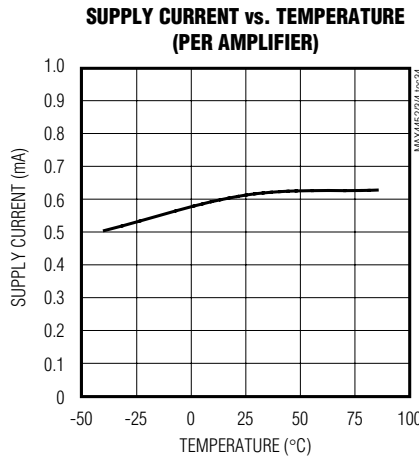
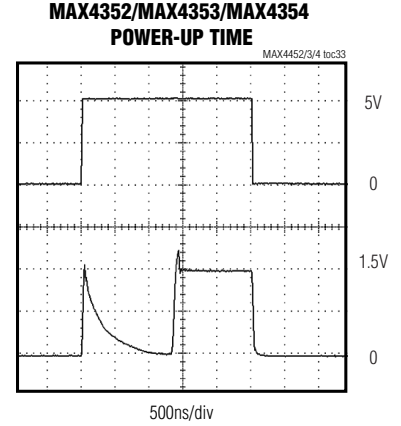
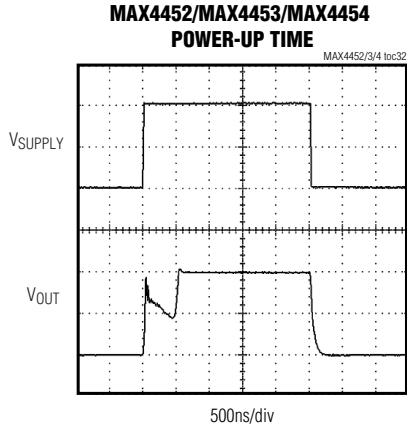
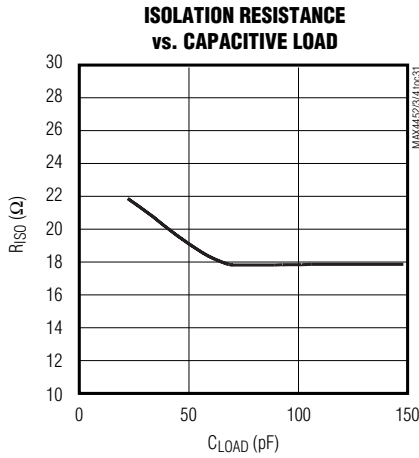




# Low-Cost, +3V/+5V, 620 $\mu$ A, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs

## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $V_{EE} = 0$ ,  $V_{CM} = +1.75V$ ,  $A_{VCL} = +1V/V$  (MAX4452/MAX4453/MAX4454),  $A_{VCL} = +5V/V$  (MAX4352/MAX4353/MAX4354),  $R_L = 1k\Omega$  to  $V_{CC}/2$ ,  $C_L = 5pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# **Low-Cost, +3V/+5V, 620μA, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs**

## **Pin Description**

| PIN                |                    |                    | NAME | FUNCTION                       |
|--------------------|--------------------|--------------------|------|--------------------------------|
| MAX4452<br>MAX4352 | MAX4453<br>MAX4353 | MAX4454<br>MAX4354 |      |                                |
| 1                  | —                  | —                  | OUT  | Amplifier Output               |
| 2                  | 4                  | 11                 | VEE  | Negative Power Supply          |
| 3                  | —                  | —                  | IN+  | Noninverting Amplifier Input   |
| 4                  | —                  | —                  | IN-  | Inverting Amplifier Input      |
| 5                  | 8                  | 4                  | VCC  | Positive Power Supply          |
| —                  | 1                  | 1                  | OUTA | Amplifier A Output             |
| —                  | 2                  | 2                  | INA- | Amplifier A Inverting Input    |
| —                  | 3                  | 3                  | INA+ | Amplifier A Noninverting Input |
| —                  | 7                  | 7                  | OUTB | Amplifier B Output             |
| —                  | 6                  | 6                  | INB- | Amplifier B Inverting Input    |
| —                  | 5                  | 5                  | INB+ | Amplifier B Noninverting Input |
| —                  | —                  | 8                  | OUTC | Amplifier C Output             |
| —                  | —                  | 9                  | INC- | Amplifier C Inverting Input    |
| —                  | —                  | 10                 | INC+ | Amplifier C Noninverting Input |
| —                  | —                  | 14                 | OUTD | Amplifier D Output             |
| —                  | —                  | 13                 | IND- | Amplifier D Inverting Input    |
| —                  | —                  | 12                 | IND+ | Amplifier D Noninverting Input |

# Low-Cost, +3V/+5V, 620μA, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs

## Detailed Description

The MAX4452/MAX4352 single, MAX4453/MAX4353 dual, and MAX4454/MAX4354 quad, single-supply, rail-to-rail, voltage-feedback amplifiers achieve high slew rates and wide bandwidths while consuming only 620μA per amplifier. Excellent speed/power ratio makes them ideal for portable devices and high-frequency signal applications.

Internal feedback around the output stage ensures low open-loop output impedance, reducing gain sensitivity to load variations. This feedback also produces demand-driven current bias to the output transistors.

### Rail-to-Rail Outputs, Ground-Sensing Input

The input common-mode range extends from ( $V_{EE} - 0.1V$ ) to ( $V_{CC} - 1.5V$ ) with excellent common-mode rejection. Beyond this range, the amplifier output is a nonlinear function of the input, but does not undergo phase reversal or latchup.

The output swings to within 180mV of either power-supply rail with a 1kΩ load. The input ground-sensing and the rail-to-rail output substantially increase the dynamic range.

### Output Capacitive Loading and Stability

The MAX4452/MAX4453/MAX4454/MAX4352/MAX4353/MAX4354 are optimized for AC performance. They are not designed to drive highly reactive loads. Such loads decrease phase margin and may produce excessive ringing and oscillation. The use of an isolation resistor eliminates this problem (Figure 1). Figure 2 is a graph of the Optimal Isolation Resistor ( $R_{ISO}$ ) vs. Capacitive Load.

## Applications Information

### Choosing Resistor Values

#### Unity-Gain Configuration

The MAX4452/MAX4453/MAX4454 are internally compensated for unity gain. When configured for unity gain, a 24Ω feedback resistor ( $R_F$ ) is recommended. This resistor improves AC response by reducing the Q of the parallel LC circuit formed by the parasitic feedback capacitance and inductance.

#### Inverting and Noninverting Configurations

Select the gain-setting feedback ( $R_F$ ) and input ( $R_G$ ) resistor values that best fit the application. Large resistor values increase voltage noise and interact with the amplifier's input and PC board capacitance. This can generate undesirable poles and zeros and decrease bandwidth or cause oscillations. For example, a noninverting gain-of-two configuration ( $R_F = R_G$ ) using 1kΩ

resistors, combined with 2pF of amplifier input capacitance and 1pF of PC board capacitance, causes a pole at 106MHz. Since this pole is within the amplifier bandwidth, it jeopardizes stability. Reducing the 1kΩ resistors to 100Ω extends the pole frequency to 1.06GHz, but could limit output swing by adding 200Ω in parallel with the amplifier's load resistor.

Note: For high-gain applications where output offset voltage is a consideration, choose  $R_S$  to be equal to the parallel combination of  $R_F$  and  $R_G$  (Figures 3a and 3b).

$$R_S = \frac{R_F \times R_G}{R_F + R_G}$$

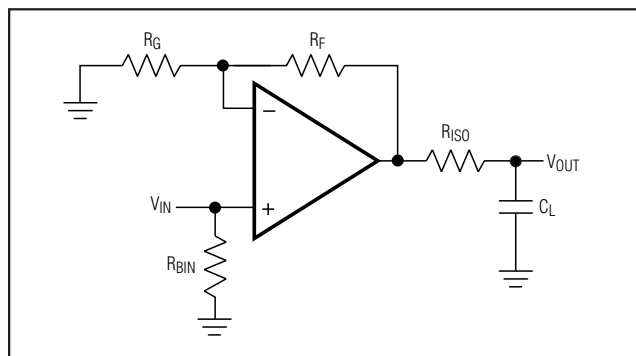


Figure 1. Driving a Capacitive Load Through an Isolation Resistor

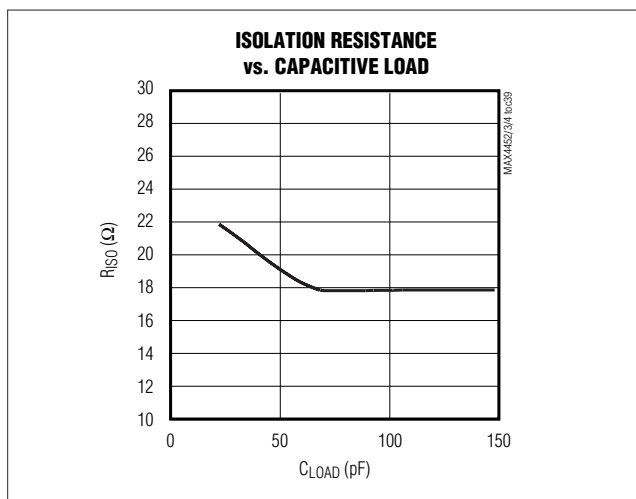


Figure 2. Optimal Isolation Resistor vs. Capacitive Load

# Low-Cost, +3V/+5V, 620μA, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs

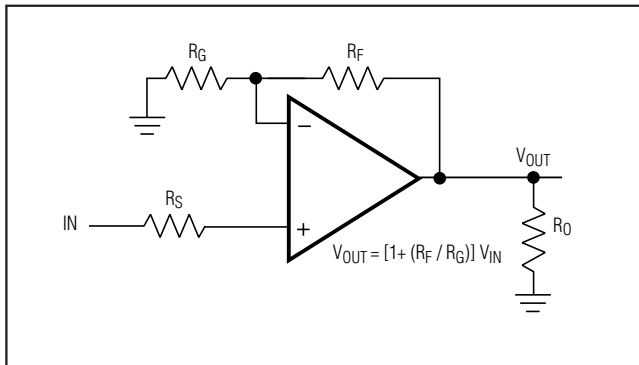


Figure 3a. Noninverting Gain Configuration

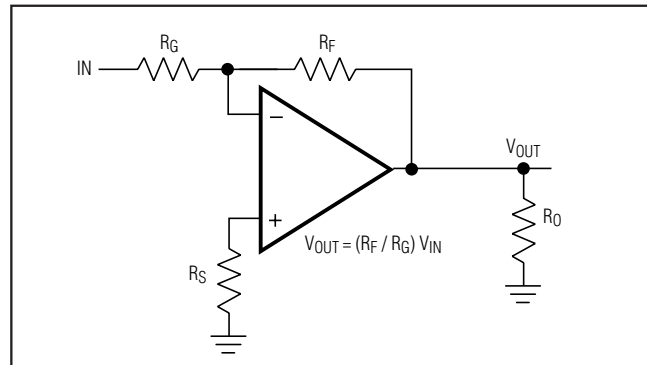


Figure 3b. Inverting Gain Configuration

## Active Filters

The low distortion and high bandwidth of the MAX4452/MAX4453/MAX4454 and MAX4352/MAX4353/MAX4354 make them ideal for use in active filter circuits. Figure 4 is a 15MHz lowpass multiple feedback active filter using the MAX4452.

$$\text{Gain} = \frac{-R_2}{R_1}$$

$$f_0 = \frac{1}{2\pi} \sqrt{\frac{1}{R_2 \times R_3 \times C_1 \times C_2}}$$

$$Q = \frac{C_2}{\sqrt{C_1 \times C_2 \times R_2 \times R_3} \left( \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right)}$$

## ADC Input Buffer

Input buffer amplifiers can be a source of significant errors in high-speed ADC applications. The input buffer is usually required to rapidly charge and discharge the ADC's input, which is often capacitive. See *Output Capacitive Loading and Stability*. In addition, since a high-speed ADC's input impedance often changes very rapidly during the conversion cycle, measurement accuracy must be maintained using an amplifier with very low output impedance at high frequencies. The combination of high speed, fast slew rate, low noise, and a low and stable distortion over load makes the MAX4452/MAX4453/MAX4454/MAX4352/MAX4353/MAX4354 ideally suited for use as buffer amplifiers in high-speed ADC applications.

## Layout and Power-Supply Bypassing

These amplifiers operate from a single +2.7V to +5.25V power supply. Bypass  $V_{CC}$  to ground with a 0.1μF capacitor as close to the pin as possible.

Maxim recommends using microstrip and stripline techniques to obtain full bandwidth. Design the PC board for a frequency greater than 1GHz to prevent amplifier performance degradation due to board parasitics. Avoid large parasitic capacitance at inputs and outputs. Whether or not a constant-impedance board is used, observe the following guidelines:

- Do not use wirewrap boards due to their high inductance.
- Do not use IC sockets because of the increased parasitic capacitance and inductance.

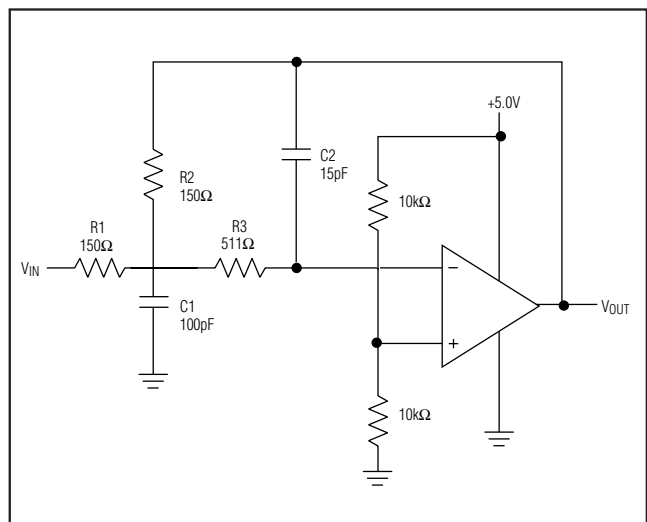


Figure 4. Multiple-Feedback Lowpass Filter

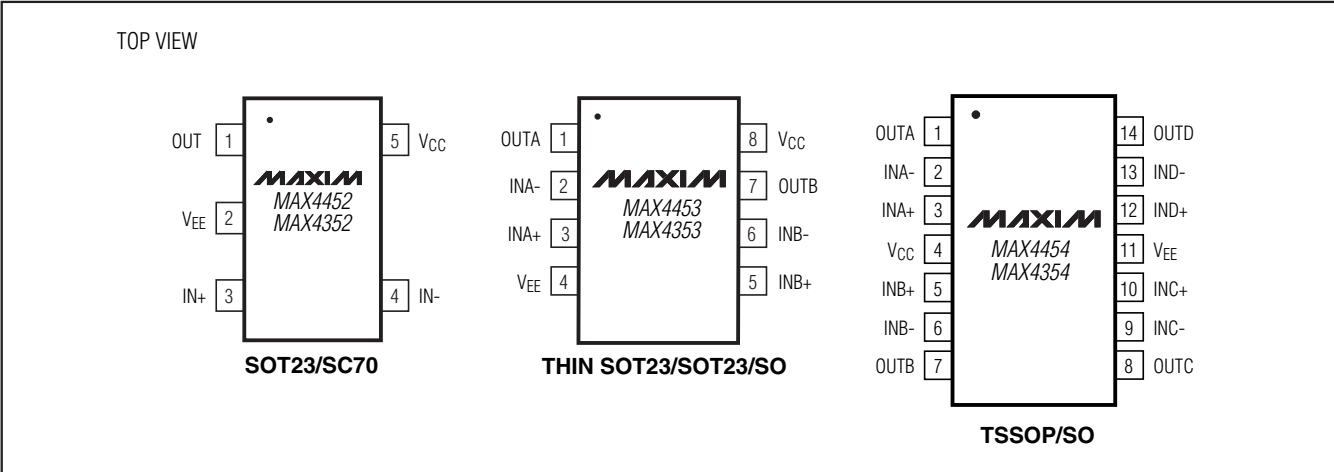
# Low-Cost, +3V/+5V, 620µA, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs

- Use surface-mount instead of through-hole components for better high-frequency performance.
- Use a PC board with at least two layers; it should be as free from voids as possible.
- Keep signal lines as short and as straight as possible. Do not make 90° turns; round all corners.

## Chip Information

MAX4452/MAX4352 TRANSISTOR COUNT: 97  
MAX4453/MAX4353 TRANSISTOR COUNT: 192  
MAX4454/MAX4354 TRANSISTOR COUNT: 378  
PROCESS: Bipolar

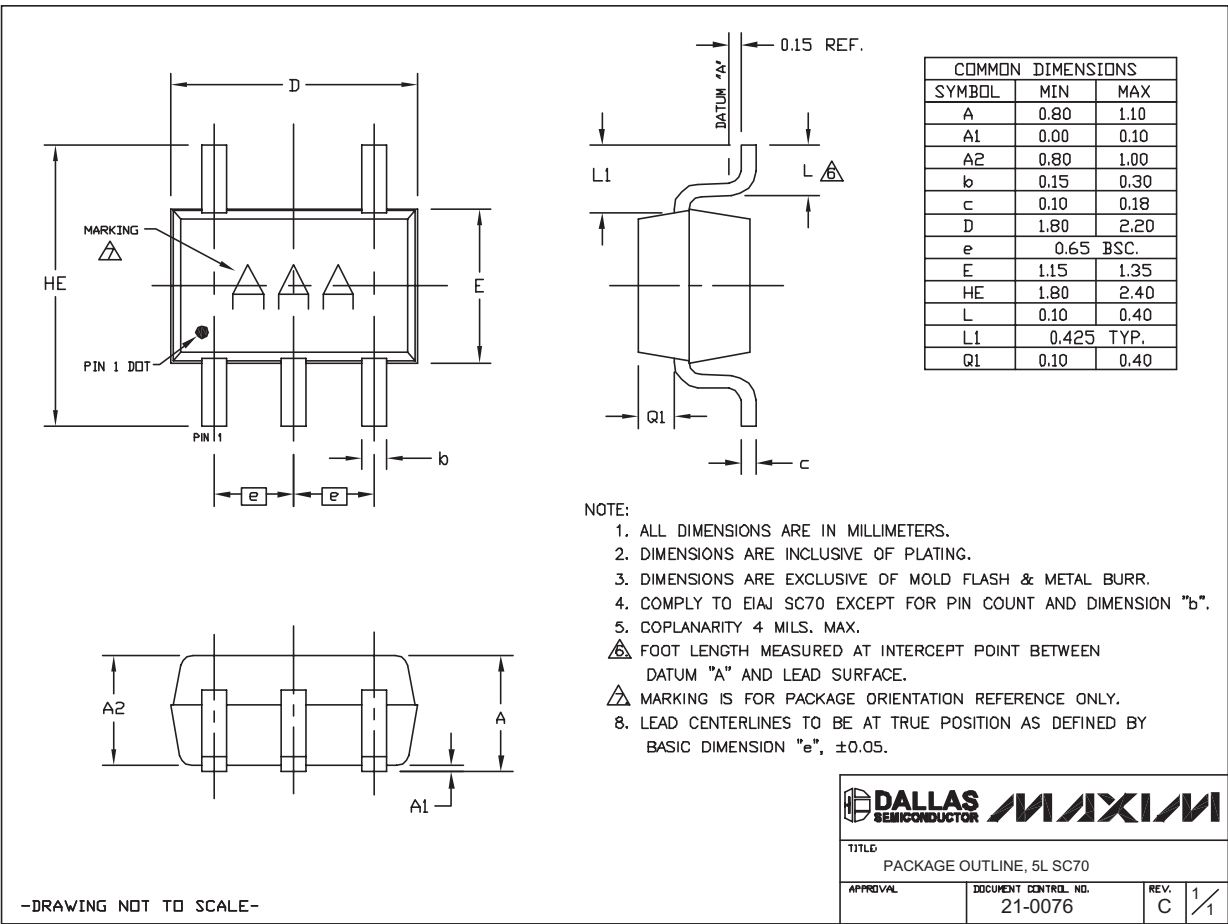
## Pin Configurations



# Low-Cost, +3V/+5V, 620 $\mu$ A, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs

## Package Information

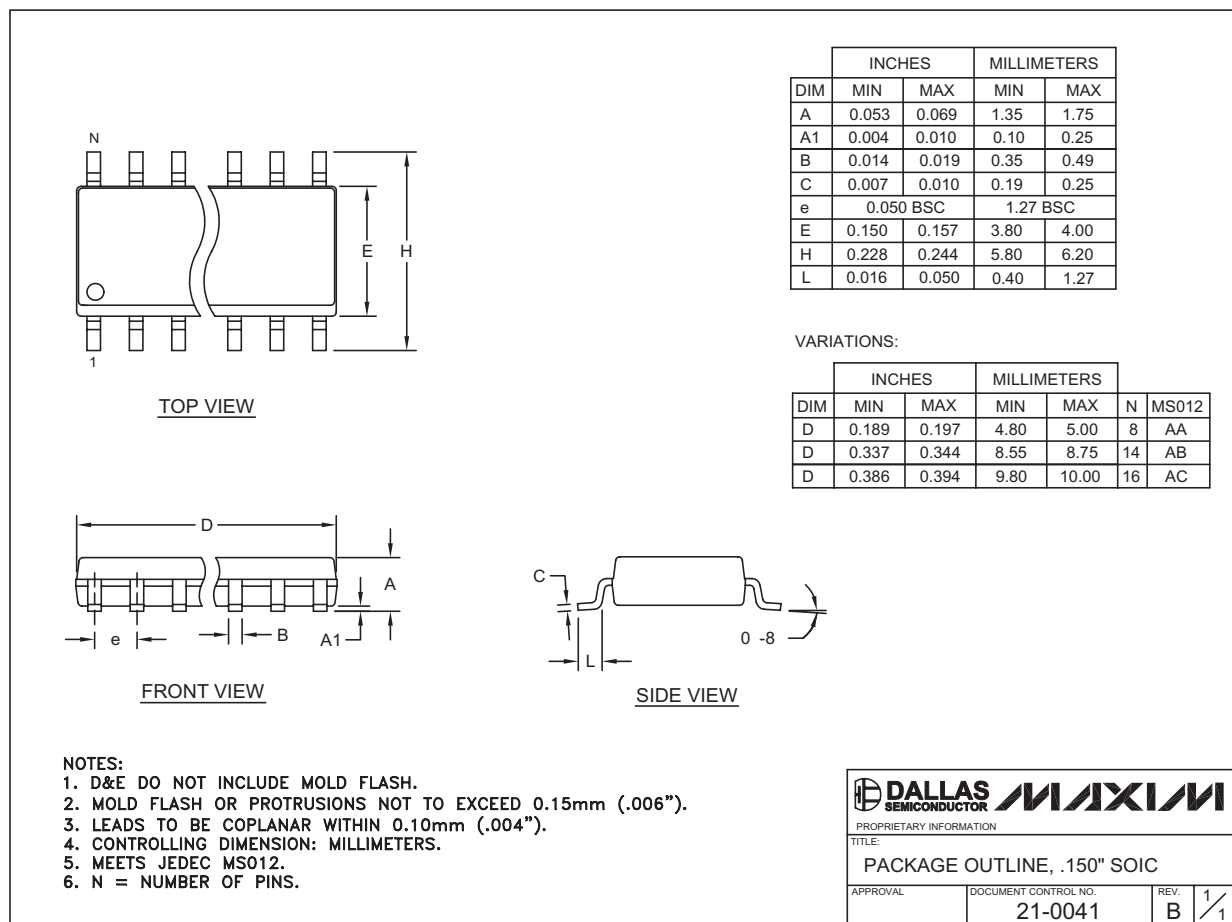
(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



# Low-Cost, +3V/+5V, 620µA, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs

## Package Information (continued)

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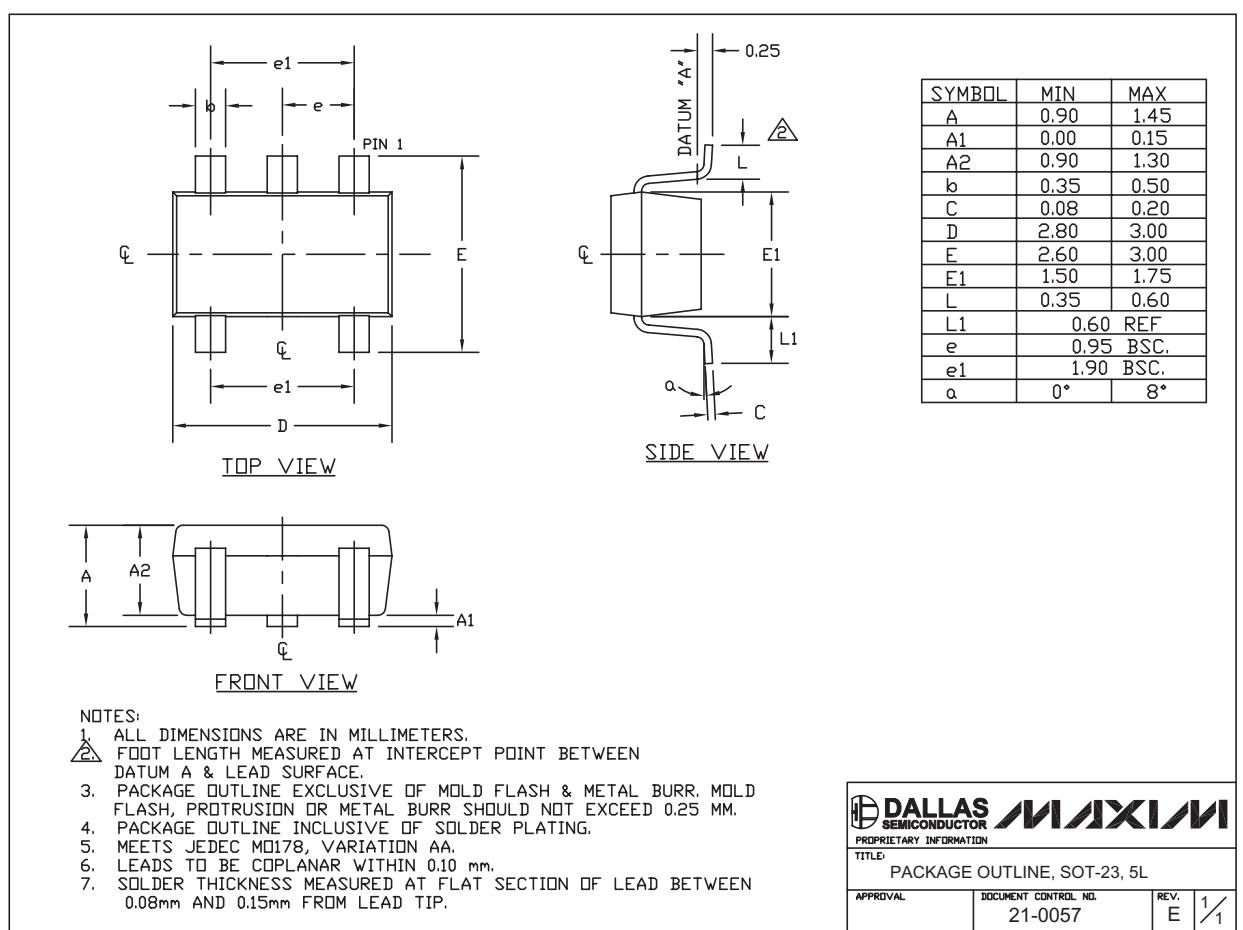
SOICN .EPS

MAX4452/MAX4453/MAX4454/MAX4352/MAX4353/MAX4354

# Low-Cost, +3V/+5V, 620 $\mu$ A, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

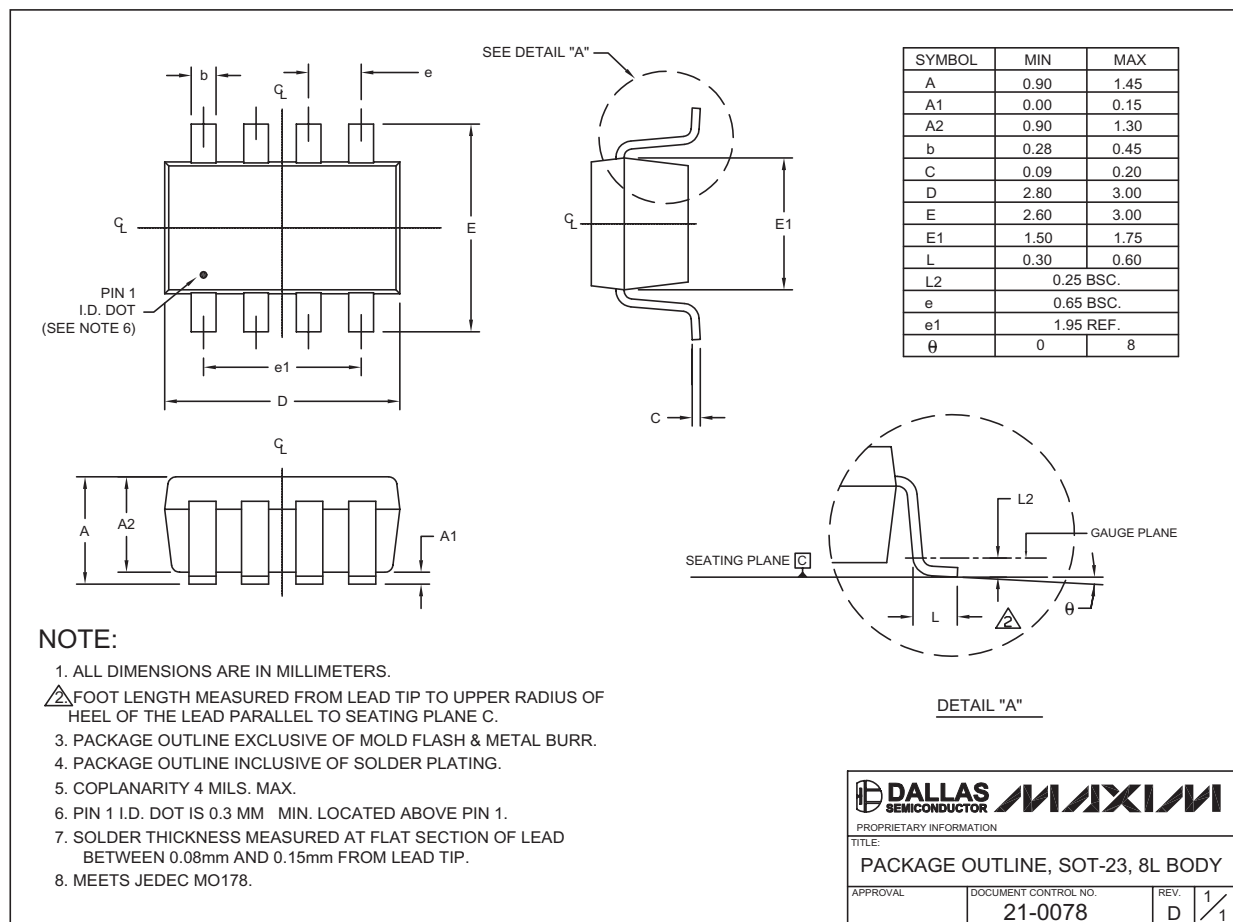




# **Low-Cost, +3V/+5V, 620 $\mu$ A, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs**

## **Package Information (continued)**

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

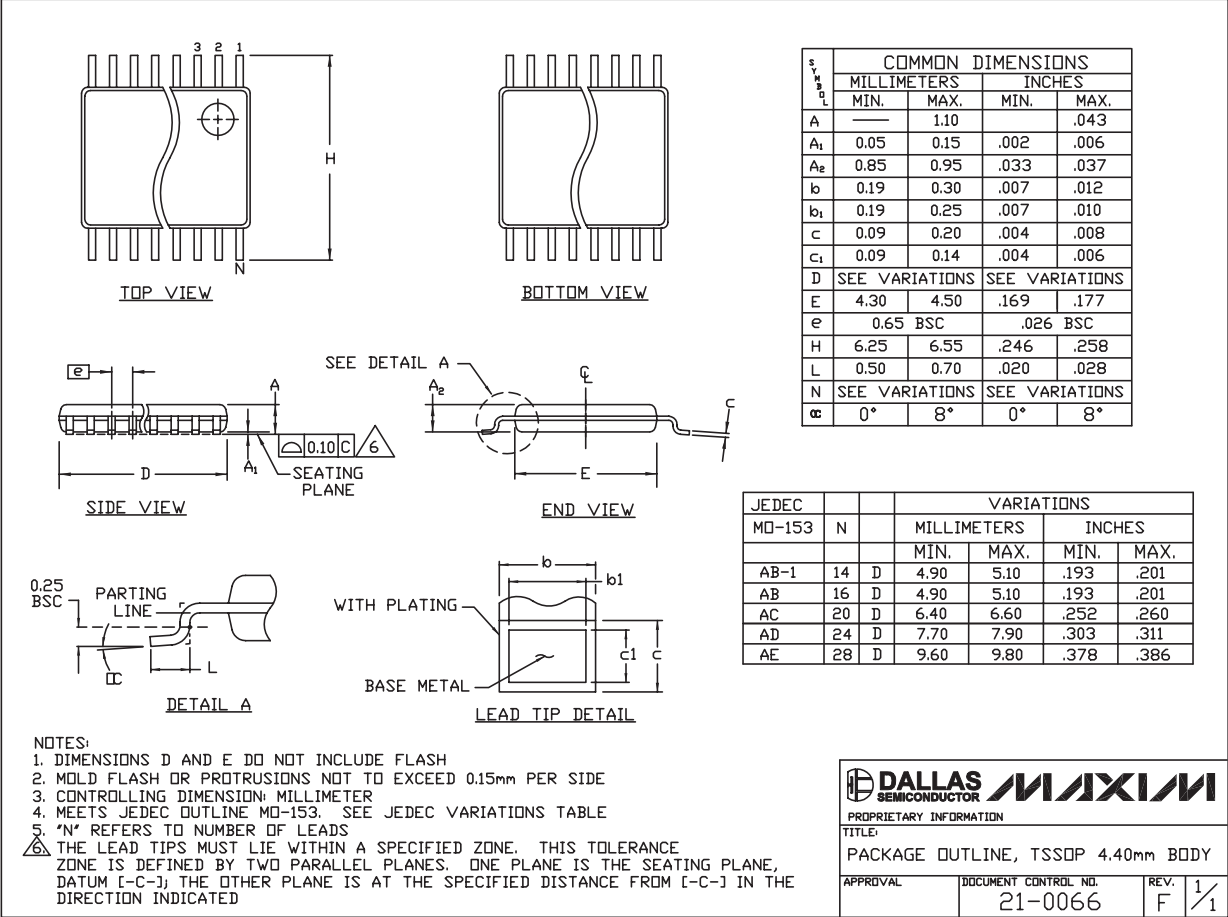


SOT23, 8L, EPS

# Low-Cost, +3V/+5V, 620µA, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs

## Package Information (continued)

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# Low-Cost, +3V/+5V, 620 $\mu$ A, 200MHz, Single-Supply Op Amps with Rail-to-Rail Outputs

## Package Information (continued)

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