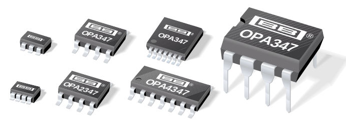
Burr-Brown Products
from Texas Instruments

OPA347
OPA2347
OPA4347



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*micro*Power, Rail-to-Rail OPERATIONAL AMPLIFIERS

FEATURES

- LOW I_Q: 20µA
- *micro*SIZE PACKAGES: SOT23-5, SOT23-8, and TSSOP-14
- HIGH SPEED/POWER RATIO WITH BANDWIDTH: 350kHz
- RAIL-TO-RAIL INPUT AND OUTPUT
- SINGLE SUPPLY: 2.3V to 5.5V

APPLICATIONS

- PORTABLE EQUIPMENT
- BATTERY-POWERED EQUIPMENT
- TWO-WIRE TRANSMITTERS
- SMOKE DETECTORS
- CO DETECTORS

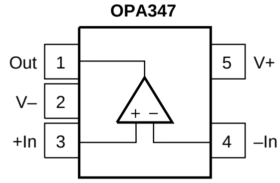
DESCRIPTION

The OPA347 is a *micro*power, low-cost operational amplifier available in *micro*packages. The OPA347 (single version) is available in the SOT23-5 and the OPA2347 (dual version) is available in the SOT23-8. Both are also available in the SO-8. The OPA347 is also available in the DIP-8. The OPA4347 (quad) is available in the SO-14 and the TSSOP-14.

The OPA347's small size and low power consumption (34µA per channel maximum) makes it ideal for portable and battery-powered applications. The input range of the OPA347 extends 200mV beyond the rails and the output range is within 5mV of the rails. The OPA347 also features an excellent speed/power ratio with a bandwidth of 350kHz.

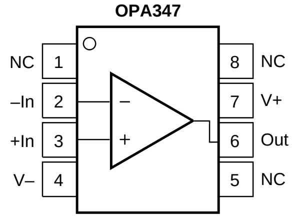
The OPA347 can be operated with a single or dual power supply from 2.3V to 5.5V. All models are specified for operation from –55°C to 125°C.

OPA347



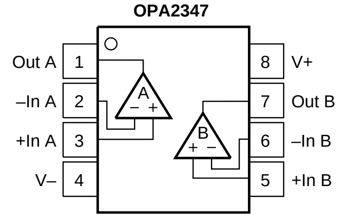
SOT23-5

OPA347



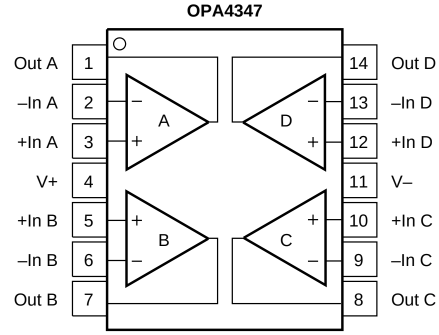
SO-8, DIP-8

OPA2347



SOT23-8, SO-8

OPA4347



TSSOP-14, SO-14

TEXAS INSTRUMENTS

SBOS167A
Printed in U.S.A. November, 2000

SPECIFICATIONS: V_S = 2.5V to 5.5V

Boldface limits apply over the specified temperature range, **T_A = –55°C to +125°C**

At T_A = +25°C, R_L = 100kΩ connected to V_S/2 and V_{OUT} = V_S/2, unless otherwise noted.

PARAMETER		CONDITION	OPA347NA, UA, PA OPA2347EA, UA OPA4347EA, UA			UNITS
			MIN	TYP	MAX	
OFFSET VOLTAGE						
Input Offset Voltage	V_{OS}	V_S = 5.5V, V_{CM} = (V–) + 0.8V		2	6	mV
Over Temperature				**2**	**7**	**mV**
Drift	**dV_{OS}/dT**			**3**		**µV/°C**
vs Power Supply	PSRR	V_S = 2.5V to 5.5V, V_{CM} < (V+) – 1.7V		60	175	µV/V
Over Temperature		**V_S = 2.5V to 5.5V, V_{CM} < (V+) – 1.7V**			**300**	**µV/V**
Channel Separation, dc				0.3		µV/V
		f = 1kHz		128		dB
INPUT VOLTAGE RANGE						
Common-Mode Voltage Range	V_{CM}		(V–) – 0.2		(V+) + 0.2	V
Common-Mode Rejection Ratio	CMRR	V_S = 5.5V, (V–) – 0.2V < V_{CM} < (V+) – 1.7V	70	80		dB
over Temperature		**V_S = 5.5V, V– < V_{CM} < (V+) – 1.7V**	**66**			**dB**
		Vs = 5.5V, (V–) – 0.2V < V_{CM} < (V+) + 0.2V	54	70		dB
over Temperature		**Vs = 5.5V, V– < V_{CM} < V+**	**48**			**dB**
INPUT BIAS CURRENT						
Input Bias Current	I_B			±0.5	±10	pA
Input Offset Current	I_{OS}			±0.5	±10	pA
INPUT IMPEDANCE						
Differential				10^{13} || 3		Ω || pF
Common-Mode				10^{13} || 6		Ω || pF
NOISE		V_{CM} < (V+) – 1.7V				
Input Voltage Noise, f = 0.1Hz to 10Hz				12		µVp-p
Input Voltage Noise Density, f = 1kHz	e_n			60		nV/$\sqrt{Hz}$
Input Current Noise Density, f = 1kHz	i_n			0.7		fA/$\sqrt{Hz}$
OPEN-LOOP GAIN						
Open-Loop Voltage Gain	A_{OL}	V_S = 5.5V, R_L = 100kΩ, 0.015V < V_O < 5.485V	100	115		dB
over Temperature		**V_S = 5.5V, R_L = 100kΩ, 0.015V < V_O < 5.485V**	**88**			**dB**
		V_S = 5.5V, R_L = 5kΩ, 0.125V < V_O < 5.375V	100	115		dB
over Temperature		**V_S = 5.5V, R_L = 5kΩ, 0.125V < V_O < 5.375V**	**88**			**dB**
OUTPUT						
Voltage Output Swing from Rail		R_L = 100kΩ, A_{OL} > 100dB		5	15	mV
over Temperature		**R_L = 100kΩ, A_{OL} > 88dB**			**15**	**mV**
		R_L = 5kΩ, A_{OL} > 100dB		90	125	mV
over Temperature		**R_L = 5kΩ, A_{OL} > 88dB**			**125**	**mV**
Short-Circuit Current	I_{SC}			±17		mA
Capacitive Load Drive	C_{LOAD}			See Typical Curve		
FREQUENCY RESPONSE		C_L = 100pF				
Gain-Bandwidth Product	GBW			350		kHz
Slew Rate	SR	G = +1		0.17		V/µs
Settling Time, 0.1%	t_S	V_S = 5V, 2V Step, G = +1		21		µs
0.01%		V_S = 5V, 2V Step, G = +1		27		µs
Overload Recovery Time		V_{IN} • Gain = V_S		23		µs
POWER SUPPLY						
Specified Voltage Range	V_S		2.5		5.5	V
Operating Voltage Range				2.3 to 5.5		V
Quiescent Current (per amplifier)	I_Q	I_O = 0		20	34	µA
over Temperature					**38**	**µA**
TEMPERATURE RANGE						
Specified Range			–55		125	°C
Operating Range			–65		150	°C
Storage Range			–65		150	°C
Thermal Resistance	θ_{JA}					
SOT23-5 Surface-Mount				200		°C/W
SOT23-8 Surface-Mount				150		°C/W
SO-8 Surface-Mount				150		°C/W
SO-14 Surface Mount				100		°C/W
TSSOP-14 Surface Mount				100		°C/W
DIP-8				100		°C/W

ABSOLUTE MAXIMUM RATINGS(1)

Supply Voltage, V+ to V–	7.5V
Signal Input Terminals, Voltage(2)	(V–) –0.5V to (V+) +0.5V
Current(2)	10mA
Output Short-Circuit(3)	Continuous
Operating Temperature	–65°C to +150°C
Storage Temperature	–65°C to +150°C
Junction Temperature	150°C
Lead Temperature (soldering, 10s)	300°C

NOTES: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only. Functional operation of the device at these conditions, or beyond the specified operating conditions, is not implied. (2) Input terminals are diode-clamped to the power supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less. (3) Short-circuit to ground, one amplifier per package.

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

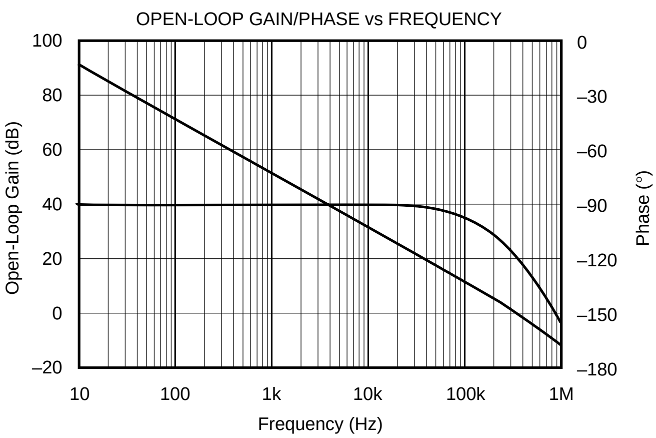
PACKAGE/ORDERING INFORMATION

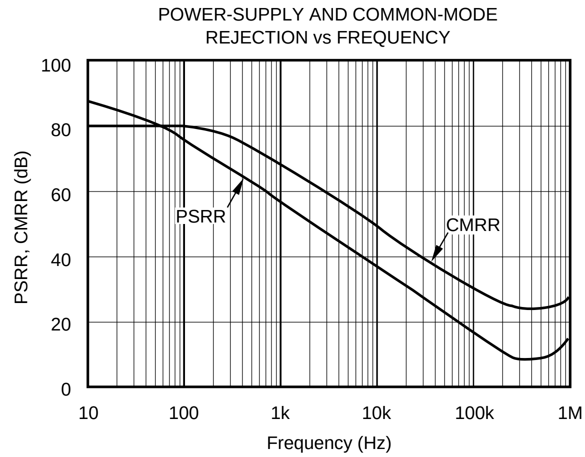
PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER(1)	TRANSPORT MEDIA
OPA347NA	SOT23-5	331	–55°C to +125°C	A47	OPA347NA/250	Tape and Reel
"	"	"	"	"	OPA347NA/3K	Tape and Reel
OPA347PA	DIP-8	006	–55°C to +125°C	OPA347PA	OPA347PA	Rails
OPA347UA	SO-8	182	–55°C to +125°C	OPA347UA	OPA347UA	Rails
"	"	"	"	"	OPA347UA/2K5	Tape and Reel
OPA2347EA	SOT23-8	348	–55°C to +125°C	B47	OPA2347EA/250	Tape and Reel
"	"	"	"	"	OPA2347EA/3K	Tape and Reel
OPA2347UA	SO-8	182	–55°C to +125°C	OPA2347UA	OPA2347UA	Rails
"	"	"	"	"	OPA2347UA/2K5	Tape and Reel
OPA4347EA	TSSOP-14	357	–55°C to +125°C	OPA4347EA	OPA4347EA/250	Tape and Reel
"	"	"	"	"	OPA4347EA/2K5	Tape and Reel
OPA4347UA	SO-14	235	–55°C to +125°C	OPA4347UA	OPA4347UA	Rails
"	"	"	"	"	OPA4347UA/2K5	Tape and Reel

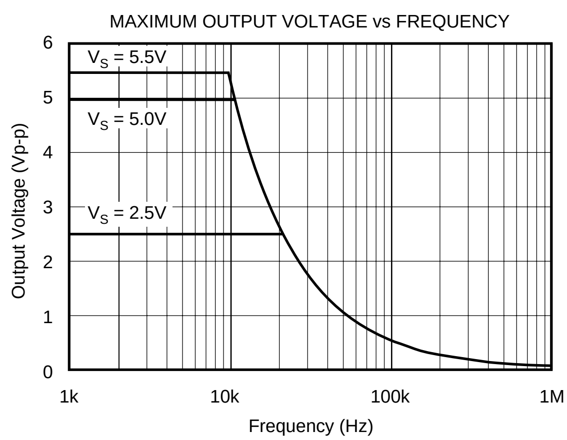
NOTES: (1) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /3K indicates 3000 devices per reel). Ordering 3000 pieces of "OPA347NA/3K" will get a single 3000-piece Tape and Reel.

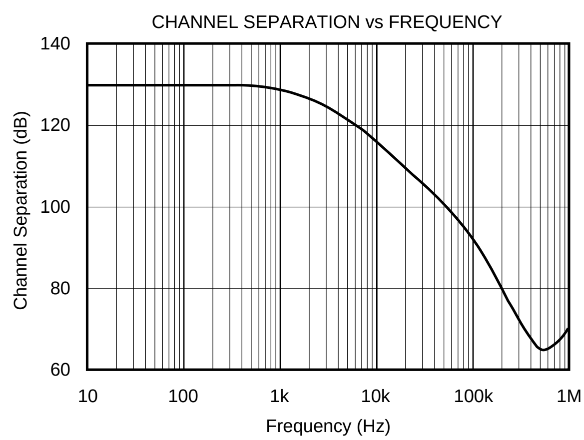
TYPICAL PERFORMANCE CURVES

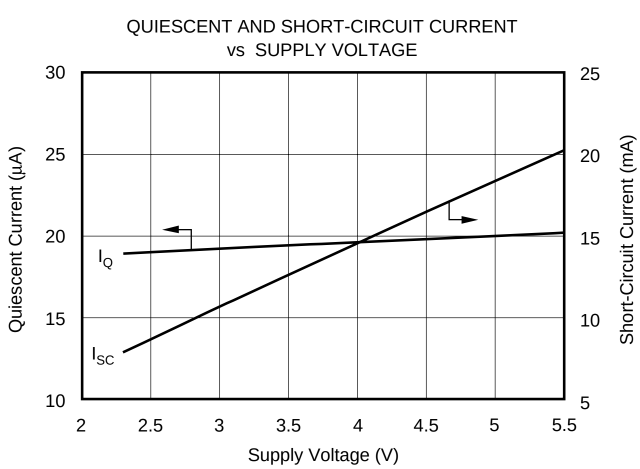
At T_A = +25°C, V_S = +5V, and R_L = 100kΩ connected to V_S/2, unless otherwise noted.

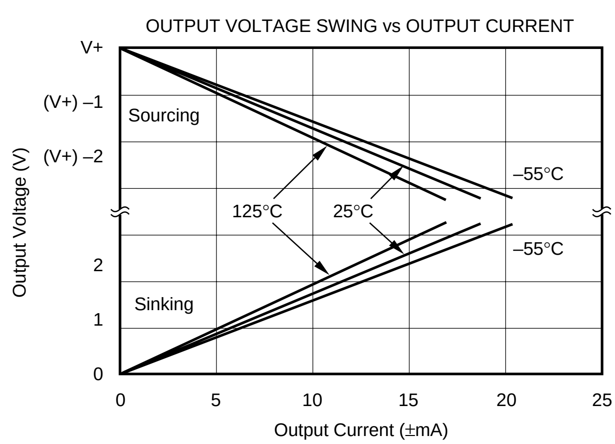






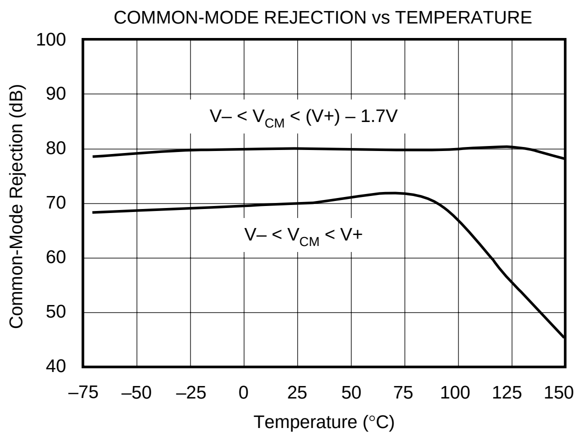


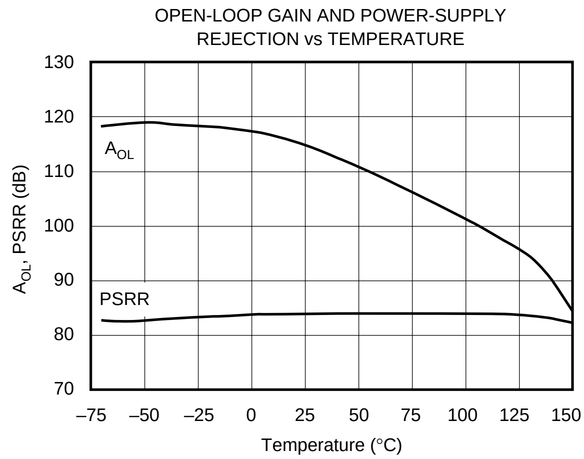


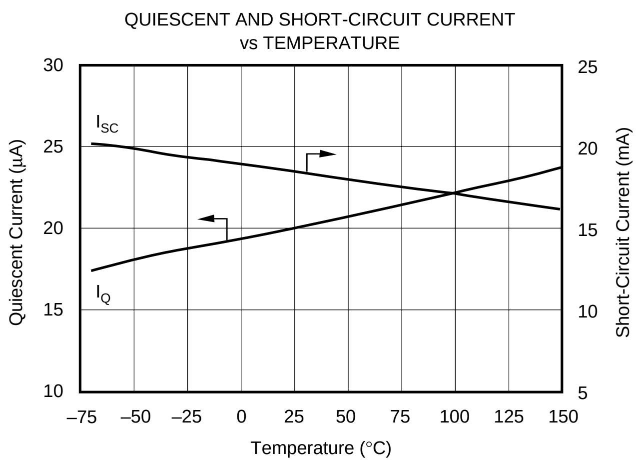


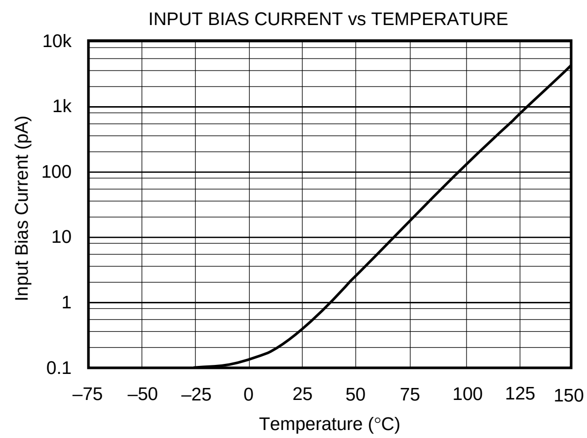
TYPICAL PERFORMANCE CURVES (Cont.)

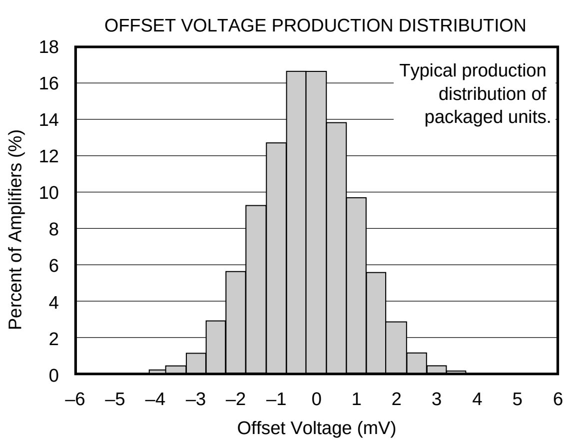
At T_A = +25°C, V_S = +5V, and R_L = 100kΩ connected to V_S/2, unless otherwise noted.

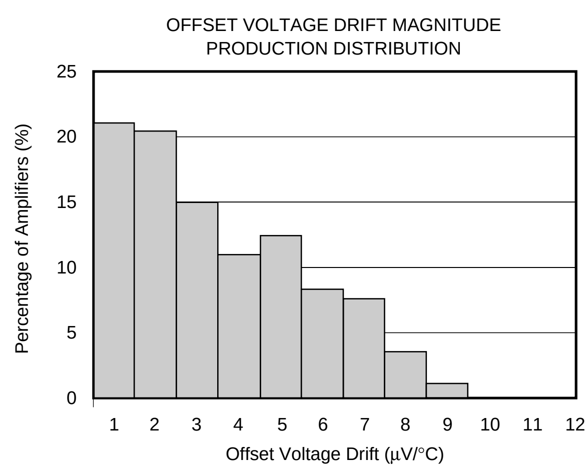






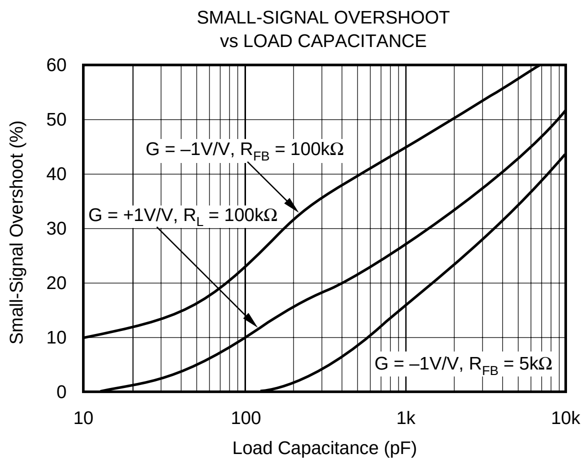


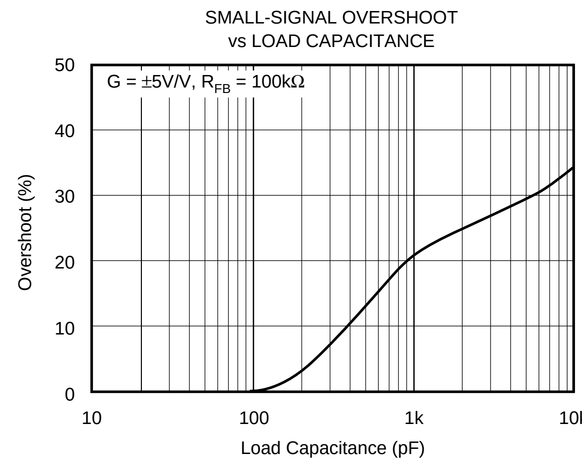


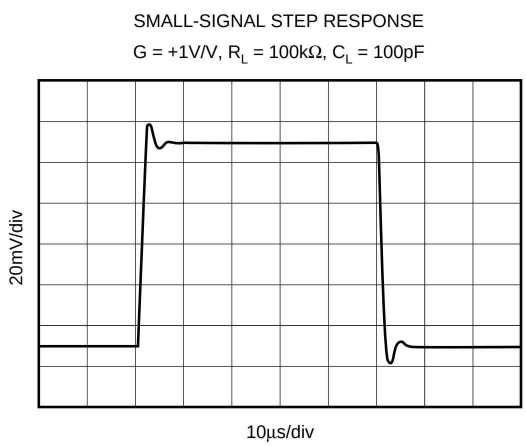


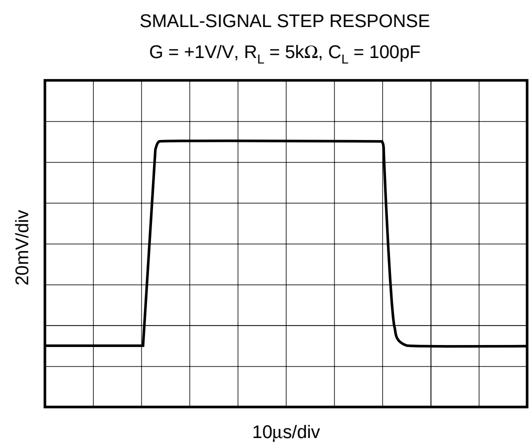
TYPICAL PERFORMANCE CURVES (Cont.)

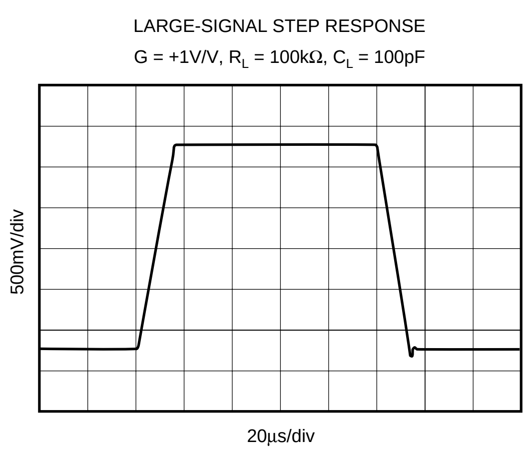
At T_A = +25°C, V_S = +5V, and R_L = 100kΩ connected to V_S/2, unless otherwise noted.

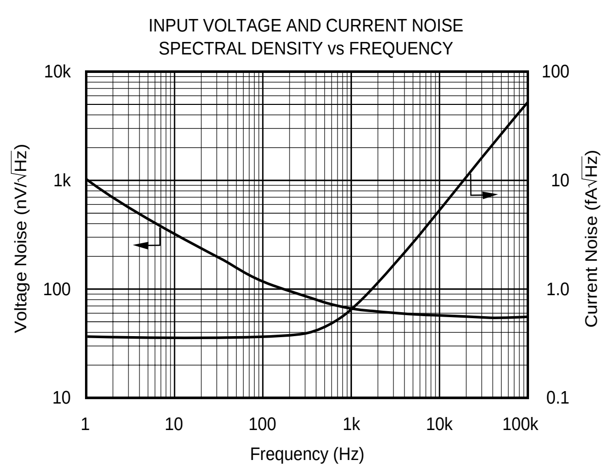












APPLICATIONS INFORMATION

OPA347 series op amps are unity gain stable and can operate on a single supply, making them highly versatile and easy to use.

Rail-to-rail input and output swing significantly increases dynamic range, especially in low supply applications. Figure 1 shows the input and output waveforms for the OPA347 in unity-gain configuration. Operation is from V_S = +5V with a 100kΩ load connected to $V_S/2$. The input is a 5Vp-p sinusoid. Output voltage is approximately 4.995Vp-p.

Power-supply pins should be bypassed with 0.01µF ceramic capacitors.

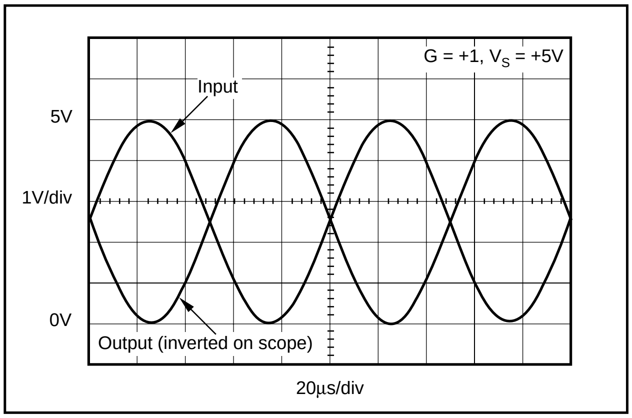


FIGURE 1. Rail-to-Rail Input and Output.

OPERATING VOLTAGE

OPA347 series op amps are fully specified and guaranteed from 2.5V to 5.5V. In addition, many specifications apply from –55ºC to +125ºC. Parameters that vary significantly with operating voltages or temperature are shown in the Typical Performance Curves.

RAIL-TO-RAIL INPUT

The input common-mode voltage range of the OPA347 series extends 200mV beyond the supply rails. This is achieved with a complementary input stage—an N-channel input differential pair in parallel with a P-channel differential pair, as shown in Figure 2. The N-channel pair is active for input voltages close to the positive rail, typically (V+) – 1.3V to 200mV above the positive supply, while the P-channel pair is on for inputs from 200mV below the negative supply to approximately (V+) – 1.3V. There is a small transition region, typically (V+) – 1.5V to (V+) – 1.1V, in which both pairs are on. This 400mV transition region can vary 300mV with process variation. Thus, the transition region (both stages on) can range from (V+) – 1.65V to (V+) – 1.25V on the low end, up to (V+) – 1.35V to (V+) – 0.95V on the high end. Within the 400mV transition region PSRR, CMRR, offset voltage, and offset drift may be degraded compared to operation outside this region. For more information on designing with rail-to-rail input op amps, see Figure 3, “Design Optimization with Rail-to-Rail Input Op Amps.”

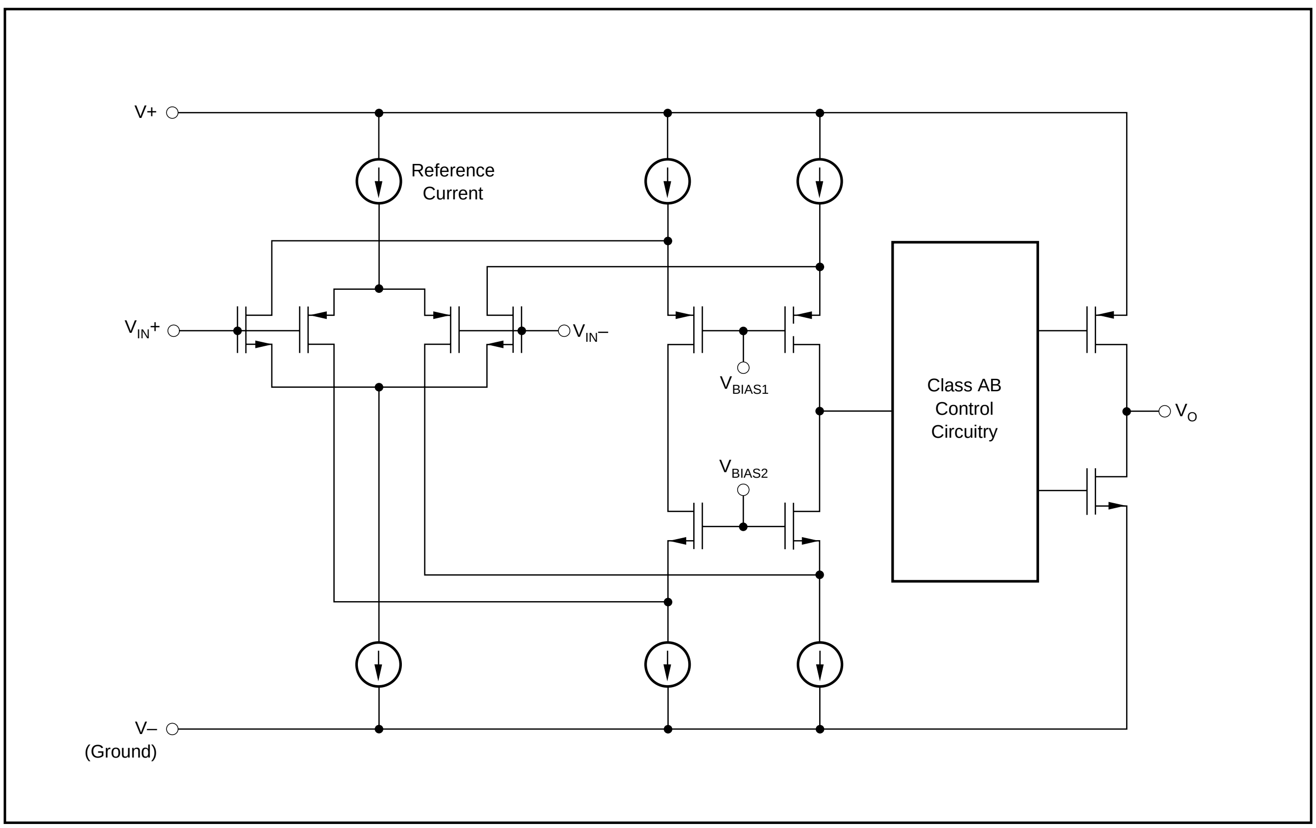


FIGURE 2. Simplified Schematic.

DESIGN OPTIMIZATION WITH RAIL-TO-RAIL INPUT OP AMPS

Rail-to-rail op amps can be used in virtually any op amp configuration. To achieve optimum performance, however, applications using these special double-input-stage op amps may benefit from consideration of their special behavior.

In many applications, operation remains within the common-mode range of only one differential input pair. However some applications exercise the amplifier through the transition region of both differential input stages. A small discontinuity may occur in this transition. Careful selection of the circuit configuration, signal levels and biasing can often avoid this transition region.

With a unity-gain buffer, for example, signals will traverse this transition at approximately 1.3V below V+ supply and may exhibit a small discontinuity at this point.

The common-mode voltage of the non-inverting amplifier is equal to the input voltage. If the input signal always remains less than the transition voltage, no discontinuity will be created. The closed-loop gain of this configuration can still produce a rail-to-rail output.

Inverting amplifiers have a constant common-mode voltage equal to V_B. If this bias voltage is constant, no discontinuity will be created. The bias voltage can generally be chosen to avoid the transition region.

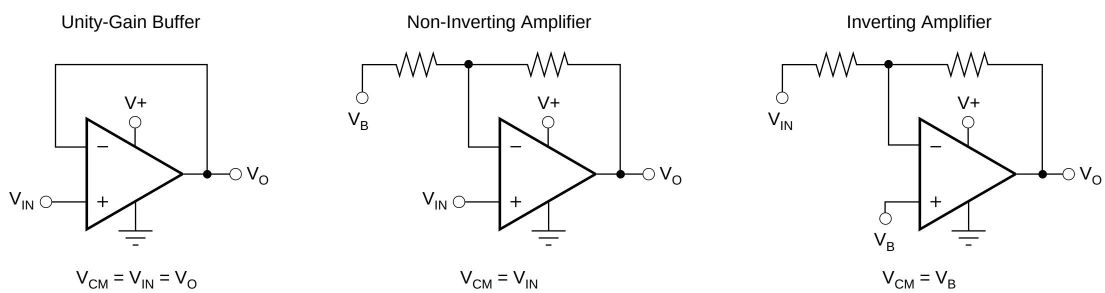


FIGURE 3. Design Optimization with Rail-to-Rail Input Op Amps.

COMMON-MODE REJECTION

The CMRR for the OPA347 is specified in several ways so the best match for a given application may be used. First, the CMRR of the device in the common-mode range below the transition region (V_{CM} < (V+) – 1.7V) is given. This specification is the best indicator of the capability of the device when the application requires use of one of the differential input pairs. Second, the CMRR at V_S = 5.5V over the entire common-mode range is specified.

INPUT VOLTAGE

The input common-mode range extends from (V–) – 0.2V to (V+) + 0.2V. For normal operation, inputs should be limited to this range. The absolute maximum input voltage is 500mV beyond the supplies. Inputs greater than the input common-mode range but less than the maximum input voltage, while not valid, will not cause any damage to the op amp. Furthermore, if input current is limited the inputs may go beyond the power supplies without phase inversion, as shown in Figure 4, unlike some other op amps.

Normally, input currents are 0.4pA. However, large inputs (greater than 500mV beyond the supply rails) can cause excessive current to flow in or out of the input pins. Therefore, as well as keeping the input voltage below the maximum rating, it is also important to limit the input current to less than 10mA. This is easily accomplished with an input resistor, as shown in Figure 5.

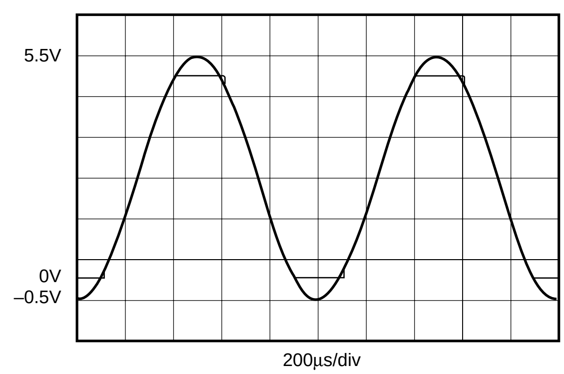


FIGURE 4. OPA347—No Phase Inversion with Inputs Greater than the Power Supply Voltage.

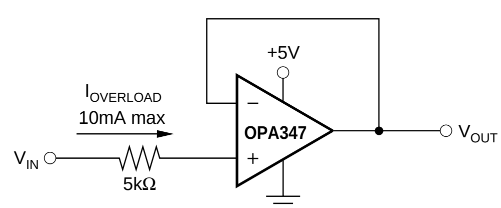


FIGURE 5. Input Current Protection for Voltages Exceeding the Supply Voltage.

RAIL-TO-RAIL OUTPUT

A class AB output stage with common-source transistors is used to achieve rail-to-rail output. This output stage is capable of driving 5kΩ loads connected to any potential between V+ and ground. For light resistive loads (> 100kΩ), the output voltage can typically swing to within 5mV from supply rail. With moderate resistive loads (10kΩ to 50kΩ), the output can swing to within a few tens of millivolts from the supply rails while maintaining high open-loop gain (see the typical performance curve "Output Voltage Swing vs Output Current").

CAPACITIVE LOAD AND STABILITY

The OPA347 in a unity-gain configuration can directly drive up to 250pF pure capacitive load. Increasing the gain enhances the amplifier's ability to drive greater capacitive loads (see the typical performance curve "Small-Signal Overshoot vs Capacitive Load"). In unity-gain configurations, capacitive load drive can be improved by inserting a small (10Ω to 20Ω) resistor, R_S, in series with the output, as shown in Figure 6. This significantly reduces ringing while maintaining dc performance for purely capacitive loads. However, if there is a resistive load in parallel with the capacitive load, a voltage divider is created, introducing a Direct Current (DC) error at the output and slightly reducing the output swing. The error introduced is proportional to the ratio R_S/R_L, and is generally negligible.

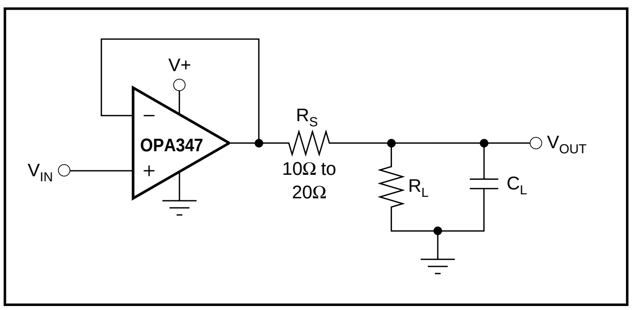


FIGURE 6. Series Resistor in Unity-Gain Buffer Configuration Improves Capacitive Load Drive.

In unity-gain inverter configuration, phase margin can be reduced by the reaction between the capacitance at the op amp input, and the gain setting resistors, thus degrading capacitive load drive. Best performance is achieved by using small valued resistors. For example, when driving a 500pF load, reducing the resistor values from 100kΩ to 5kΩ decreases overshoot from 40% to 8% (see the typical performance curve "Small-Signal Overshoot vs. Load Capacitance"). However, when large valued resistors can not be avoided, a small (4pF to 6pF) capacitor, C_{FB},can be inserted in the feedback, as shown in Figure 7. This significantly reduces overshoot by compensating the effect of capacitance, C_{IN}, which includes the amplifier's input capacitance and PC board parasitic capacitance.

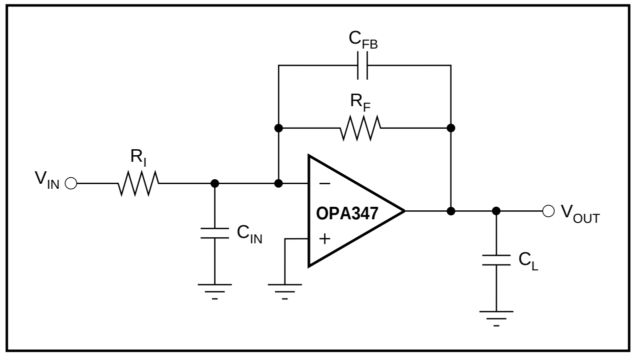


FIGURE 7. Adding A Feedback Capacitor In the Unity-Gain Inverter Configuration Improves Capacitative Load.

DRIVING A/D CONVERTERS

The OPA347 series op amps are optimized for driving medium-speed sampling ADCs. The OPA347 op amps buffer the ADC's input capacitance and resulting charge injection while providing signal gain.

Figures 8 shows the OPA347 in a basic non-inverting configuration driving the ADS7822. The ADS7822 is a 12-bit, micro-power sampling converter in the MSOP-8 package. When used with the low-power, miniature packages of the OPA347, the combination is ideal for space-limited, low-power applications. In this configuration, an RC network at the Analog-to-Digital's (ADC) input can be used to provide for anti-aliasing filter and charge injection current.

Figure 9 shows the OPA2347 driving an ADS7822 in a speech bandpass filtered data acquisition system. This small, low-cost solution provides the necessary amplification and signal conditioning to interface directly with an electret microphone. This circuit will operate with V_S = 2.7V to 5V with less than 250µA typical quiescent current.

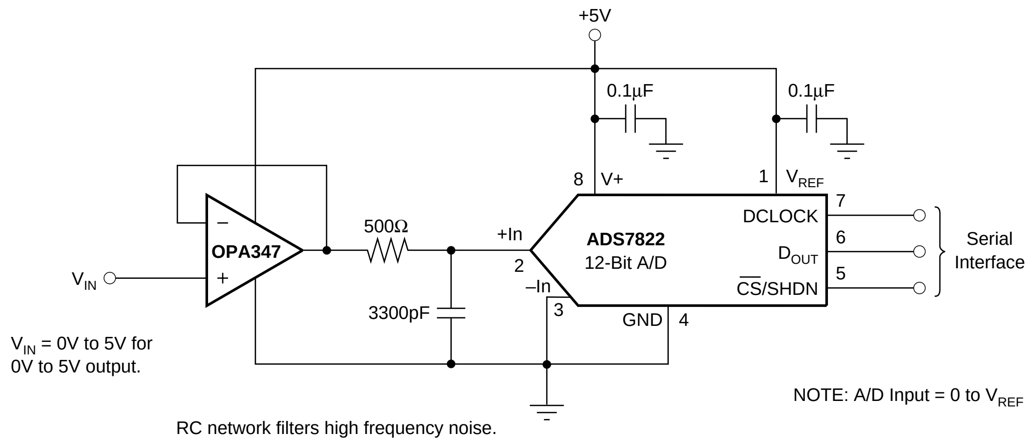


FIGURE 8. OPA347 in Noninverting Configuration Driving ADS7822.

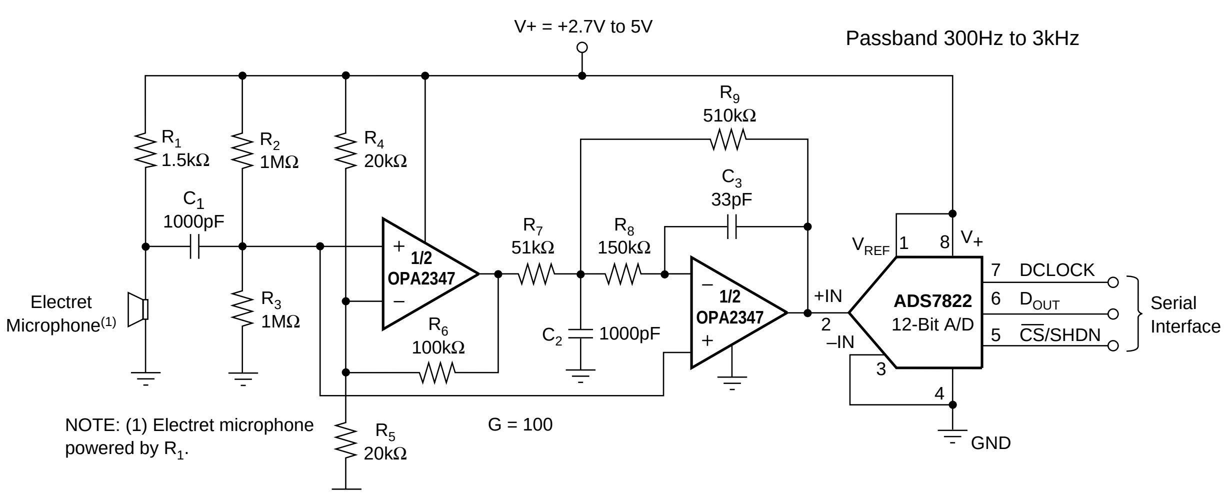


FIGURE 9. Speech Bandpass Filtered Data Acquisition System.