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

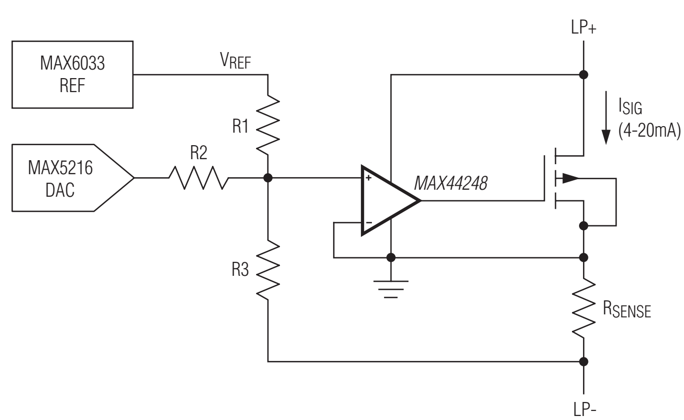
Features

- **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**
  - **$0.5\mu V_{P-P}$ 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 (θ_{JA}) .....206.3°C/W
Junction-to-Case Thermal Resistance (θ_{JC})..............42°C/W

SO
Junction-to-Ambient Thermal Resistance (θ_{JA}) ....132°C/W
Junction-to-Case Thermal Resistance (θ_{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)

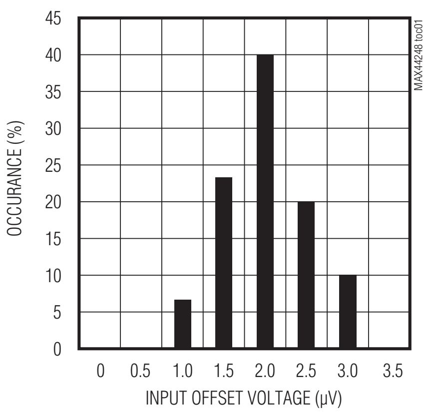
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Offset Voltage (Note 3)	V_{OS}	T_A = +25°C			2	7.5	µV
		-40°C < T_A < +125°C				10	
Input Offset Voltage Drift (Note 3)	TC V_{OS}				10	30	nV/°C
Input Bias Current (Note 3)	I_B	T_A = +25°C			150	300	pA
		-40°C < T_A < +125°C				700	
Input Offset Current (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/√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		

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}/ΔV_{OS}).

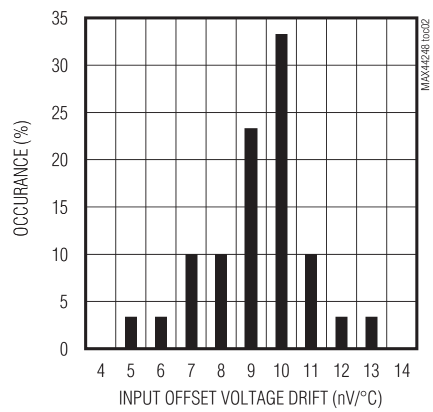
Typical Operating Characteristics

(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.)

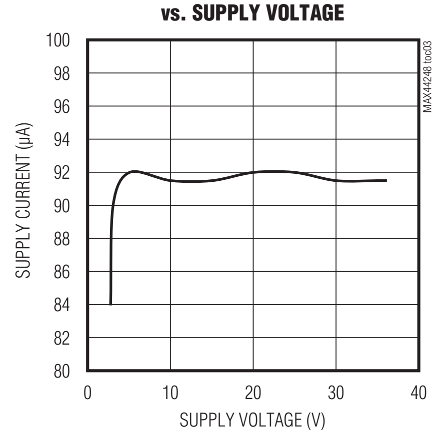
INPUT OFFSET VOLTAGE HISTOGRAM



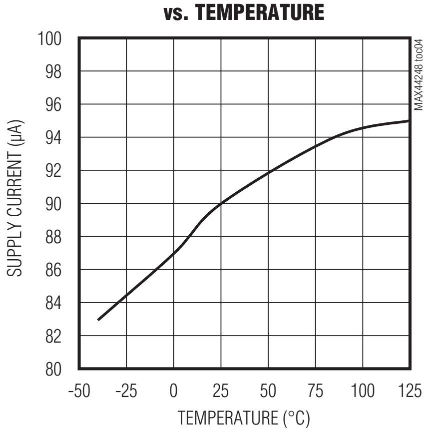
INPUT OFFSET VOLTAGE DRIFT



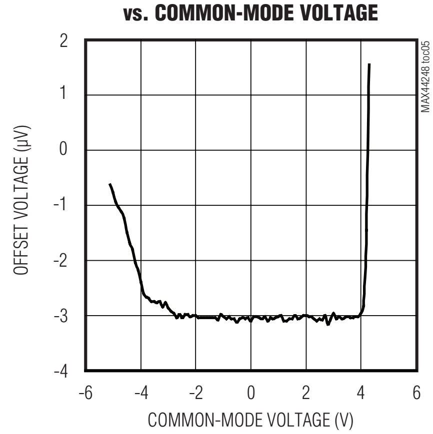
SUPPLY CURRENT vs. SUPPLY VOLTAGE



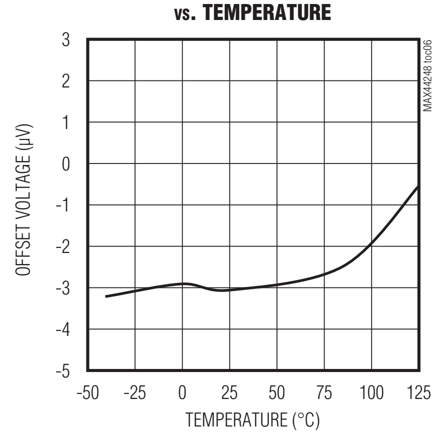
SUPPLY CURRENT vs. TEMPERATURE



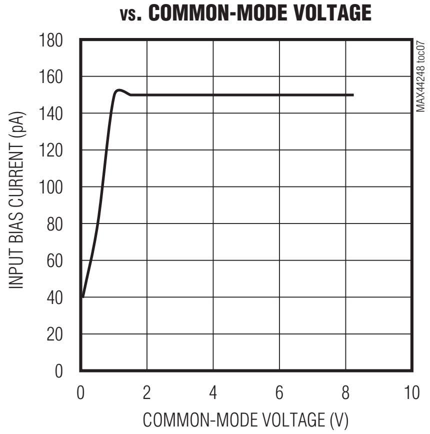
INPUT OFFSET VOLTAGE vs. COMMON-MODE VOLTAGE



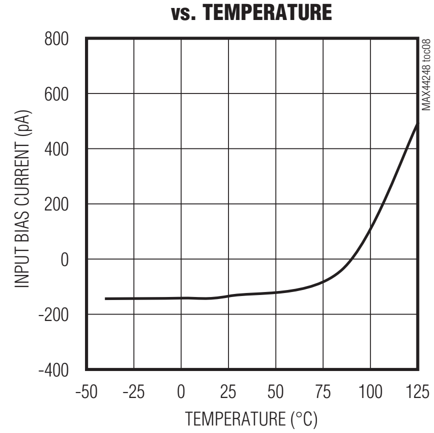
INPUT OFFSET VOLTAGE vs. TEMPERATURE



INPUT BIAS CURRENT vs. COMMON-MODE VOLTAGE



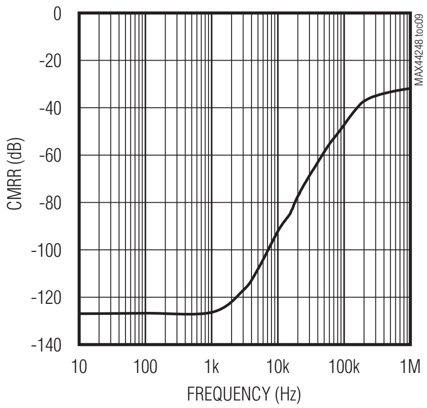
INPUT BIAS CURRENT vs. TEMPERATURE



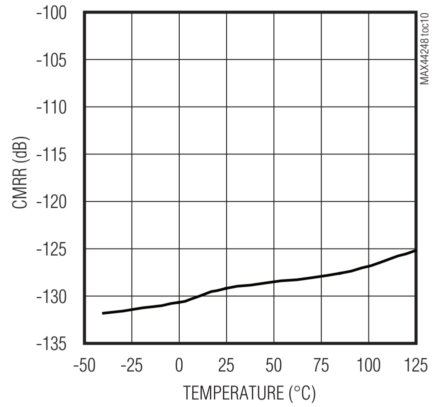
Typical Operating Characteristics (continued)

(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.)

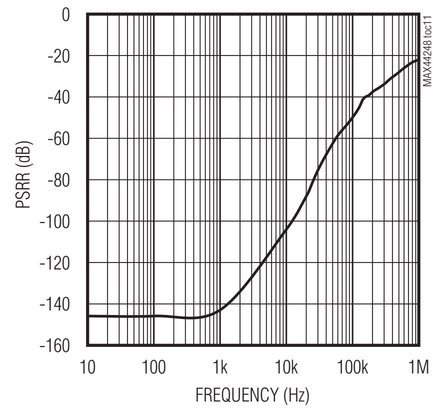
COMMON-MODE REJECTION RATIO vs. FREQUENCY



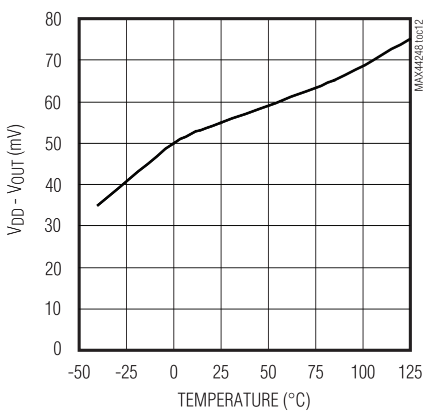
COMMON-MODE REJECTION RATIO vs. TEMPERATURE



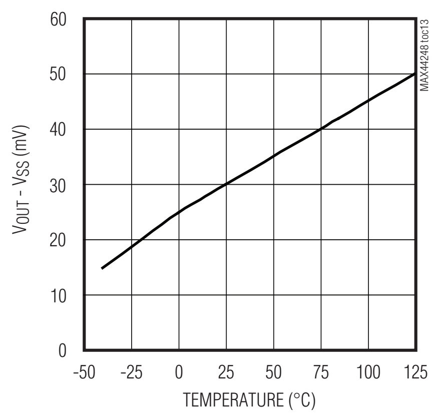
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY



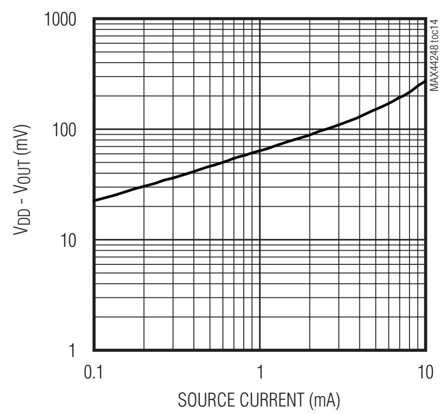
OUTPUT VOLTAGE HIGH vs. TEMPERATURE



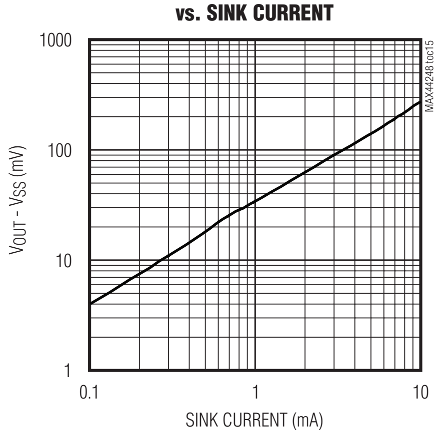
OUTPUT VOLTAGE LOW vs. TEMPERATURE



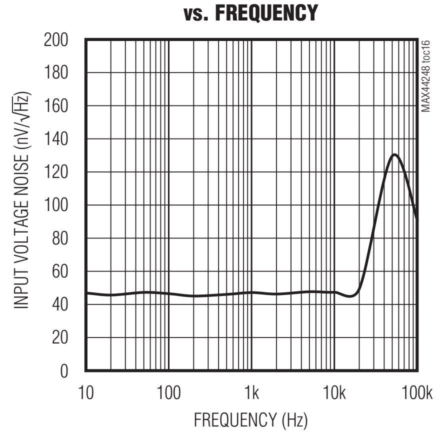
OUTPUT VOLTAGE HIGH vs. SOURCE CURRENT



OUTPUT VOLTAGE LOW vs. SINK CURRENT



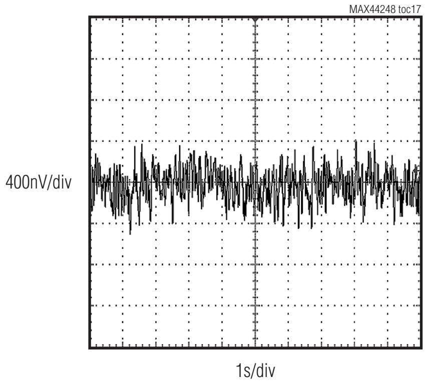
INPUT VOLTAGE NOISE vs. FREQUENCY



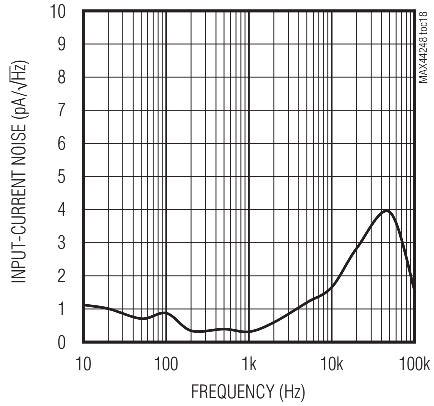
Typical Operating Characteristics (continued)

(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.)

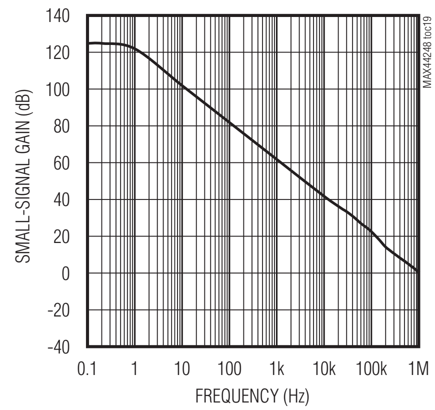
INPUT VOLTAGE 0.1Hz TO 10Hz NOISE



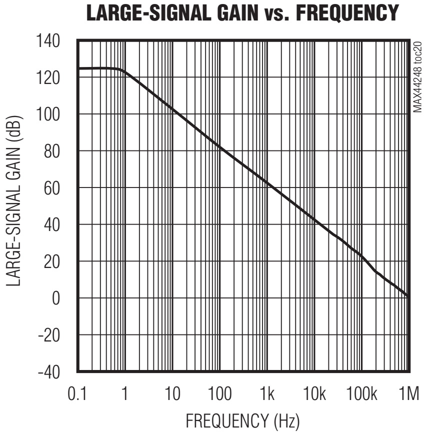
INPUT CURRENT NOISE vs. FREQUENCY



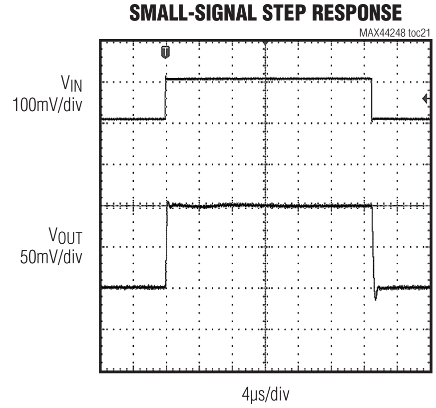
SMALL-SIGNAL GAIN vs. FREQUENCY



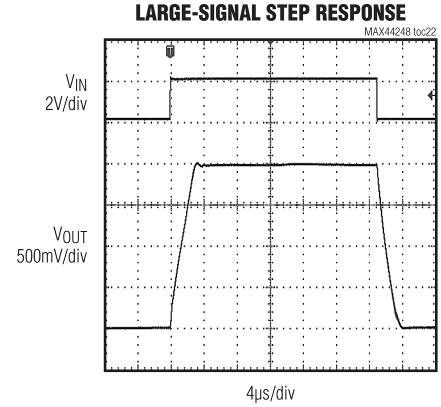
LARGE-SIGNAL GAIN vs. FREQUENCY



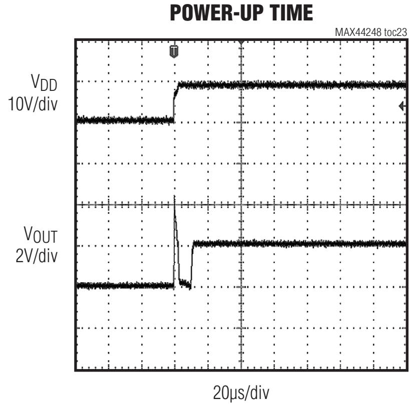
SMALL-SIGNAL STEP RESPONSE



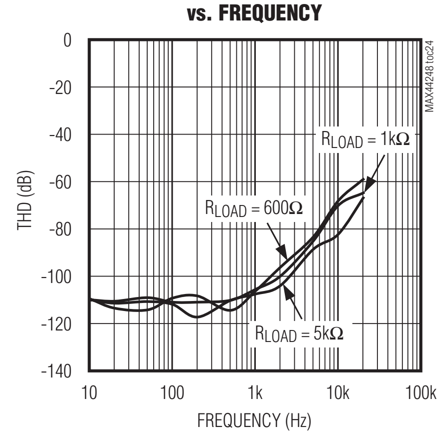
LARGE-SIGNAL STEP RESPONSE



POWER-UP TIME



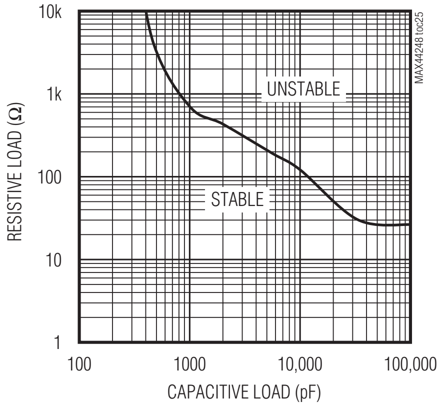
TOTAL HARMONIC DISTORTION vs. FREQUENCY



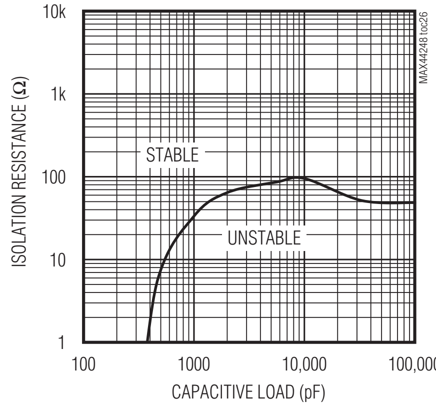
Typical Operating Characteristics (continued)

(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.)

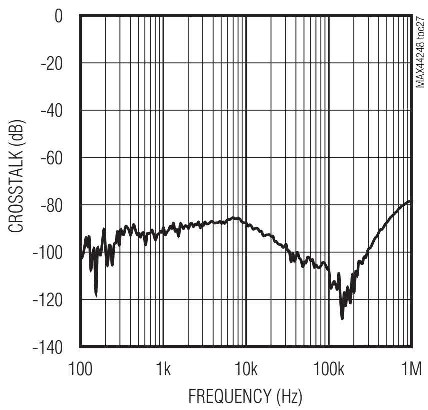
OUTPUT STABILITY vs. CAPACITIVE LOAD



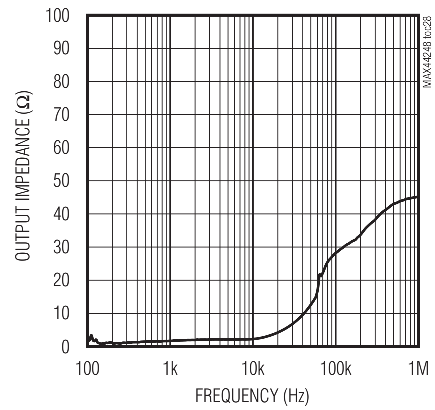
OUTPUT STABILITY vs. ISOLATION RESISTANCE



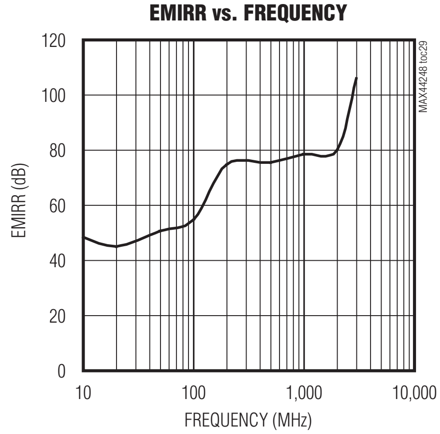
CROSSTALK vs. FREQUENCY



OUTPUT IMPEDANCE vs. FREQUENCY

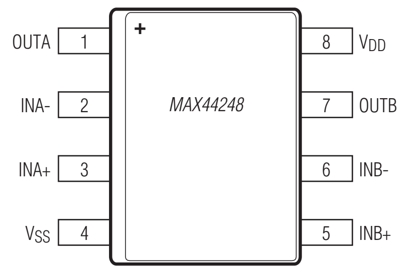


EMIRR vs. FREQUENCY

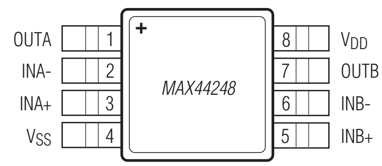


Pin Configurations

TOP VIEW



SO



µMAX

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.

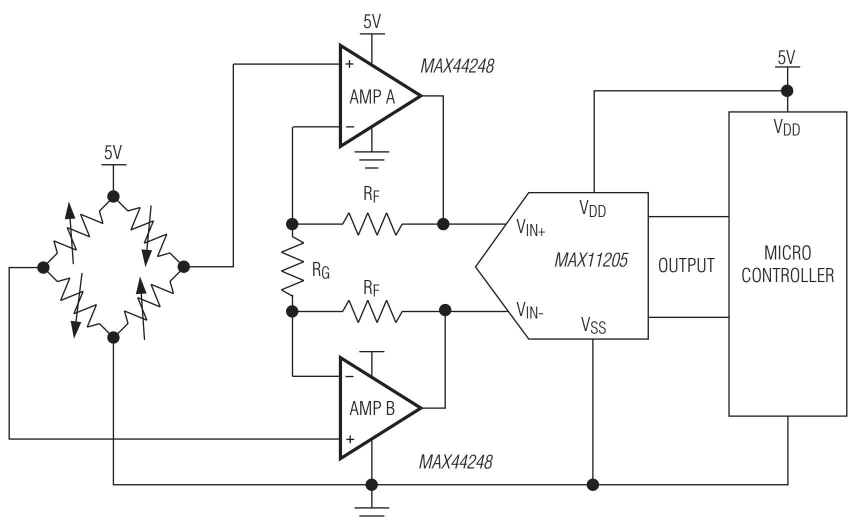


Figure 1. Weight Application

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	—

maxim integrated™

Maxim Integrated 160 Rio Robles, San Jose, CA 95134 USA 1-408-601-1000

OCEAN CHIPS

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