Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!


# Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

EVALUATION KIT AVAILABLE

# MAX44248

## 36V, Precision, Low-Power, 90µA, Dual Op Amp

### General Description

The MAX44248 is an ultra-precision, low-noise, zero-drift dual operational amplifier featuring very low-power operation with a wide supply range. The device incorporates a patented auto-zero circuit that constantly measures and compensates the input offset to eliminate drift over time and temperature as well as the effect of 1/f noise. The device also features integrated EMI filters to reduce high-frequency signal demodulation on the output. The op amp operates from either a single 2.7V to 36V supply or dual ±1.35V to ±18V supply. The device is unity-gain stable with a 1MHz gain-bandwidth product and a low 90µA supply current per amplifier.

The low offset and noise specifications and high supply range make the device ideal for sensor interfaces and transmitters.

The device is available in 8-pin µMAX® and SO packages and is specified over the -40°C to +125°C automotive operating temperature range.

### Applications

- Sensors Interfaces
- 4-20mA and 0 to10V Transmitters
- PLC Analog I/O Modules
- Weight Scales
- Portable Medical Devices

### Features

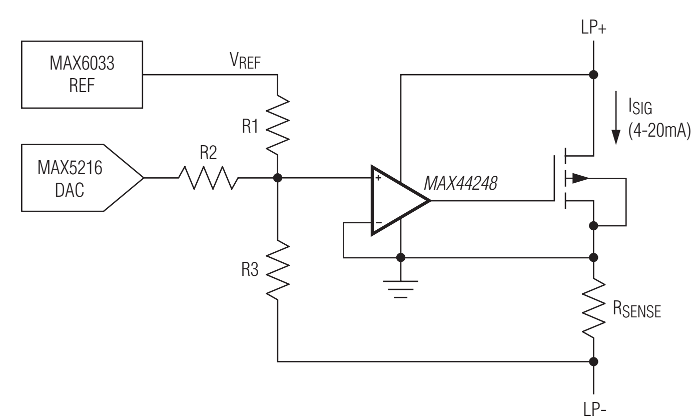
- ♦ **Very Low Input Voltage Offset 7.5µV (max)**
- ♦ **Low 30nV/°C Offset Drift (max)**
- ♦ **Low 90µA Quiescent Current per Amplifier**
- ♦ **Low Input Noise**
  - **50nV/√Hz at 1kHz**
  - **0.5µV$_{P-P}$ from 0.1Hz to 10Hz**
- ♦ **1MHz Gain-Bandwidth Product**
- ♦ **EMI Suppression Circuitry**
- ♦ **Rail-to-Rail Output**
- ♦ **2.7V to 36V Supply Range**
- ♦ **8-Pin µMAX and SO package**

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

*For related parts and recommended products to use with this part, refer to **www.maximintegrated.com/MAX44248.related**.*



### Typical Operating Circuit



## ABSOLUTE MAXIMUM RATINGS

$V_{DD}$ to $V_{SS}$ ............................................................-0.3V to +40V
Common-Mode Input Voltage........($V_{SS}$ - 0.3V) to ($V_{DD}$ + 0.3V)
Differential Input Voltage IN_+, IN_- .....................................6V
Continuous Input Current Into Any Pin .......................... ±20mA
Output Voltage to $V_{SS}$ (OUT_) ................– 0.3V to ($V_{DD}$ + 0.3V)
Output Short-Circuit Duration (OUT_).................................... 1s
Operating Temperature Range........................ -40°C to +125°C
Storage Temperature ...................................... -65°C to +150°C
Junction Temperature ....................................................+150°C
Lead Temperature (soldering, 10s) ...............................+300°C
Soldering Temperature (reflow) .....................................+260°C

## PACKAGE THERMAL CHARACTERISTICS (Note 1)

μMAX
Junction-to-Ambient Thermal Resistance ($\theta_{JA}$) .....206.3°C/W
Junction-to-Case Thermal Resistance ($\theta_{JC}$)..............42°C/W

SO
Junction-to-Ambient Thermal Resistance ($\theta_{JA}$) ........132°C/W
Junction-to-Case Thermal Resistance ($\theta_{JC}$)..............38°C/W

**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.maximintegrated.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

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

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **POWER SUPPLY** | | | | | | |
| Supply Voltage Range | $V_{DD}$ | Guaranteed by PSRR | 2.7 | | 36 | V |
| Power-Supply Rejection Ratio (Note 3) | PSRR | $T_A$ = +25°C, $V_{IN+}$ = $V_{IN-}$ = $V_{DD}$/2 - 1V | 140 | 148 | | dB |
| | | -40°C < $T_A$ < +125°C | 133 | | | |
| Quiescent Current per Amplifier | $I_{DD}$ | $T_A$ = +25°C | | 90 | 120 | μA |
| | | -40°C < $T_A$ < +125°C | | | 130 | |
| **DC SPECIFICATIONS** | | | | | | |
| Input Common-Mode Range | $V_{CM}$ | Guaranteed by CMRR test | $V_{SS}$ - 0.05 | | $V_{DD}$ - 1.5 | V |
| Common-Mode Rejection Ratio (Note 3) | CMRR | $T_A$ = +25°C, $V_{CM}$ = $V_{SS}$ - 0.05V to $V_{DD}$ - 1.5V | 126 | 130 | | dB |
| | | -40°C < $T_A$ < +125°C, $V_{CM}$ = $V_{SS}$ - 0.05V to $V_{DD}$ - 1.5V | 120 | | | |
| Input Offset Voltage (Note 3) | $V_{OS}$ | $T_A$ = +25°C | | 2 | 7.5 | μV |
| | | -40°C < $T_A$ < +125°C | | | 10 | |
| Input Offset Voltage Drift (Note 3) | TC $V_{OS}$ | | | 10 | 30 | nV/°C |
| Input Bias Current (Note 3) | $I_B$ | $T_A$ = +25°C | | 150 | 300 | pA |
| | | -40°C < $T_A$ < +125°C | | | 700 | |
| Input Offset Current (Note 3) | $I_{OS}$ | $T_A$ = +25°C | | 300 | 600 | pA |
| | | -40°C < $T_A$ < +125°C | | | 1400 | |

## ELECTRICAL CHARACTERISTICS (continued)

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

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Open-Loop Gain (Note 3) | $A_{VOL}$ | $V_{SS}$ + 0.5V ≤ $V_{OUT}$ ≤ $V_{DD}$ - 0.5V | $T_A$ = +25°C | 140 | 150 | | dB |
| | | | -40°C < $T_A$ < +125°C | 135 | | | |
| Output Short-Circuit Current | | To $V_{DD}$ or $V_{SS}$, noncontinuous | | | 40 | | mA |
| Output Voltage Swing | $V_{DD}$ – $V_{OUT}$ | $T_A$ = +25°C | | | | 80 | mV |
| | | -40°C < $T_A$ < +125°C | | | | 110 | |
| | $V_{OUT}$ – $V_{SS}$ | $T_A$ = +25°C | | | | 50 | |
| | | -40°C < $T_A$ < +125°C | | | | 75 | |
| **AC SPECIFICATIONS** | | | | | | | |
| Input Voltage-Noise Density | $e_N$ | f = 1kHz | | | 50 | | nV/√Hz |
| Input Voltage Noise | | 0.1Hz < f < 10Hz | | | 500 | | $nV_{P-P}$ |
| Input Current-Noise Density | $i_N$ | f = 1kHz | | | 0.1 | | pA/√Hz |
| Gain-Bandwidth Product | GBW | | | | 1 | | MHz |
| Slew Rate | SR | $A_V$ = 1V/V, $V_{OUT}$ = $2V_{P-P}$ | | | 0.7 | | V/µs |
| Capacitive Loading | $C_L$ | No sustained oscillation, $A_V$ = 1V/V | | | 400 | | pF |
| Total Harmonic Distortion Plus Noise | THD+N | $V_{OUT}$ = $2V_{P-P}$, $A_V$ = +1V/V, f = 1kHz | | | -100 | | dB |
| EMI Rejection Ratio | EMIRR | $V_{RF\_PEAK}$ = 100mV | f = 400MHz | | 75 | | dB |
| | | | f = 900MHz | | 78 | | |
| | | | f = 1800MHz | | 80 | | |
| | | | f = 2400MHz | | 90 | | |

## ELECTRICAL CHARACTERISTICS

(**$V_{DD}$ = 30V**, $V_{SS}$ = 0V, $V_{IN+}$ = $V_{IN-}$ = $V_{DD}$/2, $R_L$ = 5kΩ to $V_{DD}$/2, $T_A$ = -40°C to +125°C, unless otherwise noted. Typical values are at +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **POWER SUPPLY** | | | | | | |
| Quiescent Current per Amplifier | $I_{DD}$ | $T_A$ = +25°C | | 90 | 120 | µA |
| | | -40°C < $T_A$ < +125°C | | | 130 | |
| **DC SPECIFICATIONS** | | | | | | |
| Input Common-Mode Range | $V_{CM}$ | Guaranteed by CMRR test | $V_{SS}$ - 0.05 | | $V_{DD}$ - 1.5 | V |
| Common-Mode Rejection Ratio (Note 3) | CMRR | $T_A$ = +25°C, $V_{CM}$ = $V_{SS}$ - 0.05V to $V_{DD}$ - 1.5V | 130 | 140 | | dB |
| | | -40°C < $T_A$ < +125°C, $V_{CM}$ = $V_{SS}$ - 0.05V to $V_{DD}$ - 1.5V | 126 | | | |

## ELECTRICAL CHARACTERISTICS (continued)

(**$V_{DD}$ = 30V**, $V_{SS}$ = 0V, $V_{IN+}$ = $V_{IN-}$ = $V_{DD}$/2, $R_L$ = 5kΩ to $V_{DD}$/2, $T_A$ = -40°C to +125°C, unless otherwise noted. Typical values are at +25°C.) (Note 2)

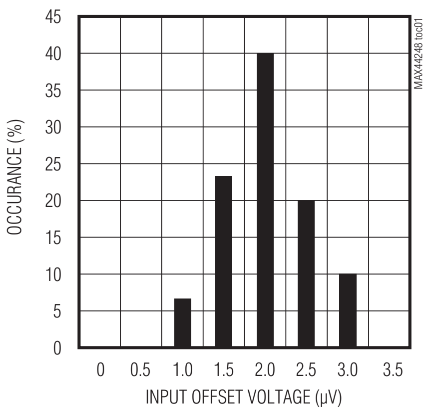
| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Input Offset Voltage (Note 3) | $V_{OS}$ | $T_A$ = +25°C | | | 2 | 7.5 | µV |
| | | -40°C < $T_A$ < +125°C | | | | 10 | |
| Input Offset Voltage Drift (Note 3) | TC $V_{OS}$ | | | | 10 | 30 | nV/°C |
| Input Bias Current (Note 3) | $I_B$ | $T_A$ = +25°C | | | 150 | 300 | pA |
| | | -40°C < $T_A$ < +125°C | | | | 700 | |
| Input Offset Current (Note 3) | $I_{OS}$ | $T_A$ = +25°C | | | 300 | 600 | pA |
| | | -40°C < $T_A$ < +125°C | | | | 1400 | |
| Open-Loop Gain (Note 3) | $A_{VOL}$ | $V_{SS}$ + 0.5V ≤ $V_{OUT}$ ≤ $V_{DD}$ - 0.5V | $T_A$ = +25°C | 146 | 150 | | dB |
| | | | -40°C < $T_A$ < +125°C | 140 | | | |
| Output Short-Circuit Current | | To $V_{DD}$ or $V_{SS}$, noncontinuous | | | 40 | | mA |
| Output Voltage Swing | $V_{DD}$ -$V_{OUT}$ | $T_A$ = +25°C | | | | 200 | mV |
| | | -40°C < $T_A$ < +125°C | | | | 270 | |
| | $V_{OUT}$ - $V_{SS}$ | $T_A$ = +25°C | | | | 140 | |
| | | -40°C < $T_A$ < +125°C | | | | 220 | |
| **AC SPECIFICATIONS** | | | | | | | |
| Input Voltage-Noise Density | $e_N$ | f = 1kHz | | | 50 | | nV/$\sqrt{Hz}$ |
| Input Voltage Noise | | 0.1Hz < f < 10Hz | | | 500 | | $nV_{P-P}$ |
| Input Current-Noise Density | $i_N$ | f = 1kHz | | | 0.1 | | pA/$\sqrt{Hz}$ |
| Gain-Bandwidth Product | GBW | | | | 1 | | MHz |
| Slew Rate | SR | $A_V$ = 1V/V, $V_{OUT}$ = $2V_{P-P}$ | | | 0.7 | | V/µs |
| Capacitive Loading | $C_L$ | No sustained oscillation, $A_V$ = 1V/V | | | 400 | | pF |
| Total Harmonic Distortion Plus Noise | THD+N | $V_{OUT}$ = $2V_{P-P}$, $A_V$ = +1V/V, f = 1kHz | | | -100 | | dB |
| EMI Rejection Ratio | EMIRR | $V_{RF\_PEAK}$ = 100mV | f = 400MHz | | 75 | | dB |
| | | | f = 900MHz | | 78 | | |
| | | | f = 1800MHz | | 80 | | |
| | | | f = 2400MHz | | 90 | | |

**Note 2:** All devices are 100% production tested at $T_A$ = +25°C. Temperature limits are guaranteed by design.
**Note 3:** Guaranteed by design.
**Note 4:** At IN+ and IN-. Defined as 20log ($V_{RF\_PEAK}$/$\Delta V_{OS}$).

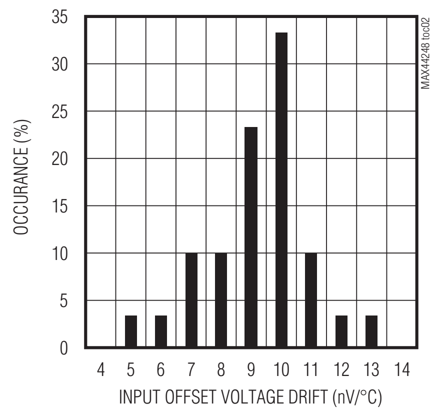
### *Typical Operating Characteristics*

($V_{DD}$ = 10V, $V_{SS}$ = 0V, $V_{IN+}$ = $V_{IN-}$ = $V_{DD}/2$, $R_L$ = 5kΩ to $V_{DD}/2$. Typical values are at $T_A$ = +25°C.)

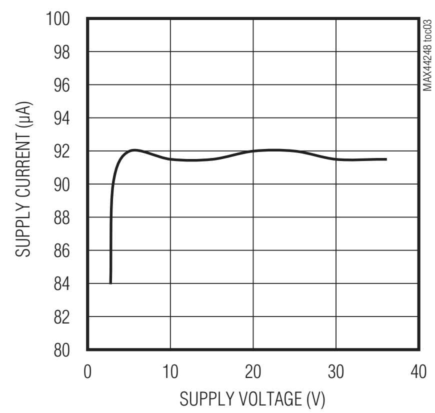
**INPUT OFFSET VOLTAGE HISTOGRAM**



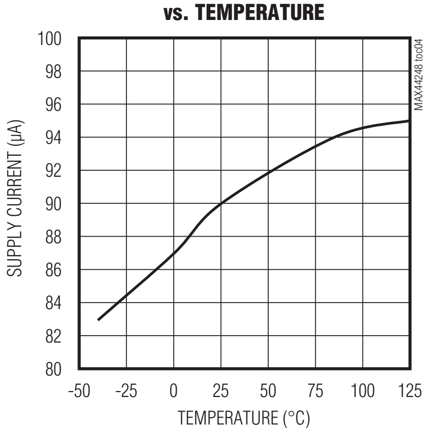

**INPUT OFFSET VOLTAGE DRIFT**



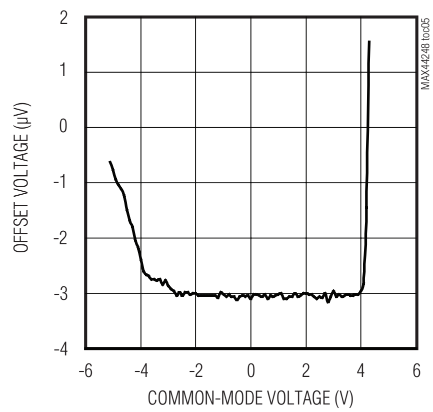

**SUPPLY CURRENT vs. SUPPLY VOLTAGE**



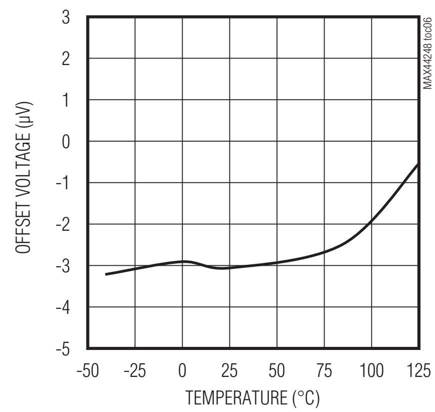

**SUPPLY CURRENT vs. TEMPERATURE**



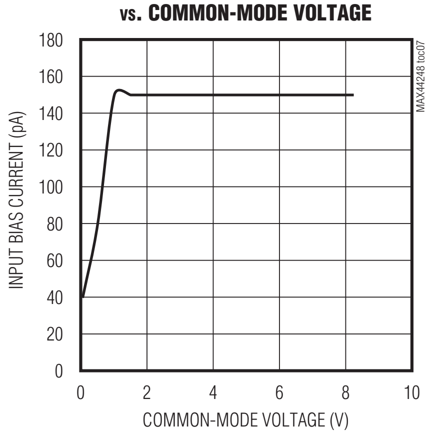

**INPUT OFFSET VOLTAGE vs. COMMON-MODE VOLTAGE**



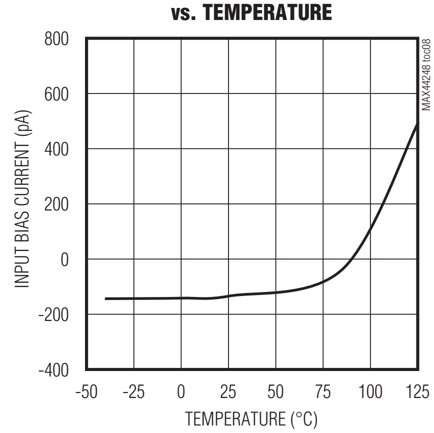

**INPUT OFFSET VOLTAGE vs. TEMPERATURE**




**INPUT BIAS CURRENT vs. COMMON-MODE VOLTAGE**



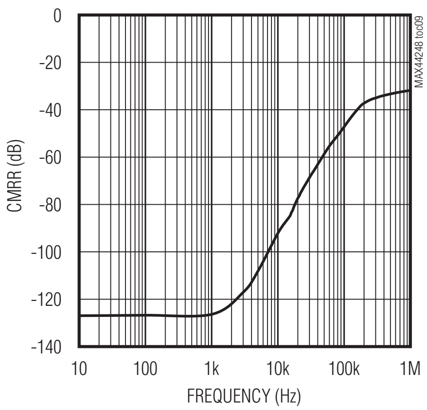

**INPUT BIAS CURRENT vs. TEMPERATURE**



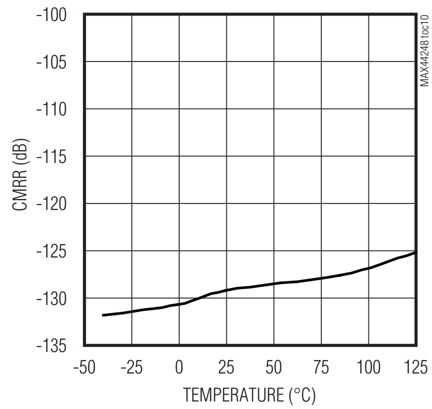
### *Typical Operating Characteristics (continued)*

($V_{DD}$ = 10V, $V_{SS}$ = 0V, $V_{IN+}$ = $V_{IN-}$ = $V_{DD}$/2, $R_L$ = 5kΩ to $V_{DD}$/2. Typical values are at $T_A$ = +25°C.)

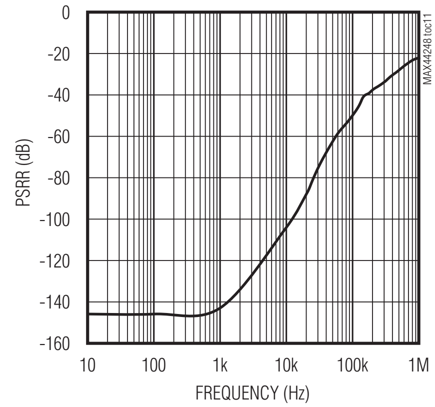
**COMMON-MODE REJECTION RATIO vs. FREQUENCY**



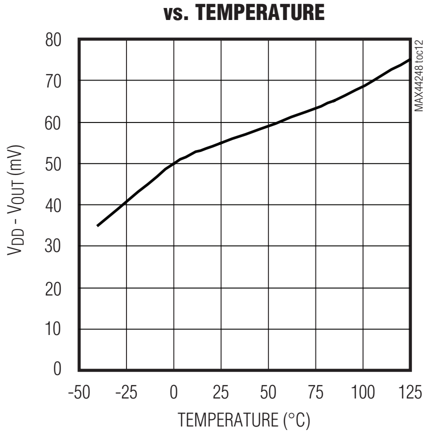

**COMMON-MODE REJECTION RATIO vs. TEMPERATURE**



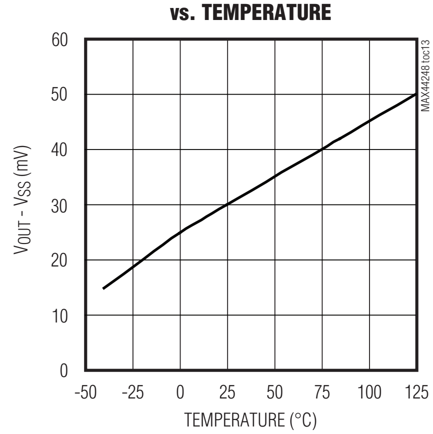

**POWER-SUPPLY REJECTION RATIO vs. FREQUENCY**



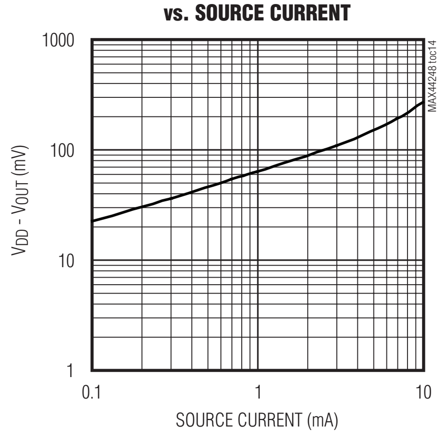

**OUTPUT VOLTAGE HIGH vs. TEMPERATURE**



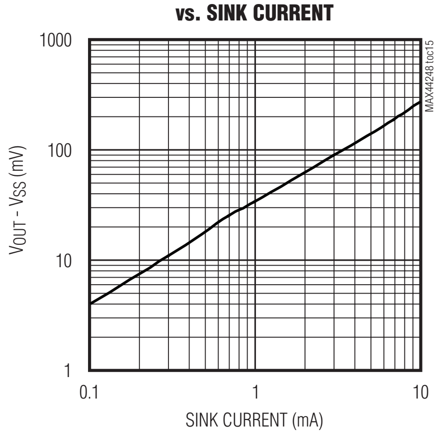

**OUTPUT VOLTAGE LOW vs. TEMPERATURE**



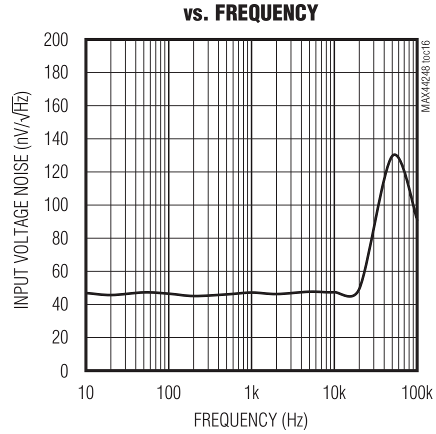

**OUTPUT VOLTAGE HIGH vs. SOURCE CURRENT**




**OUTPUT VOLTAGE LOW vs. SINK CURRENT**



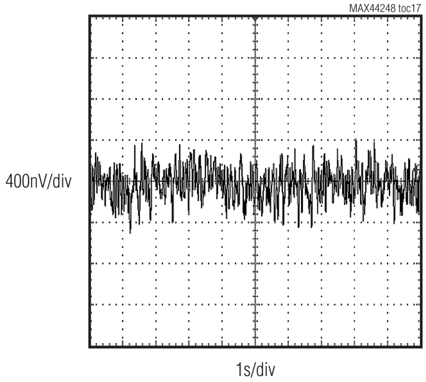

**INPUT VOLTAGE NOISE vs. FREQUENCY**



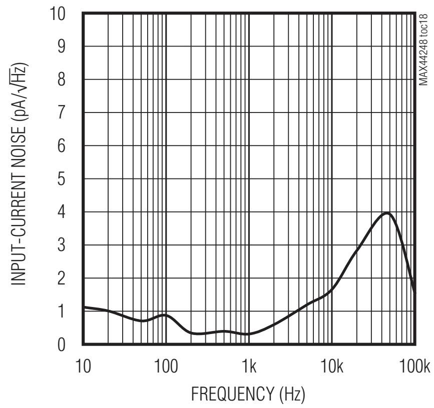
### *Typical Operating Characteristics (continued)*

($V_{DD}$ = 10V, $V_{SS}$ = 0V, $V_{IN+}$ = $V_{IN-}$ = $V_{DD}$/2, $R_L$ = 5kΩ to $V_{DD}$/2. Typical values are at $T_A$ = +25°C.)

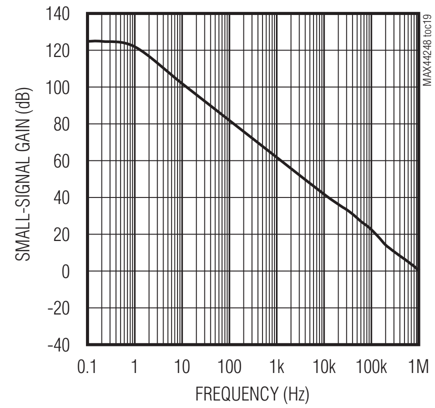
**INPUT VOLTAGE 0.1Hz TO 10Hz NOISE**



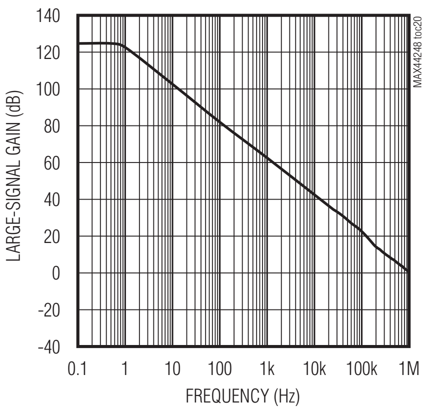

**INPUT CURRENT NOISE vs. FREQUENCY**



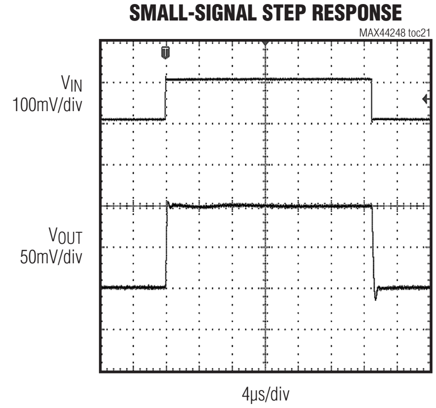

**SMALL-SIGNAL GAIN vs. FREQUENCY**



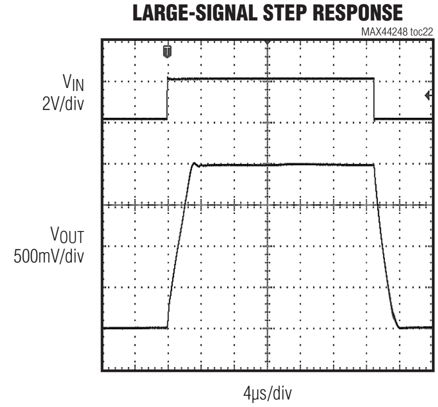

**LARGE-SIGNAL GAIN vs. FREQUENCY**



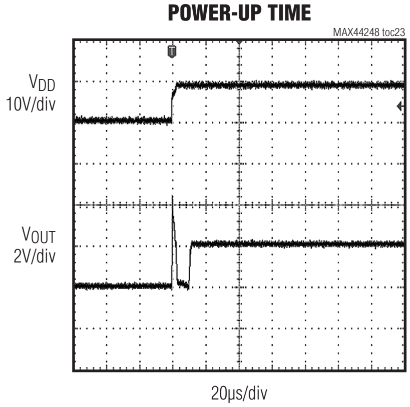

**SMALL-SIGNAL STEP RESPONSE**



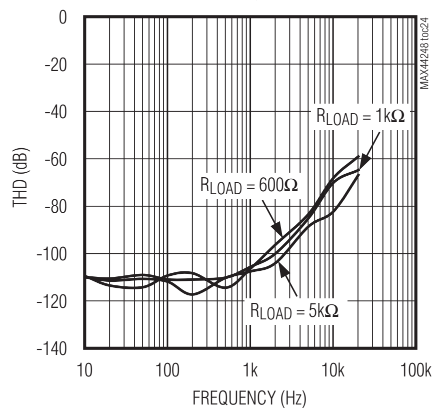

**LARGE-SIGNAL STEP RESPONSE**




**POWER-UP TIME**

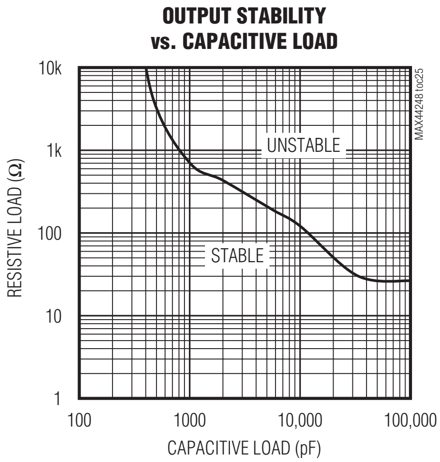


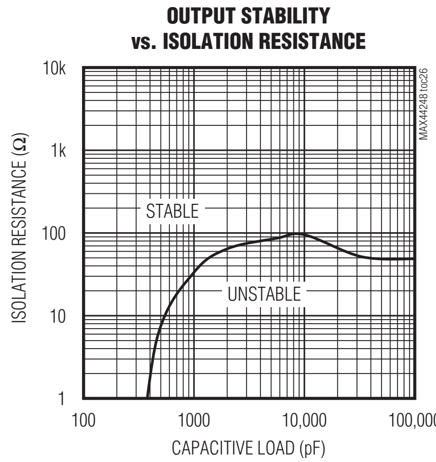

**TOTAL HARMONIC DISTORTION vs. FREQUENCY**

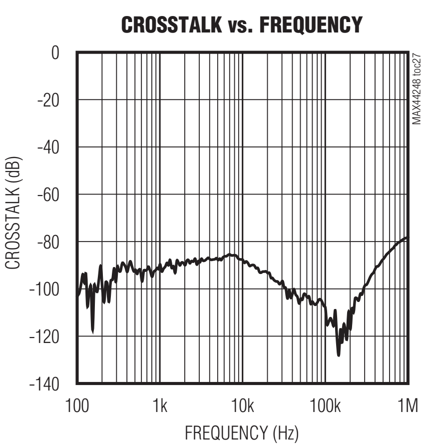


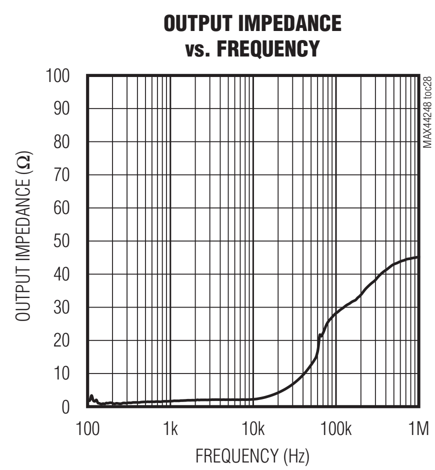
### *Typical Operating Characteristics (continued)*

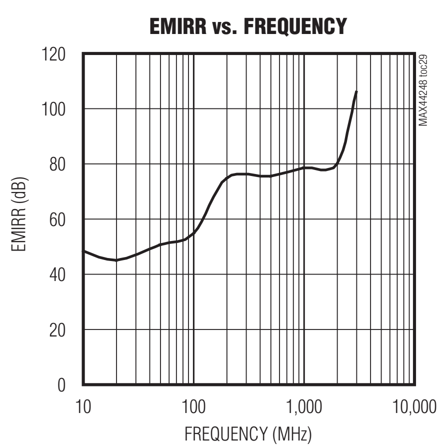
($V_{DD}$ = 10V, $V_{SS}$ = 0V, $V_{IN+}$ = $V_{IN-}$ = $V_{DD}$/2, $R_L$ = 5kΩ to $V_{DD}$/2. Typical values are at $T_A$ = +25°C.)



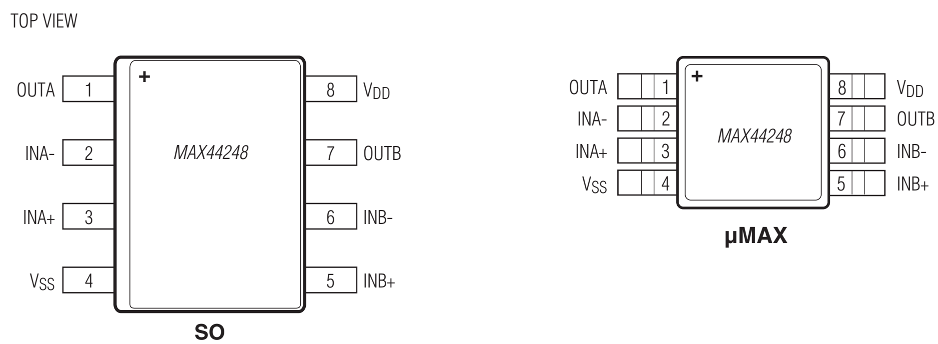



## Pin Configurations




## Pin Description

| PIN | | NAME | FUNCTION |
|---|---|---|---|
| SO | µMAX | | |
| 1 | 1 | OUTA | Channel A Output |
| 2 | 2 | INA- | Channel A Negative Input |
| 3 | 3 | INA+ | Channel A Positive Input |
| 4 | 4 | $V_{SS}$ | Negative Supply Voltage |
| 5 | 5 | INB+ | Channel B Positive Input |
| 6 | 6 | INB- | Channel B Negative Input |
| 7 | 7 | OUTB | Channel B Output |
| 8 | 8 | $V_{DD}$ | Positive Supply Voltage |

## Detailed Description

The MAX44248 is a high-precision amplifier that has a less than 2µV (typ) input-referred offset and low input voltage-noise density at 10Hz. 1/f noise, in fact, is eliminated to improve the performance in low-frequency applications. These characteristics are achieved through an auto-zeroing technique that cancels the input offset voltage and 1/f noise of the amplifier.

### External Noise Suppression in EMI Form

The device has input EMI filters to prevent effects of radio frequency interference on the output. The EMI filters comprise passive devices that present significant higher impedance to higher frequency signals. See the EMIRR vs. Frequency graph in the *Typical Operating Characteristics* section for details.

### High Supply Voltage Range

The device features 90µA current consumption per channel and a voltage supply range from either 2.7V to 36V single supply or ±1.35V to ±18V split supply.

## Applications Information

The device is an ultra-high precision operational amplifier with a high supply voltage range designed for load cell, medical instrumentation, and precision instrument applications.

### 4–20mA Current-Loop Communication

Industrial environments typically have a large amount of broadcast electromagnetic interference (EMI) from high-voltage transients and switching motors. This combined with long cables for sensor communication leads to high-voltage noise on communication lines. Current-Loop communication is resistant to this noise because the EMI induced current is low. This configuration also allows for low-power sensor applications to be powered from the communication lines.

The *Typical Operating Circuit* shows how the device can be used to make a current loop driver.

The circuit uses low-power components such as the MAX44248 op amp, the 16-bit MAX5216 DAC, and the high-precision 60µA-only MAX6033 reference. In this circuit, both the DAC and the reference are referred to the local ground. The MAX44248 op-amp inputs are capable of swinging to the negative supply (which is the local ground in this case). R3 acts as a current mirror with $R_{SENSE}$. Therefore, if $R_{SENSE}$ = 50Ω (i.e. 20mA will drop 1V) and if the current through R3 is 10µA when $I_{OUT}$ is 20mA (0.05% error) then R3 = 100kΩ. R1 is chosen along with the reference voltage to provide the 4mA offset. R2 = 512kΩ for 20mA full scale or R2 = 614kΩ for 20% over-range. $R_{SENSE}$ is ratiometric with R3, R1 independently sets the offset current and R2 independently sets the DAC scaling.

### Driving High-Performance ADCs

The MAX44248's low input offset voltage and low noise make this amplifier ideal for ADC buffering. Weight scale applications require a low-noise, precision amplifier in front of an ADC. Figure 1 details an example of a load cell and amplifier driven from the same 5V supply, along with a 16-bit delta sigma ADC such as the MAX11205.

The MAX11205 is an ultra-low-power (< 300µA, max active current), high-resolution, serial output ADC. It provides the highest resolution per unit power in the industry and is optimized for applications that require very high dynamic range with low power such as sensors on a 4–20mA industrial control loop. The device provides a high-accuracy internal oscillator that requires no external components.

### *Layout Guidelines*

The MAX44248 features ultra-low voltage and noise. Therefore, to get optimum performance follow the layout guidelines.

Avoid temperature tradients at the junction of two dissimilar metals. The most common dissimilar metals used on a PCB are solder-to-component lead and solder-to-board trace. Dissimilar metals create a local thermocouple. A variation in temperature across the board can cause an additional offset due to Seebeck effect at the solder junctions. To minimize the Seebeck effect, place the amplifier away from potential heat sources on the board, if possible. Orient the resistors such that both the ends are heated equally. It is a good practice to match the input signal path to ensure that the type and number of thermoelectric juntions remain the same. For example, consider using dummy 0Ω resistors oriented in such a way that the thermoelectric source, due to the real resistors in the signal path, are cancelled. It is recommended to flood the PCB with ground plane. The ground plane ensures that heat is distributed uniformly reducing the potential offset voltage degradation due to Seebeck effect.

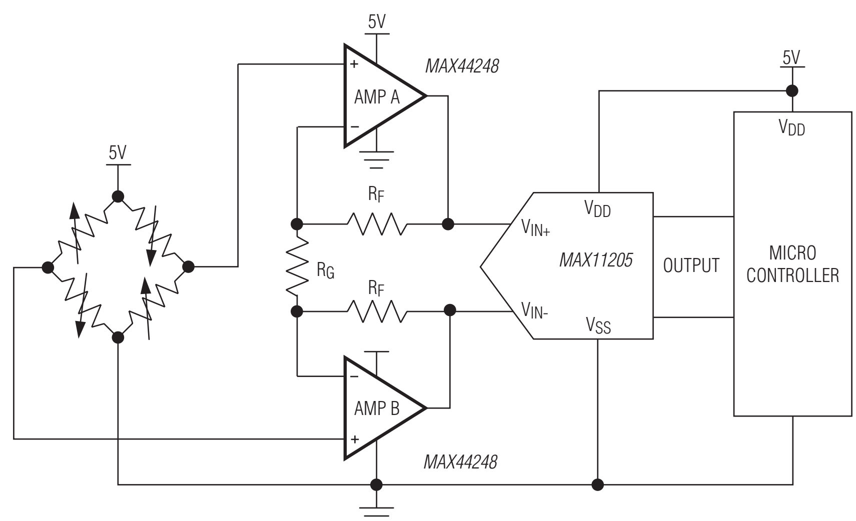



*Figure 1. Weight Application*

### Chip Information

PROCESS: BiCMOS

### Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE |
|---|---|---|
| MAX44248AUA+ | -40°C to +125°C | 8 µMAX |
| MAX44248ASA+ | -40°C to +125°C | 8 SO |

*+Denotes a lead(Pb)-free/RoHS-compliant package.*

### Package Information

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.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. |
|---|---|---|---|
| 8 SO | S8+4 | 21-0041 | 90-0096 |
| 8 µMAX | U8+1 | 21-0036 | 90-0092 |

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 7/12 | Initial release | — |