EVALUATION KIT AVAILABLE

MAX44246

36V, Low-Noise, Precision, Dual Op Amp

General Description

The MAX44246 is a 36V, ultra-precision, low-noise, low-drift, dual operational amplifier that offers near-zero DC offset and drift through the use of patented chopper stabilized and auto-zeroing techniques. This method constantly measures and compensates the input offset, eliminating drift over time and temperature and the effect of 1/f noise. This dual device features rail-to-rail outputs, operates from a single 2.7V to 36V supply or dual ±1.35V to ±18V supplies, and consumes only 0.42mA per channel, with only 9nV/√Hz input-referred voltage noise.

The IC is unity-gain stable with a gain-bandwidth product of 5MHz. With excellent specifications such as offset voltage of 5μV (max), drift of 20nV/°C (max), and 117nV$_{P-P}$ noise in 0.1Hz to 10Hz, the IC is ideally suited for applications requiring ultra-low noise, and DC precision such as interfacing with pressure sensors, strain gauges, precision weight scales, and medical instrumentation.

The IC is available in 8-pin μMAX® or SO packages and is rated over the -40°C to +125°C temperature range.

Features

- ♦ **2.7V to 36V Power-Supply Range**
- ♦ **Ultra-Low Input V_{OS}: 5μV (max)**
- ♦ **Low 20nV/°C (max) of Offset Drift**
- ♦ **Low 9nV/√Hz noise at 1kHz**
- ♦ **1μs Fast Settling Time**
- ♦ **5MHz Gain-Bandwidth Product**
- ♦ **Rail-to-Rail Output**
- ♦ **Integrated EMI Filter**
- ♦ **Low 0.55mA Per Channel (max) Quiescent Current**
- ♦ **8-Pin μMAX/SO Package**

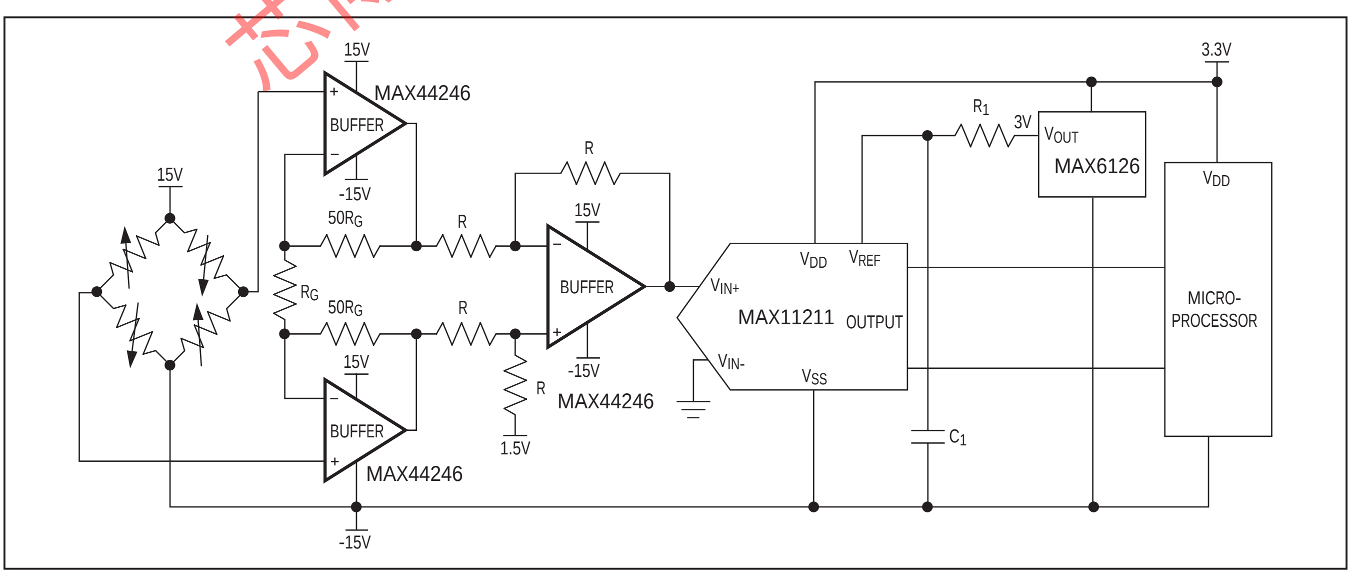
***Ordering Information* appears at end of data sheet.**

*For related parts and recommended products to use with this part, refer to **www.maximintegrated.com/MAX44246.related**.*

Applications

- Transducer Amplifiers
- Load Cell Amplifiers
- Precision Instrumentation
- Battery-Powered Equipment
- PLC Analog I/O Modules

Typical Operating Circuit



ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{DD} to GND) ....-0.3V to +40V
All Other Pins...............................(GND - 0.3V) to (V_{DD} + 0.3V)
Short-Circuit Duration, OUTA,
  OUTB to Either Supply Rail.. 1s
Continuous Input Current (Any Pin) 20mA
Differential Input Current .... ±20mA
Differential Input Voltage (Note 1)...................................... .±6V

Continuous Power Dissipation (T_A = +70°C)
  8-Pin μMAX (derate 4.8mW/C above +70°C) 387.8mW
  8-Pin SO (derate 4.8mW/C above +70°C).............470.6mW
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: The amplifier inputs are connected by internal back-to-back clamp diodes. In order to minimize noise in the input stage, current-limiting resistors are not used. If differential input voltages exceeding ±1V are applied, limit input current to 20mA.

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.

PACKAGE THERMAL CHARACTERISTICS (Note 2)

μMAX
  Junction-to-Ambient Thermal Resistance (θ_{JA}) ....221°C/W
  Junction-to-Case Thermal Resistance (θ_{JC}) ....42°C/W

SO
  Junction-to-Ambient Thermal Resistance (θ_{JA}) ....120°C/W
  Junction-to-Case Thermal Resistance (θ_{JC}) ....37°C/W

Note 2: 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**.

ELECTRICAL CHARACTERISTICS

(**V_{DD} = 30V**, V_{GND} = 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 at T_A = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{DD}	Guaranteed by PSRR		2.7		36	V
Power-Supply Rejection Ratio (Note 4)	PSRR	V_{DD} = 2.7V to 36V, T_A = +25°C		148	166		dB
		V_{DD} = 2.7V to 36V, -40°C < T_A < +125°C		146			
Quiescent Current per Amplifier	I_{DD}	R_L = ∞	T_A = +25°C		0.42	0.55	mA
			-40°C < T_A < +125°C			0.60	
Power-Up Time	t_{ON}				20		μs
DC SPECIFICATIONS							
Input Common-Mode Range	V_{CM}	Guaranteed by CMRR test		V_{GND} - 0.05		V_{DD} - 1.5	V
Common-Mode Rejection Ratio (Note 4)	CMRR	V_{CM} = (V_{GND} + 0.05V) to (V_{DD} - 1.5V)		146	166		dB
Input Offset Voltage (Note 4)	V_{OS}				1	5	μV
Input Offset Voltage Drift (Note 4)	TC V_{OS}				1	20	nV/°C
Input Bias Current (Note 4)	I_B	T_A = +25°C			300	600	pA
		-40°C < T_A < +125°C				1250	

ELECTRICAL CHARACTERISTICS (continued)

(**V_{DD} = 30V**, V_{GND} = 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 at T_A = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Offset Current (Note 4)	I_{OS}	T_A = +25°C			600	1200	pA
		-40°C < T_A < +125°C				2500	
Open-Loop Gain (Note 4)	A_{VOL}	(V_{GND} + 0.5V) ≤ V_{OUT} ≤ (V_{DD} – 0.5V)		154	168		dB
Output Short-Circuit Current		Noncontinuous	Sinking		40		mA
			Sourcing		30		
Output Voltage Low	V_{OL}	T_A = +25°C			90	115	mV
		-40°C < T_A < +125°C				180	
Output Voltage High	V_{OH}	T_A = +25°C		(V_{DD} - 0.17)	(V_{DD} - 0.13)		V
		-40°C < T_A < +125°C		(V_{DD} - 0.25)			
AC SPECIFICATIONS							
Input Voltage-Noise Density	e_N	f = 1kHz			9		nV/√Hz
Input Voltage Noise		0.1Hz < f < 10Hz			117		nV_{P-P}
Input Capacitance	C_{IN}				2		pF
Gain-Bandwidth Product	GBW				5		MHz
Phase Margin	PM	C_L = 20pF			60		Degrees
Slew Rate	SR	A_V = 1V/V, V_{OUT} = $4V_{P-P}$			3.8		V/µs
Capacitive Loading	C_L	No sustained oscillation, A_V = 1V/V			300		pF
Total Harmonic Distortion	THD	V_{OUT} = $4V_{P-P}$, A_V = +1V/V	f = 1kHz		-96		dB
			f = 20kHz		-77		
		V_{OUT} = $2V_{P-P}$, A_V = +1V/V	f = 1kHz		-91		dB
			f = 20kHz		-76		

ELECTRICAL CHARACTERISTICS

(**V_{DD} = 10V**, V_{GND} = 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 at T_A = +25°C.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
POWER SUPPLY							
Quiescent Current per Amplifier	I_{DD}	R_L = ∞	T_A = +25°C		0.42	0.55	mA
			-40°C < T_A < +125°C			0.60	
Power-Up Time	t_{ON}				20		µs
DC SPECIFICATIONS							
Input Common-Mode Range	V_{CM}	Guaranteed by CMRR test		(GND - 0.05)		(V_{DD} – 1.5)	V

ELECTRICAL CHARACTERISTICS (continued)

(**V_{DD} = 10V**, V_{GND} = 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 at T_A = +25°C.) (Note 3)

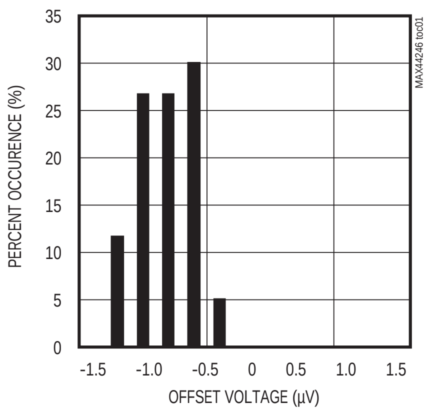
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Common-Mode Rejection Ratio (Note 4)	CMRR	T_A = +25°C, V_{CM} = (V_{GND} - 0.05V) to (V_{DD} - 1.5V)	142	158		dB
		-40°C < T_A < +125°C, V_{CM} = (V_{GND} - 0.05V) to (V_{DD} - 1.5V)	140			
Input Offset Voltage (Note 4)	V_{OS}			1	5	µV
Input Offset Voltage Drift (Note 4)	TC V_{OS}			2.4	20	nV/°C
Input Bias Current (Note 4)	I_B	T_A = +25°C		300	600	pA
		-40°C < T_A < +125°C			1100	
Input Offset Current (Note 4)	I_{OS}	T_A = +25°C		600	1200	pA
		-40°C < T_A < +125°C			2200	
Open-Loop Gain (Note 4)	A_{VOL}	(V_{GND} + 0.5V) ≤ V_{OUT} ≤ (V_{DD} - 0.5V)	144	164		dB
Output Short-Circuit Current		Noncontinuous, Sinking		40		mA
		Noncontinuous, Sourcing		30		
Output Voltage Low	V_{OL}	T_A = +25°C		30	40	mV
		-40°C < T_A < +125°C			60	
Output Voltage High	V_{OH}	T_A = +25°C	(V_{DD} - 0.06)	(V_{DD} - 0.05)		V
		-40°C < T_A < +125°C	(V_{DD} - 0.09)			
AC SPECIFICATIONS						
Input Voltage-Noise Density	e_N	f = 1kHz		9		nV/√Hz
Input Voltage Noise		0.1Hz < f < 10Hz		117		nV_{P-P}
Input Capacitance	C_{IN}			2		pF
Gain-Bandwidth Product	GBW			5		MHz
Phase Margin	PM	C_L = 20pF		60		Degrees
Slew Rate	SR	A_V = +1V/V, V_{OUT} = $2V_{P-P}$, 10% to 90%		3.8		V/µs
Capacitive Loading	C_L	No sustained oscillation, A_V = 1V/V		300		pF
Total Harmonic Distortion	THD	V_{OUT} = $2V_{P-P}$, A_V = 1V/V, f = 1kHz		-92		dB
		V_{OUT} = $2V_{P-P}$, A_V = 1V/V, f = 20kHz		-76		
Settling Time		To 0.01%, V_{OUT} = 2V step, A_V = 1V/V		1		µs

Note 3: All devices are 100% production tested at T_A = +25°C. Temperature limits are guaranteed by design.
Note 4: Guaranteed by design.

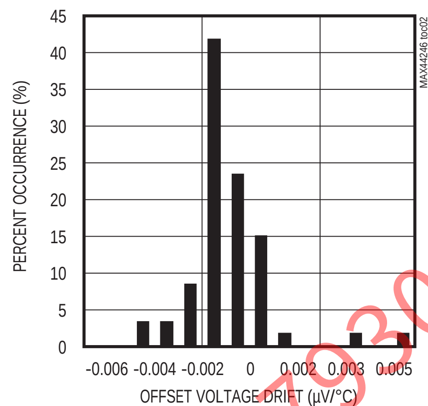
Typical Operating Characteristics

(V_{DD} = 10V, V_{GND} = 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 T_A = +25°C.) (Note 3)

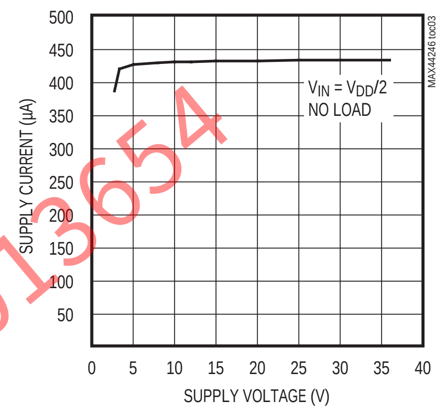
INPUT OFFSET VOLTAGE HISTOGRAM



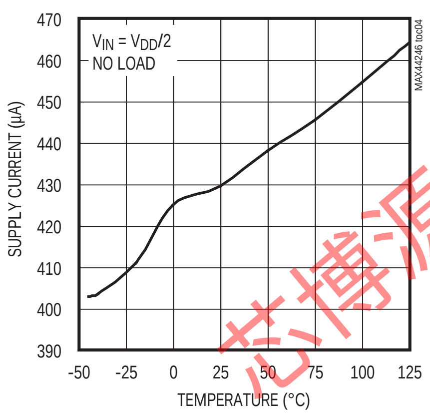
INPUT OFFSET VOLTAGE DRIFT HISTOGRAM



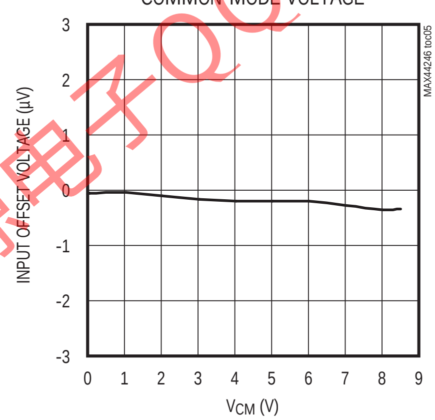
SUPPLY CURRENT PER AMPLIFIER vs. SUPPLY VOLTAGE



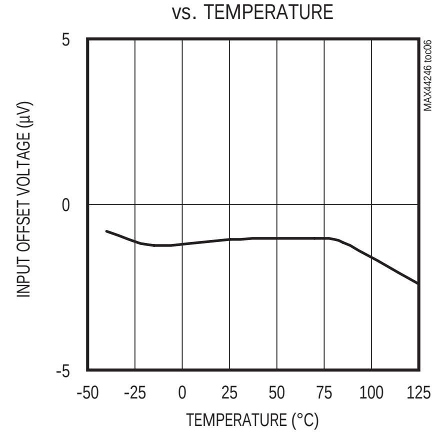
SUPPLY CURRENT PER AMPLIFIER vs. TEMPERATURE



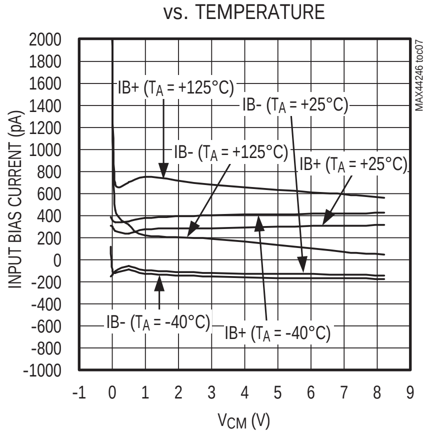
INPUT OFFSET VOLTAGE vs. INPUT COMMON-MODE VOLTAGE



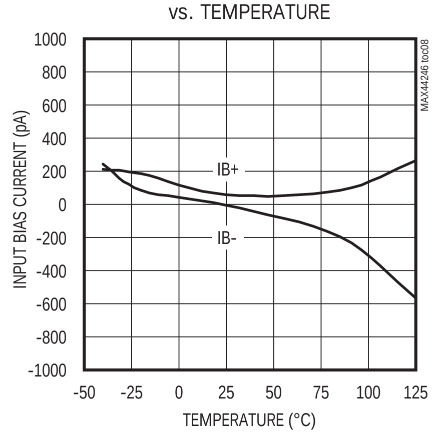
INPUT OFFSET VOLTAGE vs. TEMPERATURE



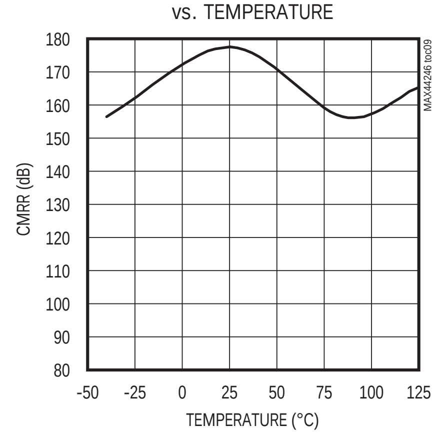
INPUT BIAS CURRENT vs. V_{CM} vs. TEMPERATURE



INPUT BIAS CURRENT vs. TEMPERATURE



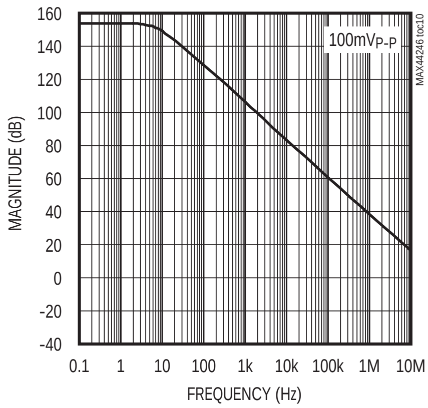
COMMON-MODE REJECTION RATIO vs. TEMPERATURE



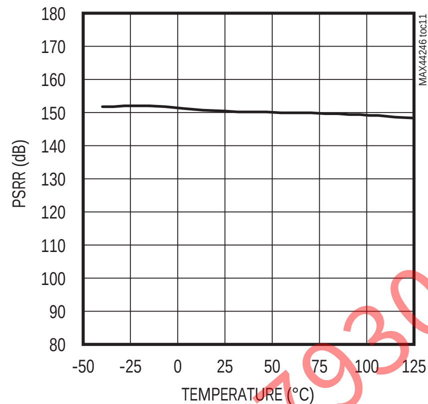
Typical Operating Characteristics (continued)

(V_{DD} = 10V, V_{GND} = 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 T_A = +25°C.) (Note 3)

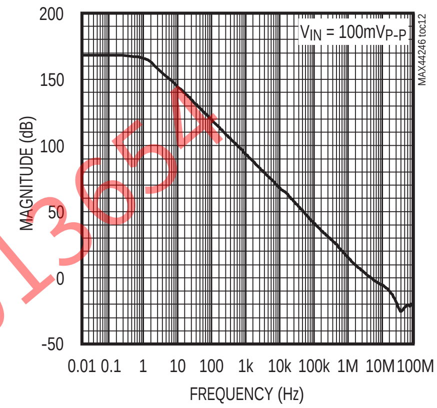
COMMON-MODE REJECTION RATIO vs. FREQUENCY



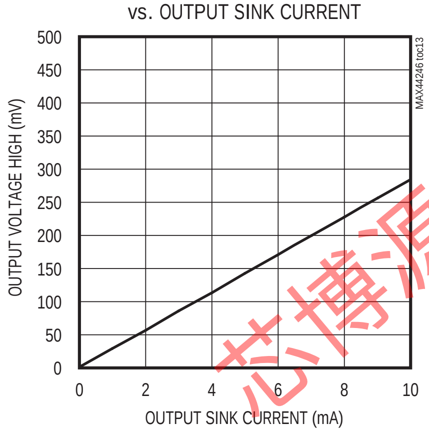
POWER-SUPPLY REJECTION RATIO vs. TEMPERATURE



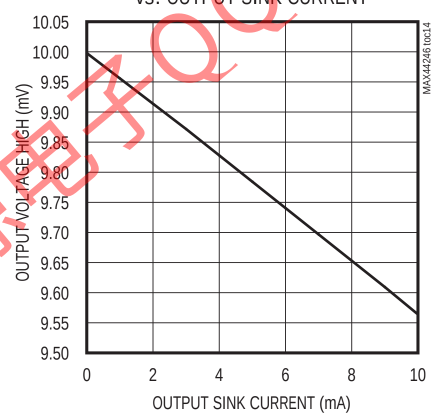
OPEN-LOOP GAIN vs. FREQUENCY



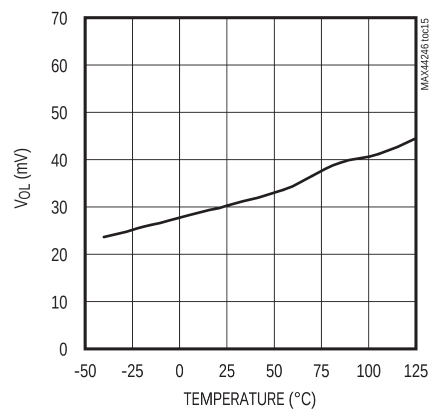
OUTPUT VOLTAGE LOW vs. OUTPUT SINK CURRENT



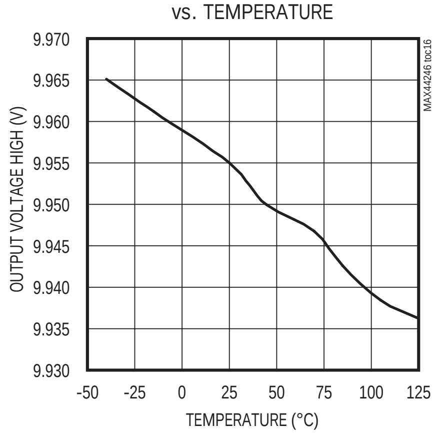
OUTPUT VOLTAGE HIGH vs. OUTPUT SINK CURRENT



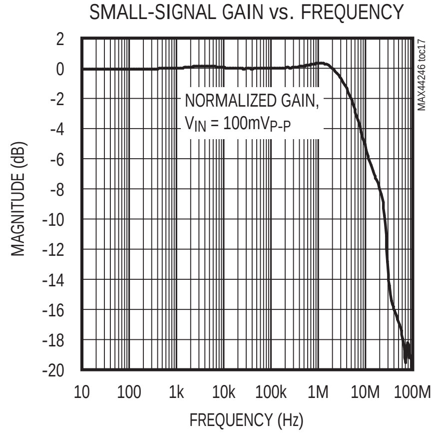
OUTPUT VOLTAGE LOW vs. TEMPERATURE



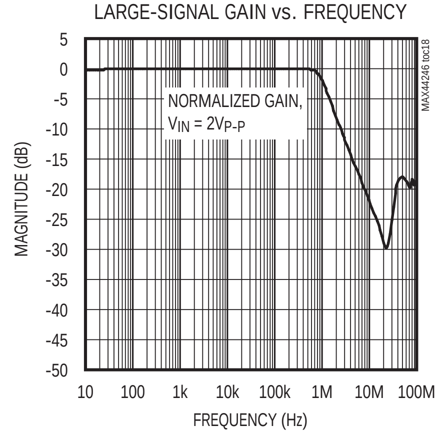
OUTPUT VOLTAGE HIGH vs. TEMPERATURE



SMALL-SIGNAL GAIN vs. FREQUENCY



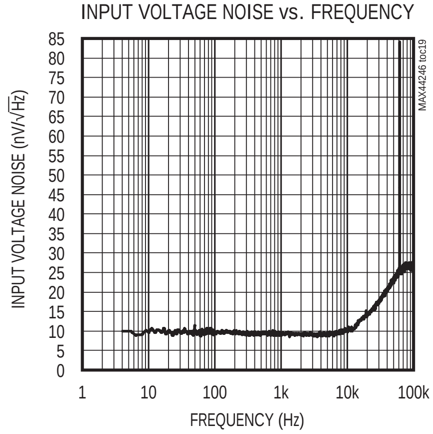
LARGE-SIGNAL GAIN vs. FREQUENCY



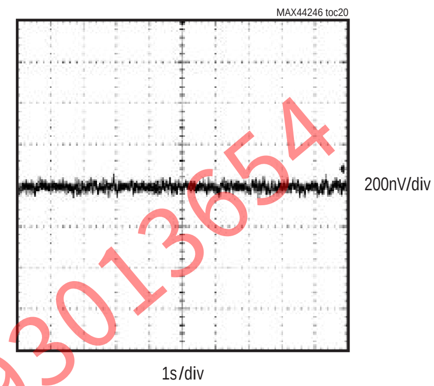
Typical Operating Characteristics (continued)

(V_{DD} = 10V, V_{GND} = 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 T_A = +25°C.) (Note 3)

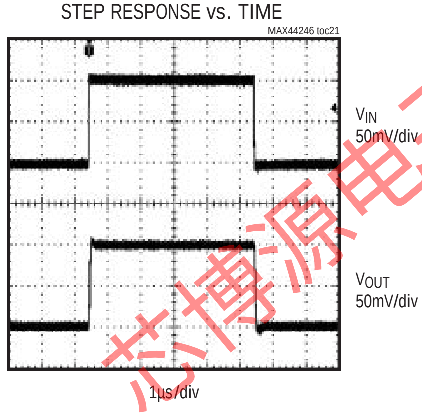
INPUT VOLTAGE NOISE vs. FREQUENCY



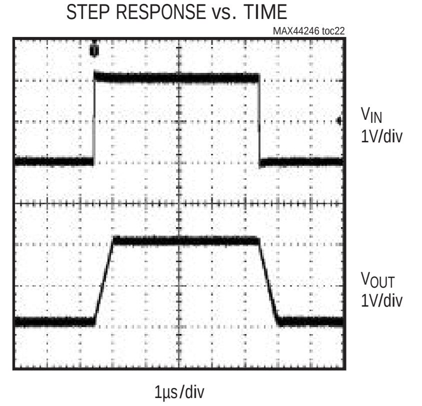
INPUT VOLTAGE 0.1Hz TO 10Hz NOISE



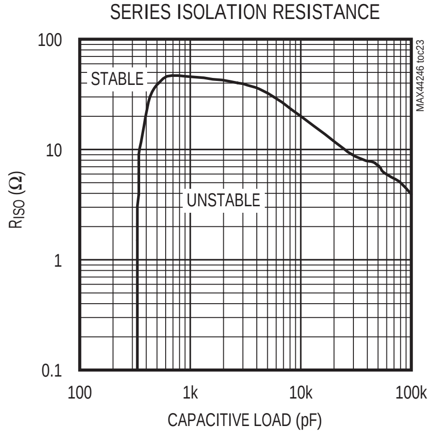
SMALL-SIGNAL (100mVP-P) STEP RESPONSE vs. TIME



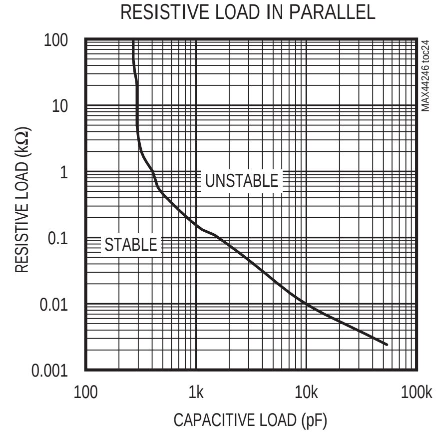
LARGE-SIGNAL (2VP-P) STEP RESPONSE vs. TIME



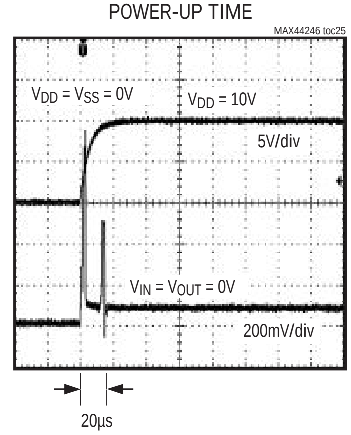
STABILITY vs. CAPACITIVE LOAD AND SERIES ISOLATION RESISTANCE



STABILITY vs. CAPACITIVE AND RESISTIVE LOAD IN PARALLEL



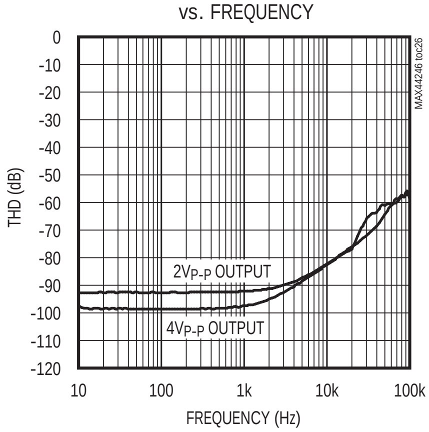
POWER-UP TIME



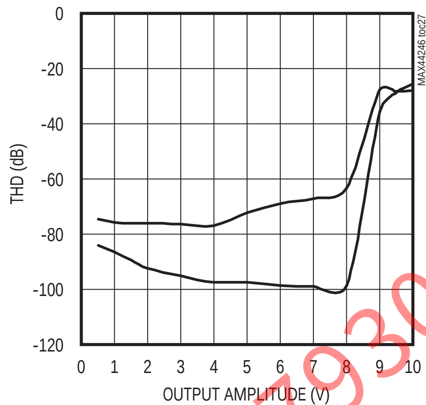
Typical Operating Characteristics (continued)

(V_{DD} = 10V, V_{GND} = 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 T_A = +25°C.) (Note 3)

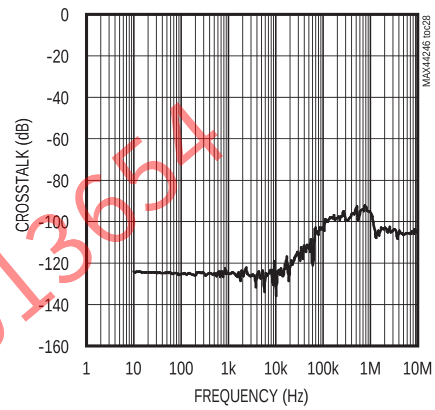
TOTAL HARMONIC DISTORTION vs. FREQUENCY



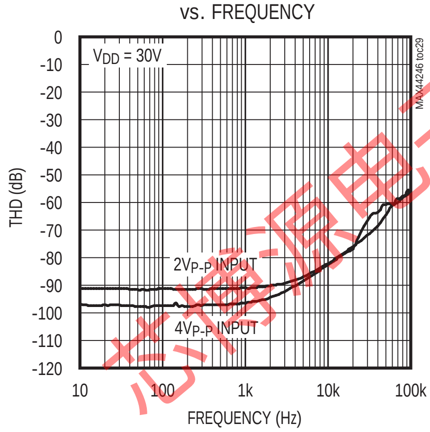
TOTAL HARMONIC DISTORTION vs. OUTPUT AMPLITUDE



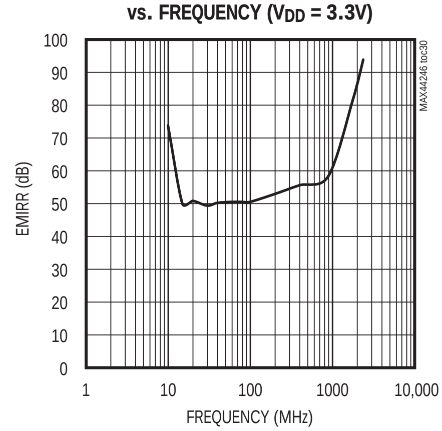
CROSSTALK vs. FREQUENCY



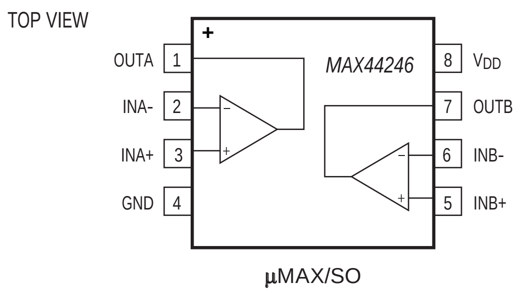
TOTAL HARMONIC DISTORTION vs. FREQUENCY



EMIRR vs. FREQUENCY (V_{DD} = 3.3V)



Pin Configuration



Pin Description

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

Detailed Description

The MAX44246 is a high-precision amplifier that provides below 5µV of maximum input-referred offset and low flicker noise. These characteristics are achieved by using a combination of proprietary auto-zeroing and chopper stabilized techniques. This combination of auto-zeroing and chopping ensures that these amplifiers give all the benefits of zero-drift amplifiers, while still ensuring low noise, minimizing chopper spikes, and providing wide bandwidth. Offset voltages due to power ripple/spikes as well as common-mode variation, are corrected resulting in excellent PSRR and CMRR specifications.

Noise Suppression

Flicker noise, inherent in all active devices, is inversely proportional to frequency present. Charges at the oxide-silicon interface that are trapped-and-released by MOSFET oxide occurs at low frequency more often. For this reason, flicker noise is also called 1/f noise. The MAX44246 eliminates the 1/f noise internally, thus making it an ideal choice for DC or sub-Hz precision applications.

The 1/f noise appears as a slow varying offset voltage and is eliminated by the chopping technique used.

Electromagnetic interference (EMI) noise occurs at higher frequency, resulting in malfunction or degradation of electrical equipment. The ICs have an input EMI filter to avoid the output being affected by radio frequency interference. The EMI filter composed of passive devices, presents significant higher impedance to higher frequency.

Applications Information

ADC Buffer Amplifier

The MAX44246 has low input offset voltage, low noise, and fast settling time that make this amplifier ideal for ADC buffers. Weight scales are one application that often requires a low-noise, high-voltage amplifier in front of an ADC. The *Typical Operating Circuit* details an example of a load cell and amplifier driven from the same ±10V supplies, along with the MAX11211 18-bit delta sigma ADC. Load cells produce a very small voltage change at their outputs; therefore driving the excitation source with a higher voltage produces a wider dynamic range that can be measured at the ADC inputs.

The MAX11211 ADC operates from a single 2.7V to 3.6V analog supply, offers 18-bit noise-free resolution and 0.86mW power dissipation. The MAX11211 also offers > 100dB rejection at 50Hz and 60Hz. This ADC is part of a family of 16-, 18-, 20-, and 24-bit delta sigma ADCs with high precision and < 1mW power dissipation.

The low input offset voltage and low noise of MAX44246 allows a gain circuit to precede the MAX11211 without losing any dynamic range at the ADC. See the *Typical Operating Circuit*.

Precision Low-Side Current Sensing

The ICs' ultra-low offset voltage and drift make them ideal for precision current-sensing applications. Figure 1 shows the ICs in a low-side current-sense configuration. This circuit produces an accurate output voltage, V_{OUT} equal to $I_{LOAD} \times R_{SENSE} \times (1 + R_2/R_1)$.

Layout Guidelines

The MAX44246 features ultra-low offset voltage and noise. Therefore, to get optimum performance follow the following layout guidelines.

Avoid temperature gradients 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 junctions remain the same. For example, consider using dummy 0Ω resistors oriented in such a way that the thermoelectric sources, 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.

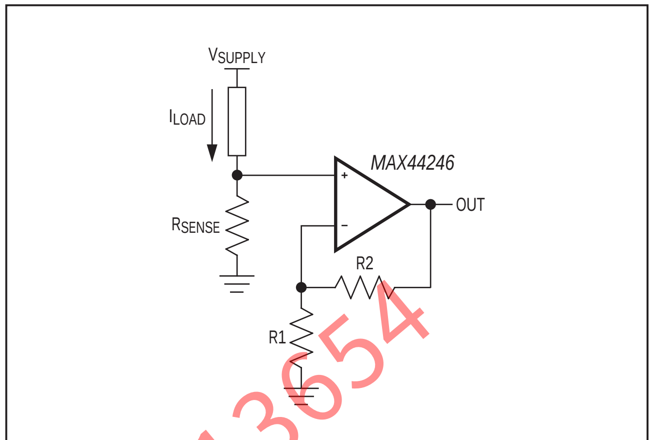


Figure 1. Low-Side Current Sensing

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX44246ASA+	-40°C to +125°C	8 SO
MAX44246AUA+	-40°C to +125°C	8 µMAX

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

Chip Information

PROCESS: BiCMOS

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 µMAX	U8+3	21-0036	90-0092
8 SO	S8+4	21-0041	90-0096

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	7/12	Initial release	—
1	9/12	Revised the *Electrical Characteristics* and the *Typical Operating Characteristics*.	1, 2, 3, 5
2	2/13	Revised the *Typical Operating Characteristics*.	8
3	5/13	Updated *General Description*, *Typical Application Circuit*, and *Pin Description*.	1, 9