

OPA349
OPA2349

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1 μ A, Rail-to-Rail, CMOS OPERATIONAL AMPLIFIERS

FEATURES

- **LOW SUPPLY CURRENT:** 1 μ A
- **GAIN-BANDWIDTH:** 70kHz
- **UNITY GAIN STABLE**
- **LOW INPUT BIAS CURRENT:** 10pA
- **WIDE SUPPLY RANGE:** 1.8V to 5.5V
- **INPUT RANGE 200mV BEYOND RAILS**
- **OUTPUT SWINGS TO 150mV OF RAILS**
- **OUTPUT DRIVE CURRENT:** 20mA
- **OPEN-LOOP GAIN:** 90dB
- **SOT23 MicroPACKAGES**

APPLICATIONS

- **BATTERY PACKS AND POWER SUPPLIES**
- **PORTABLE PHONES/PAGERS/CAMERAS**
- **SOLAR-POWERED SYSTEMS**
- **SMOKE/GAS/FIRE DETECTION SYSTEMS**
- **REMOTE SENSORS**
- **PCMCIA CARDS**
- **DRIVING A/D CONVERTERS**
- **MicroPOWER FILTERS**

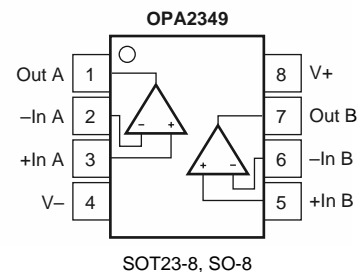
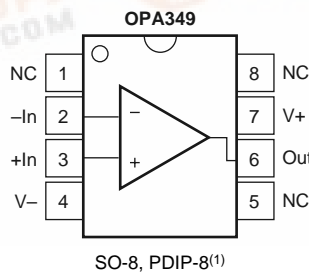
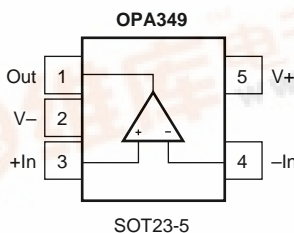
DESCRIPTION

The OPA349 and OPA2349 are ultra-low power operational amplifiers that provide 70kHz bandwidth with only 1 μ A quiescent current. These rail-to-rail input and output amplifiers are specifically designed for battery powered applications. Unlike some micropower op amps, these parts are unity-gain stable and require no external compensation. The OPA349's low input bias current allows the use of large source and feedback resistors. The input common-mode voltage range extends 200mV beyond the power supply rails and the output swings to within 150mV of the rails, maintaining wide dynamic range.

OPA349 can be operated with power supplies from 1.8V to 5.5V with little change in performance, guaranteeing continuing superior performance even in low battery situations.

OPA349 comes in the miniature SOT23-5, SO-8 surface mount and PDIP-8⁽¹⁾ packages. OPA2349 dual is also available in the SOT23 (8-lead SOT23-8), as well as the SO-8 surface mount packages. These tiny packages are ideal for use in high-density applications, such as PCMCIA cards, battery packs and portable instruments.

All models are specified for the commercial temperature range, 0°C to +70°C.



NOTE: (1) Available Q4 2000.



SPECIFICATIONS: $V_S = +1.8V$ to $+5.5V$

Boldface limits apply over the specified temperature range, $T_A = 0^\circ\text{C}$ to $+70^\circ\mathbf{C}$

At $T_A = +25^\circ\text{C}$, $R_L = 1\text{M}\Omega$ connected to $V_S/2$, unless otherwise noted.

PARAMETER	CONDITION	OPA349NA, UA, PA OPA2349EA, UA			UNITS
		MIN	TYP	MAX	
OFFSET VOLTAGE Input Offset Voltage Drift vs Power Supply Channel Separation, dc (Dual version)	V_{OS} dV_{OS}/dT PSRR	$V_S = 5V, V_{CM} = 2.5V$ $V_S = 1.8V$ to $5.5V, V_{CM} = (V-) + 0.3V$ $R_L = 100k\Omega$	± 2 ± 10 350 10	± 10 1000	mV $\mu\text{V}/^\circ\text{C}$ $\mu\text{V}/V$ $\mu\text{V}/V$
INPUT VOLTAGE RANGE Common-Mode Voltage Range Common-Mode Rejection Ratio	V_{CM} CMRR	$V_S = +5V, -0.2V < V_{CM} < 3.5V$ $V_S = +5V, -0.2V < V_{CM} < 5.2V$	$(V-) - 0.2$ 52 48	$(V+) + 0.2$	V dB dB
INPUT BIAS CURRENT Input Bias Current Input Offset Current	I_B I_{OS}		± 1 ± 1	± 10 ± 10	pA pA
INPUT IMPEDANCE Differential Common-Mode			$10^{13} \parallel 2$ $10^{13} \parallel 4$		$\Omega \parallel \text{pF}$ $\Omega \parallel \text{pF}$
NOISE Input Voltage Noise, $f = 0.1\text{Hz}$ to 10Hz Input Voltage Noise Density, $f = 1\text{kHz}$ Current Noise Density, $f = 1\text{kHz}$	e_n i_n		8 300 4		$\mu\text{Vp-p}$ $\text{nV}/\sqrt{\text{Hz}}$ $\text{fA}/\sqrt{\text{Hz}}$
OPEN-LOOP GAIN Open-Loop Voltage Gain Open-Loop Voltage Gain	A_{OL}	$R_L = 1\text{M}\Omega, V_S = +5.5V, +0.3V < V_O < +5.2V$ $R_L = 10k\Omega, V_S = +5.5V, +0.35V < V_O < +5.15V$	74 74	90 90	dB dB
OUTPUT Voltage Output Swing from Rail Output Current Short-Circuit Current	I_{SC}	$R_L = 1\text{M}\Omega, V_S = +5.5V, A_{OL} > 74\text{dB}$ $R_L = 10k\Omega, V_S = +5.5V, A_{OL} > 74\text{dB}$	150 200 ± 8 ± 25	300 350	mV mV mA mA
FREQUENCY RESPONSE Gain-Bandwidth Product Slew Rate Settling Time, 0.1% 0.01% Overload Recovery Time	GBW SR t_S	$C_L = 10\text{pF}$ $G = +1$ $V_S = +5V, G = +1$ $V_S = 5V, 1V$ Step $V_S = 5V, 1V$ Step $V_{IN} \cdot \text{Gain} = V_S$	70 0.02 65 80 5		kHz $\text{V}/\mu\text{s}$ μs μs μs
POWER SUPPLY Specified Voltage Range Operating Voltage Range Quiescent Current (per amplifier)	V_S I_Q	$I_Q = 0$	1.8 1.8	5.5 5.5 2	V V μA
TEMPERATURE RANGE Specified Range Storage Range Thermal Resistance SOT23-5 Surface Mount SOT23-8 Surface Mount SO-8 Surface Mount PDIP-8	θ_{JA}		0 -65	+70 +150	$^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C}/\text{W}$ $^\circ\text{C}/\text{W}$ $^\circ\text{C}/\text{W}$ $^\circ\text{C}/\text{W}$ $^\circ\text{C}/\text{W}$

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

Supply Voltage, V+ to V-	5.5V
Signal Input Terminals, Voltage ⁽²⁾	(V-) - 0.5V to (V+) + 0.5V
Current ⁽²⁾	10mA
Output Short Circuit ⁽³⁾	Continuous
Operating Temperature	-55°C to +125°C
Storage Temperature	-65°C to +150°C
Junction Temperature	150°C
Lead Temperature (soldering, 3s)	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, and functional operation of the device at these, or any other conditions beyond those specified, 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.

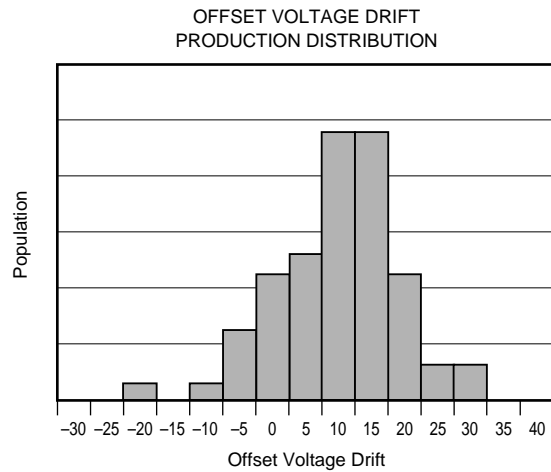
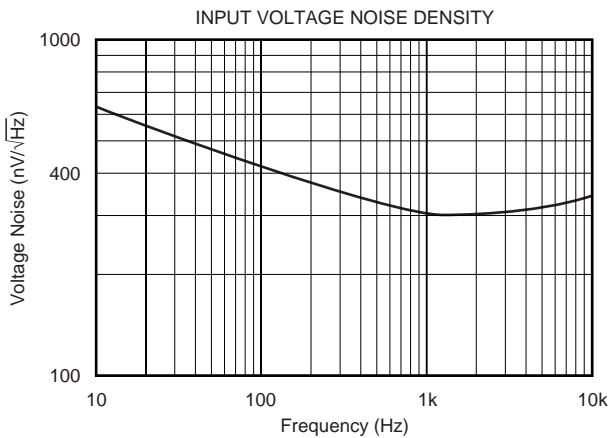
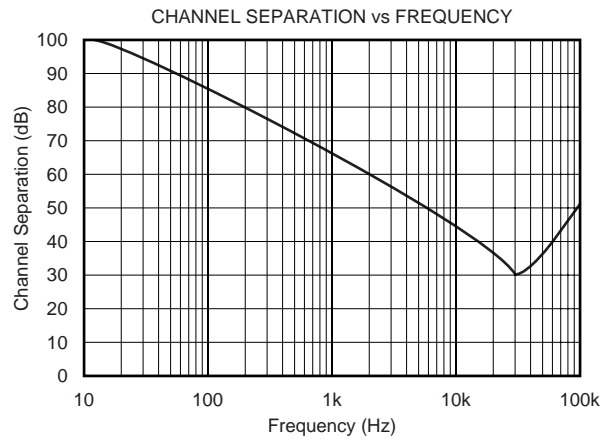
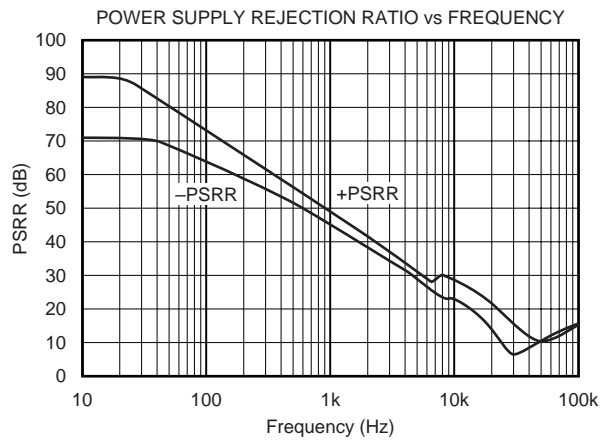
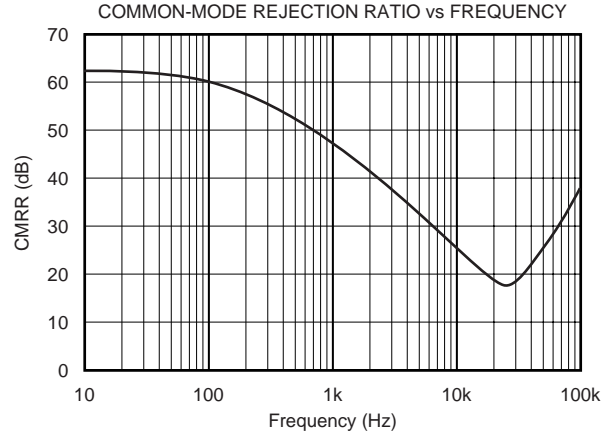
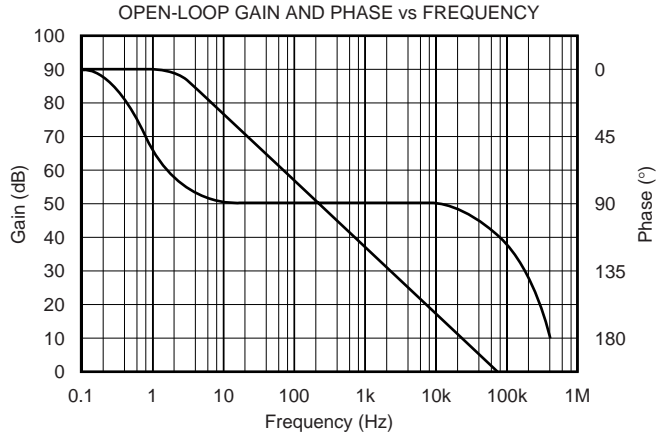
PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER ⁽¹⁾	TRANSPORT MEDIA
Single						
OPA349NA	SOT23-5	331	0°C to +70°C	A49	OPA349NA/250	Tape and Reel
"	"	"	"	"	OPA349NA/3K	Tape and Reel
OPA349UA	SO-8	182	0°C to +70°C	OPA349UA	OPA349UA	Rails
"	"	"	"	"	OPA349UA/2K5	Tape and Reel
OPA349PA ⁽²⁾	PDIP-8	006	0°C to +70°C	OPA349PA	OPA349PA	Rails
Dual						
OPA2349EA	SOT23-8	348	0°C to +70°C	C49	OPA2349EA/250	Tape and Reel
"	"	"	"	"	OPA2349EA/3K	Tape and Reel
OPA2349UA	SO-8	182	0°C to +70°C	OPA2349UA	OPA2349UA	Rails
"	"	"	"	"	OPA2349UA/2K5	Tape and Reel

NOTE: (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 "OPA2349EA/3K" will get a single 3000-piece Tape and Reel. (2) OPA349PA (DIP) available Q4 2000.

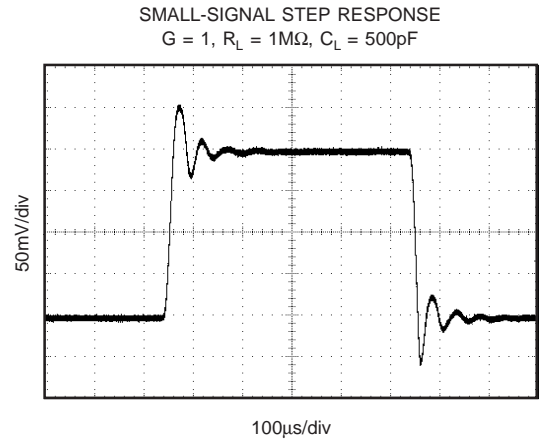
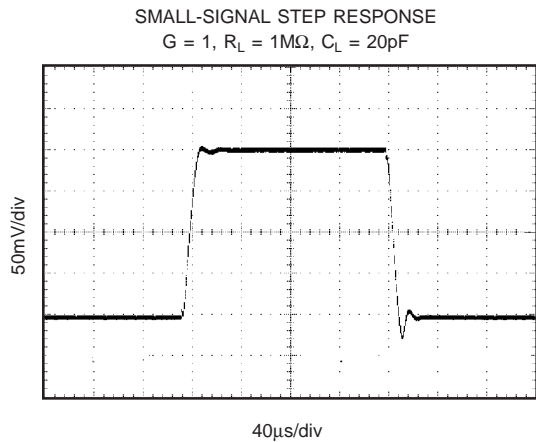
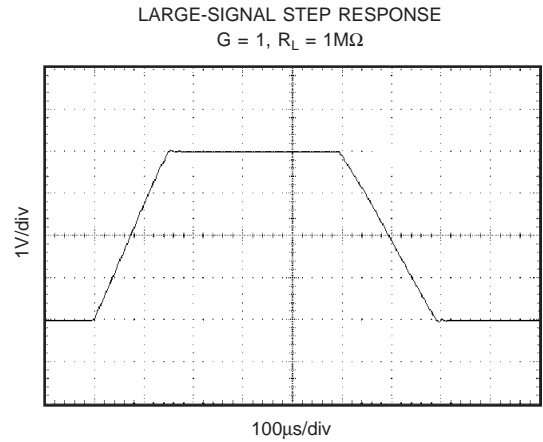
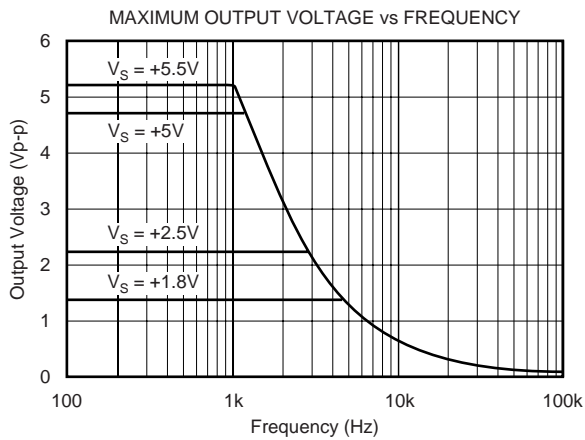
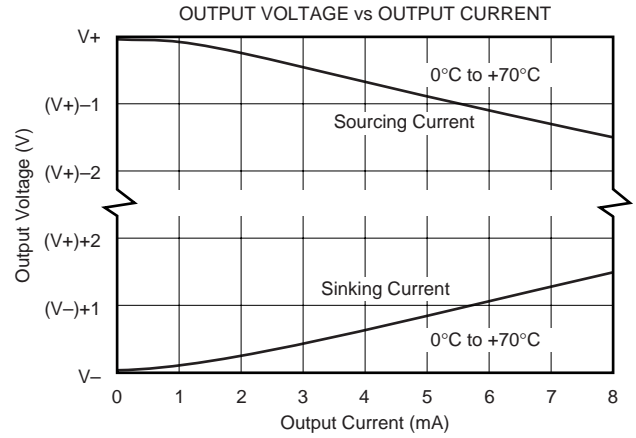
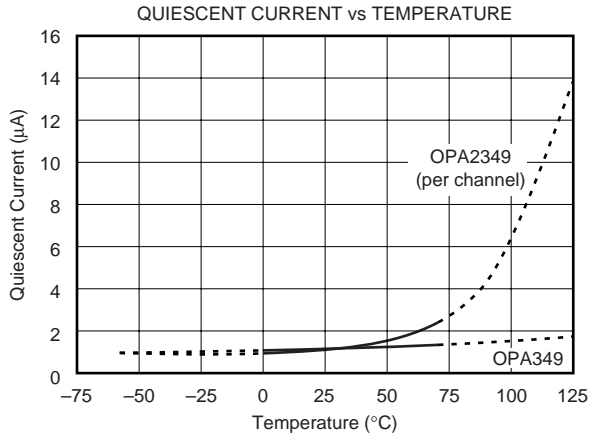
TYPICAL PERFORMANCE CURVES

At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, unless otherwise noted.



TYPICAL PERFORMANCE CURVES (Cont.)

At $T_A = +25^\circ\text{C}$, unless otherwise noted.



APPLICATIONS INFORMATION

OPA349 series op amps are unity gain stable and can operate on a single supply, making them highly versatile and easy to use. Power supply pins should be bypassed with 0.01 μ F ceramic capacitors.

OPA349 series op amps are fully specified and guaranteed from +1.8V to +5.5V. Parameters that vary significantly with operating voltages or temperature are shown in the Typical Performance Curves.

The ultra low quiescent current of the OPA349 requires careful applications circuit techniques to achieve low overall current consumption. Figure 1 shows an ac-coupled amplifier biased with a voltage divider. Resistor values must be very large to minimize current. The large feedback resistor

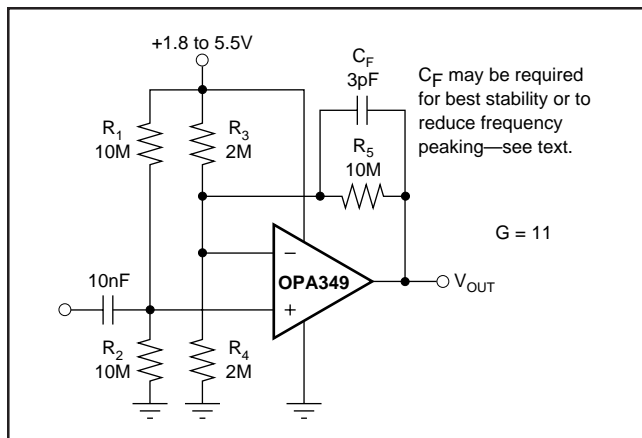


FIGURE 1. AC-Coupled Amplifier.

value reacts with input capacitance and stray capacitance to produce a pole in the feedback network. A feedback capacitor may be required to assure stability and limit overshoot or gain peaking. Check circuit performance carefully to assure that biasing and feedback techniques meet your signal and quiescent current requirements.

RAIL-TO-RAIL INPUT

The input common-mode voltage range of the OPA349 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 (see 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 $(V+) - 1.8V$ to $(V+) - 1.4V$ on the low end, up to $(V+) - 1.2V$ to $(V+) - 0.8V$ on the high end. Within the 400mV transition region PSRR, CMRR, offset voltage, offset drift, and THD 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.”

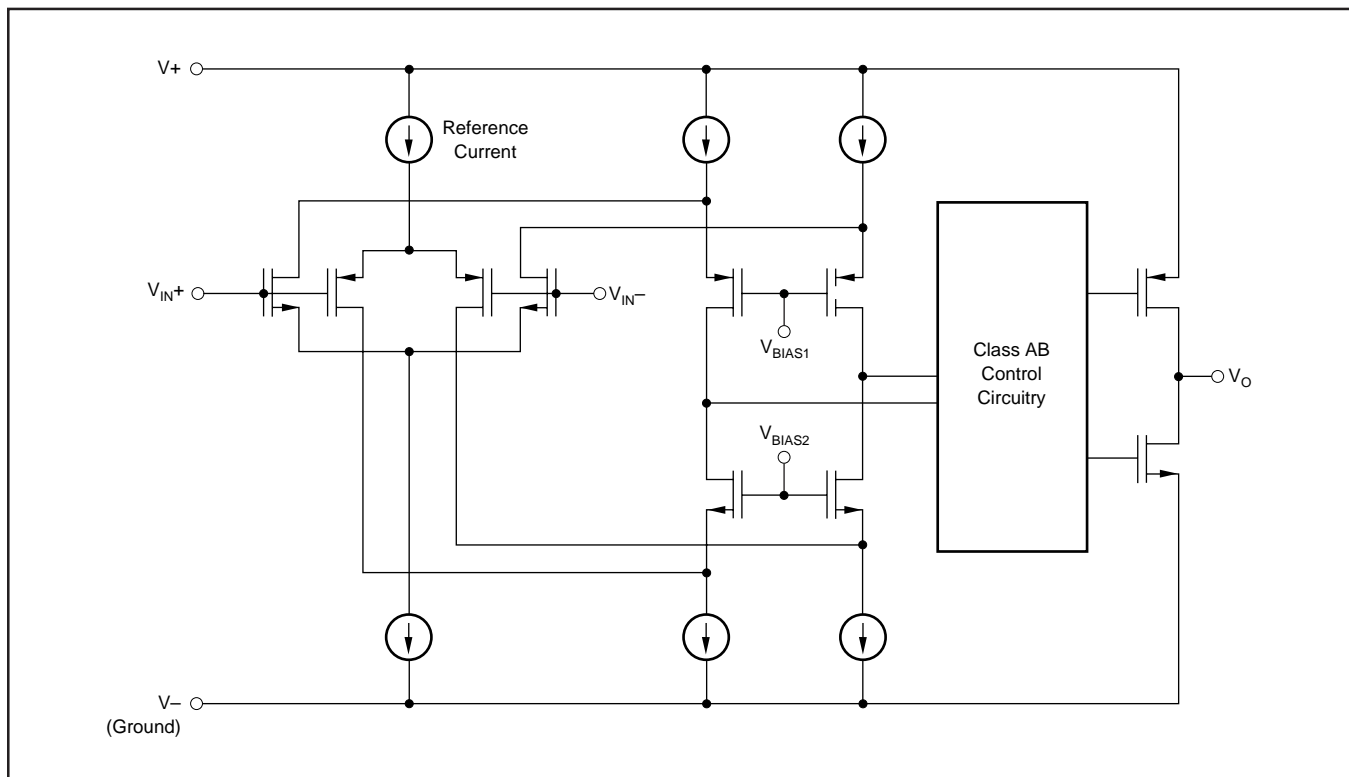


FIGURE 2. Simplified Schematic.

DESIGN OPTIMIZATION WITH RAIL-TO-RAIL INPUT OP AMPS

In most applications, operation is within the range of only one differential pair. However, some applications can subject the amplifier to a common-mode signal in the transition region. Under this condition, the inherent mismatch between the two differential pairs may lead to degradation of the CMRR and THD. The unity-gain buffer configuration is the most problematic—it will traverse through the transition region if a sufficiently wide input

swing is required. A design option would be to configure the op amp as a unity-gain inverter as shown below and hold the noninverting input at a set common-mode voltage outside the transition region. This can be accomplished with a voltage divider from the supply. The voltage divider should be designed such that the biasing point for the noninverting input is outside the transition region.

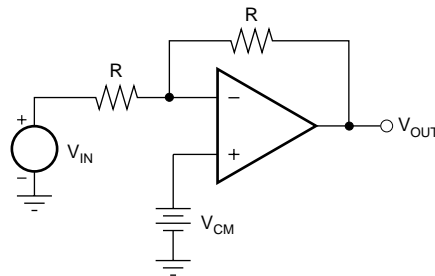


FIGURE 3. Design Optimization.

COMMON-MODE REJECTION

The CMRR for the OPA349 is specified in two 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 ($V_{CM} < (V+) - 1.5V$) 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 $V_S = 5V$ over the entire common-mode range is specified.

RAIL-TO-RAIL OUTPUT

A class AB output stage with common-source transistors is used to achieve rail-to-rail output.

Loads that connect to single supply ground (or the V_- supply pin) can cause the op amp to oscillate if the output voltage

is driven to the low limit (Figure 4). Similarly, loads that can cause current to flow out of the output pin when the output voltage is near V_- can cause oscillations. The op amp will recover to normal operation a few milliseconds after the output is driven positively out of the rail.

Some op amp applications can produce this condition even without a load connected to V_- . The integrator in Figure 4a shows an example. Assume that the output ramps negatively, and saturates near $0V$. Any negative-going step at V_{IN} will produce a positive output current pulse through R_1 and C_1 . This may incite the oscillation. Diode, D_1 , prevents the input step from pulling output current when the output is saturated at the rail, thus preventing the oscillation.

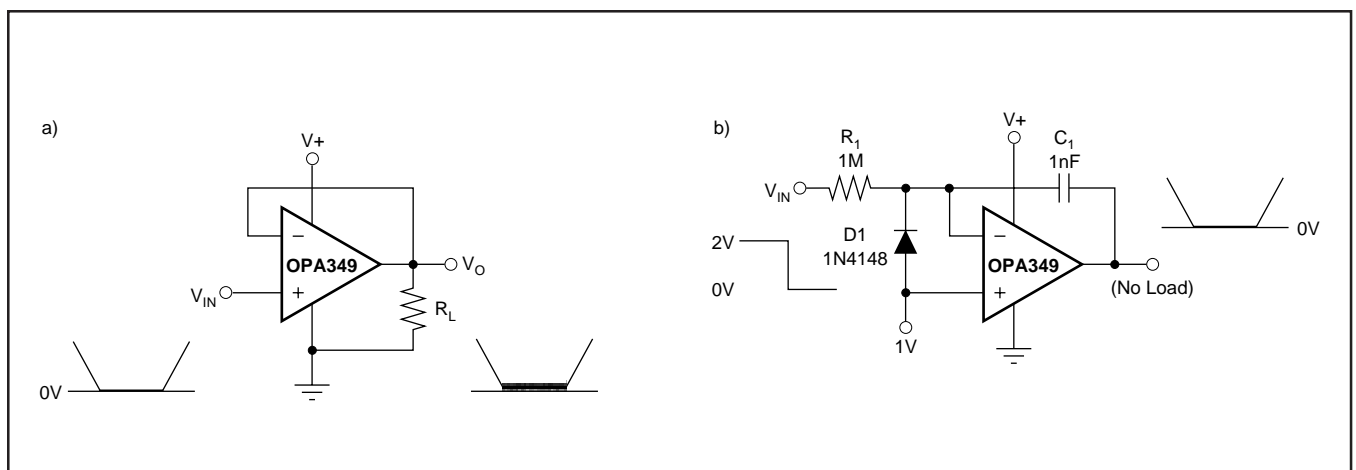


FIGURE 4. Output Driven to Negative Rail.