19-5227; Rev 0; 9/10

EVALUATION KIT AVAILABLE

# Precision, High-Bandwidth Op Amp



## General Description

The MAX9622 op amp features rail-to-rail output and 50MHz GBW at just 1mA supply current. At power-up, this device autocalibrates its input offset voltage to less than 100µV. It operates from a single-supply voltage of 2.0V to 5.25V.

The MAX9622 is available in a tiny 2mm x 2mm, 5-pin SC70 package and is rated over the -40°C to +125°C automotive temperature range.

## Features

- ♦ **50MHz UGBW**
- ♦ **Low Input Voltage Offset Voltage (100µV max)**
- ♦ **Input Common-Mode Voltage Range Extends Below Ground**
- ♦ **Wide 2.0V to 5.25V Supply Range**
- ♦ **Low 1mA Supply Current**

## Applications

Power Modules

Automotive Power Supplies

ADC Drivers for Industrial Systems

Instrumentation

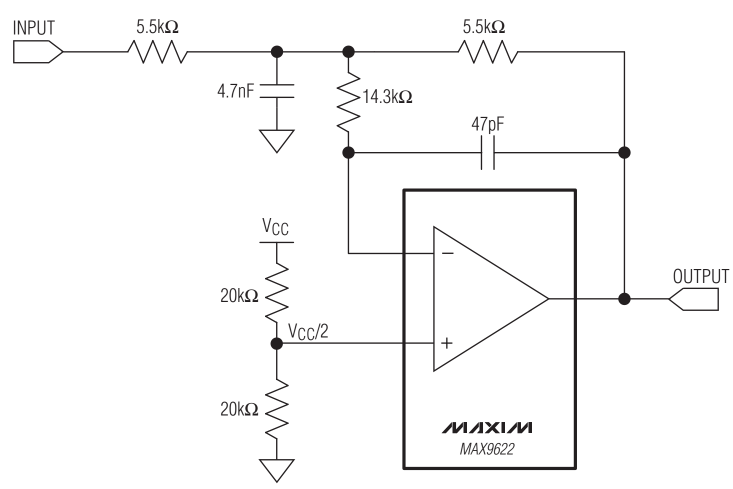
Filters

## Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|---|---|---|---|
| MAX9622AXK+T | -40°C to +125°C | 5 SC70 | AUA |

*+Denotes a lead(Pb)-free/RoHS-compliant package.*
*T = Tape and reel.*

## Typical Application Circuit




USING THE MAX9622 AS A LOWPASS BESSEL FILTER (CORNER FREQUENCY = 100kHz).



**For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.**

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ($V_{CC}$ to GND)..............................-0.3V to +5.5V
All Other Pins................................(GND - 0.3V) to ($V_{CC}$ + 0.3V)
Short-Circuit Duration to GND or $V_{CC}$ .................................. 1s
Continuous Input Current (any pins).............................. ±20mA
Thermal Limits (Note 1)
Continuous Power Dissipation ($T_A$ = +70°C)
5-Pin SC70 (derate 3.1mW/°C above +70°C) ..........245.4mW
Operating Temperature Range........................ -40°C to +125°C
Junction Temperature ...................................................+150°C
Storage Temperature Range........................... -65°C to +150°C
Lead Temperature (soldering, 10s) ...............................+300°C
Soldering Temperature (reflow) .....................................+260°C

**Note 1:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maxim-ic.com/thermal-tutorial**.

*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

($V_{CC}$ = 5V, $V_{IN+}$ = $V_{IN-}$ = 0V, $R_L$ = 10kΩ to $V_{CC}$/2, $T_A$ = -40°C to +125°C, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **POWER SUPPLY** | | | | | | | |
| Supply Voltage Range | $V_{CC}$ | Guaranteed by PSRR | | 2 | | 5.25 | V |
| Supply Current | $I_{CC}$ | No load | $T_A$ = +25°C | | 1 | 1.5 | mA |
| | | | -40°C ≤ $T_A$ ≤ +125°C | | | 2.1 | |
| Power-Supply Rejection Ratio | PSRR | $T_A$ = +25°C | | 97 | 126 | | dB |
| | | -40°C ≤ $T_A$ ≤ +125°C | | 93 | | | |
| Power-Up Time | $t_{ON}$ | | | | 3 | | ms |
| **DC SPECIFICATIONS** | | | | | | | |
| Input Offset Voltage | $V_{OS}$ | After power-up autocalibration | | | 8 | 100 | µV |
| | | -40°C ≤ $T_A$ ≤ +125°C | | | 8 | 3000 | |
| Input Offset Voltage Drift | $\Delta V_{OS}$ | | | | 3 | | µV/°C |
| Input Bias Current | $I_B$ | $T_A$ = +25°C | | | 62 | 150 | nA |
| | | -40°C ≤ $T_A$ ≤ +125°C | | | | 320 | |
| Input Offset Current | $I_{OS}$ | $T_A$ = +25°C | | | 3 | 12 | nA |
| | | -40°C ≤ $T_A$ ≤ +125°C | | | | 30 | |
| Input Common-Mode Range | $V_{CM}$ | Guaranteed by CMRR, $T_A$ = -40°C to +125°C | | -0.1 | | $V_{CC}$ -1.3 | V |
| Common-Mode Rejection Ratio | CMRR | $T_A$ = +25°C | | 87 | 121 | | dB |
| | | -40°C ≤ $T_A$ ≤ +125°C | | 80 | | | |
| Large-Signal Gain | $A_{VOL}$ | 400mV ≤ $V_{OUT}$ ≤ $V_{CC}$ - 400mV | $T_A$ = +25°C | 91 | 103 | | dB |
| | | | -40°C ≤ $T_A$ ≤ +125°C | 84 | | | |
| | | 400mV ≤ $V_{OUT}$ ≤ $V_{CC}$ - 400mV, $R_L$ = 1kΩ to $V_{CC}$/2 | $T_A$ = +25°C | 77 | 89 | | |
| | | | -40°C ≤ $T_A$ ≤ +125°C | 69 | | | |
| Output Voltage Swing | $V_{OH}$ - $V_{CC}$ | $R_L$ = 10kΩ to $V_{CC}$/2 | | | | 60 | mV |
| | $V_{OL}$ | $R_L$ = 10kΩ to $V_{CC}$/2 | | | | 60 | |
| | | $R_L$ = 10kΩ to GND, $T_A$ = +25°C | | | | 40 | |
| | | $R_L$ = 10kΩ to GND | | | | 48 | |
| Short-Circuit Current | $I_{SC}$ | (Note 3) | | | 80 | | mA |

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = 5V, $V_{IN+}$ = $V_{IN-}$ = 0V, $R_L$ = 10kΩ to $V_{CC}$/2, $T_A$ = -40°C to +125°C, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 2)

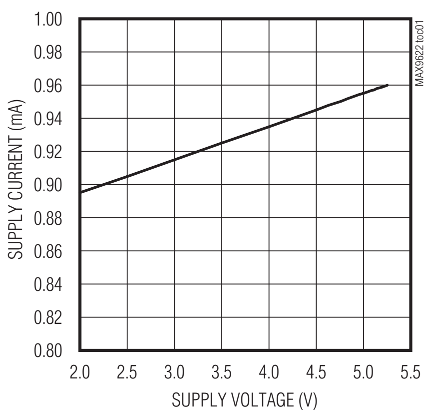
| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **AC SPECIFICATIONS** | | | | | | |
| Gain-Bandwidth Product | GBW | | | 50 | | MHz |
| Large-Signal Bandwidth | $BW_{LS}$ | $V_{OUT}$ = $2V_{P-P}$ | | 3 | | MHz |
| Slew Rate | SR | $V_{OUT}$ = $2V_{P-P}$, 10% to 90% | | 20 | | V/µs |
| Settling Time | $t_S$ | To 0.1%, $V_{OUT}$ = $2V_{P-P}$, $C_L$ = 10pF | | 200 | | ns |
| Total Harmonic Distortion | THD | f = 10kHz, $V_{OUT}$ = $2V_{P-P}$ | | 90 | | dB |
| Input Voltage Noise Density | $E_N$ | f = 10kHz | | 13 | | $nV/\sqrt{Hz}$ |
| Input Current Noise Density | $I_N$ | f = 10kHz | | 3 | | $pA/\sqrt{Hz}$ |

**Note 2:** The device is 100% production tested at $T_A$ = +25°C. Temperature limits are guaranteed by design.
**Note 3:** Guaranteed by design.

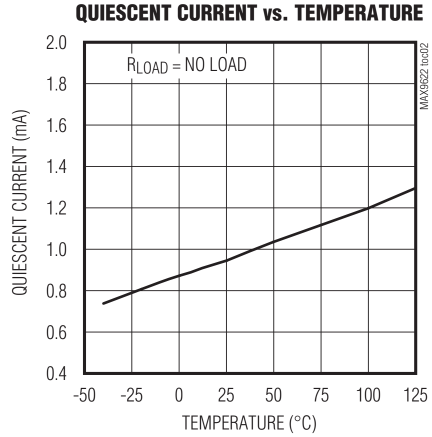
## *Typical Operating Characteristics*

($V_{CC}$ = 5V, $R_L$ = 10kΩ to $V_{CC}$/2, $T_A$ = +25°C, unless otherwise noted.)

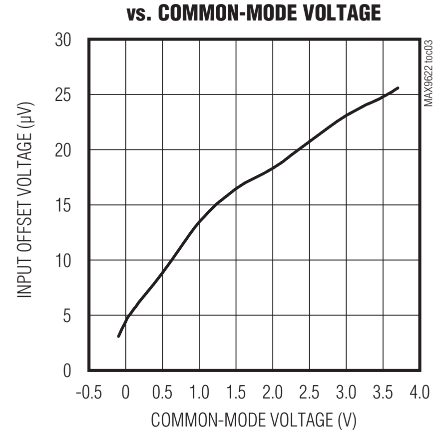
**SUPPLY CURRENT vs. SUPPLY VOLTAGE**



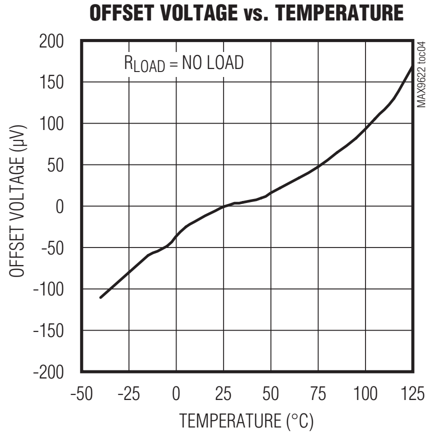

**QUIESCENT CURRENT vs. TEMPERATURE**



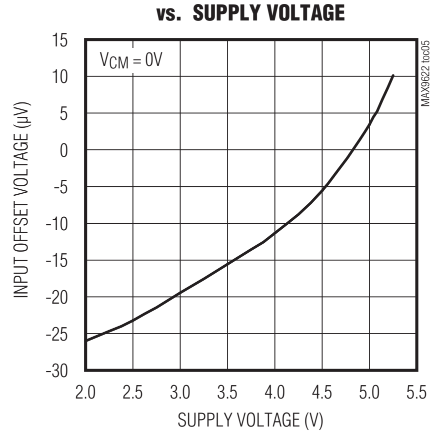

**INPUT OFFSET VOLTAGE vs. COMMON-MODE VOLTAGE**



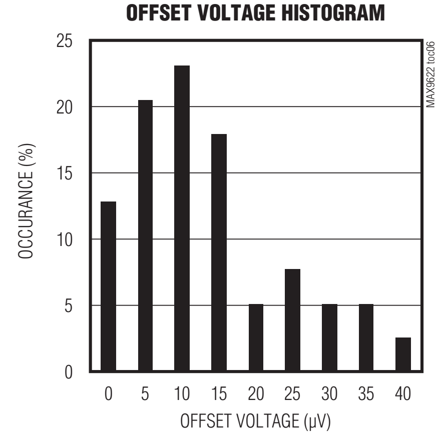

**OFFSET VOLTAGE vs. TEMPERATURE**




**INPUT OFFSET VOLTAGE vs. SUPPLY VOLTAGE**



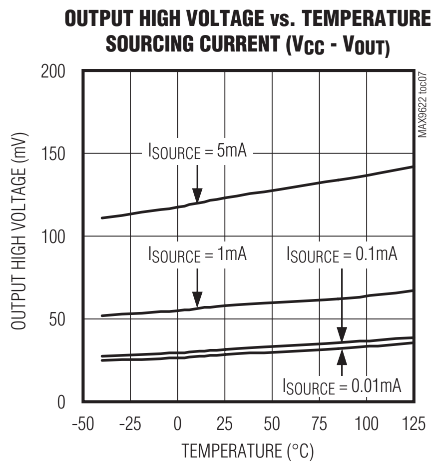

**OFFSET VOLTAGE HISTOGRAM**

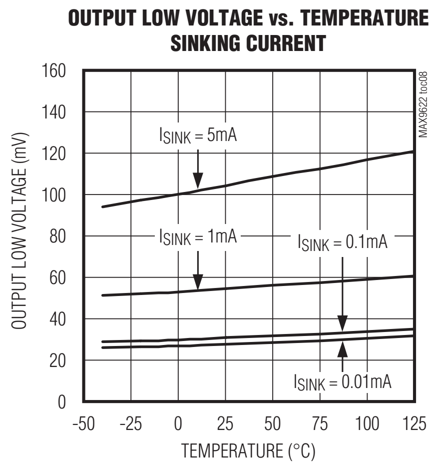


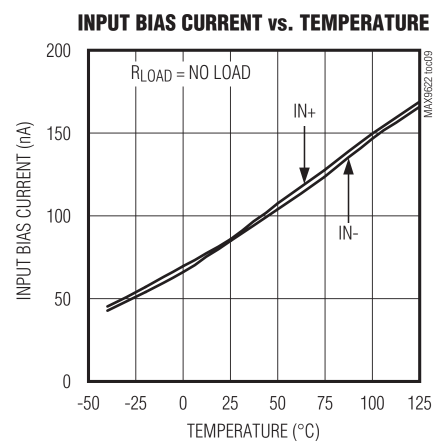
# Precision, High-Bandwidth Op Amp

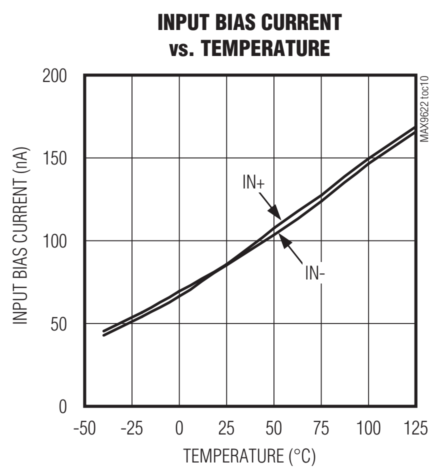
## Typical Operating Characteristics (continued)

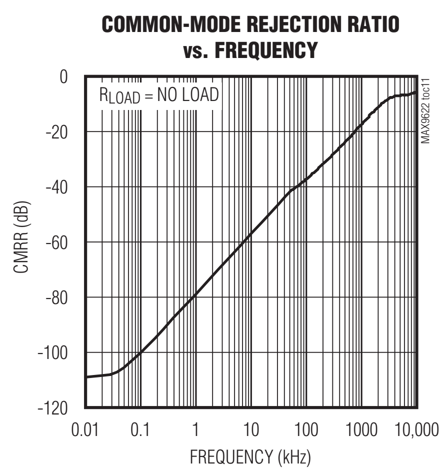
($V_{CC}$ = 5V, $R_L$ = 10kΩ to $V_{CC}$/2, $T_A$ = +25°C, unless otherwise noted.)

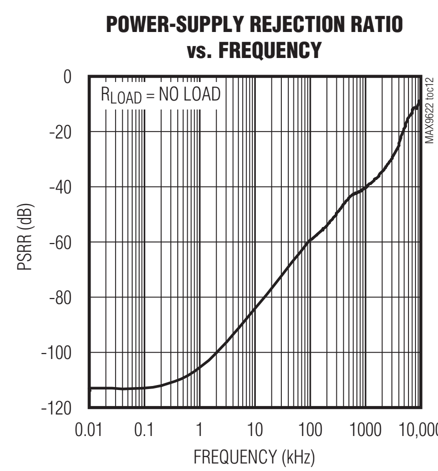


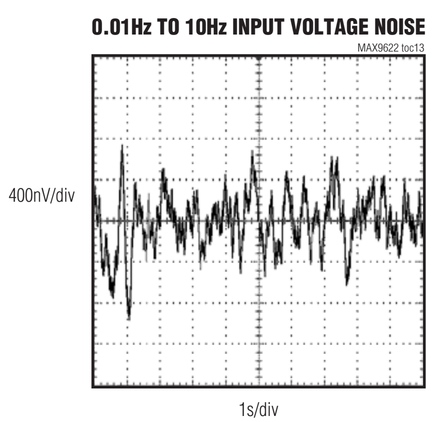



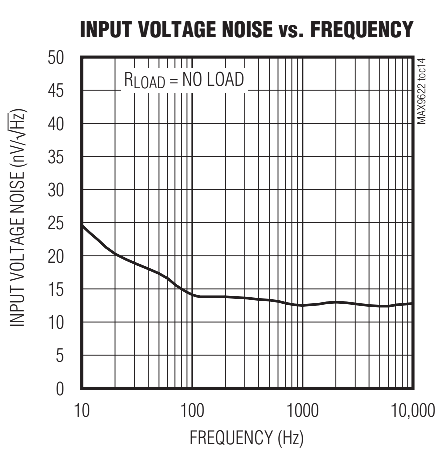



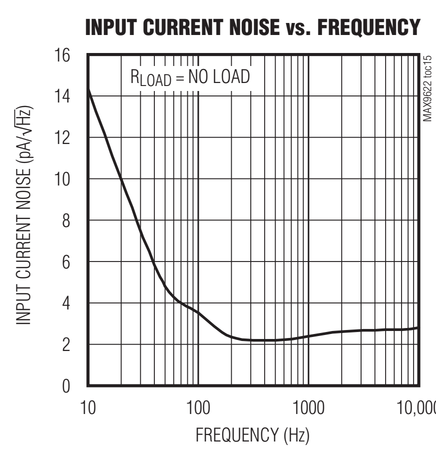



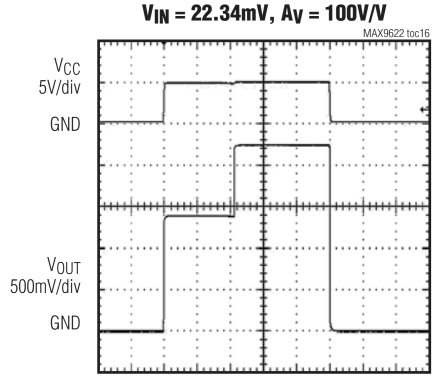



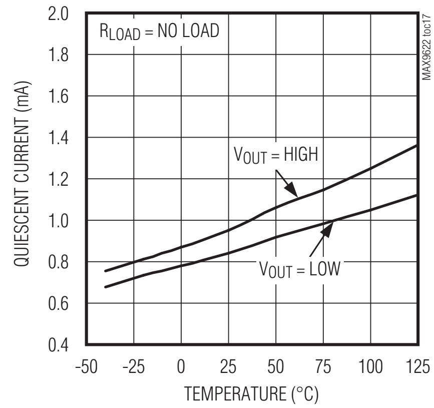
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5V, $R_L$ = 10kΩ to $V_{CC}$/2, $T_A$ = +25°C, unless otherwise noted.)

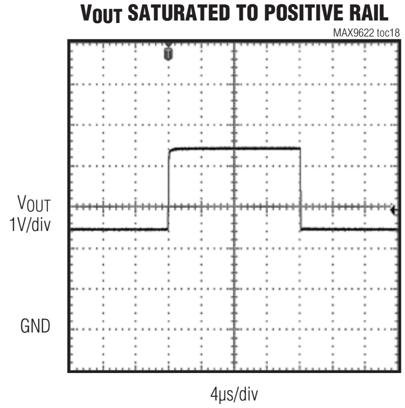
**TURN-ON RESPONSE**
**$V_{IN}$ = 22.34mV, $A_V$ = 100V/V**



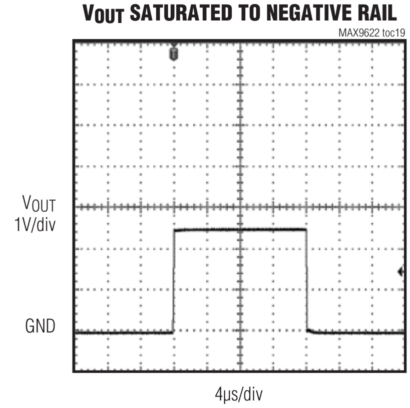

**QUIESCENT CURRENT vs. TEMPERATURE**
**$V_{CC}$ = 5V, $V_{OUT}$ IN SATURATION**



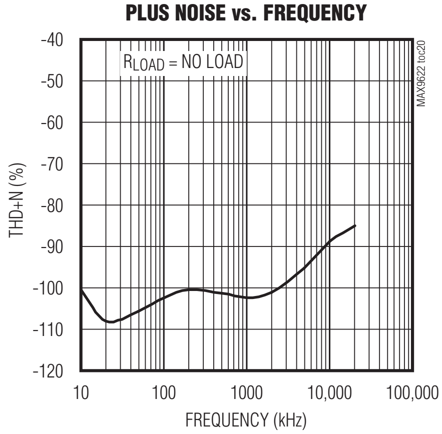

**OUTPUT RECOVERY FROM SATURATION**
**$V_{OUT}$ SATURATED TO POSITIVE RAIL**



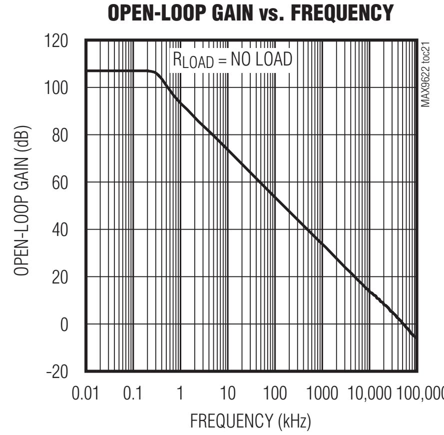

**OUTPUT RECOVERY FROM SATURATION**
**$V_{OUT}$ SATURATED TO NEGATIVE RAIL**




**TOTAL HARMONIC DISTORTION**
**PLUS NOISE vs. FREQUENCY**




**OPEN-LOOP GAIN vs. FREQUENCY**

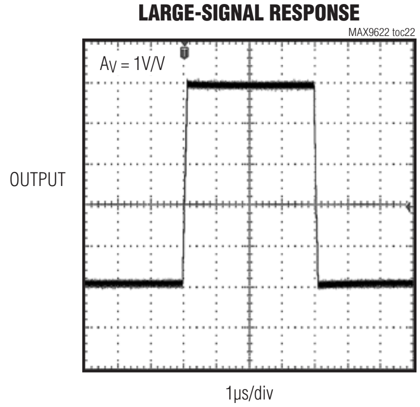


# Precision, High-Bandwidth Op Amp

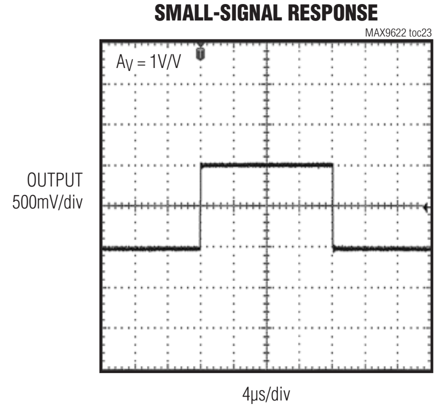
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5V, $R_L$ = 10kΩ to $V_{CC}$/2, $T_A$ = +25°C, unless otherwise noted.)

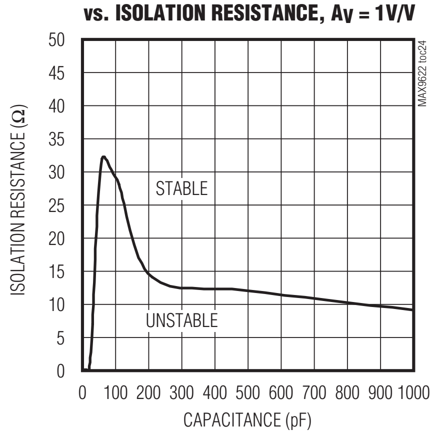
**LARGE-SIGNAL RESPONSE**



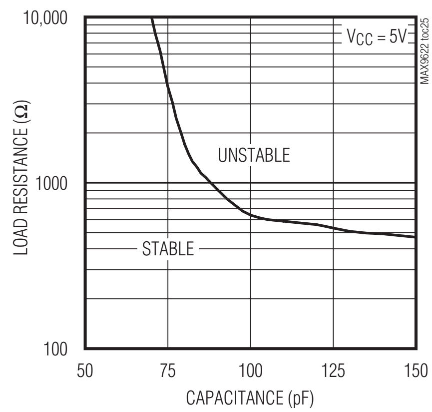

**SMALL-SIGNAL RESPONSE**



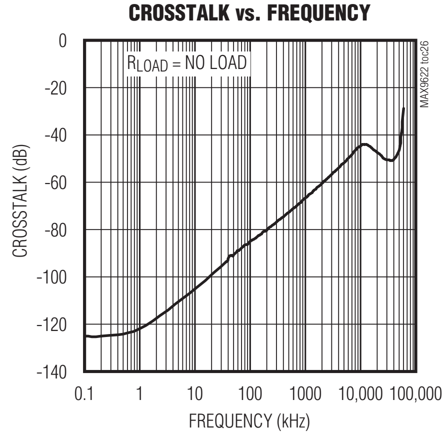

**CAPACITIVE LOADING STABILITY vs. ISOLATION RESISTANCE, $A_V$ = 1V/V**



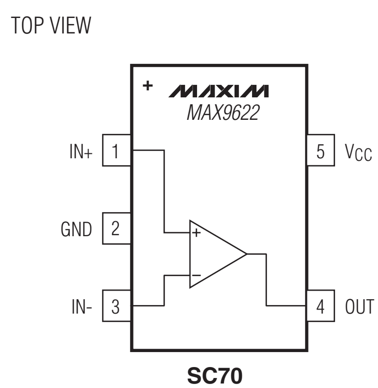

**PARALLEL CAPACITIVE LOADING**




**CROSSTALK vs. FREQUENCY**



## Pin Configuration




## Pin Description

| PIN | NAME | FUNCTION |
|---|---|---|
| 1 | IN+ | Positive Input |
| 2 | GND | Ground |
| 3 | IN- | Negative Input |
| 4 | OUT | Output |
| 5 | $V_{CC}$ | Positive Power Supply. Bypass with a 0.1µF capacitor to ground. |

## Detailed Description

The MAX9622 is a power-efficient, high-speed op amp ideal for capturing fast edges in a wide variety of signal processing applications.

It precisely calibrates its $V_{OS}$ on power-up to eliminate the effects of package stresses, power supplies, and temperature.

## Applications Information

### Power-Up Autotrim

The MAX9622 features power-up autotrimming that allows the devices to achieve less than 100µV of input offset voltage. The startup sequence takes approximately 4ms to complete after the supply voltage exceeds an internal threshold of 1.8V. During this time, the inputs and outputs are connected to an auxiliary amplifier that has an input offset of 5mV (typ). As soon as the autotrimming is completed, the inputs and outputs switch from the auxiliary amplifier to the calibrated amplifier. The calibration settings hold until the supply voltage drops below an internal threshold of 1.4V. This could be used to recalibrate the amplifier. The supply current of the part increases to about 2.5mA during the power-up autotrim period. Use good supply decoupling with low ESR capacitors.

### Active Filters

The MAX9622 is ideal for a wide variety of active filter circuits that make use of their wide output voltage swings and large bandwidth capabilities. The *Typical Application Circuit* shows a multiple feedback active filter circuit example with a 100kHz corner frequency. At low frequencies, the amplifier behaves like a simple low-distortion inverting amplifier gain = -1, while its high bandwidth gives excellent stopband attenuation above its corner frequency. See the *Typical Application Circuit*.

### Input Differential Voltage Protection

During normal op-amp operation, the inverting and noninverting inputs of the MAX9622 are at essentially the same voltage. However, either due to fast input voltage transients or due to loss of negative feedback, these pins can be forced to different voltages. Internal back-to-back diodes and series resistors protect input-stage transistors from large input differential voltages (see Figure 2). IN+ and IN- can survive any voltage between the power-supply rails.

This op amp has been designed to exhibit no phase inversion to overdriven inputs.

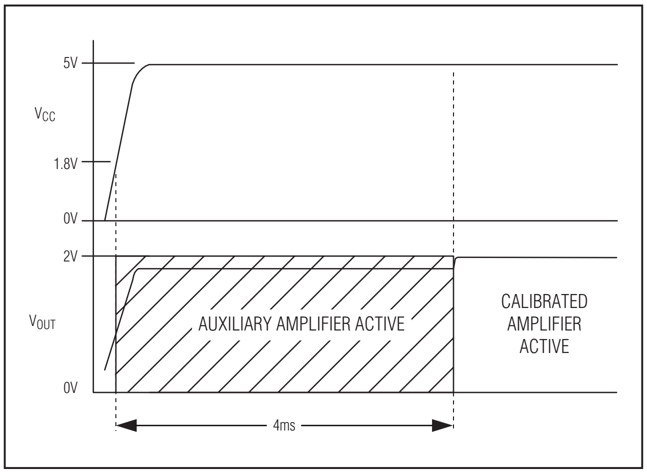



*Figure 1. Autotrim Timing Diagram*

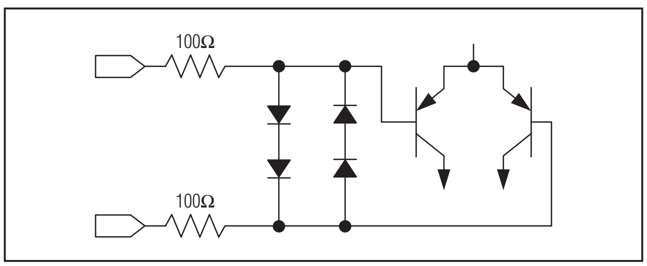
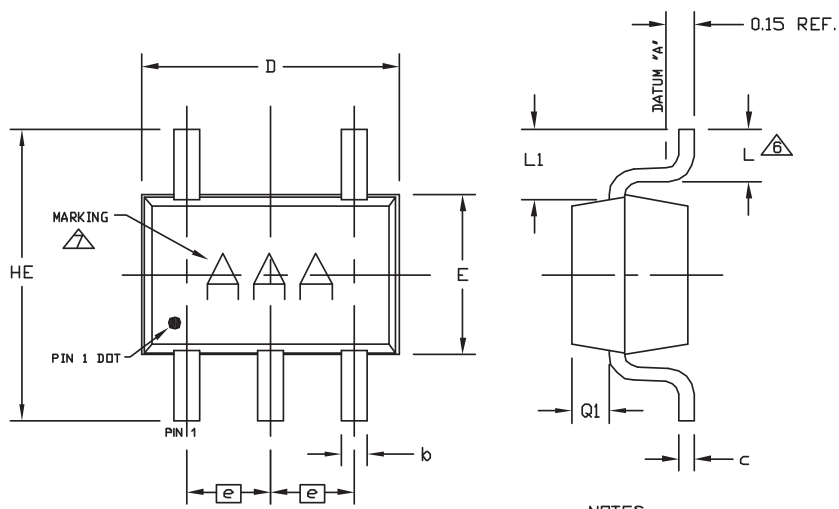



*Figure 2. Input Protection Circuit*

## Package Information

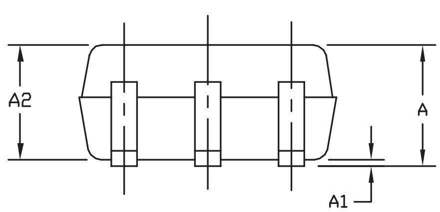
For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO. | LAND PATTERN NO. |
|---|---|---|---|
| 5 SC70 | X5+1 | 21-0076 | 90-0188 |




| 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. CODE | X5-1 | | |

SC70, 5L.EPS




NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONS ARE INCLUSIVE OF PLATING.
3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. COMPLY TO JEITA SC-88A EXCEPT FOR DIMENSION "L". ALL DIMENSIONS COMPLY TO JEDEC MO-203.
5. COPLANARITY 4 MILS. MAX.
6. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM "A" AND LEAD SURFACE.
7. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
8. LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION "e", ±0.05.

-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM

TITLE: PACKAGE OUTLINE, 5L SC70

| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0076 | E | 1/1 |

# Precision, High-Bandwidth Op Amp

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 9/10 | Initial release | — |