19-2322; Rev 4; 11/09

# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable



## General Description

The MAX4389/MAX4390/MAX4392–MAX4396 family of op amps are unity-gain stable devices that combine high-speed performance, rail-to-rail outputs, and disable mode. These devices are targeted for applications where an input or an output is exposed to the outside world, such as video and communications.

The MAX4389/MAX4390/MAX4392–MAX4396 operate from a single 4.5V to 11V supply or from dual ±2.25V to ±5.5V supplies. The common-mode input voltage range extends to the negative power-supply rail (ground in single-supply applications). The MAX4389/MAX4390/MAX4392–MAX4396 consume only 5.5mA of quinescent supply current per amplifier while achieving a 85MHz -3dB bandwidth, 27MHz 0.1dB gain flatness, and a 500V/µs slew rate. Disable mode sets the outputs to high impedance while consuming only 450µA of current.

The MAX4389 single, MAX4393 dual, MAX4394 triple, and MAX4396 quad include disable capabilities. The MAX4389 and MAX4390 are available in ultra-small, 6-pin SC70 packages.

## Applications

Set-Top Boxes

Surveillance Video Systems

Analog-to-Digital Converter Interface

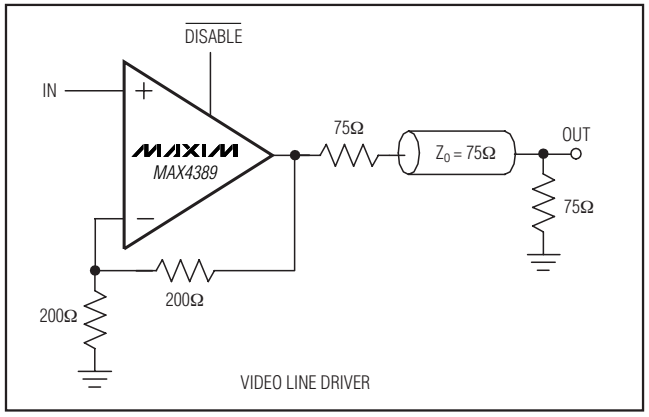
CCD Imaging Systems

Digital Cameras

Video-on-Demand

Video Line Driver

## Typical Operating Circuit




## Features

- **Low Cost**
- **High Speed**
  **85MHz -3dB Bandwidth**
  **27MHz 0.1dB Gain Flatness**
  **500V/µs Slew Rate**
- **Single 4.5V to 11V or Dual ±2.25V to ±5.5V Operation**
- **Rail-to-Rail Outputs**
- **Input Common-Mode Range Extends to $V_{EE}$**
- **Low Differential Gain/Phase: 0.015%/0.015°**
- **Low Distortion at 5MHz**
  **-59dBc Spurious-Free Dynamic Range**
- **High Output Drive: ±50mA**
- **450µA Disable Capability (MAX4389/MAX4393/MAX4394/MAX4396)**
- **Space-Saving SC70, SOT23, µMAX, or TSSOP Packages**

## Ordering Information

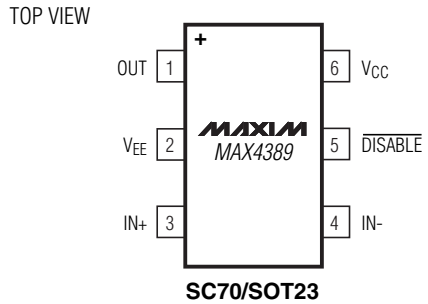
| PART | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|---|---|---|---|
| **MAX4389**EXT+T | -40°C to +85°C | 6 SC70 | ABF |
| MAX4389EUT+T | -40°C to +85°C | 6 SOT23 | ABDC |
| MAX4389EUT/V+T | -40°C to +85°C | 6 SOT23 | ABDC |
| **MAX4390**EXT+T | -40°C to +85°C | 6 SC70 | ABE |
| MAX4390EUK+T | -40°C to +85°C | 5 SOT23 | ADZM |

***Ordering Information continued at end of data sheet.***

***Selector Guide appears at end of data sheet.***

*+Denotes a lead(Pb)-free/RoHs-compliant package.*
*/V denotes an automotive qualified part.*
*T = Tape and reel.*

## Pin Configurations




**SC70/SOT23**

*Pin Configurations continued at end of data sheet.*

# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ($V_{CC}$ to $V_{EE}$) .....-0.3V to +12V
IN_+, IN_-, OUT_, $\overline{DISABLE}$.....($V_{EE}$ - 0.3V) to ($V_{CC}$ + 0.3V)
Differential Input Voltage .....±2.5V
Current into Input Pins .....±20mA
Output Short-Circuit Duration to
$V_{CC}$ or $V_{EE}$ (Note 1).....Continuous
Continuous Power Dissipation ($T_A$ = +70°C)
5-Pin SOT23 (derate 7.1mW/°C above +70°C).....571mW
6-Pin SOT23 (derate 8.7mW/°C above +70°C).....696mW
6-Pin SC70 (derate 3.1mW/°C above +70°C).....245mW
8-Pin SO (derate 5.88mW/°C above +70°C).....471mW
8-Pin µMAX (derate 4.5mW/°C above +70°C).....362mW
10-Pin µMAX (derate 5.6mW/°C above +70°C).....444mW
14-Pin SO (derate 8.33mW/°C above +70°C).....667mW
14-Pin TSSOP (derate 10mW/°C above +70°C).....727mW
20-Pin TSSOP (derate 10.9mW/°C above +70°C).....879mW
Operating Temperature Range .....-40°C to +85°C
Junction Temperature.....+150°C
Storage Temperature Range.....-65°C to +150°C
Lead Temperature (soldering, 10s).....+300°C

**Note 1:** Continuous power dissipation must also be observed.

*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—Single Supply

($V_{CC}$ = 5V, $V_{EE}$ = 0V, $V_{CM}$ = $V_{CC}$/2, $V_{OUT}$ = $V_{CC}$/2, $R_L$ = ∞ to $V_{CC}$/2, $\overline{DISABLE\_}$ = $V_{CC}$ (MAX4389/MAX4393/MAX4394/MAX4396), $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Input Common-Mode Voltage Range | $V_{CM}$ | Guaranteed by CMRR test | | $V_{EE}$ - 0.2 | | $V_{CC}$ - 2.25 | V |
| Input Offset Voltage | $V_{OS}$ | $T_A$ = +25°C | | | 5 | 18 | mV |
| | | $T_A$ = -40°C to +85°C | | | | 26 | |
| Input Offset Voltage Matching | | MAX4392–MAX4396 | | | 1 | | mV |
| Input Offset Voltage Tempco | $TC_{VOS}$ | | | | 15 | | µV/°C |
| Input Bias Current | $I_B$ | | | | 2.5 | 15 | µA |
| Input Offset Current | $I_{OS}$ | | | | 0.2 | 5 | µA |
| Input Resistance | $R_{IN}$ | Differential mode (-1V ≤ $V_{IN}$ ≤ +1V) | | | 70 | | kΩ |
| | | Common mode (-0.2V ≤ $V_{CM}$ ≤ +2.75V) | | | 3 | | MΩ |
| Common-Mode Rejection Ratio | CMRR | ($V_{EE}$ - 0.2V) ≤ $V_{CM}$ ≤ ($V_{CC}$ - 2.25V) | | 70 | 95 | | dB |
| Open-Loop Gain | $A_{VOL}$ | 0.25V ≤ $V_{OUT}$ ≤ 4.75V, $R_L$ = 2kΩ | | 50 | 70 | | dB |
| | | 0.8V ≤ $V_{OUT}$ ≤ 4.5V, $R_L$ = 150Ω | | 50 | 60 | | |
| | | 1V ≤ $V_{OUT}$ ≤ 4V, $R_L$ = 50Ω | | | 58 | | |
| Output Voltage Swing | $V_{OUT}$ | $R_L$ = 2kΩ | $V_{CC}$ - $V_{OH}$ | | 0.065 | 0.25 | V |
| | | | $V_{OL}$ - $V_{EE}$ | | 0.05 | 0.15 | |
| | | $R_L$ = 150Ω | $V_{CC}$ - $V_{OH}$ | | 0.3 | 0.5 | |
| | | | $V_{OL}$ - $V_{EE}$ | | 0.25 | 0.5 | |
| | | $R_L$ = 75Ω | $V_{CC}$ - $V_{OH}$ | | 0.5 | 0.8 | |
| | | | $V_{OL}$ - $V_{EE}$ | | 0.45 | 0.8 | |
| | | $R_L$ = 75Ω to ground | $V_{CC}$ - $V_{OH}$ | | 1 | 1.7 | |
| | | | $V_{OL}$ - $V_{EE}$ | | 0.025 | 0.1 | |
| Output Current | $I_{OUT}$ | Sinking from $R_L$ = 75Ω to $V_{CC}$ | | 40 | 55 | | mA |
| | | Sourcing into $R_L$ = 75Ω to $V_{EE}$ | | 40 | 50 | | |
| Output Short-Circuit Current | $I_{SC}$ | Sinking or sourcing | | | ±100 | | mA |
| Open-Loop Output Resistance | $R_{OUT}$ | | | | 8 | | Ω |

## DC ELECTRICAL CHARACTERISTICS—Single Supply (continued)

($V_{CC}$ = 5V, $V_{EE}$ = 0V, $V_{CM}$ = $V_{CC}$/2, $V_{OUT}$ = $V_{CC}$/2, $R_L$ = ∞ to $V_{CC}$/2, $\overline{DISABLE\_}$ = $V_{CC}$ (MAX4389/MAX4393/MAX4394/MAX4396), $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Power-Supply Rejection Ratio | PSRR | $V_{EE}$ = 0V, $V_{CC}$ = 4.5V to 5.5V | 48 | 65 | | dB |
| Operating Supply Voltage Range | $V_S$ | Guaranteed by PSRR | 4.5 | | 11 | V |
| Disabled Output Resistance | $R_{OUT(OFF)}$ | $\overline{DISABLE\_}$ = 0, 0 ≤ $V_{OUT}$ ≤ 5V | 40 | 95 | | kΩ |
| $\overline{DISABLE\_}$ Logic-Low Threshold | $V_{IL}$ | | | | $V_{CC}$ - 3 | V |
| $\overline{DISABLE\_}$ Logic-High Threshold | $V_{IH}$ | | $V_{CC}$ - 1.25 | | | V |
| $\overline{DISABLE\_}$ Logic Input Low Current | $I_{IL}$ | $\overline{DISABLE\_}$ = 0 | | 20 | 60 | µA |
| $\overline{DISABLE\_}$ Logic Input High Current | $I_{IH}$ | $\overline{DISABLE\_}$ = $V_{CC}$ | | 5 | 40 | µA |
| Quiescent Supply Current (Per Amplifier) | $I_S$ | $\overline{DISABLE\_}$ = $V_{CC}$ | | 3.2 | 5 | mA |
| | | $\overline{DISABLE\_}$ = 0 | | 0.3 | 0.4 | |

## DC ELECTRICAL CHARACTERISTICS—Dual Supply

($V_{CC}$ = 5V, $V_{EE}$ = -5V, $V_{CM}$ = 0V, $V_{OUT}$ = 0V, $R_L$ = ∞ to 0, $\overline{DISABLE\_}$ = $V_{CC}$ (MAX4389/MAX4393/MAX4394/MAX4396), $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Input Common-Mode Voltage | $V_{CM}$ | Guaranteed by CMRR test | $V_{EE}$ | | $V_{CC}$ - 2.25 | V |
| Input Offset Voltage | $V_{OS}$ | $T_A$ = +25°C | | 7 | 20 | mV |
| | | $T_A$ = -40°C to +85°C | | | 28 | |
| Input Offset Voltage Matching | | MAX4392–MAX4396 | | 1 | | mV |
| Input Offset Voltage Tempco | $TC_{VOS}$ | | | 20 | | µV/°C |
| Input Bias Current | $I_B$ | | | 5 | 15 | µA |
| Input Offset Current | $I_{OS}$ | | | 0.5 | 5 | µA |
| Input Resistance | $R_{IN}$ | Differential mode (-1V ≤ $V_{IN}$ ≤ +1V) | | 70 | | kΩ |
| | | Common mode (-0.2V ≤ $V_{CM}$ ≤ +2.75V) | | 3 | | MΩ |
| Common-Mode Rejection Ratio | CMRR | $V_{EE}$ ≤ $V_{CM}$ ≤ ($V_{CC}$ - 2.25V) | 70 | 90 | | dB |
| Open-Loop Gain | $A_{VOL}$ | -4.5V ≤ $V_{OUT}$ ≤ 4.5V, $R_L$ = 2kΩ | 65 | 80 | | dB |
| | | -4.25V ≤ $V_{OUT}$ ≤ 4.25V, $R_L$ = 150Ω | 50 | 60 | | |

# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

## DC ELECTRICAL CHARACTERISTICS—Dual Supply (continued)

($V_{CC}$ = 5V, $V_{EE}$ = -5V, $V_{CM}$ = 0V, $V_{OUT}$ = 0V, $R_L$ = ∞ to 0, $\overline{DISABLE\_}$ = $V_{CC}$ (MAX4389/MAX4393/MAX4394/MAX4396), $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Output Voltage Swing | $V_{OUT}$ | $R_L$ = 2kΩ | $V_{CC}$ - $V_{OH}$ | | 0.175 | 0.3 | V |
| | | | $V_{OL}$ - $V_{EE}$ | | 0.075 | 0.2 | |
| | | $R_L$ = 150Ω | $V_{CC}$ - $V_{OH}$ | | 0.575 | 0.85 | |
| | | | $V_{OL}$ - $V_{EE}$ | | 0.4 | 1.5 | |
| | | $R_L$ = 75Ω | $V_{CC}$ - $V_{OH}$ | | 1.5 | 2.35 | |
| | | | $V_{OL}$ - $V_{EE}$ | | 0.75 | 1.6 | |
| Output Current | $I_{OUT}$ | Sinking from $R_L$ = 75Ω to $V_{CC}$ | | 50 | 95 | | mA |
| | | Sourcing into $R_L$ = 75Ω to $V_{EE}$ | | 50 | 75 | | |
| Output Short-Circuit Current | $I_{SC}$ | Sinking or sourcing | | | ±100 | | mA |
| Open-Loop Output Resistance | $R_{OUT}$ | | | | 8 | | Ω |
| Power-Supply Rejection Ratio | PSRR | $V_{EE}$ = 0V, $V_{CC}$ = 4.5V to 5.5V | | 48 | 60 | | dB |
| Operating Supply Voltage Range | $V_S$ | Guaranteed by PSRR | | 4.5 | | 11 | V |
| Disabled Output Resistance | $R_{OUT(OFF)}$ | $\overline{DISABLE\_}$ = 0V, -5V ≤ $V_{OUT}$ ≤ +5V | | 40 | 95 | | kΩ |
| $\overline{DISABLE\_}$ Logic-Low Threshold | $V_{IL}$ | | | | | $V_{CC}$ - 3 | V |
| $\overline{DISABLE\_}$ Logic-High Threshold | $V_{IH}$ | | | $V_{CC}$ - 1.25 | | | V |
| Quiescent Supply Current (Per Amplifier) | $I_S$ | $\overline{DISABLE\_}$ = $V_{CC}$ | | | 6 | 10 | mA |
| | | $\overline{DISABLE\_}$ = 0V | | | 0.45 | 0.8 | |

## AC ELECTRICAL CHARACTERISTICS—Single Supply

($V_{CC}$ = 5V, $V_{EE}$ = 0V, $V_{CM}$ = 1.5V, $R_L$ = 100Ω to $V_{CC}$/2, $\overline{DISABLE\_}$ = $V_{CC}$ (MAX4389/MAX4393/MAX4394/MAX4396), $V_{OUT}$ = $V_{CC}$/2, $A_{VCL}$ = 1V/V, $T_A$ = +25°C, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Small-Signal -3dB Bandwidth | $BW_{SS}$ | $V_{OUT}$ = 100m$V_{P-P}$ | | 72 | | MHz |
| Large-Signal -3dB Bandwidth | $BW_{LS}$ | $V_{OUT}$ = 2$V_{P-P}$ | | 80 | | MHz |
| Small-Signal 0.1dB Gain Flatness | $BW_{0.1dBSS}$ | $V_{OUT}$ = 100m$V_{P-P}$ | | 30 | | MHz |
| Large-Signal 0.1dB Gain Flatness | $BW_{0.1dBLS}$ | $V_{OUT}$ = 2$V_{P-P}$ | | 30 | | MHz |
| Slew Rate | SR | $V_{OUT}$ = 2V step | | 500 | | V/µs |
| Settling Time to 0.1% | $t_S$ | $V_{OUT}$ = 2V step | | 28 | | ns |
| Rise/Fall Time | $t_R/t_F$ | $V_{OUT}$ = 100m$V_{P-P}$ | | 4 | | ns |
| Spurious-Free Dynamic Range | SFDR | $f_C$ = 5MHz, $V_{OUT}$ = 2$V_{P-P}$ | | -59 | | dBc |

## AC ELECTRICAL CHARACTERISTICS—Single Supply (continued)

($V_{CC}$ = 5V, $V_{EE}$ = 0V, $V_{CM}$ = 1.5V, $R_L$ = 100Ω to $V_{CC}/2$, $\overline{DISABLE\_}$ = $V_{CC}$ (MAX4389/MAX4393/MAX4394/MAX4396), $V_{OUT}$ = $V_{CC}/2$, $A_{VCL}$ = 1V/V, $T_A$ = +25°C, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Differential Phase Error | DP | NTSC, $R_L$ = 150Ω | | 0.015 | | degrees |
| Differential Gain Error | DG | NTSC, $R_L$ = 150Ω | | 0.015 | | % |
| Input Noise-Voltage Density | $e_n$ | f = 10kHz | | 13 | | nV/√Hz |
| Input Noise-Current Density | $i_n$ | f = 10kHz | | 2.1 | | pA/√Hz |
| Input Capacitance | $C_{IN}$ | | | 1 | | pF |
| Output Impedance | $Z_{OUT}$ | f = 5MHz | | 0.6 | | Ω |
| Disable OFF Time | | MAX4389/MAX4393/MAX4394/MAX4396 | | 80 | | ns |
| Disable ON Time | | MAX4389/MAX4393/MAX4394/MAX4396 | | 40 | | ns |
| Channel-to-Channel Isolation | $CH_{ISO}$ | MAX4392–MAX4396, specified at DC | | -97 | | dB |

## AC ELECTRICAL CHARACTERISTICS—Dual Supply

($V_{CC}$ = 5V, $V_{EE}$ = -5V, $R_L$ = ∞ to GND, GND = 0, $V_{OUT}$ = 0V, Gain = 1V/V, $\overline{DISABLE}$ = $V_{CC}$, and $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $T_A$ = +25°C.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Small-Signal -3dB Bandwidth | $BW_{SS}$ | $V_{OUT}$ = 100m$V_{P-P}$ | | 85 | | MHz |
| Large-Signal -3dB Bandwidth | $BW_{LS}$ | $V_{OUT}$ = 2$V_{P-P}$ | | 90 | | MHz |
| Small-Signal Bandwidth for 0.1dB Gain Flatness | $BW_{0.1dBss}$ | $V_{OUT}$ = 100m$V_{P-P}$ | | 27 | | MHz |
| Large-Signal Bandwidth for 0.1dB Gain Flatness | $BW_{0.1dBLS}$ | $V_{OUT}$ = 2$V_{P-P}$ | | 24 | | MHz |
| Slew Rate | SR | $V_{OUT}$ = 2V step | | 500 | | V/µs |
| Settling Time to 0.1% | $t_S$ | $V_{OUT}$ = 2V step | | 21 | | ns |
| Rise/Fall Time | $t_R/t_F$ | $V_{OUT}$ = 100m$V_{P-P}$ | | 4 | | ns |
| Spurious-Free Dynamic Range | SFDR | $f_C$ = 5MHz, $V_{OUT}$ = 2$V_{P-P}$ | | -59 | | dBc |
| Differential Phase Error | DP | NTSC, $R_L$ = 150Ω | | 0.015 | | degrees |
| Differential Gain Error | DG | NTSC, $R_L$ = 150Ω | | 0.015 | | % |
| Input Noise-Voltage Density | $e_n$ | f = 10kHz | | 13 | | nV/√Hz |
| Input Noise-Current Density | $i_n$ | f = 10kHz | | 2.1 | | pA/√Hz |
| Input Capacitance | $C_{IN}$ | | | 1 | | pF |
| Output Impedance | $Z_{OUT}$ | f = 5MHz | | 0.6 | | Ω |
| Disable OFF Time | | MAX4389/MAX4393/MAX4394/MAX4396 | | 80 | | ns |
| Disable ON Time | | MAX4389/MAX4393/MAX4394/MAX4396 | | 40 | | ns |
| Channel-to-Channel Isolation | $CH_{ISO}$ | MAX4392/MAX4393/MAX4394/MAX4395/ MAX4396, specified at DC | | -97 | | dB |

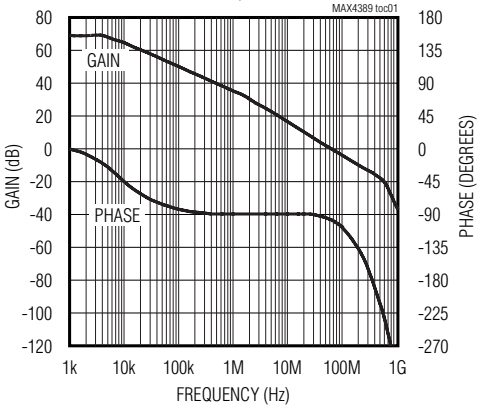
**Note 2:** All devices are 100% production tested at $T_A$ = +25°C. Specifications over temperature limits are guaranteed by design.

# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

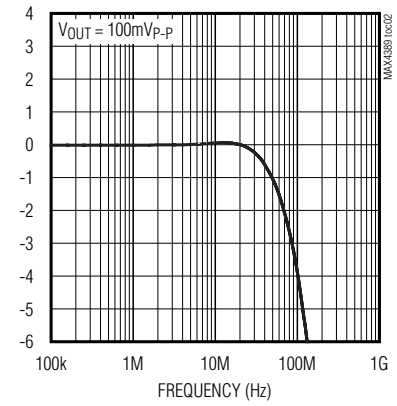
## Typical Operating Characteristics

($V_{CC}$ = 5V, $V_{EE}$ = -5V, $V_{CM}$ = 0V, $A_{VCL}$ = 1V/V, $R_L$ = 100Ω to GND, GND = 0, $T_A$ = +25°C, unless otherwise noted.)

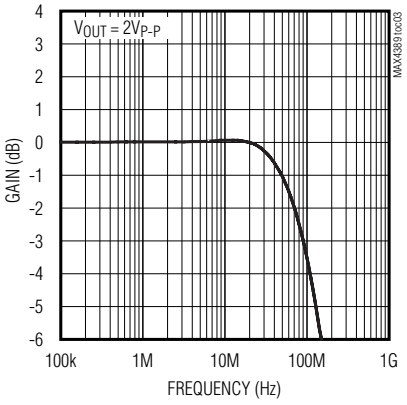
**GAIN AND PHASE vs. FREQUENCY**



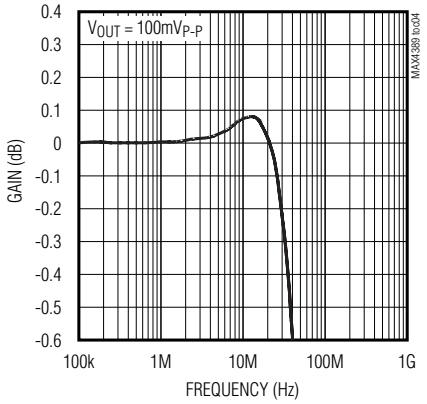

**SMALL-SIGNAL GAIN vs. FREQUENCY**



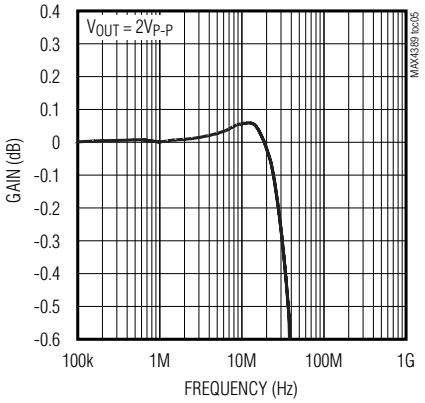

**LARGE-SIGNAL GAIN vs. FREQUENCY**



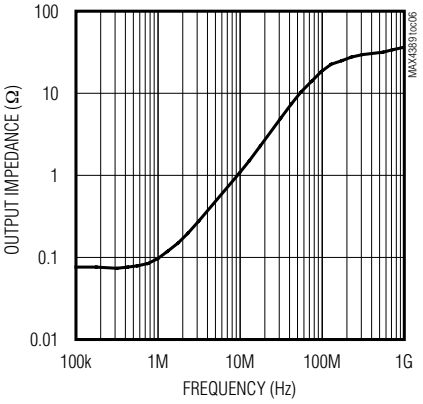

**SMALL-SIGNAL GAIN FLATNESS vs. FREQUENCY**



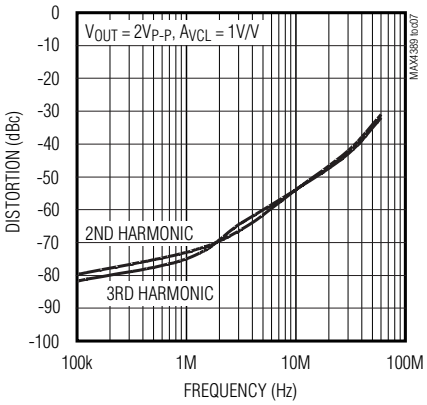

**LARGE-SIGNAL GAIN FLATNESS vs. FREQUENCY**



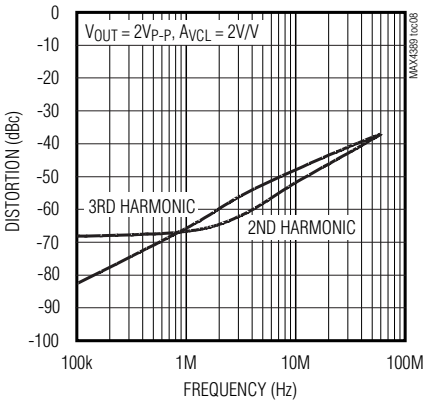

**OUTPUT IMPEDANCE vs. FREQUENCY**



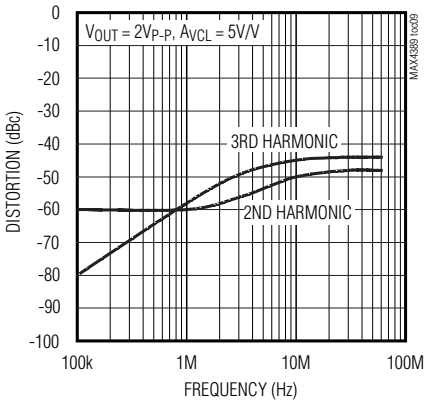

**DISTORTION vs. FREQUENCY**




**DISTORTION vs. FREQUENCY**



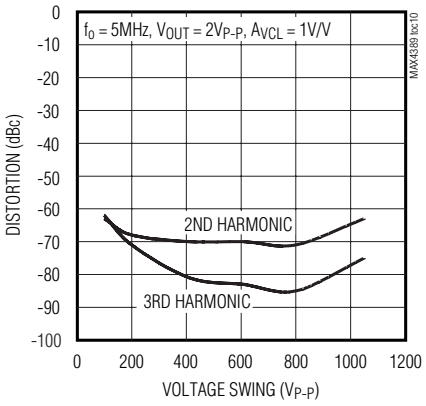

**DISTORTION vs. FREQUENCY**



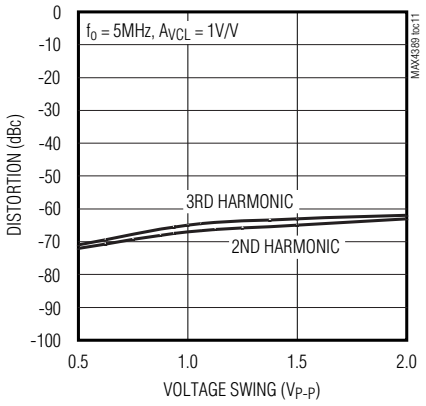
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5V, $V_{EE}$ = -5V, $V_{CM}$ = 0V, $A_{VCL}$ = 1V/V, $R_L$ = 100Ω to GND, GND = 0, $T_A$ = +25°C, unless otherwise noted.)

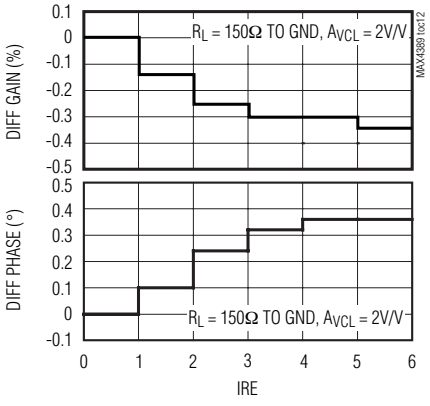
**DISTORTION vs. RESISTIVE LOAD**



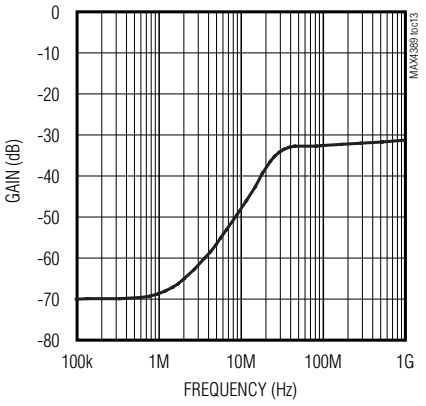

**DISTORTION vs. VOLTAGE SWING**



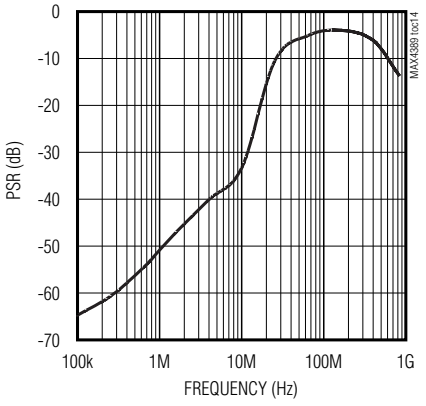

**DIFFERENTIAL GAIN AND PHASE**



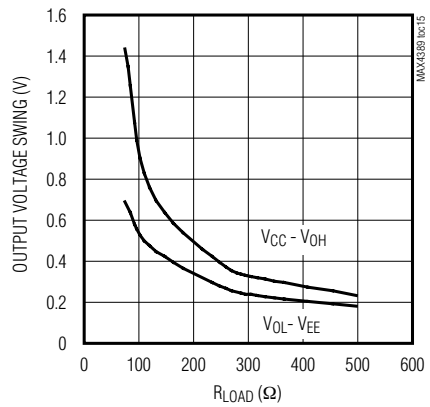

**COMMON-MODE REJECTION vs. FREQUENCY**



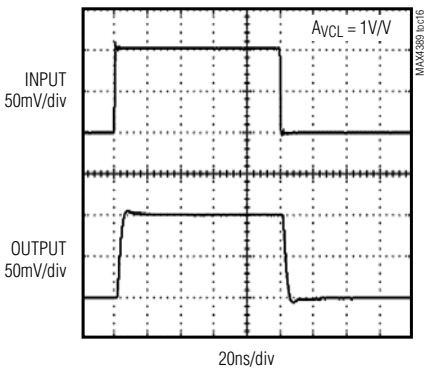

**POWER-SUPPLY REJECTION vs. FREQUENCY**



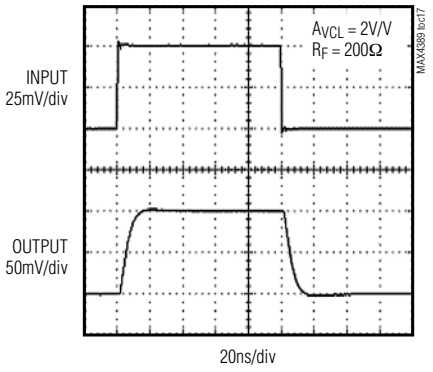

**OUTPUT VOLTAGE SWING vs. RESISTIVE LOAD**



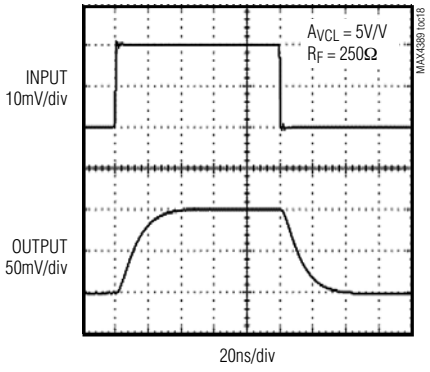

**SMALL-SIGNAL PULSE RESPONSE**




**SMALL-SIGNAL PULSE RESPONSE**




**SMALL-SIGNAL PULSE RESPONSE**

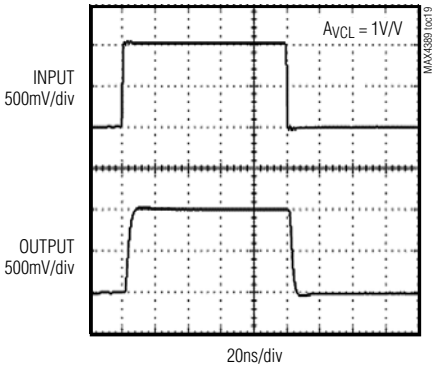


# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

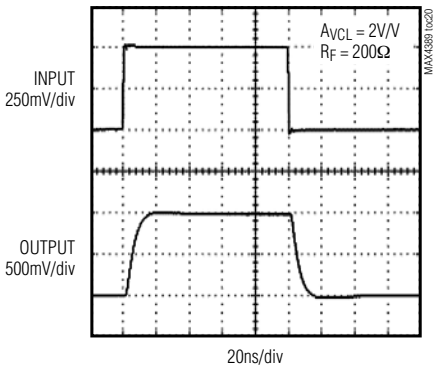
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5V, $V_{EE}$ = -5V, $V_{CM}$ = 0V, $A_{VCL}$ = 1V/V, $R_L$ = 100Ω to GND, GND = 0, $T_A$ = +25°C, unless otherwise noted.)

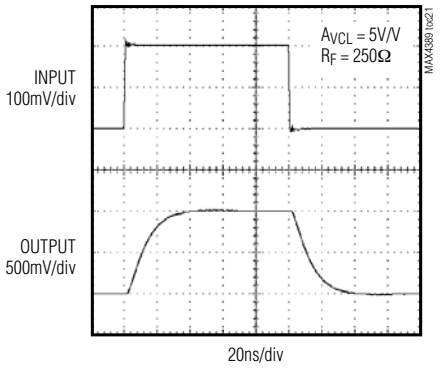
**LARGE-SIGNAL PULSE RESPONSE**



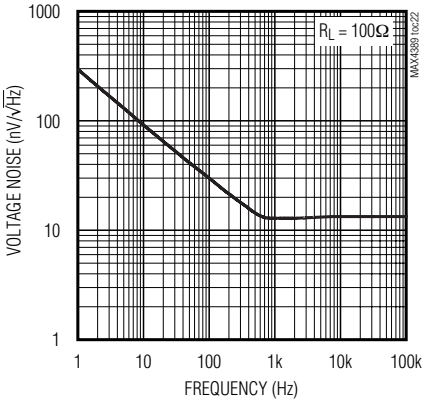

**LARGE-SIGNAL PULSE RESPONSE**



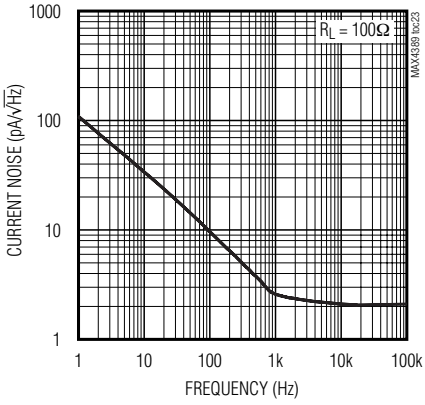

**LARGE-SIGNAL PULSE RESPONSE**



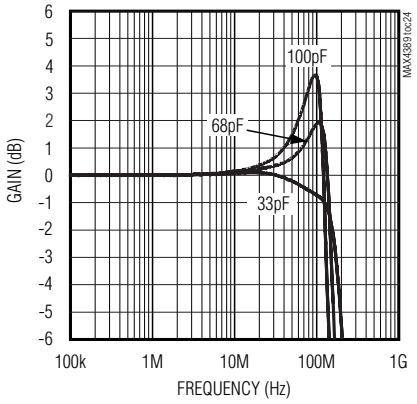

**VOLTAGE NOISE vs. FREQUENCY**




**CURRENT NOISE vs. FREQUENCY**



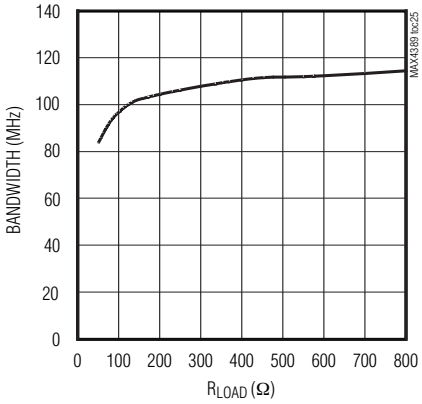

**ISOLATION RESISTANCE vs. CAPACITIVE LOAD**



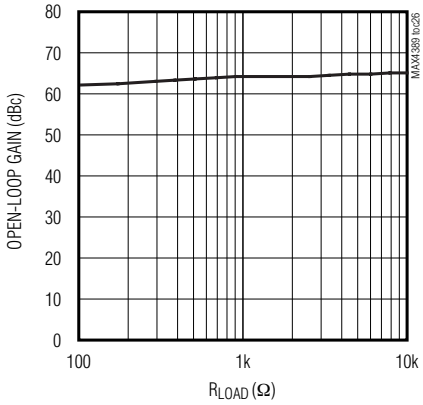
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5V, $V_{EE}$ = -5V, $V_{CM}$ = 0V, $A_{VCL}$ = 1V/V, $R_L$ = 100Ω to GND, GND = 0, $T_A$ = +25°C, unless otherwise noted.)

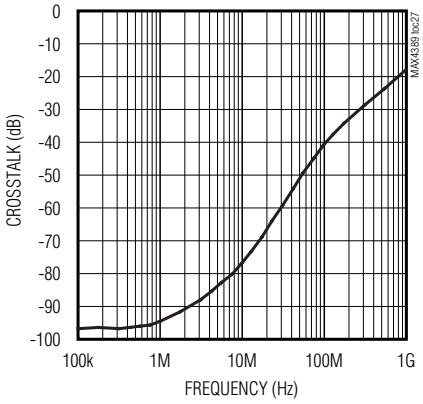
**SMALL-SIGNAL BANDWIDTH vs. LOAD RESISTANCE**



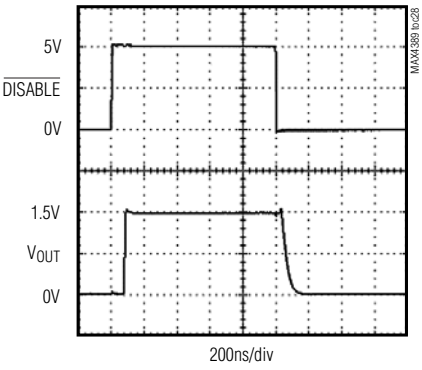

**OPEN-LOOP GAIN vs. RESISTIVE LOAD**



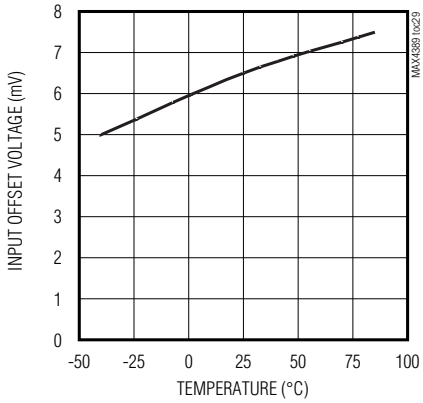

**CROSSTALK vs. FREQUENCY**



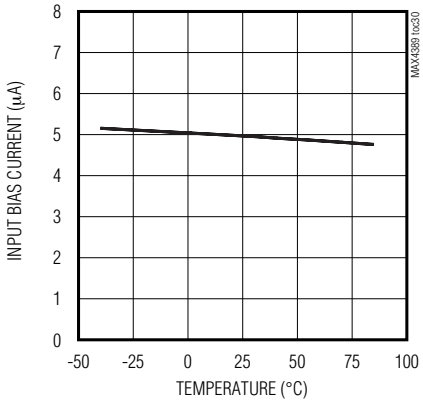

**DISABLE RESPONSE**



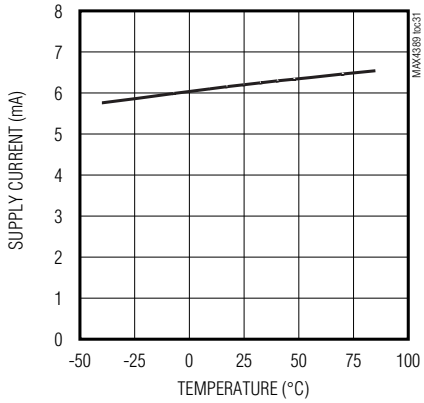

**INPUT OFFSET VOLTAGE vs. TEMPERATURE**




**INPUT BIAS CURRENT vs. TEMPERATURE**




**SUPPLY CURRENT vs. TEMPERATURE**



# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

## Pin Description

| PIN | | | | | | | | NAME | FUNCTION |
|---|---|---|---|---|---|---|---|---|---|
| MAX4389 | MAX4390 | | MAX4392 | MAX4393 | MAX4394 | MAX4395 | MAX4396 | | |
| SC70/SOT23 | SC70 | SOT23 | µMAX/SO | µMAX | SO/TSSOP | SO/TSSOP | TSSOP | | |
| 1 | 1 | 1 | — | — | — | — | — | OUT | Amplifier Output |
| 2 | 2 | 2 | 4 | 4 | 11 | 11 | 16 | $V_{EE}$ | Negative Power Supply. Connect a 0.1µF Capacitor to GND. |
| 3 | 3 | 3 | — | — | — | — | — | IN+ | Noninverting Input |
| 4 | 4 | 4 | — | — | — | — | — | IN- | Inverting Input |
| 5 | — | — | — | — | — | — | — | $\overline{DISABLE}$ | Disable. Connect to $V_{CC}$ to Enable. |
| 6 | 6 | 5 | 8 | 10 | 4 | 4 | 5 | $V_{CC}$ | Positive Power Supply. Connect a 0.1µF Capacitor to GND. |
| — | 5 | — | — | — | — | — | 10, 11 | N.C. | No Connection. Not Internally Connected. |
| — | — | — | 3 | 3 | 5 | 3 | 4 | INA+ | Amplifier A Noninverting Input |
| — | — | — | 2 | 2 | 6 | 2 | 3 | INA- | Amplifier A Inverting Input |
| — | — | — | 1 | 1 | 7 | 1 | 2 | OUTA | Amplifier A Output |
| — | — | — | — | 5 | 1 | — | 1 | $\overline{DISABLEA}$ | Shutdown Amplifier A. Connect to $V_{CC}$ to Enable. |
| — | — | — | 5 | 7 | 10 | 5 | 6 | INB+ | Amplifier B Noninverting Input |
| — | — | — | 6 | 8 | 9 | 6 | 7 | INB- | Amplifier B Inverting Input |
| — | — | — | 7 | 9 | 8 | 7 | 8 | OUTB | Amplifier B Output |

## Pin Description (continued)

| PIN | | | | | | | | NAME | FUNCTION |
|---|---|---|---|---|---|---|---|---|---|
| MAX4389 | MAX4390 | | MAX4392 | MAX4393 | MAX4394 | MAX4395 | MAX4396 | | |
| SC70/SOT23 | SC70 | SOT23 | µMAX/SO | µMAX | SO/TSSOP | SO/TSSOP | TSSOP | | |
| — | — | — | — | 6 | 3 | — | 9 | $\overline{\text{DISABLEB}}$ | Shutdown Amplifier B. Connect to $V_{CC}$ to Enable. |
| — | — | — | — | — | 12 | 10 | 15 | INC+ | Amplifier C Noninverting Input |
| — | — | — | — | — | 13 | 9 | 14 | INC- | Amplifier C Inverting Input |
| — | — | — | — | — | 14 | 8 | 13 | OUTC | Amplifier C Output |
| — | — | — | — | — | 2 | — | 12 | $\overline{\text{DISABLEC}}$ | Shutdown Amplifier C. Connect to $V_{CC}$ to Enable. |
| — | — | — | — | — | — | 12 | 17 | IND+ | Amplifier D Noninverting Input |
| — | — | — | — | — | — | 13 | 18 | IND- | Amplifier D Inverting Input |
| — | — | — | — | — | — | 14 | 19 | OUTD | Amplifier D Output |
| — | — | — | — | — | — | — | 20 | $\overline{\text{DISABLED}}$ | Shutdown Amplifier D. Connect to $V_{CC}$ to Enable. |

## Detailed Description

The MAX4389/MAX4390/MAX4392–MAX4396 are dual-supply, rail-to-rail, voltage-feedback amplifiers that employ current-feedback techniques to achieve 500V/µs slew rates and 85MHz bandwidths. Excellent harmonic distortion and differential gain/phase performance make these amplifiers an ideal choice for a wide variety of video and RF signal-processing applications.

## Applications Information

The output voltage swings to within 200mV of each supply rail. Local feedback around the output stage ensures low open-loop output impedance to reduce gain sensitivity to load variations. The input stage permits common-mode voltages to the negative supply and to within 2.25V of the positive supply rail.

### Choosing Resistor Values

#### Unity-Gain Configuration

The MAX4389/MAX4390/MAX4392–MAX4396 are internally compensated for unity gain. When configured for unity gain, a 24Ω resistor ($R_F$) in series with the feedback path optimizes AC performance. This resistor improves AC response by reducing the Q of the parallel LC circuit formed by the parasitic feedback capacitance and inductance.

# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

### Video Line Driver

The MAX4389/MAX4390/MAX4392–MAX4396 are low-power, voltage-feedback amplifiers featuring large-signal ($2V_{P-P}$) bandwidths of 90MHz and 0.1dB large-signal gain flatness of 24MHz. They are designed to minimize differential-gain error and differential-phase error to 0.015% and 0.015°, respectively. They have a 21ns settling time to 0.1%, 500V/µs slew rates, and output-current-drive capability of up to 50mA making them ideal for driving video loads.

### Inverting and Noninverting Configurations

Select the gain-setting feedback ($R_F$) and input ($R_G$) resistor values to fit your 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 2kΩ resistors, combined with 1pF of amplifier input capacitance and 1pF of PC board capacitance, causes a pole at 79.6MHz. Since this pole is within the amplifier bandwidth, it jeopardizes stability. Reducing the 2kΩ resistors to 100Ω extends the pole frequency to 1.59GHz, but could limit output swing by adding 200Ω in parallel with the amplifier's load resistor (Figures 1a and 1b).

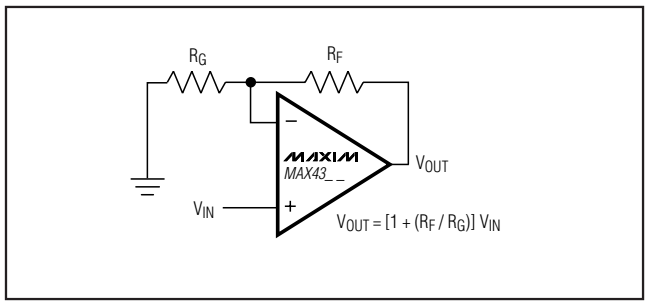



*Figure 1a. Noninverting Gain Configuration*

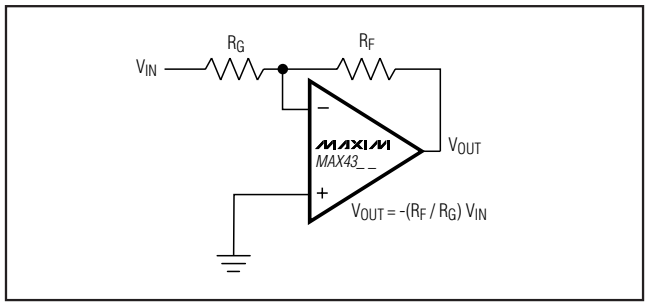



*Figure 1b. Inverting Gain Configuration*

### Layout and Power-Supply Bypassing

The MAX4389/MAX4390/MAX4392–MAX4396 operate from single 4.5V to 11V or from dual ±2.25V to ±5.5V supplies. Bypass each supply with a 0.1µF capacitor as close to the pin as possible.

Maxim recommends using microstrip and stripline techniques to obtain full bandwidth. To ensure that the PC board does not degrade the amplifier's performance, design it for a frequency greater than 1GHz. Pay careful attention to inputs and outputs to avoid large parasitic capacitance. Whether or not you use a constant-impedance board, observe the following design guidelines:

- Do not use wire-wrap boards; they are too inductive.
- Do not use IC sockets; they increase parasitic capacitance and inductance.
- 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.

### Low-Power Disable Mode

The MAX4389/MAX4393/MAX4394/MAX4396 feature a disable function that allows the amplifiers to be placed in a low-power, high-output-impedance state. When the disable pin ($\overline{DISABLE}$) is active, the amplifier's output impedance is 95kΩ. This high resistance and the low 2pF output capacitance make the MAX4389/MAX4390/MAX4392–MAX4396 in RF/video multiplexer or switch applications. For larger arrays, pay careful attention to capacitive loading (see the *Output Capacitive Loading and Stability* section).

### Output Capacitive Loading and Stability

The MAX4389/MAX4390/MAX4392–MAX4396 are optimized for AC performance. They are not designed to drive highly reactive loads, which decrease phase margin and may produce excessive ringing and oscillation. Figure 2 shows a circuit that eliminates this problem. Figure 3 is a graph of the Optimal Isolation Resistor ($R_S$) vs. Capacitive Load. Figure 4 shows how a capacitive load causes excessive peaking of the amplifier's frequency response if the capacitor is not isolated from the amplifier by a resistor. A small isolation resistor (usually 10Ω to 15Ω) placed before the reactive load prevents ringing and oscillation. At higher capacitive loads, AC performance is controlled by the interaction of the load capacitance and the isolation resistor. Figure 5 shows the effect of a 15Ω isolation resistor on closed-loop response.

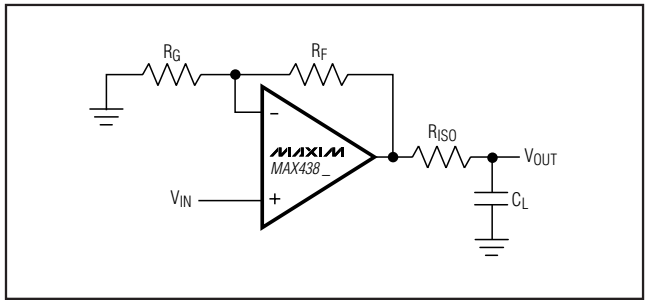



*Figure 2. Driving a Capacitive Load Through an Isolation Resistor*

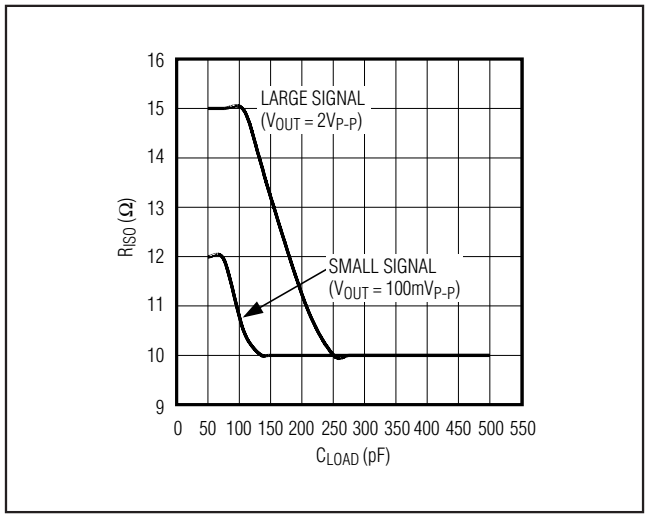



*Figure 3. Isolation Resistance vs. Capacitive Load*

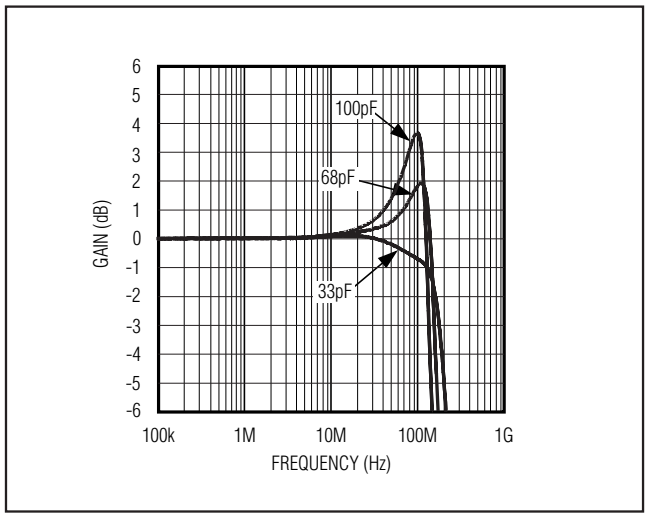



*Figure 4. Small-Signal Gain vs. Frequency with Load Capacitance and No Isolation Resistor*

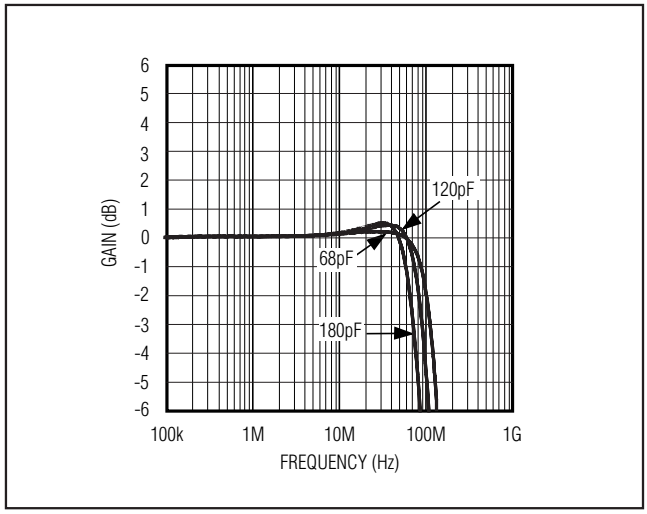



*Figure 5. Small-Signal Gain vs. Frequency with Load Capacitance and 27Ω Isolation Resistor*

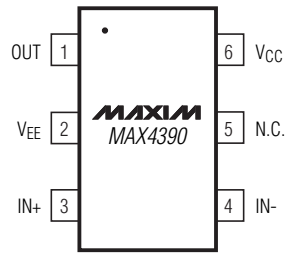
## Chip Information

MAX4389 TRANSISTOR COUNT: 70
MAX4390 TRANSISTOR COUNT: 70
MAX4392 TRANSISTOR COUNT: 204
MAX4393 TRANSISTOR COUNT: 204
MAX4394 TRANSISTOR COUNT: 298
MAX4395 TRANSISTOR COUNT: 396
MAX4396 TRANSISTOR COUNT: 396
PROCESS: BiCMOS

# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

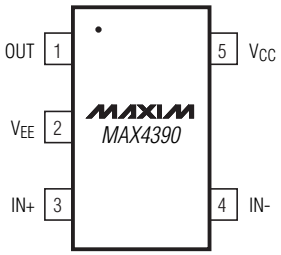
## Pin Configurations (continued)

TOP VIEW



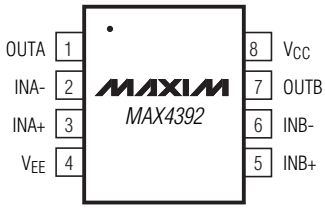

SC70

TOP VIEW



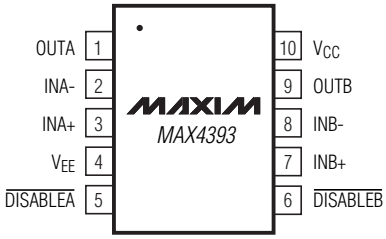

SOT23

TOP VIEW



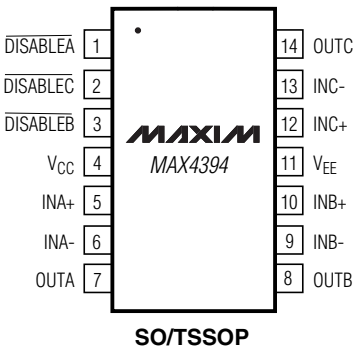

µMAX/SO

TOP VIEW



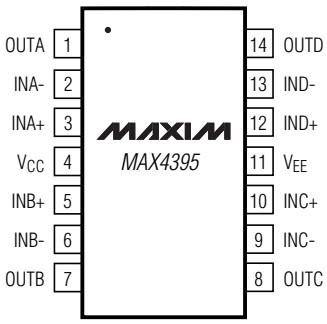

µMAX

TOP VIEW



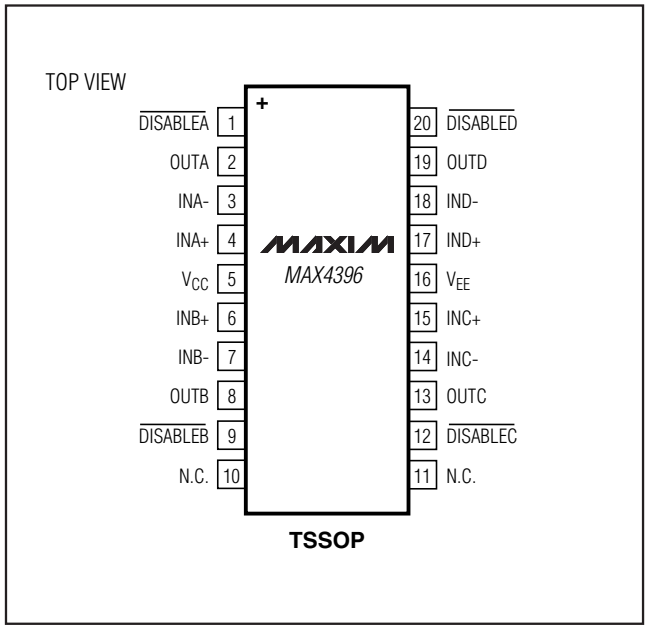

SO/TSSOP

TOP VIEW




SO/TSSOP

## Pin Configurations (continued)




## Ordering Information (continued)

| PART | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|---|---|---|---|
| **MAX4392**ESA+T | -40°C to +85°C | 8 SO | — |
| MAX4392EUA+T | -40°C to +85°C | 8 µMAX | — |
| MAX4392EUA/V+T | -40°C to +85°C | 8 µMAX | — |
| **MAX4393**EUB+T | -40°C to +85°C | 10 µMAX | — |
| **MAX4394**ESD+T | -40°C to +85°C | 14 SO | — |
| MAX4394ESD/V+T | -40°C to +85°C | 14 SO | — |
| MAX4394EUD+T | -40°C to +85°C | 14 TSSOP | — |
| MAX4394EUD/V+T | -40°C to +85°C | 14 TSSOP | — |
| **MAX4395**ESD+T | -40°C to +85°C | 14 SO | — |
| MAX4395ESD/V+T | -40°C to +85°C | 14 SO | — |
| MAX4395EUD+T | -40°C to +85°C | 14 TSSOP | — |
| MAX4395EUD/V+T | -40°C to +85°C | 14 TSSOP | — |
| **MAX4396**EUP+T | -40°C to +85°C | 20 TSSOP | — |

*+Denotes a lead(Pb)-free/RoHs-compliant package.*
*/V denotes an automotive qualified part.*
*T = Tape and reel.*

## Selector Guide

| PART | NO. OF AMPS | DISABLE |
|---|---|---|
| MAX4389 | 1 | Yes |
| MAX4390 | 1 | No |
| MAX4392 | 2 | No |
| MAX4393 | 2 | Yes |
| MAX4394 | 3 | Yes |
| MAX4395 | 4 | No |
| MAX4396 | 4 | Yes |

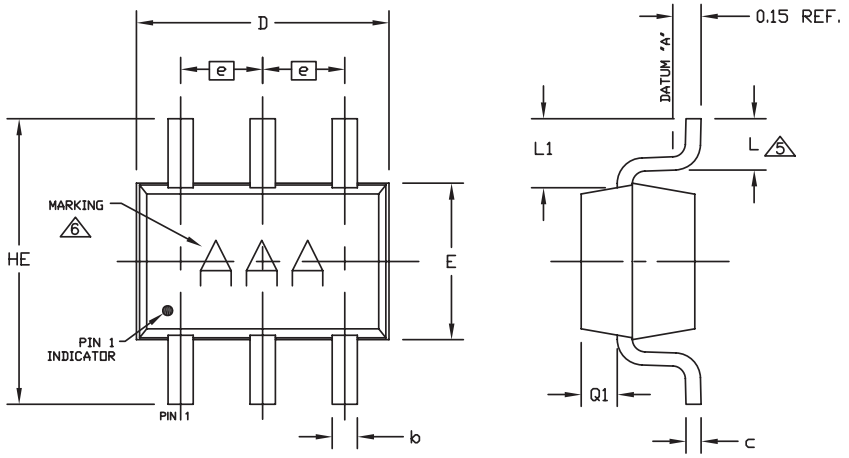
# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

## Package Information

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE | PACKAGE CODE | DOCUMENT NO. |
|---|---|---|
| 6 SC70 | X5-1 | 21-0077 |
| 6 SOT23 | U6-1 | 21-0058 |
| 5 SOT23 | U5-1 | 21-0057 |
| 8 µMAX | U8-1 | 21-0036 |
| 10 µMAX | U10-2 | 21-0061 |
| 8 SO, 14 SO | S8-2, S14-1 | 21-0041 |
| 14 TSSOP, 20 TSSOP | U14-1, U20-3 | 21-0066 |

SC70, 6L.EPS




| COMMON DIMENSIONS | | | |
|---|---|---|---|
| SYMBOL | MIN | NOM | MAX |
| A | 0.80 | 0.95 | 1.10 |
| A1 | 0.00 | 0.07 | 0.10 |
| A2 | 0.80 | 0.90 | 1.00 |
| b | 0.15 | 0.22 | 0.30 |
| c | 0.10 | 0.14 | 0.18 |
| D | 1.80 | 2.00 | 2.20 |
| e | 0.65 BSC. | | |
| E | 1.15 | 1.25 | 1.35 |
| HE | 1.80 | 2.20 | 2.40 |
| L | 0.26 | 0.34 | 0.46 |
| L1 | 0.425 TYP. | | |
| Q1 | 0.10 | 0.25 | 0.40 |
| PKG. CODES | X6SN-1 | | |

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONS ARE INCLUSIVE OF PLATING.
3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. COPLANARITY 4 MILS. MAX.
5. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM "A" AND LEAD SURFACE.
6. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
7. LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION "e", ±0.05.
8. ALL DIMENSIONS COMPLY TO JEDEC MO-203.
9. ALL DIMENSIONS APPLY TO BOTH LEADED (-) AND LEAD FREE (+) PACKAGE CODES.

MAXIM

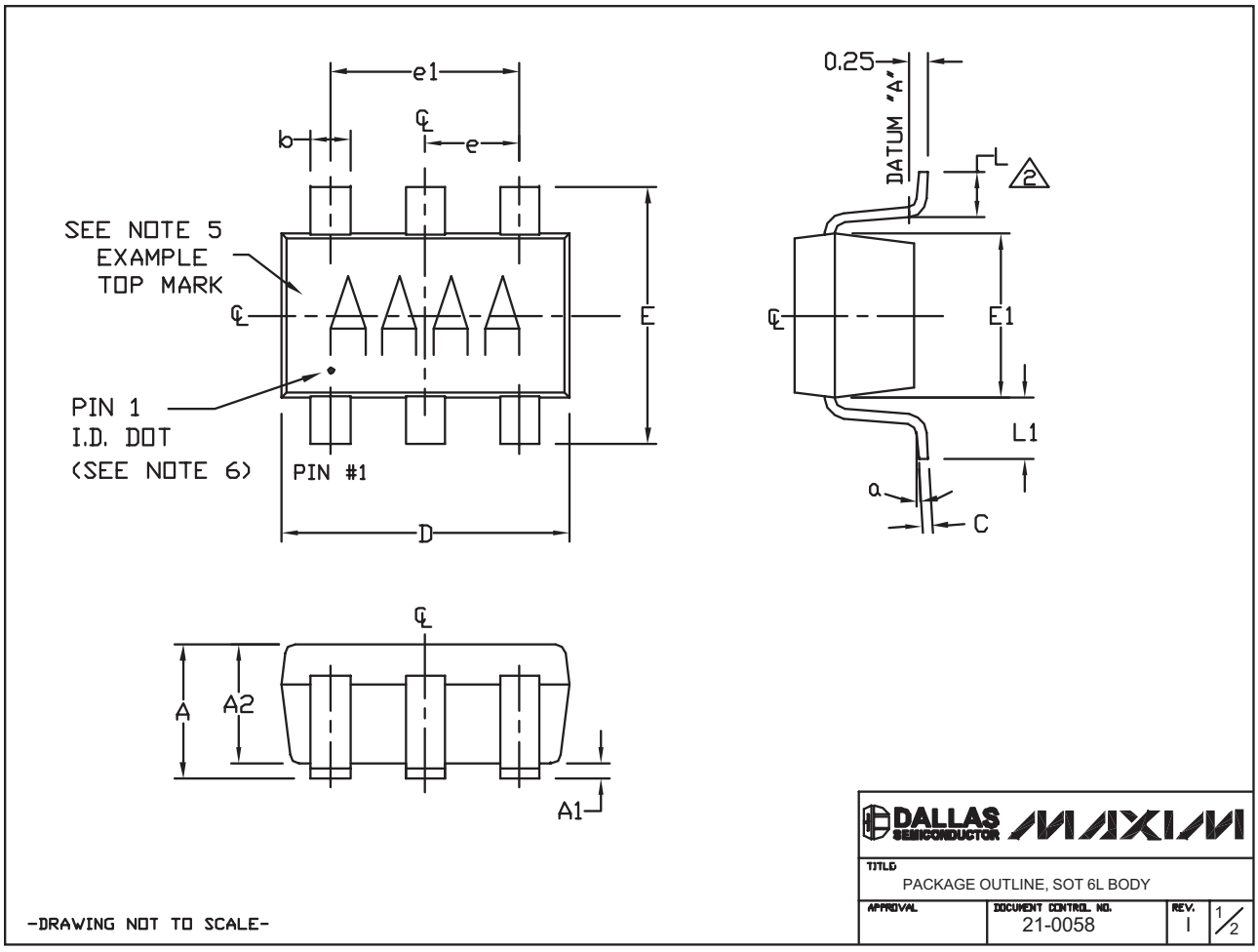
TITLE: PACKAGE OUTLINE, 6L SC70

| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0077 | G | 1/1 |

–DRAWING NOT TO SCALE–

## Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.



# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

## Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR. MOLD FLASH, PROTRUSION OR METAL BURR SHOULD NOT EXCEED 0.25mm.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. PIN 1 IS LOWER LEFT PIN WHEN READING TOP MARK FROM LEFT TO RIGHT. (SEE EXAMPLE TOP MARK)
6. PIN 1 I.D. DOT IS 0.3mm ø MIN. LOCATED ABOVE PIN 1.
7. MEETS JEDEC MO178, VARIATION AB.
8. SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEADTIP.
9. LEAD TO BE COPLANAR WITHIN 0.1mm.
10. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
11. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.

| SYMBOL | MIN | NOMINAL | MAX |
|---|---|---|---|
| A | 0.90 | 1.25 | 1.45 |
| A1 | 0.00 | 0.05 | 0.15 |
| A2 | 0.90 | 1.10 | 1.30 |
| b | 0.35 | 0.40 | 0.50 |
| C | 0.08 | 0.15 | 0.20 |
| D | 2.80 | 2.90 | 3.00 |
| E | 2.60 | 2.80 | 3.00 |
| E1 | 1.50 | 1.625 | 1.75 |
| L | 0.35 | 0.45 | 0.60 |
| L1 | | 0.60 REF. | |
| e1 | | 1.90 BSC. | |
| e | | 0.95 BSC. | |
| α | 0° | 2.5° | 10° |

PKG CODES:
U6-1, U6-2, U6-4, U6C-8, U6SN-1, U6CN-2, U6S-3, U6F-5, U6F-6, U6FH-5, U6FH-6

-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM

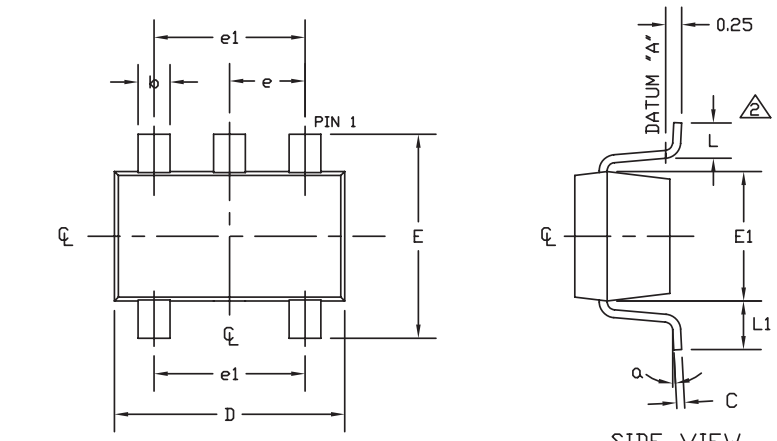
TITLE: PACKAGE OUTLINE, SOT 6L BODY

| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0058 | I | 2/2 |

## Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

SOT-23 5L .EPS




| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 0.90 | 1.25 | 1.45 |
| A1 | 0.00 | 0.05 | 0.15 |
| A2 | 0.90 | 1.10 | 1.30 |
| b | 0.35 | 0.40 | 0.50 |
| C | 0.08 | 0.15 | 0.20 |
| D | 2.80 | 2.90 | 3.00 |
| E | 2.60 | 2.80 | 3.00 |
| E1 | 1.50 | 1.625 | 1.75 |
| L | 0.35 | 0.45 | 0.60 |
| L1 | 0.60 REF | | |
| e | 0.95 BSC. | | |
| e1 | 1.90 BSC. | | |
| α | 0° | 2.5° | 8° |
| PKG CODES: U5-1, U5-2 | | | |

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR. MOLD FLASH, PROTRUSION OR METAL BURR SHOULD NOT EXCEED 0.25 MM.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. MEETS JEDEC MO178, VARIATION AA.
6. LEADS TO BE COPLANAR WITHIN 0.10 mm.
7. SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEAD TIP.

DALLAS SEMICONDUCTOR MAXIM
PROPRIETARY INFORMATION

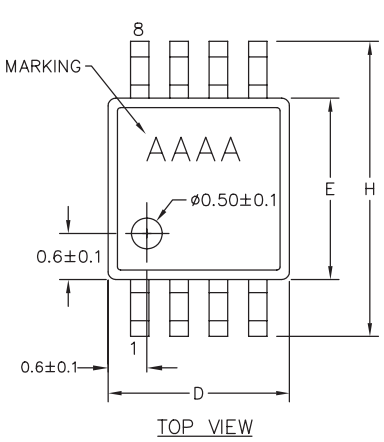
TITLE: PACKAGE OUTLINE, SOT-23, 5L

| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0057 | F | 1/1 |

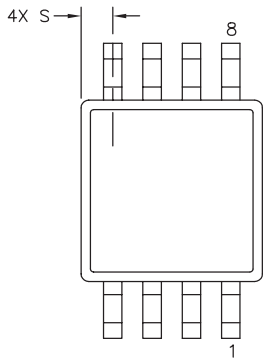
# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

## Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

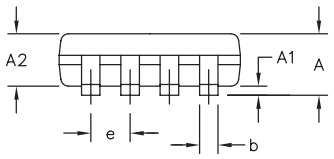



TOP VIEW

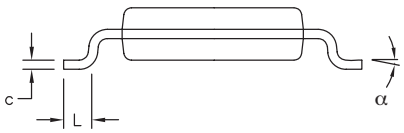



BOTTOM VIEW

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | — | 0.043 | — | 1.10 |
| A1 | 0.002 | 0.006 | 0.05 | 0.15 |
| A2 | 0.030 | 0.037 | 0.75 | 0.95 |
| b | 0.010 | 0.014 | 0.25 | 0.36 |
| c | 0.005 | 0.007 | 0.13 | 0.18 |
| D | 0.114 | 0.122 | 2.90 | 3.10 |
| e | 0.0256 BSC | | 0.65 BSC | |
| E | 0.114 | 0.122 | 2.90 | 3.10 |
| H | 0.188 | 0.198 | 4.78 | 5.03 |
| L | 0.016 | 0.026 | 0.41 | 0.66 |
| α | 0° | 6° | 0° | 6° |
| S | 0.0207 BSC | | 0.5250 BSC | |
| PKG. CODES: U8–1; U8–3; U8CN–1 | | | | |




FRONT VIEW




SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15MM (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. COMPLIES TO JEDEC MO–187, LATEST REVISION, VARIATION AA.
5. MARKING SHOWN IS FOR PKG. ORIENTATION ONLY.
6. ALL DIMENSIONS APPLY TO BOTH LEADED (–) AND PbFREE (+) PKG. CODES.

–DRAWING NOT TO SCALE–

MAXIM

TITLE: PACKAGE OUTLINE, 8L uMAX/uSOP

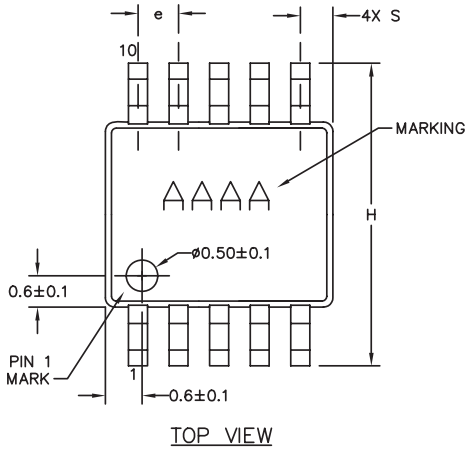
| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21–0036 | L | 1/1 |

# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

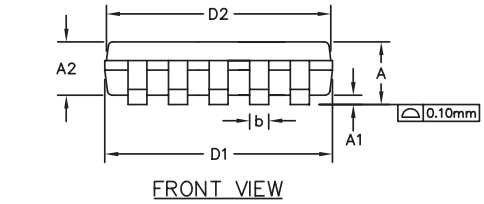
## Package Information (continued)

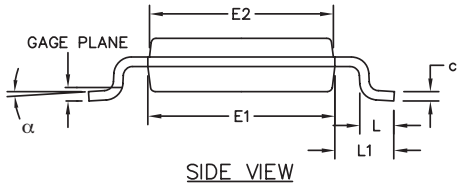
For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

10LUMAX.EPS




| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | – | 0.043 | – | 1.10 |
| A1 | 0.002 | 0.006 | 0.05 | 0.15 |
| A2 | 0.030 | 0.037 | 0.75 | 0.95 |
| D1 | 0.116 | 0.120 | 2.95 | 3.05 |
| D2 | 0.114 | 0.118 | 2.89 | 3.00 |
| E1 | 0.116 | 0.120 | 2.95 | 3.05 |
| E2 | 0.114 | 0.118 | 2.89 | 3.00 |
| H | 0.187 | 0.199 | 4.75 | 5.05 |
| L | 0.0157 | 0.0275 | 0.40 | 0.70 |
| L1 | 0.037 REF | | 0.940 REF | |
| b | 0.007 | 0.0106 | 0.177 | 0.270 |
| e | 0.0197 BSC | | 0.500 BSC | |
| c | 0.0035 | 0.0078 | 0.090 | 0.200 |
| S | 0.0196 REF | | 0.498 REF | |
| α | 0° | 6° | 0° | 6° |
| Pkg Codes: U10–2; U10CN–1 | | | | |




NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. COMPLIES TO JEDEC MO–187, LATEST REVISION, VARIATION BA.
5. MARKING SHOWN IS FOR PKG. ORIENTATION ONLY.
6. ALL DIMENSIONS APPLY TO BOTH LEADED (–) AND PbFREE (+) PKG. CODES.

–DRAWING NOT TO SCALE–

MAXIM

TITLE: PACKAGE OUTLINE, 10L uMAX/uSOP

| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21–0061 | L | 1/1 |

# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

## Package Information (continued)

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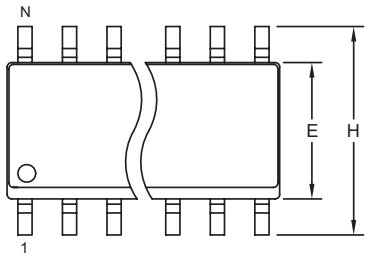
SOICN .EPS

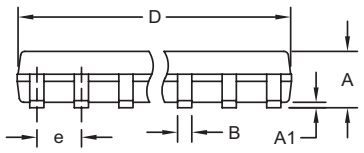
| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 0.053 | 0.069 | 1.35 | 1.75 |
| A1 | 0.004 | 0.010 | 0.10 | 0.25 |
| B | 0.014 | 0.019 | 0.35 | 0.49 |
| C | 0.007 | 0.010 | 0.19 | 0.25 |
| e | 0.050 BSC | | 1.27 BSC | |
| E | 0.150 | 0.157 | 3.80 | 4.00 |
|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



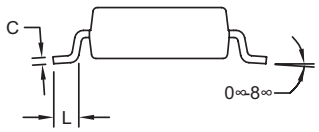

TOP VIEW

VARIATIONS:

| | INCHES | | MILLIMETERS | | | |
|---|---|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX | N | MS012 |
| D | 0.189 | 0.197 | 4.80 | 5.00 | 8 | AA |
| D | 0.337 | 0.344 | 8.55 | 8.75 | 14 | AB |
| D | 0.386 | 0.394 | 9.80 | 10.00 | 16 | AC |




FRONT VIEW




SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS012.
6. N = NUMBER OF PINS.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

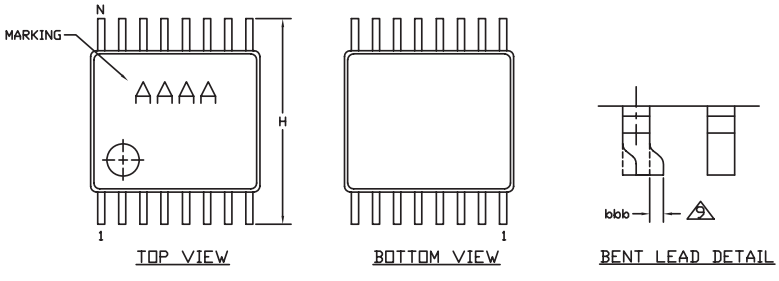
TITLE: PACKAGE OUTLINE, .150" SOIC

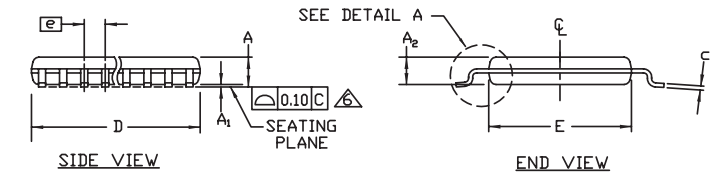
| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0041 | B | 1/1 |

## Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

TSSOP4.40mm.EPS





| SYMBOL | COMMON DIMENSIONS | | | |
|---|---|---|---|---|
| | MILLIMETERS | | INCHES | |
| | MIN. | MAX. | MIN. | MAX. |
| A | —— | 1.10 | | .043 |
| $A_1$ | 0.05 | 0.15 | .002 | .006 |
| $A_2$ | 0.85 | 0.95 | .033 | .037 |
| b | 0.19 | 0.30 | .007 | .012 |
| $b_1$ | 0.19 | 0.25 | .007 | .010 |
| c | 0.09 | 0.20 | .004 | .008 |
| $c_1$ | 0.09 | 0.14 | .004 | .006 |
| D | SEE VARIATIONS | | SEE VARIATIONS | |
| E | 4.30 | 4.50 | .169 | .177 |
| e | 0.65 BSC | | .026 BSC | |
| H | 6.25 | 6.55 | .246 | .258 |
| L | 0.50 | 0.70 | .020 | .028 |
| N | SEE VARIATIONS | | SEE VARIATIONS | |
| α | 0° | 8° | 0° | 8° |
| bbb | 0.10 MAX | | | |

| JEDEC MO-153 | N | | PKG. CODES | VARIATIONS | | | |
|---|---|---|---|---|---|---|---|
| | | | | MILLIMETERS | | INCHES | |
| | | | | MIN. | MAX. | MIN. | MAX. |
| AB-1 | 14 | D | U14-1; U14-2 | 4.90 | 5.10 | .193 | .201 |
| AB | 16 | D | U16-1; U16-2 | 4.90 | 5.10 | .193 | .201 |
| AC | 20 | D | U20-2; U20M-2 U20-3 | 6.40 | 6.60 | .252 | .260 |
| AD | 24 | D | U24-1 | 7.70 | 7.90 | .303 | .311 |
| AE | 28 | D | U28-1; U28-2; U28-3 | 9.60 | 9.80 | .378 | .386 |

NOTES
1. DIMENSIONS D AND E DO NOT INCLUDE FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm PER SIDE
3. CONTROLLING DIMENSION: MILLIMETER
4. MEETS JEDEC OUTLINE MO-153. SEE JEDEC VARIATIONS TABLE
5. "N" REFERS TO NUMBER OF LEADS
6. LEAD COPLANARITY 0.10 MM MAX.
7. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY
8. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY
9. BENT LEAD 0.10 MM MAX.
10. ALL DIMENSIONS APPLY TO BOTH LEADED (-) AND PBFREE (+) PKG. CODES.

—DRAWING NOT TO SCALE—

MAXIM

TITLE: PACKAGE OUTLINE, TSSOP 4.40mm BODY

| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0066 | J | 1/1 |

# Ultra-Small, Low-Cost, 85MHz Op Amps with Rail-to-Rail Outputs and Disable

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 4 | 11/09 | Added automotive qualified parts | 2, 15 |