20 µA Maximum, Rail-to-Rail I/O, Zero Input Crossover Distortion Amplifiers

AD8506/AD8508

FEATURES

PSRR: 100 dB minimum
CMRR: 105 dB typical
Very low supply current: 20 µA per amp maximum
1.8 V to 5 V single-supply or ±0.9 V to ±2.5 V dual-supply operation
Rail-to-rail input and output
Low noise: 45 nV/√Hz @ 1 kHz
2.5 mV offset voltage maximum
Very low input bias current: 1 pA typical

APPLICATIONS

Pressure and position sensors
Remote security
Bio sensors
IR thermometers
Battery-powered consumer equipment
Hazard detectors

PIN CONFIGURATIONS

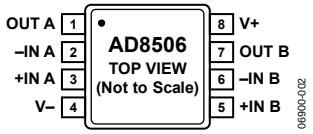


Figure 1. 8-Lead MSOP (RM-8)

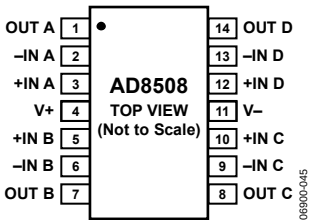


Figure 2. 14-Lead TSSOP (RU-14)

GENERAL DESCRIPTION

The AD8506/AD8508 are dual and quad micropower amplifiers featuring rail-to-rail input and output swings while operating from a 1.8 V to 5 V single or from ±0.9 V to ±2.5 V dual power supply.

Using a novel circuit technology, these low cost amplifiers offer zero crossover distortion (excellent PSRR and CMRR performance) and very low bias current, while operating with a supply current of less than 20 µA per amplifier. This amplifier family offers the lowest noise in its power class.

This combination of features makes the AD8506/AD8508 amplifiers ideal choices for battery-powered applications because they minimize errors due to power supply voltage variations over the lifetime of the battery and maintain high CMRR even for a rail-to-rail input op amp.

Remote battery-powered sensors, handheld instrumentation and consumer equipment, hazard detection (for example, smoke, fire, and gas), and patient monitors can benefit from the features of the AD8506/AD8508 amplifiers.

The AD8506/AD8508 are specified for both the industrial temperature range of −40°C to +85°C and the extended industrial temperature range of −40°C to +125°C. The AD8506 dual amplifiers are available in an 8-lead MSOP package. The AD8508 quad amplifiers are available in the 14-lead TSSOP package.

Rev. A

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700 **www.analog.com**
Fax: 781.461.3113

TABLE OF CONTENTS

REVISION HISTORY

7/08—Rev. 0 to Rev. A

Added AD8508 ..... Universal
Added TSSOP Package ..... Universal
Changes to Features Section and General Description Section 1
Added Figure 2; Renumbered Sequentially 1
Changed Electrical Characteristics Heading to Electrical Characteristics—5 V Operation 3
Changes to Table 1 3
Added Electrical Characteristics—1.8 V Operation Heading 4
Changes to Table 2 4
Changes to Table 3, Thermal Resistance Section, and Table 4 5
Added T_A = 25°C Condition to Typical Performance Characteristics Section 6
Changes to Figure 3, Figure 4, Figure 6, and Figure 7 6
Added Figure 11 and Figure 14 7
Changes to Figure 17 Through Figure 20 8
Changes to Figure 21 Through Figure 26 9
Changes to Figure 27, Figure 28, Figure 30, and Figure 31 10
Changes to Figure 34, Figure 37, and Figure 38 11
Added Figure 39 and Figure 40 12
Added Theory of Operation Section, Figure 41, and Figure 42 13
Added Figure 43 and Figure 44 14
Added Applications Information Section and Figure 45 15
Added Figure 46 16
Updated Outline Dimensions 17
Added Figure 48 17
Changes to Ordering Guide 17

11/07—Revision 0: Initial Version

SPECIFICATIONS

ELECTRICAL CHARACTERISTICS—5 V OPERATION

V_{SY} = 5 V, V_{CM} = V_{SY}/2, T_A = 25°C, R_L = 100 kΩ to GND, unless otherwise noted.

Table 1.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Offset Voltage	V_{OS}	0 V ≤ V_{CM} ≤ 5 V		0.5	2.5	mV
		−40°C ≤ T_A ≤ +125°C			3.5	mV
Input Bias Current	I_B			1	10	pA
		−40°C ≤ T_A ≤ +85°C			100	pA
		−40°C ≤ T_A ≤ +125°C			600	pA
Input Offset Current	I_{OS}			0.5	5	pA
		−40°C ≤ T_A ≤ +85°C			50	pA
		−40°C ≤ T_A ≤ +125°C			130	pA
Input Voltage Range		−40°C ≤ T_A ≤ +125°C	0		5	V
Common-Mode Rejection Ratio	CMRR	0 V ≤ V_{CM} ≤ 5 V	90	105		dB
		−40°C ≤ T_A ≤ +85°C	90			dB
		−40°C ≤ T_A ≤ +125°C	85			dB
Large Signal Voltage Gain	A_{VO}	0.05 V ≤ V_{OUT} ≤ 4.95 V	105	120		dB
		−40°C ≤ T_A ≤ +125°C	100			dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	−40°C ≤ T_A ≤ +125°C		2		µV/°C
Input Capacitance Differential Mode	C_{DIFF}			3		pF
Input Capacitance Common Mode	C_{CM}			4.2		pF
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	R_L = 100 kΩ to GND	4.98	4.99		V
		−40°C ≤ T_A ≤ +125°C	4.98			V
		R_L = 10 kΩ to GND	4.9	4.95		V
		−40°C ≤ T_A ≤ +125°C	4.9			V
Output Voltage Low	V_{OL}	R_L = 100 kΩ to V_{SY}		2	5	mV
		−40°C ≤ T_A ≤ +125°C			5	mV
		R_L = 10 kΩ to V_{SY}		10	25	mV
		−40°C ≤ T_A ≤ +125°C			30	mV
Short-Circuit Limit	I_{SC}	V_{OUT} = V_{SY} or GND		±45		mA
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	V_{SY} = 1.8 V to 5 V	100	110		dB
		−40°C ≤ T_A ≤ +85°C	100			dB
		−40°C ≤ T_A ≤ +125°C	95			dB
Supply Current per Amplifier	I_{SY}	V_{OUT} = V_{SY}/2		15	20	µA
		−40°C ≤ T_A ≤ +125°C			25	µA
DYNAMIC PERFORMANCE						
Slew Rate	SR	R_L = 100 kΩ, C_L = 10 pF, G = 1		13		mV/µs
Gain Bandwidth Product	GBP	R_L = 1 MΩ, C_L = 20 pF, G = 1		95		kHz
Phase Margin	Φ_M	R_L = 1 MΩ, C_L = 20 pF, G = 1		60		Degrees
NOISE PERFORMANCE						
Voltage Noise	e_n p-p	f = 0.1 Hz to 10 Hz		2.8		µV p-p
Voltage Noise Density	e_n	f = 1 kHz		45		nV/√Hz
Current Noise Density	i_n	f = 1 kHz		15		fA/√Hz

ELECTRICAL CHARACTERISTICS—1.8 V OPERATION

V_{SY} = 1.8 V, V_{CM} = V_{SY}/2, T_A = 25°C, R_L = 100 kΩ to GND, unless otherwise noted.

Table 2.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Offset Voltage	V_{OS}	0 V ≤ V_{CM} ≤ 1.8 V		0.5	2.5	mV
		−40°C ≤ T_A ≤ +125°C			3.5	mV
Input Bias Current	I_B			1	10	pA
		−40°C ≤ T_A ≤ +85°C			100	pA
		−40°C ≤ T_A ≤ +125°C			600	pA
Input Offset Current	I_{OS}			0.5	5	pA
		−40°C ≤ T_A ≤ +85°C			50	pA
		−40°C ≤ T_A ≤ +125°C			100	pA
Input Voltage Range		−40°C ≤ T_A ≤ +125°C	0		1.8	V
Common-Mode Rejection Ratio	CMRR	0 V ≤ V_{CM} ≤ 1.8 V	85	100		dB
		−40°C ≤ T_A ≤ +85°C	85			dB
		−40°C ≤ T_A ≤ +125°C	80			dB
Large Signal Voltage Gain	A_{VO}	0.05 V ≤ V_{OUT} ≤ 1.75 V	95	115		dB
		−40°C ≤ T_A ≤ +125°C	95			dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	−40°C ≤ T_A ≤ +125°C		2.5		µV/°C
Input Capacitance Differential Mode	C_{DIFF}			3		pF
Input Capacitance Common Mode	C_{CM}			4.2		pF
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	R_L = 100 kΩ to GND	1.78	1.79		V
		−40°C ≤ T_A ≤ +125°C	1.78			V
		R_L = 10 kΩ to GND	1.65	1.75		V
		−40°C ≤ T_A ≤ +125°C	1.65			V
Output Voltage Low	V_{OL}	R_L = 100 kΩ to V_{SY}		2	5	mV
		−40°C ≤ T_A ≤ +125°C			5	mV
		R_L = 10 kΩ to V_{SY}		12	25	mV
		−40°C ≤ T_A ≤ +125°C			25	mV
Short-Circuit Limit	I_{SC}	V_{OUT} = V_{SY} or GND		±4.5		mA
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	V_{SY} = 1.8 V to 5 V	100	110		dB
		−40°C ≤ T_A ≤ +85°C	100			dB
		−40°C ≤ T_A ≤ +125°C	95			dB
Supply Current per Amplifier	I_{SY}	V_{OUT} = V_{SY}/2		16.5	20	µA
		−40°C ≤ T_A ≤ +125°C			25	µA
DYNAMIC PERFORMANCE						
Slew Rate	SR	R_L = 100 kΩ, C_L = 10 pF, G = 1		13		mV/µs
Gain Bandwidth Product	GBP	R_L = 1 MΩ, C_L = 20 pF, G = 1		95		kHz
Phase Margin	Φ_M	R_L = 1 MΩ, C_L = 20 pF, G = 1		60		Degrees
NOISE PERFORMANCE						
Voltage Noise	e_n p-p	f = 0.1 Hz to 10 Hz		2.8		µV p-p
Voltage Noise Density	e_n	f = 1 kHz		45		nV/√Hz
Current Noise Density	i_n	f = 1 kHz		15		fA/√Hz

ABSOLUTE MAXIMUM RATINGS

Table 3.

Parameter	Rating
Supply Voltage	5.5 V
Input Voltage	$\pm V_{SY} \pm 0.1$ V
Input Current[1]	±10 mA
Differential Input Voltage[2]	$\pm V_{SY}$
Output Short-Circuit Duration to GND	Indefinite
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−40°C to +125°C
Junction Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 60 sec)	300°C

[1] Input pins have clamp diodes to the supply pins. Input current should be limited to 10 mA or less whenever the input signal exceeds the power supply rail by 0.5 V.
[2] Differential input voltage is limited to 5 V or the supply voltage, whichever is less.

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

THERMAL RESISTANCE

θ_{JA} is specified for the worst-case conditions, that is, a device soldered in a circuit board for surface-mount packages. This was measured using a standard two-layer board.

Table 4. Thermal Resistance

Package Type	θ_{JA}	θ_{JC}	Unit
8-Lead MSOP (RM-8)	190	44	°C/W
14-Lead TSSOP (RU-14)	180	35	°C/W

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

TYPICAL PERFORMANCE CHARACTERISTICS

T_A = 25°C, unless otherwise noted.

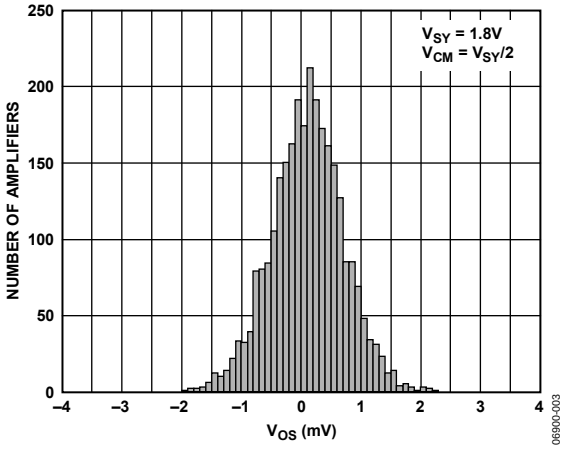


Figure 3. Input Offset Voltage Distribution

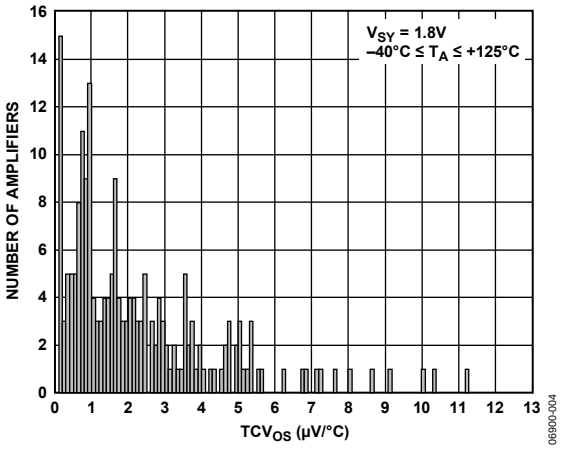


Figure 4. Input Offset Voltage Drift Distribution

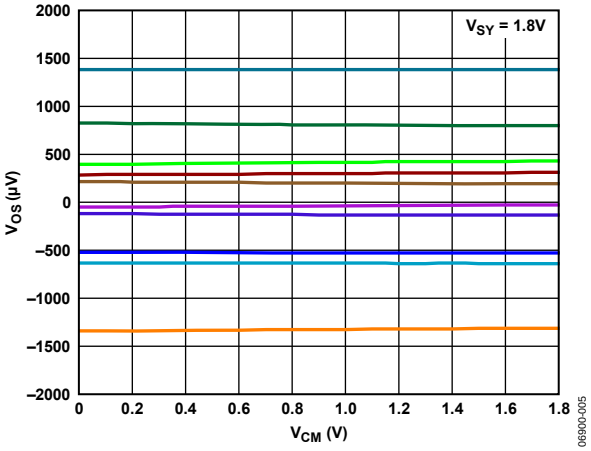


Figure 5. Input Offset Voltage vs. Input Common-Mode Voltage

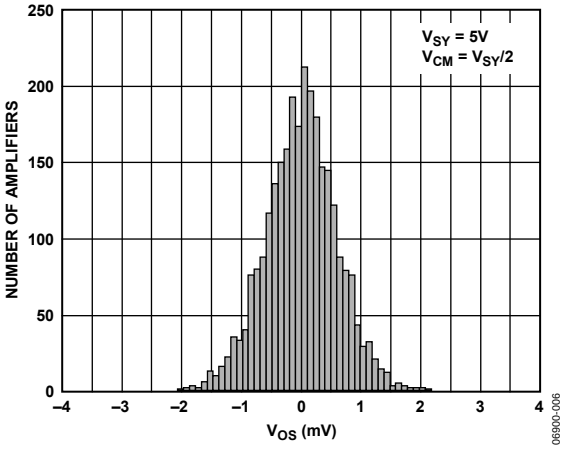


Figure 6. Input Offset Voltage Distribution

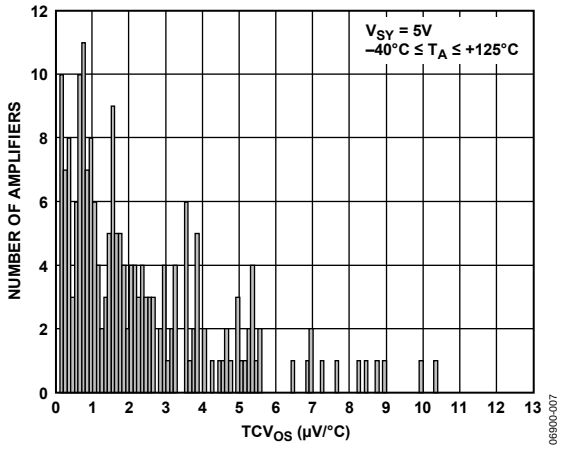


Figure 7. Input Offset Voltage Drift Distribution

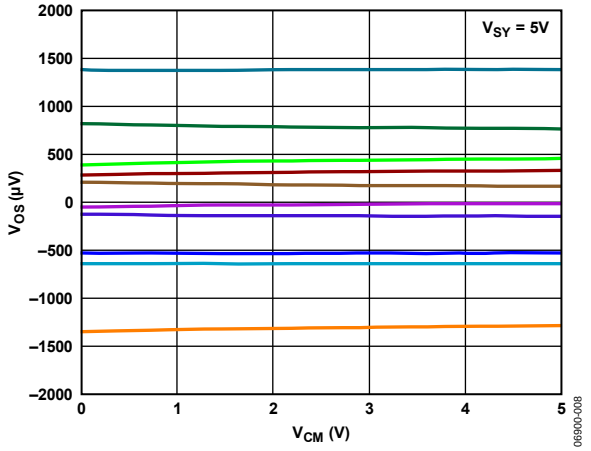


Figure 8. Input Offset Voltage vs. Input Common-Mode Voltage

T_A = 25°C, unless otherwise noted.

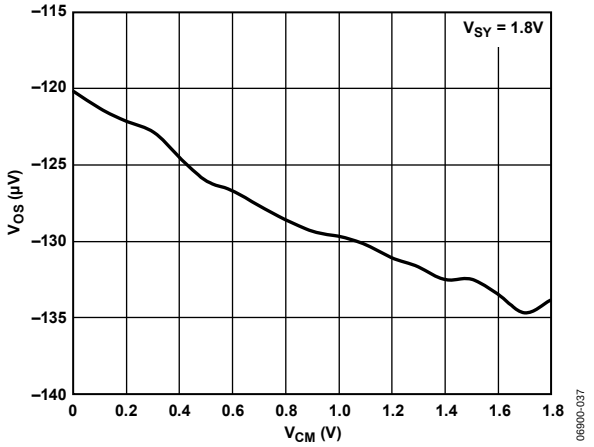


Figure 9. Input Offset Voltage vs. Input Common-Mode Voltage

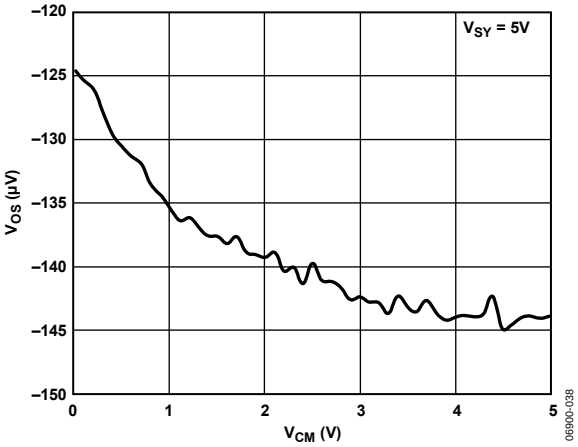


Figure 12. Input Offset Voltage vs. Input Common-Mode Voltage

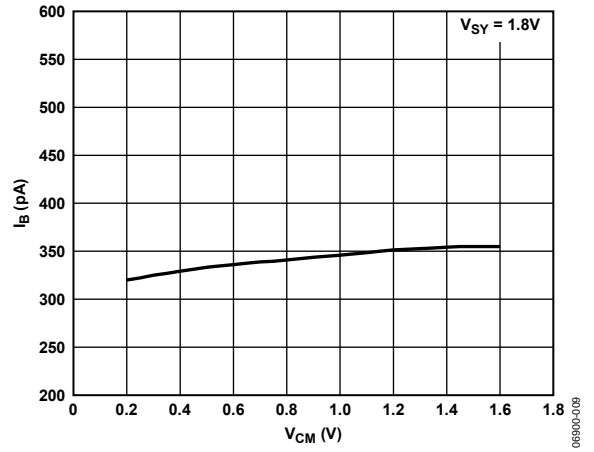


Figure 10. Input Bias Current vs. Common-Mode Voltage at 125°C

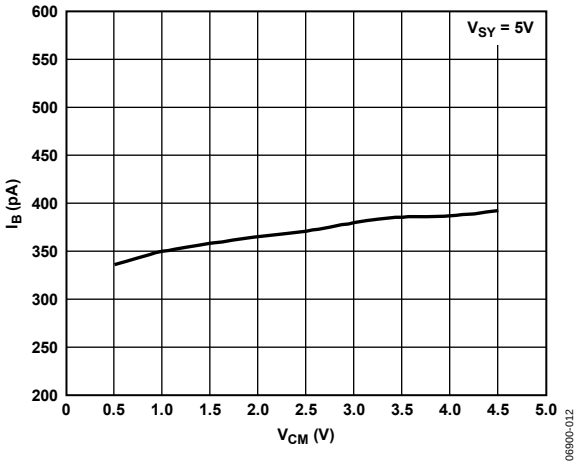


Figure 13. Input Bias Current vs. Common-Mode Voltage at 125°C

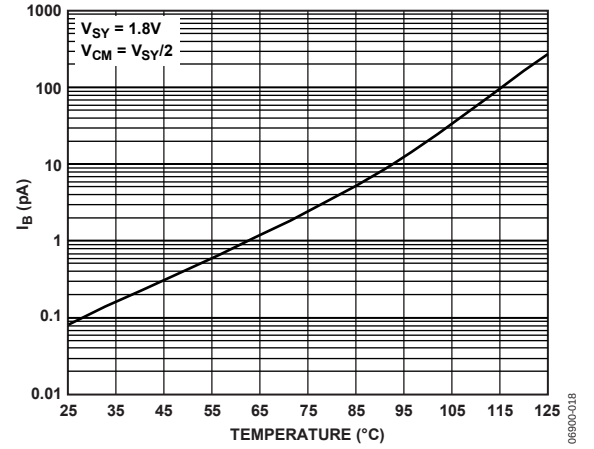


Figure 11. Input Bias Current vs. Temperature

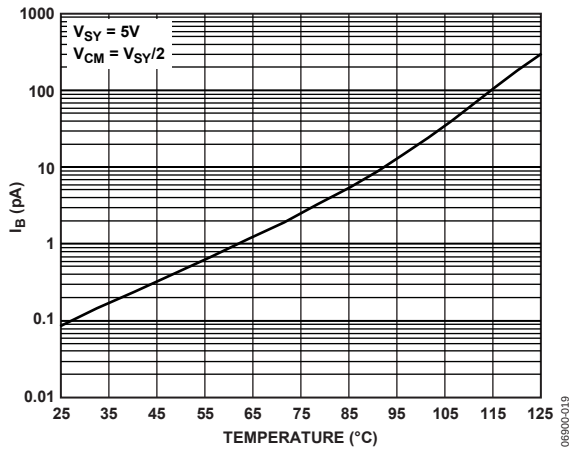


Figure 14. Input Bias Current vs. Temperature

T_A = 25°C, unless otherwise noted.

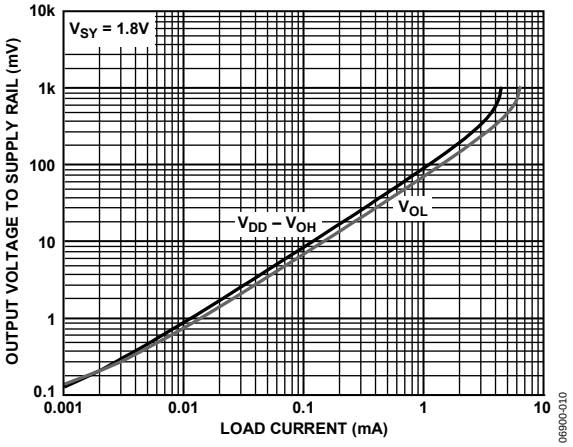


Figure 15. Output Voltage to Supply Rail vs. Load Current

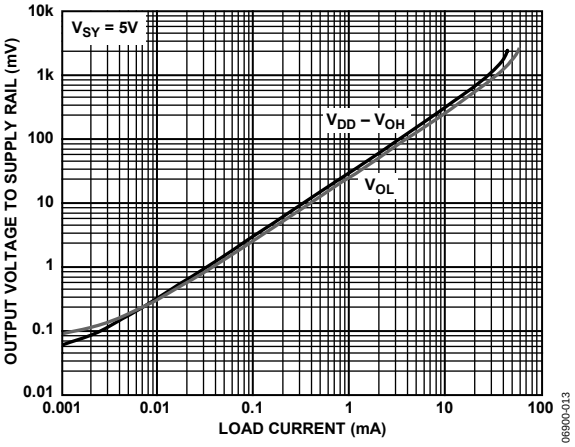


Figure 18. Output Voltage to Supply Rail vs. Load Current

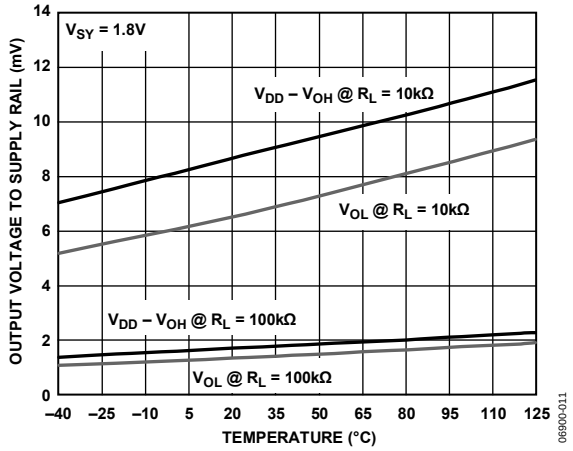


Figure 16. Output Voltage to Supply Rail vs. Temperature

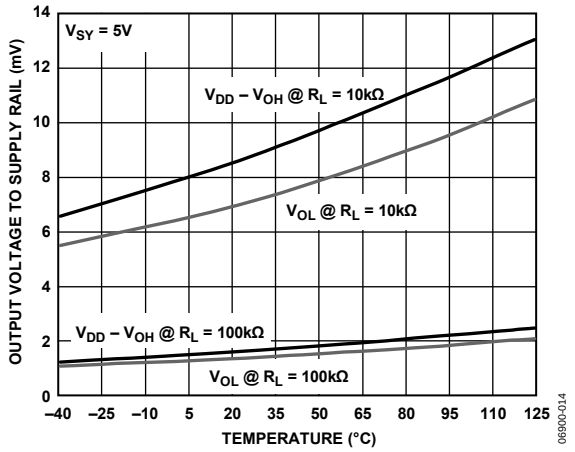


Figure 19. Output Voltage to Supply Rail vs. Temperature

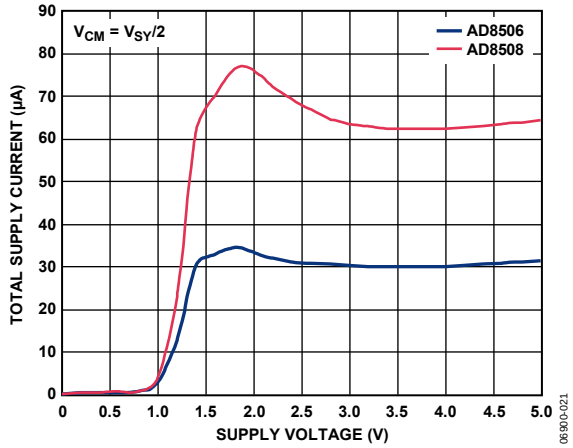


Figure 17. Total Supply Current vs. Supply Voltage

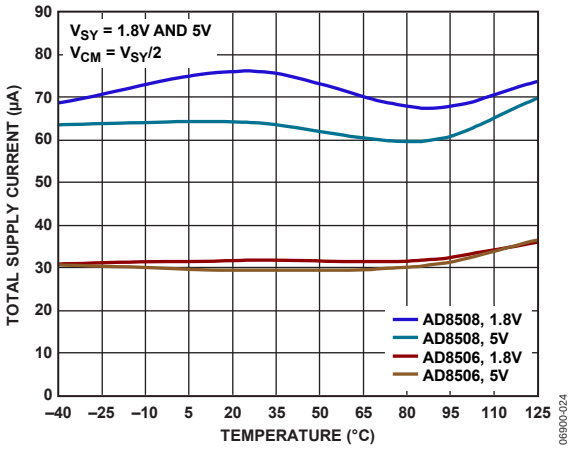


Figure 20. Total Supply Current vs. Temperature

T_A = 25°C, unless otherwise noted.

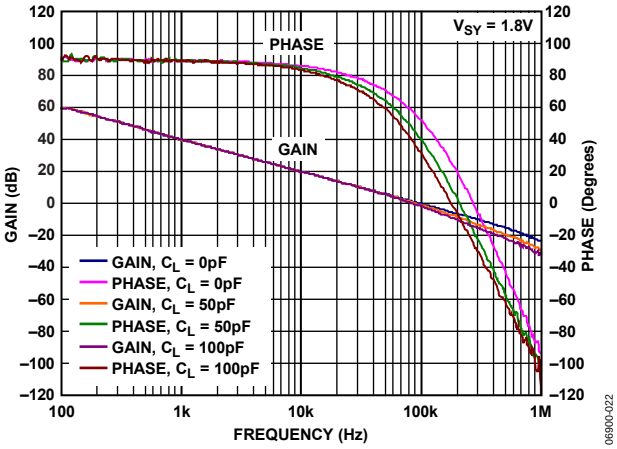


Figure 21. Open-Loop Gain and Phase vs. Frequency

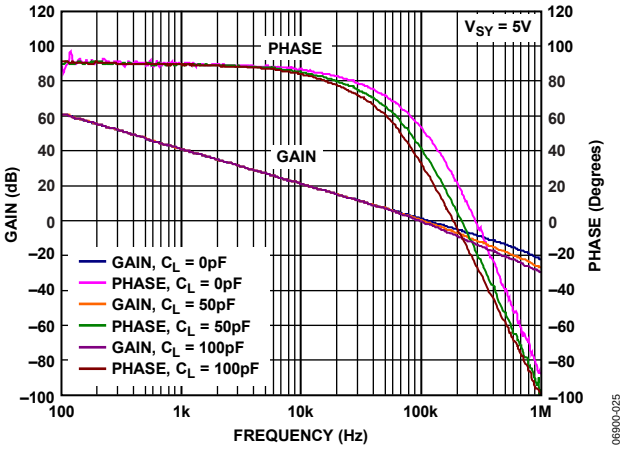


Figure 24. Open-Loop Gain and Phase vs. Frequency

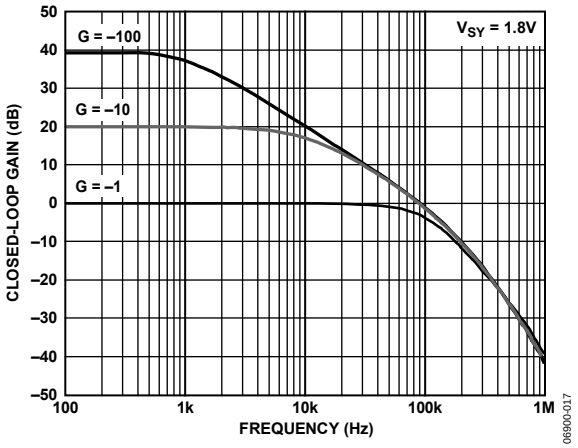


Figure 22. Closed-Loop Gain vs. Frequency

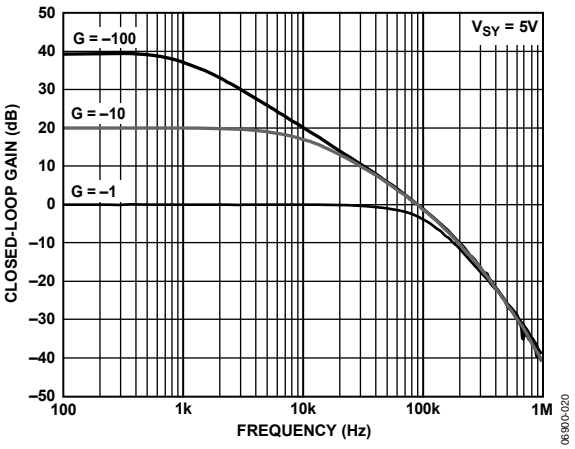


Figure 25. Closed-Loop Gain vs. Frequency

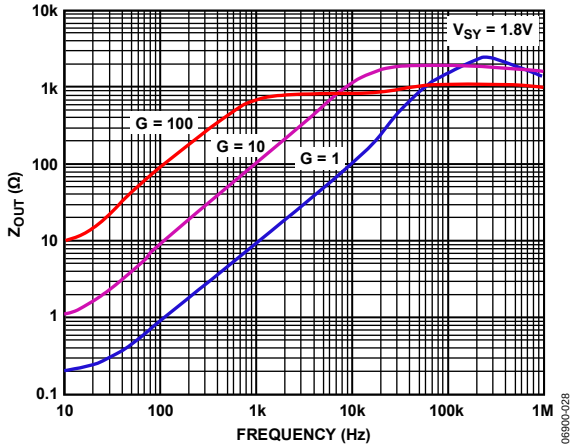


Figure 23. Z_{OUT} vs. Frequency

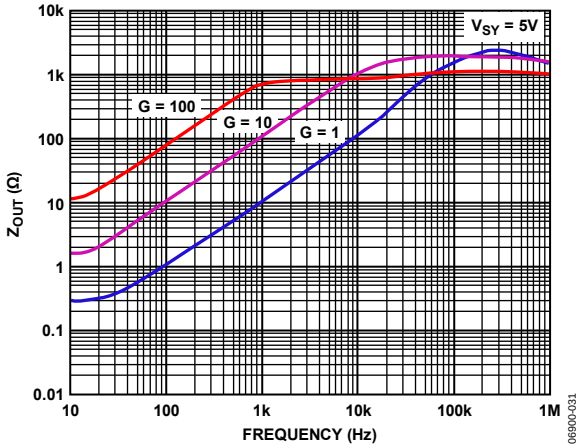


Figure 26. Z_{OUT} vs. Frequency

T_A = 25°C, unless otherwise noted.

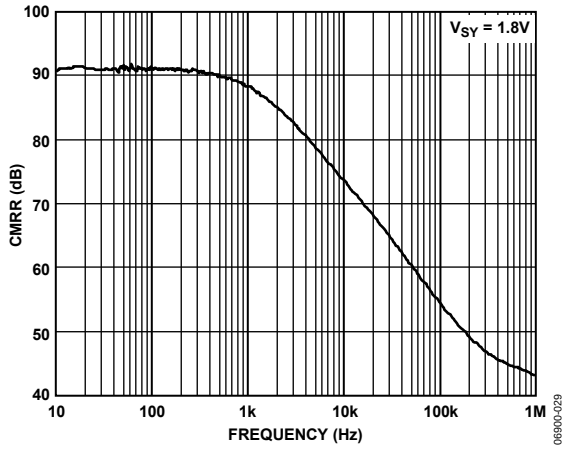


Figure 27. CMRR vs. Frequency

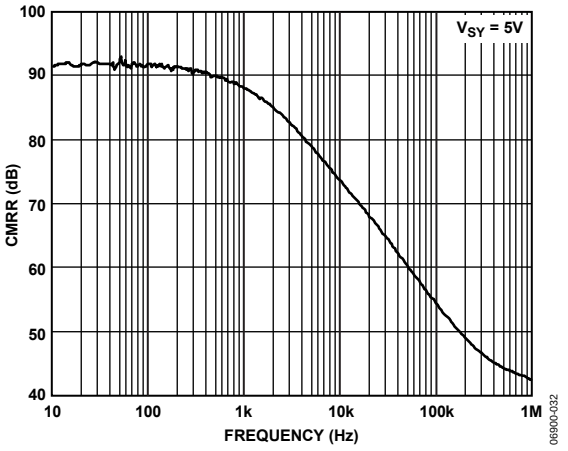


Figure 30. CMRR vs. Frequency

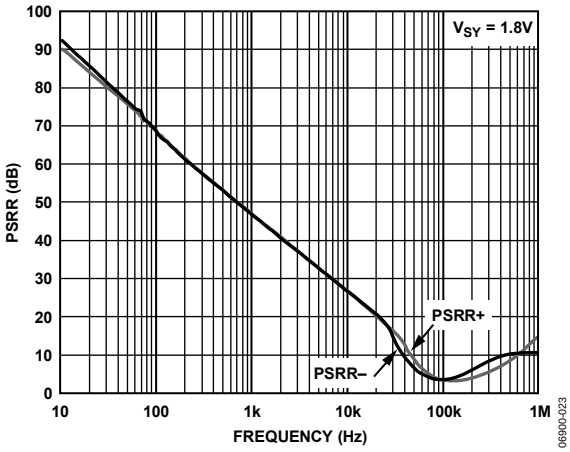


Figure 28. PSRR vs. Frequency

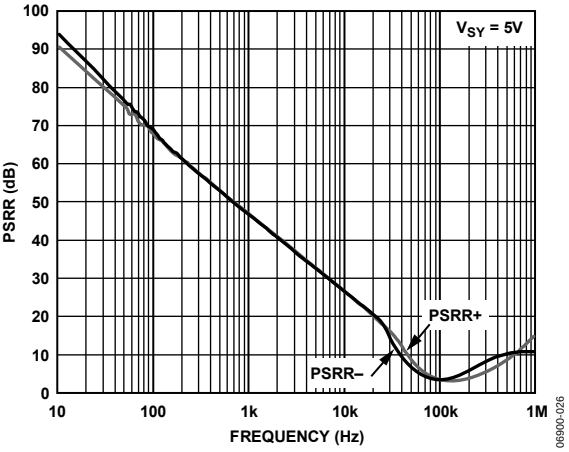


Figure 31. PSRR vs. Frequency

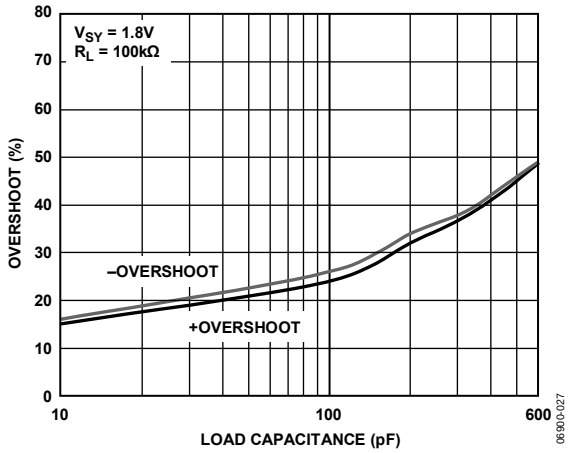


Figure 29. Small Signal Overshoot vs. Load Capacitance

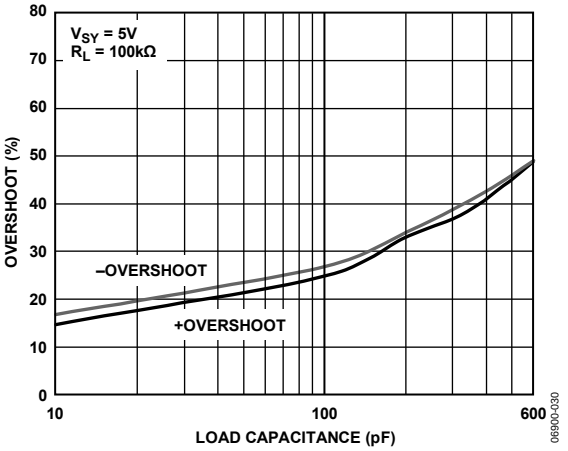


Figure 32. Small Signal Overshoot vs. Load Capacitance

T_A = 25°C, unless otherwise noted.

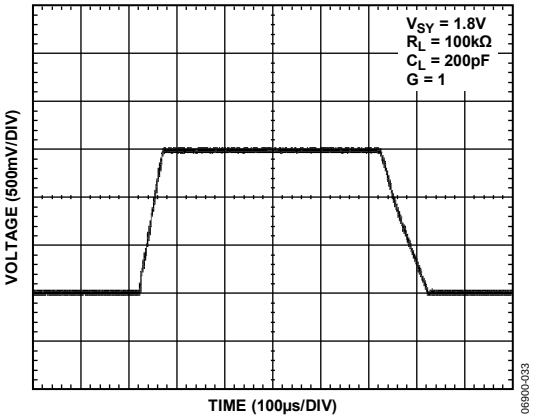


Figure 33. Large Signal Transient Response

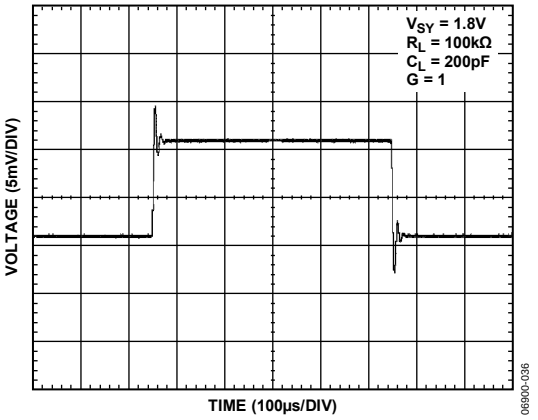


Figure 34. Small Signal Transient Response

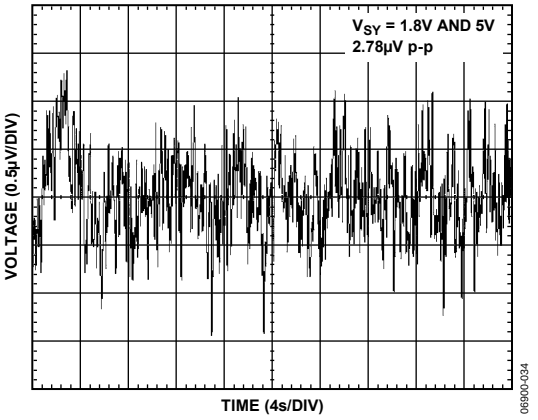


Figure 35. Voltage Noise 0.1 Hz to 10 Hz

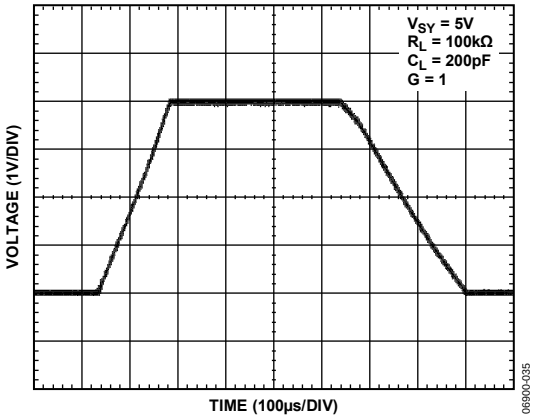


Figure 36. Large Signal Transient Response

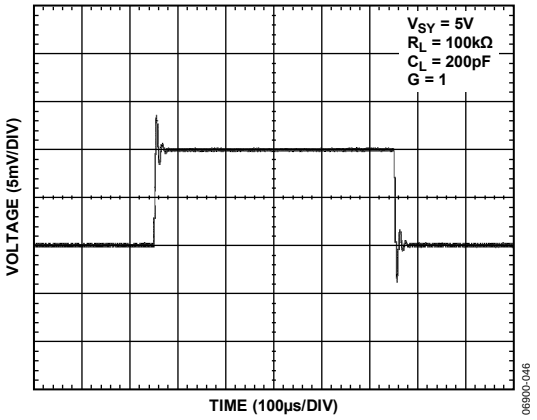


Figure 37. Small Signal Transient Response

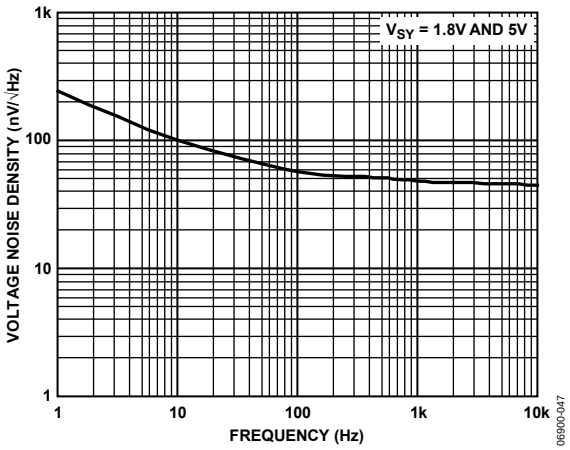


Figure 38. Voltage Noise Density vs. Frequency

T_A = 25°C, unless otherwise noted.

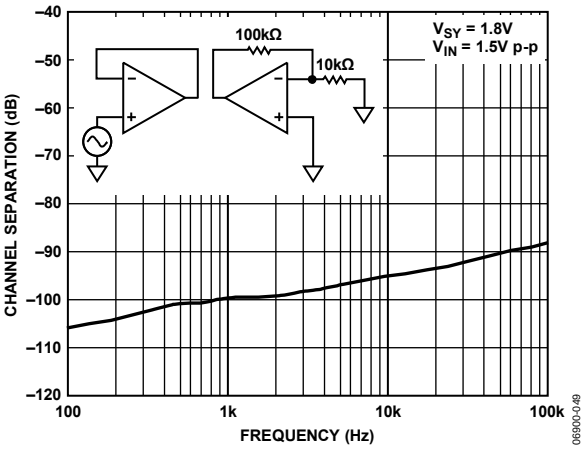


Figure 39. Channel Separation vs. Frequency

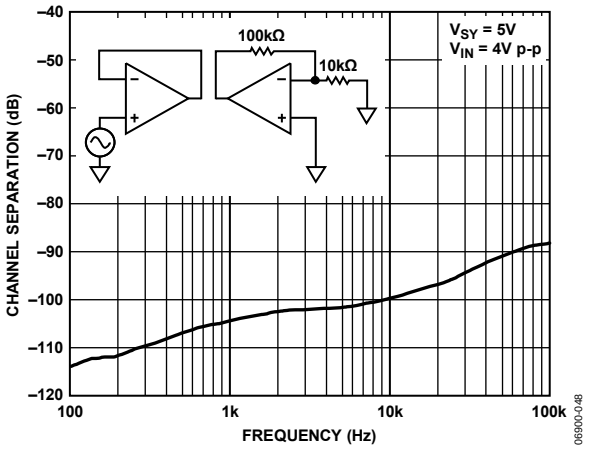


Figure 40. Channel Separation vs. Frequency

THEORY OF OPERATION

The AD8506/AD8508 are unity-gain stable CMOS rail-to-rail input/output operational amplifiers designed to optimize performance in current consumption, PSRR, CMRR, and zero crossover distortion, all embedded in a small package. The typical offset voltage is 500 μV, with a low peak-to-peak voltage noise of 2.8 μV p-p from 0.1 Hz to 10 Hz and a voltage noise density of 45 nV/√Hz at 1 kHz.

The AD8506/AD8508 are designed to solve two key problems in low voltage battery-powered applications: battery voltage decrease over time and rail-to-rail input stage distortion.

In battery-powered applications, the supply voltage available to the IC is the voltage of the battery. Unfortunately, the voltage of a battery decreases as it discharges itself through the load. This voltage drop over the lifetime of the battery causes an error in the output of the op amps. Some applications requiring precision measurements during the entire lifetime of the battery use voltage regulators to power up the op amps as a solution. If a design uses standard battery cells, the op amps experience a supply voltage change from roughly 3.2 V to 1.8 V during the lifetime of the battery. This means that for a PSRR of 70 dB minimum in a typical op amp, the input-referred offset error is approximately 440 μV. If the same application uses the AD8506/AD8508 with a 100 dB minimum PSRR, the error is only 14 μV. It is possible to calibrate out this error or to use an external voltage regulator to power the op amp, but these solutions can increase system cost and complexity. The AD8506/AD8508 solve the impasse with no additional cost or error-nullifying circuitry.

The second problem with battery-powered applications is the distortion caused by the standard rail-to-rail input stage. Using a CMOS non-rail-to-rail input stage (that is, a single differential pair) limits the input voltage to approximately one V_{GS} (gate-source voltage) away from one of the supply lines. Because V_{GS} for normal operation is commonly over 1 V, a single differential pair input stage op amp greatly restricts the allowable input voltage range when using a low supply voltage. This limitation restricts the number of applications where the non-rail-to-rail input op amp was originally intended to be used. To solve this problem, a dual differential pair input stage is usually implemented (see Figure 41); however, this technique has its own drawbacks.

One differential pair amplifies the input signal when the common-mode voltage is on the high end, whereas the other pair amplifies the input signal when the common-mode voltage is on the low end. This method also requires a control circuitry to operate the two differential pairs appropriately. Unfortunately, this topology leads to a very noticeable and undesirable problem: if the signal level moves through the range where one input stage turns off and the other one turns on, noticeable distortion occurs (see Figure 42).

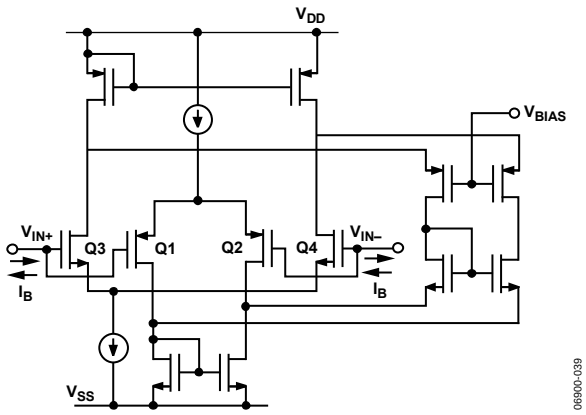


Figure 41. A Typical Dual Differential Pair Input Stage Op Amp (Dual PMOS Q1 and Q2 Transistors Form the Lower End of the Input Voltage Range Whereas Dual NMOS Q3 and Q4 Compose the Upper End)

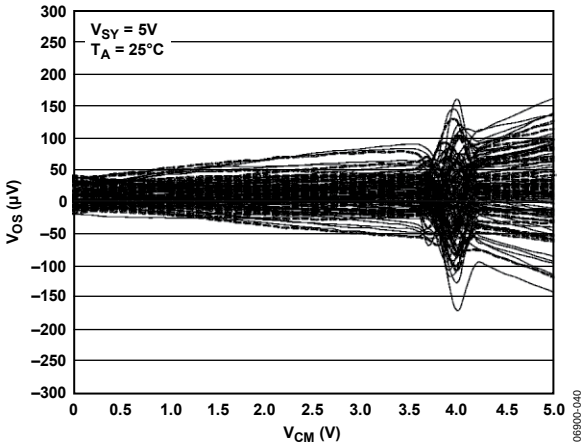


Figure 42. Typical Input Offset Voltage vs. Common-Mode Voltage Response in a Dual Differential Pair Input Stage Op Amp (Powered by 5 V Supply; Results of Approximately 100 Units per Graph Are Displayed)

This distortion forces the designer to come up with impractical ways to avoid the crossover distortion areas, therefore narrowing the common-mode dynamic range of the operational amplifier. The AD8506/AD8508 solve this crossover distortion problem by using an on-chip charge pump to power the input differential pair. The charge pump creates a supply voltage higher than the voltage of the battery, allowing the input stage to handle a wide range of input signal voltages without using a second differential pair. With this solution, the input voltage can vary from one supply extreme to the other with no distortion, thereby restoring the op amp full common-mode dynamic range.

The charge pump has been carefully designed so that switching noise components at any frequency, both within and beyond the amplifier bandwidth, are much lower than the thermal noise floor. Therefore, the spurious-free dynamic range (SFDR) is limited only by the input signal and the thermal or flicker noise. There is no intermodulation between input signal and switching noise.

Figure 43 displays a typical front-end section of an operational amplifier with an on-chip charge pump.

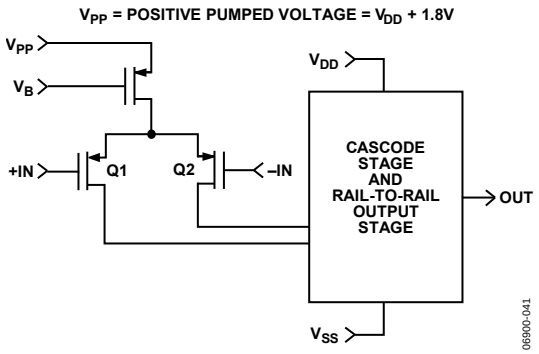


Figure 43. Typical Front-End Section of an Op Amp with Embedded Charge Pump

Figure 44, input offset voltage vs. input common-mode voltage response, shows the typical response of 12 devices from Figure 8. Figure 44 has been expanded so that it is easier to compare with Figure 42, typical input offset voltage vs. common-mode voltage response in a dual differential pair input stage op amp.

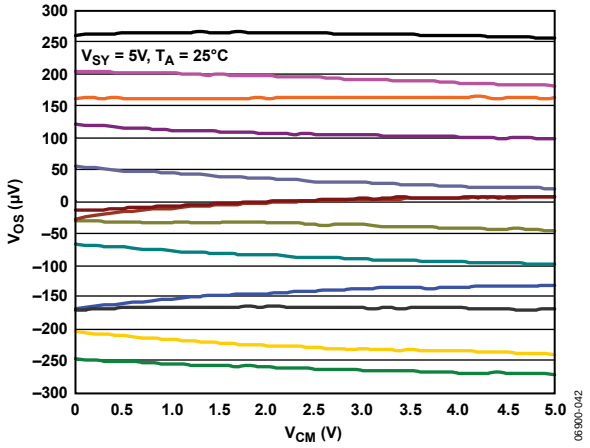


Figure 44. Input Offset Voltage vs. Input Common-Mode Voltage Response (Powered by a 5 V Supply; Results of 12 Units Are Displayed)

This solution improves the CMRR performance tremendously. For instance, if the input varies from rail-to-rail on a 2.5 V supply rail, using a part with a CMRR of 70 dB minimum, an input-referred error of 790 µV is introduced. Another part with a CMRR of 52 dB minimum generates a 6.3 mV error. The AD8506/AD8508 CMRR of 90 dB minimum causes only a 79 µV error. As with the PSRR error, there are complex ways to minimize this error, but the AD8506/AD8508 solve this problem without incurring unnecessary circuitry complexity or increased cost.

APPLICATIONS INFORMATION

PULSE OXIMETER CURRENT SOURCE

A pulse oximeter is a noninvasive medical device used for measuring continuously the percentage of hemoglobin (Hb) saturated with oxygen and the pulse rate of a patient. Hemoglobin that is carrying oxygen (oxyhemoglobin) absorbs light in the infrared (IR) region of the spectrum; hemoglobin that is not carrying oxygen (deoxyhemoglobin) absorbs visible red (R) light. In pulse oximetry, a clip containing two LEDs (sometimes more, depending on the complexity of the measurement algorithm) and the light sensor (photodiode) is placed on the finger or earlobe of the patient. One LED emits red light (600 nm to 700 nm) and the other emits light in the near IR (800 nm to 900 nm) region. The clip is connected by a cable to a processor unit. The LEDs are rapidly and sequentially excited by two current sources (one for each LED), whose dc levels depend on the LED being driven, based on manufacturer requirements, and the detector is synchronized to capture the light from each LED as it is transmitted through the tissue.

An example design of a dc current source driving the red and infrared LEDs is shown in Figure 45. These dc current sources allow 62.5 mA and 101 mA to flow through the red and infrared LEDs, respectively. First, to prolong battery life, the LEDs are driven only when needed. One-third of the ADG733 SPDT analog switch is used to disconnect/connect the 1.25 V voltage reference from/to each current circuit. When driving the LEDs, the ADR1581 1.25 V voltage reference is buffered by ½ of the AD8506; the presence of this voltage on the noninverting input forces the output of the op amp (due to the negative feedback) to maintain a level that makes its inverting input-to-track the noninverting pin. Therefore, the 1.25 V appears in parallel with the 20 Ω R1 or 12.4 Ω R5 current source resistor, creating the flow of the 62.5 mA or 101 mA current through the red or infrared LED as the output of the op amp turns on the Q1 or Q2 N-MOSFET IRLMS2002.

The maximum total quiescent currents for the ½ AD8506, ADR1581, and ADG733 are 25 µA, 70 µA, and 1 µA, respectively, making a total of 96 µA current consumption (480 µW power consumption) per circuit, which is good for a system powered by a battery. If the accuracy and temperature drift of the total design need to be improved, then a more accurate and low temperature coefficient drift voltage reference and current source resistor should be utilized. C3 and C4 are used to improve stabilization of U1; R3 and R7 are used to provide some current limit into the U1 inverting pin; and R2 and R6 are used to slow down the rise time of the N-MOSFET when it turns on. These elements may not be needed, or some bench adjustments may be required.

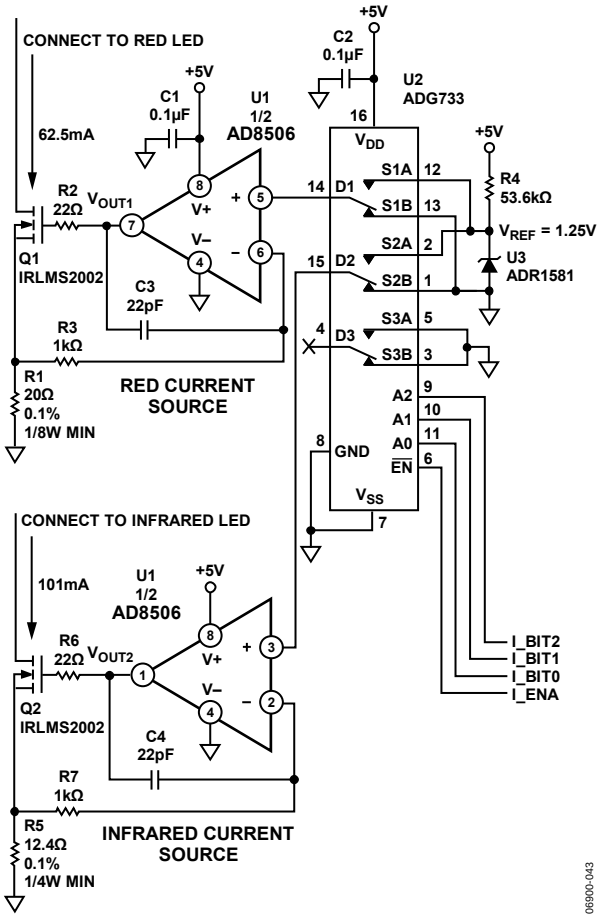


Figure 45. Pulse Oximeter Red and Infrared Current Sources Using the AD8506 as a Buffer to the Voltage Reference Device

FOUR-POLE LOW-PASS BUTTERWORTH FILTER FOR GLUCOSE MONITOR

There are several methods of glucose monitoring: spectroscopic absorption of infrared light in the 2 μm to 2.5 μm range, reflectance spectrophotometry, and the amperometric type using electrochemical strips with glucose oxidase enzymes. The amperometric type generally uses three electrodes: a reference electrode, a control electrode, and a working electrode. Although this is a very old technique and widely used, signal-to-noise ratio and repeatability can be improved using the AD8506 with its low peak-to-peak voltage noise of 2.8 μV p-p from 0.1 Hz to 10 Hz and voltage noise density of 45 nV/√Hz at 1 kHz.

Another consideration is operation from a 3.3 V battery. Glucose signal currents are usually less than 3 μA full scale, so the I-to-V converter requires low input bias current. The AD8506 is an excellent choice because it provides 1 pA typical and 10 pA maximum of input bias current at ambient temperature.

A low-pass filter with a cutoff frequency of 80 Hz to 100 Hz is desirable in a glucose meter device to remove extraneous noise; this can be a simple two- or four-pole Butterworth. Low power op amps with bandwidths of 50 kHz to 500 kHz should be adequate. The AD8506 with its 95 kHz GBP and 15 μA typical of current consumption meets these requirements. A circuit design of a four-pole Butterworth filter (preceded by a one-pole low-pass filter) is shown in Figure 46. With a 3.3 V battery, the total power consumption of this design is 297 μW typical at ambient temperature.

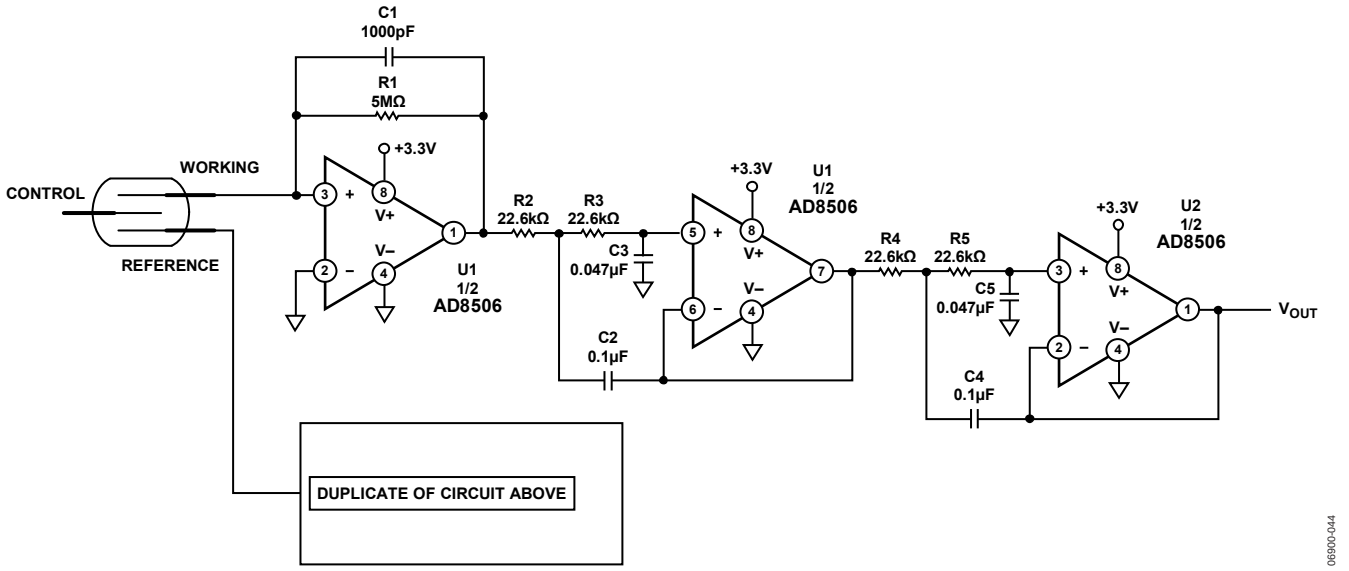
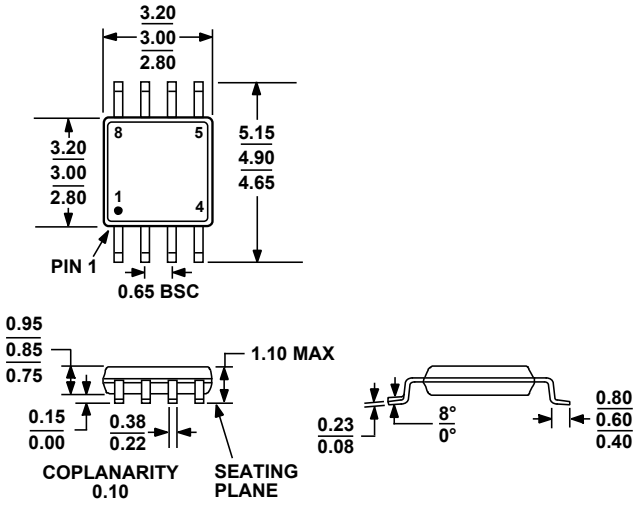


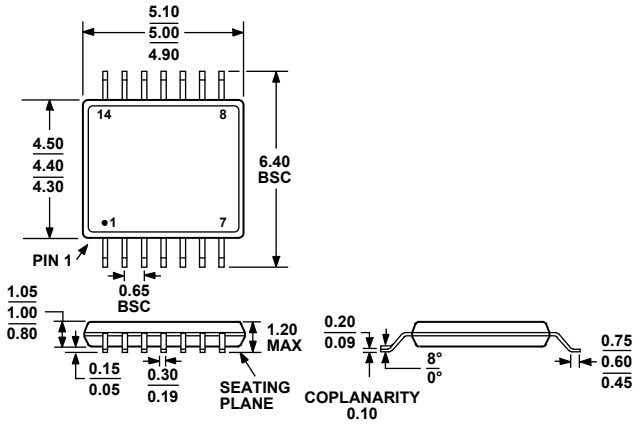
Figure 46. A Four-Pole Butterworth Filter That Can Be Used in a Glucose Meter

OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MO-187-AA

Figure 47. 8-Lead Mini Small Outline Package [MSOP]
(RM-8)
Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MO-153-AB-1

Figure 48. 14-Lead Thin Shrink Small Outline Package [TSSOP]
(RU-14)
Dimensions shown in millimeters

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option	Branding
AD8506ARMZ-R2[1]	–40°C to +125°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	A1X
AD8506ARMZ-REEL[1]	–40°C to +125°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	A1X
AD8508ARUZ[1]	–40°C to +125°C	14-Lead Thin Shrink Small Outline Package [TSSOP]	RU-14	
AD8508ARUZ-REEL[1]	–40°C to +125°C	14-Lead Thin Shrink Small Outline Package [TSSOP]	RU-14	

[1] Z = RoHS Compliant Part.

NOTES

NOTES

NOTES

D06900-0-7/08(A)