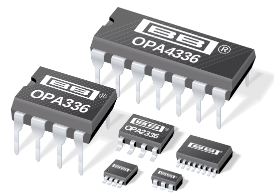
Burr-Brown Products from Texas Instruments

OPA336
OPA2336
OPA4336



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SINGLE-SUPPLY, *micro*Power CMOS OPERATIONAL AMPLIFIERS *microAmplifier*™ Series

FEATURES

- SINGLE-SUPPLY OPERATION
- RAIL-TO-RAIL OUTPUT (within 3mV)
- *micro*POWER: I_Q = 20µA/Amplifier
- *micro*SIZE PACKAGES
- LOW OFFSET VOLTAGE: 125µV max
- SPECIFIED FROM V_S = 2.3V to 5.5V
- SINGLE, DUAL, AND QUAD VERSIONS

APPLICATIONS

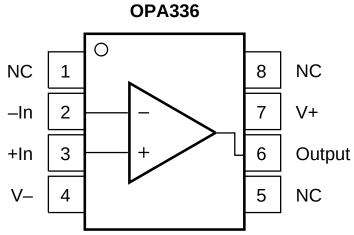
- BATTERY-POWERED INSTRUMENTS
- PORTABLE DEVICES
- HIGH-IMPEDANCE APPLICATIONS
- PHOTODIODE PRE-AMPS
- PRECISION INTEGRATORS
- MEDICAL INSTRUMENTS
- TEST EQUIPMENT

DESCRIPTION

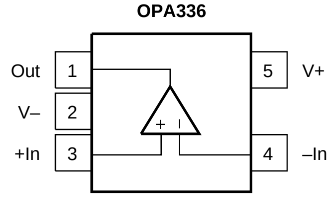
OPA336 series micropower CMOS operational amplifiers are designed for battery-powered applications. They operate on a single supply with operation as low as 2.1V. The output is rail-to-rail and swings to within 3mV of the supplies with a 100kΩ load. The common-mode range extends to the negative supply—ideal for single-supply applications. Single, dual, and quad versions have identical specifications for maximum design flexibility.

In addition to small size and low quiescent current (20µA/amplifier), they feature low offset voltage (125µV max), low input bias current (1pA), and high open-loop gain (115dB). Dual and quad designs feature completely independent circuitry for lowest crosstalk and freedom from interaction.

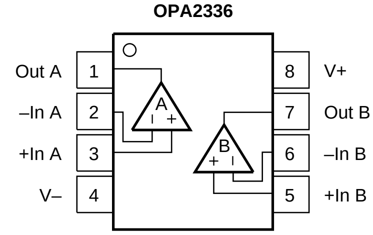
OPA336 packages are the tiny SOT23-5 surface mount, SO-8 surface-mount, and DIP-8. OPA2336 comes in the miniature MSOP-8 surface-mount, SO-8 surface-mount, and DIP-8 packages. OPA4336 packages are the space-saving SSOP-16 surface-mount and the DIP-14. All are specified from –40°C to +85°C and operate from –55°C to +125°C. A macromodel is available for design analysis.



DIP-8, SO-8



SOT23-5



DIP-8, SO-8, MSOP-8

Texas Instruments

 SBOS068A Printed in U.S.A. September, 2000

SPECIFICATIONS: V_S = 2.3V to 5.5V

Boldface limits apply over the specified temperature range, **T_A = –40°C to +85°C**.

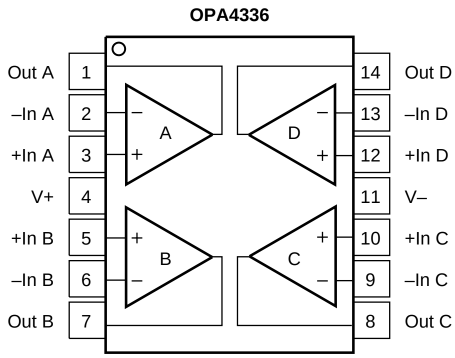
At T_A = +25°C, V_S = +5V, and R_L = 25kΩ connected to V_S/2, unless otherwise noted.

		OPA336N, P, U OPA2336E, P, U			OPA336NA, PA, UA OPA2336EA, PA, UA OPA4336EA, PA			
PARAMETER	CONDITION	MIN	TYP(1)	MAX	MIN	TYP(1)	MAX	UNITS
OFFSET VOLTAGE								
Input Offset Voltage V_{OS}			±60	±125		*	±500	μV
vs Temperature dV_{OS}/dT			**±1.5**			*		μV/°C
vs Power Supply PSRR	V_S = 2.3V to 5.5V		25	100		*	*	μV/V
Over Temperature	V_S = 2.3V to 5.5V			**130**			*	μV/V
Channel Separation, dc			0.1			*		μV/V
INPUT BIAS CURRENT								
Input Bias Current I_B			±1	±10		*	*	pA
Over Temperature				**±60**			*	pA
Input Offset Current I_{OS}			±1	±10		*	*	pA
NOISE								
Input Voltage Noise, f = 0.1 to 10Hz			3			*		μVp-p
Input Voltage Noise Density, f = 1kHz e_n			40			*		nV/√Hz
Current Noise Density, f = 1kHz i_n			30			*		fA/√Hz
INPUT VOLTAGE RANGE								
Common-Mode Voltage Range V_{CM}		–0.2		(V+) –1	*		*	V
Common-Mode Rejection Ratio CMRR	–0.2V < V_{CM} < (V+) –1V	80	90		76	86		dB
Over Temperature	–0.2V < V_{CM} < (V+) –1V	**76**			**74**			dB
INPUT IMPEDANCE								
Differential			10^{13} || 2			*		Ω || pF
Common-Mode			10^{13} || 4			*		Ω || pF
OPEN-LOOP GAIN								
Open-Loop Voltage Gain A_{OL}	R_L = 25kΩ, 100mV < V_O < (V+) – 100mV	100	115		90	*		dB
Over Temperature	R_L = 25kΩ, 100mV < V_O < (V+) – 100mV	**100**			**90**			dB
	R_L = 5kΩ, 500mV < V_O < (V+) – 500mV	90	106		*	*		dB
Over Temperature	R_L = 5kΩ, 500mV < V_O < (V+) – 500mV	**90**			*			dB
FREQUENCY RESPONSE								
Gain-Bandwidth Product GBW	V_S = 5V, G = 1		100			*		kHz
Slew Rate SR	V_S = 5V, G = 1		0.03			*		V/μs
Overload Recovery Time	V_{IN} • G = V_S		100			*		μs
OUTPUT								
Voltage Output Swing from Rail(2)	R_L = 100kΩ, A_{OL} ≥ 70dB		3			*		mV
	R_L = 25kΩ, A_{OL} ≥ 90dB		20	100		*	*	mV
Over Temperature	R_L = 25kΩ, A_{OL} ≥ 90dB			**100**			*	mV
	R_L = 5kΩ, A_{OL} ≥ 90dB		70	500		*	*	mV
Over Temperature	R_L = 5kΩ, A_{OL} ≥ 90dB			**500**			*	mV
Short-Circuit Current I_{SC}			±5			*		mA
Capacitive Load Drive C_{LOAD}			See Text			*		pF
POWER SUPPLY								
Specified Voltage Range V_S		2.3		5.5	*		*	V
Minimum Operating Voltage			2.1			*		V
Quiescent Current (per amplifier) I_Q	I_O = 0		20	32		*	*	μA
Over Temperature	I_O = 0			**36**			*	μA
TEMPERATURE RANGE								
Specified Range		–40		+85	*		*	°C
Operating Range		–55		+125	*		*	°C
Storage Range		–55		+125	*		*	°C
Thermal Resistance θ_{JA}								
SOT-23-5 Surface-Mount			200			*		°C/W
MSOP-8 Surface-Mount			150			*		°C/W
SO-8 Surface-Mount			150			*		°C/W
DIP-8			100			*		°C/W
SSOP-16 Surface-Mount			100			*		°C/W
DIP-14			80			*		°C/W

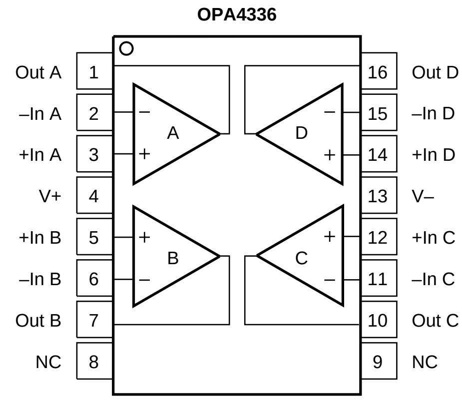
*Specifications same as OPA2336E, P, U.

NOTES: (1) V_S = +5V. (2) Output voltage swings are measured between the output and positive and negative power-supply rails.

Top View



DIP-14



SSOP-16

ABSOLUTE MAXIMUM RATINGS(1)

Supply Voltage	7.5V
Signal Input Terminals, Voltage(2)	(V–) –0.3V to (V+) +0.3V
Current(2)	10mA
Output Short-Circuit(3)	Continuous
Operating Temperature	–55°C to +125°C
Storage Temperature	–55°C to +125°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 0.3V 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.

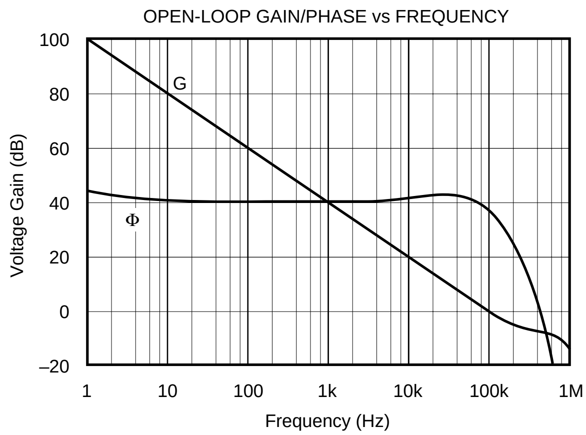
PACKAGE/ORDERING INFORMATION

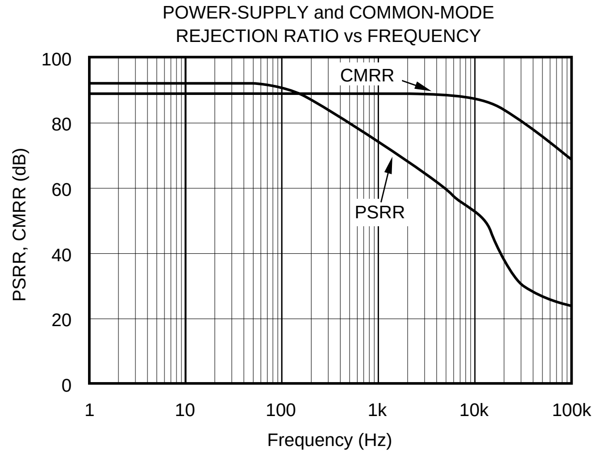
PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER(1)	TRANSPORT MEDIA
Single						
OPA336NA	SOT-23-5	331	–40°C to +85°C	A36(2)	OPA336NA/250	Tape and Reel
"	"	"	"	"	OPA336NA/3K	Tape and Reel
OPA336N	SOT-23-5	331	–40°C to +85°C	A36(2)	OPA336N/250	Tape and Reel
"	"	"	"	"	OPA336N/3K	Tape and Reel
OPA336PA	DIP-8	006	–40°C to +85°C	OPA336PA	OPA336PA	Rails
OPA336P	"	"	"	OPA336P	OPA336P	Rails
OPA336UA	SO-8 Surface-Mount	182	–40°C to +85°C	OPA336UA	OPA336UA	Rails(3)
OPA336U	"	"	"	OPA336U	OPA336U	Rails(3)
Dual						
OPA2336PA	DIP-8	006	–40°C to +85°C	OPA2336PA	OPA2336PA	Rails
OPA2336P	"	"	"	OPA2336P	OPA2336P	Rails
OPA2336UA	SO-8 Surface-Mount	182	–40°C to +85°C	OPA2336UA	OPA2336UA	Rails(3)
OPA2336U	"	"	"	OPA2336U	OPA2336U	Rails(3)
OPA2336EA	MSOP-8 Surface-Mount	337	–40°C to +85°C	B36(2)	OPA2336EA/250	Tape and Reel
"	"	"	"	"	OPA2336EA/2K5	Tape and Reel
OPA2336E	MSOP-8 Surface-Mount	337	–40°C to +85°C	B36(2)	OPA2336E/250	Tape and Reel
"	"	"	"	"	OPA2336E/2K5	Tape and Reel
Quad						
OPA4336EA	SSOP-16 Surface-Mount	322	–40°C to +85°C	OPA4336EA	OPA4336EA/250	Tape and Reel
"	"	"	"	"	OPA4336EA/2K5	Tape and Reel
OPA4336PA	DIP-14	010	–40°C to +85°C	OPA4336PA	OPA4336PA	Rails

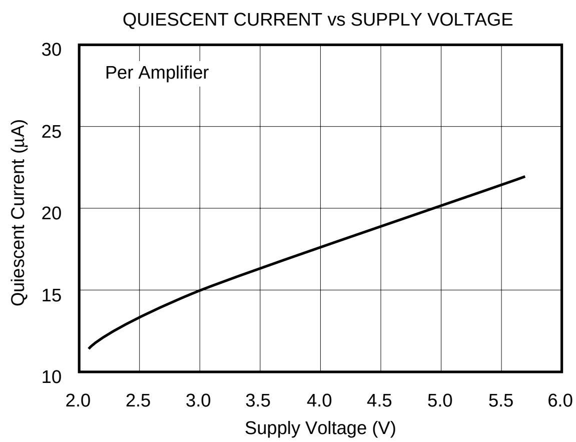
NOTES: (1) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /2K5 indicates 2500 devices per reel). Ordering 2500 pieces of "OPA336NA/3K" will get a single 3000 piece Tape and Reel. (2) Grade will be marked on the Reel. (3) SO-8 models also available in Tape and Reel.

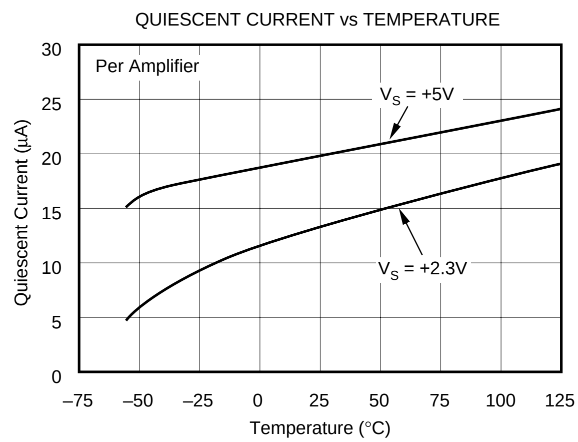
TYPICAL PERFORMANCE CURVES

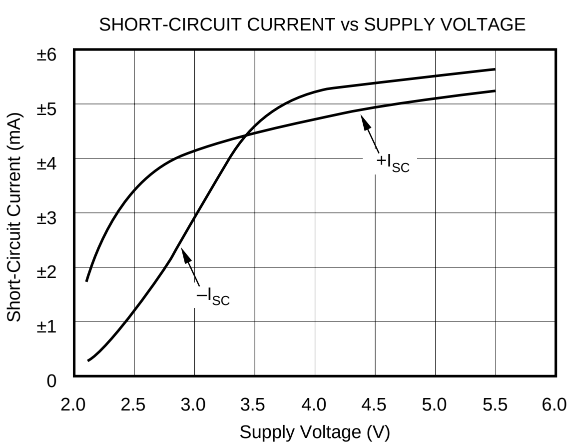
At T_A = +25°C, V_S = +5V, and R_L = 25kΩ connected to V_S/2, unless otherwise noted.

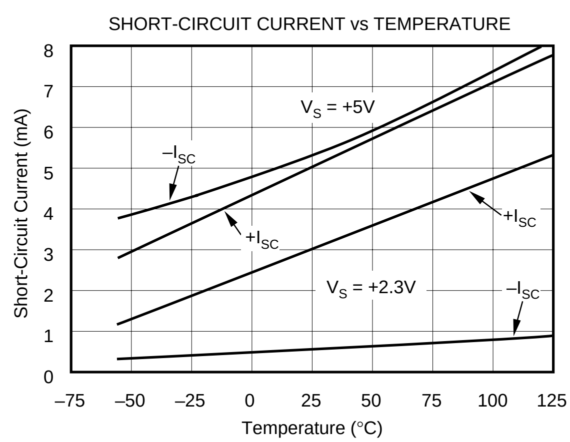








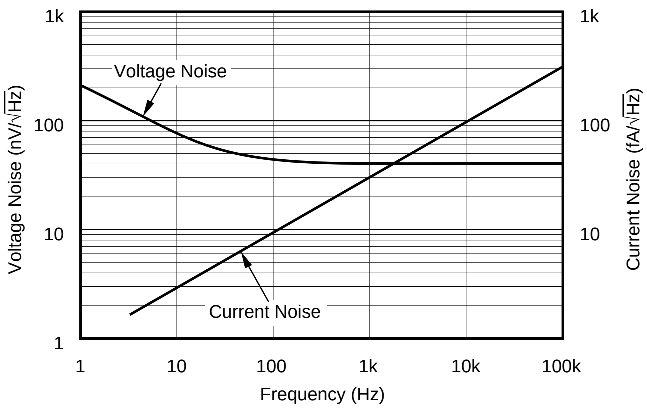




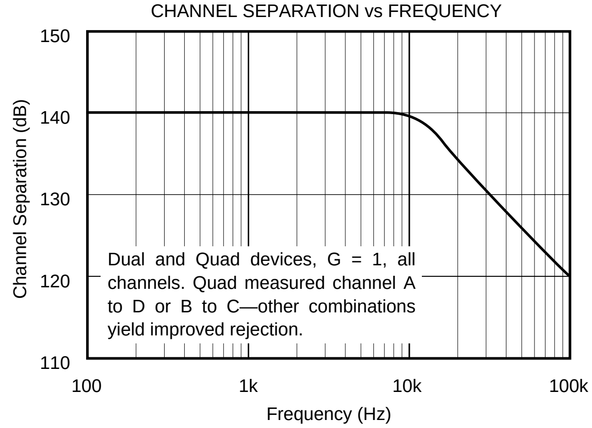
TYPICAL PERFORMANCE CURVES (Cont.)

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

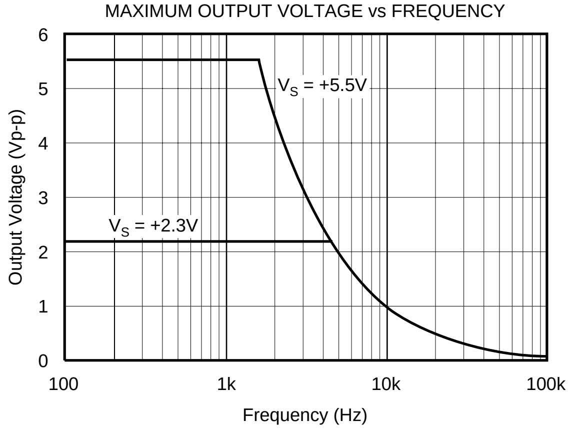
INPUT VOLTAGE AND CURRENT NOISE SPECTRAL DENSITY vs FREQUENCY



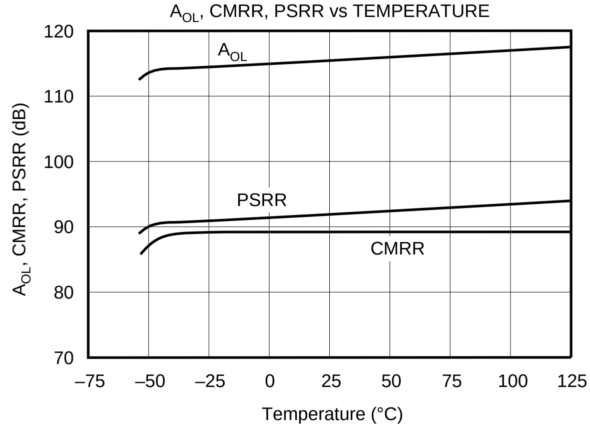
CHANNEL SEPARATION vs FREQUENCY



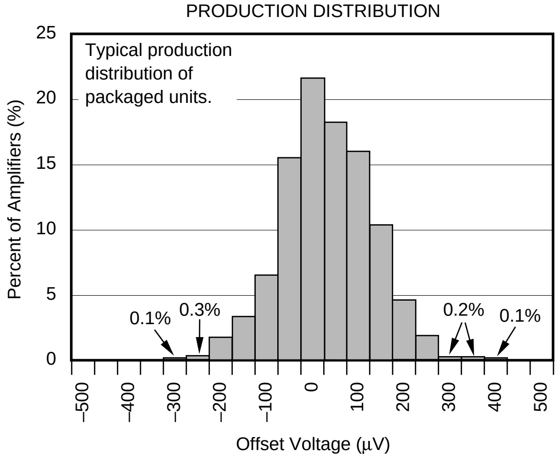
MAXIMUM OUTPUT VOLTAGE vs FREQUENCY



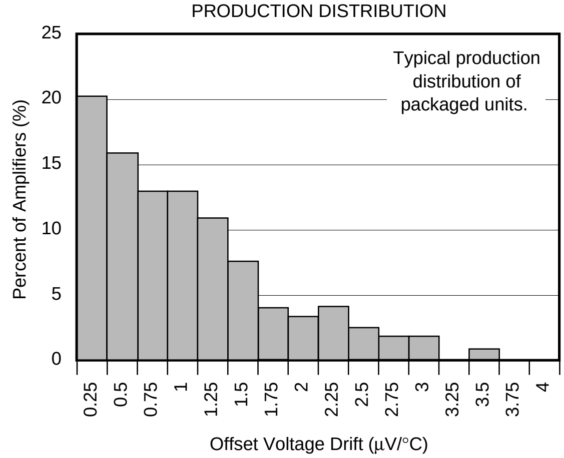
A_{OL}, CMRR, PSRR vs TEMPERATURE



OFFSET VOLTAGE PRODUCTION DISTRIBUTION



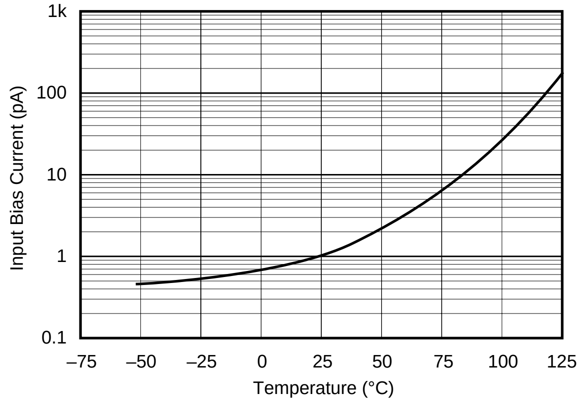
OFFSET VOLTAGE DRIFT MAGNITUDE PRODUCTION DISTRIBUTION



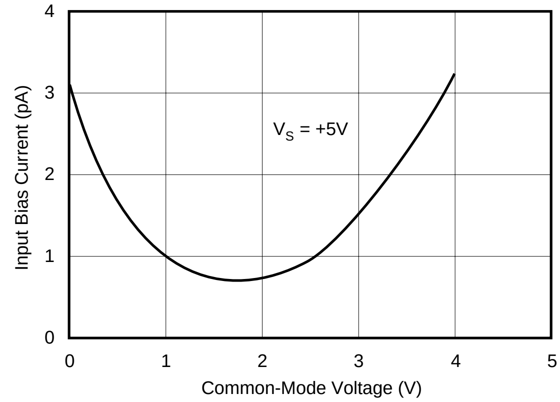
TYPICAL PERFORMANCE CURVES (Cont.)

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

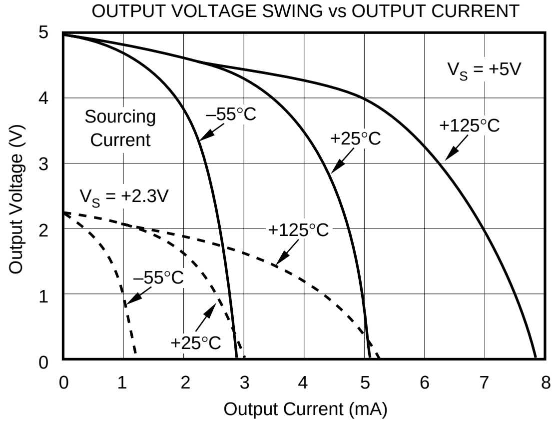
INPUT BIAS CURRENT vs TEMPERATURE



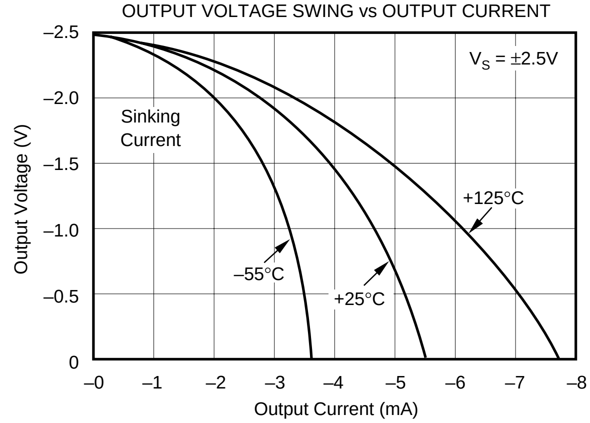
INPUT BIAS CURRENT
vs INPUT COMMON-MODE VOLTAGE



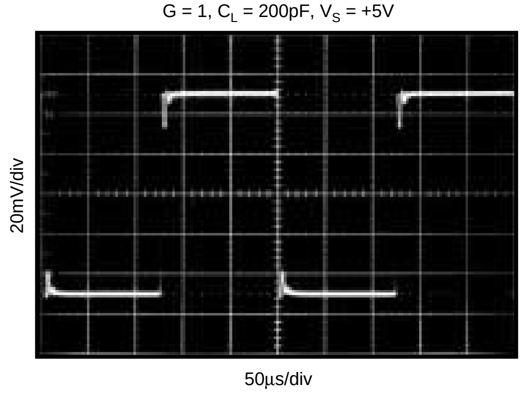
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



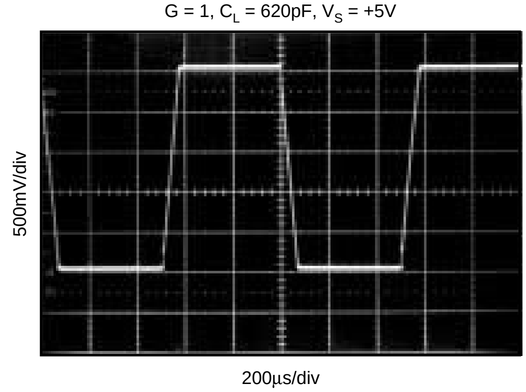
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



SMALL-SIGNAL STEP RESPONSE
G = 1, C_L = 200pF, V_S = +5V



LARGE-SIGNAL STEP RESPONSE
G = 1, C_L = 620pF, V_S = +5V



APPLICATIONS INFORMATION

OPA336 series op amps are fabricated on a state-of-the-art 0.6 micron CMOS process. They are unity-gain stable and suitable for a wide range of general-purpose applications. Power-supply pins should be bypassed with 0.01µF ceramic capacitors. OPA336 series op amps are protected against reverse battery voltages.

OPERATING VOLTAGE

OPA336 series op amps can operate from a +2.1V to +5.5V single supply with excellent performance. Most behavior remains unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltage are shown in the typical performance curves. OPA336 series op amps are fully specified for operation from +2.3V to +5.5V; a single limit applies over the supply range. In addition, many parameters are guaranteed over the specified temperature range, –40°C to +85°C.

INPUT VOLTAGE

The input common-mode range of OPA336 series op amps extends from (V–) – 0.2V to (V+) – 1V. For normal operation, inputs should be limited to this range. The absolute maximum input voltage is 300mV beyond the supplies. Thus, inputs greater than the input common-mode range but less than maximum input voltage, while not valid, will not cause any damage to the op amp. Furthermore, the inputs may go beyond the power supplies without phase inversion, as shown in Figure 1, unlike some other op amps.

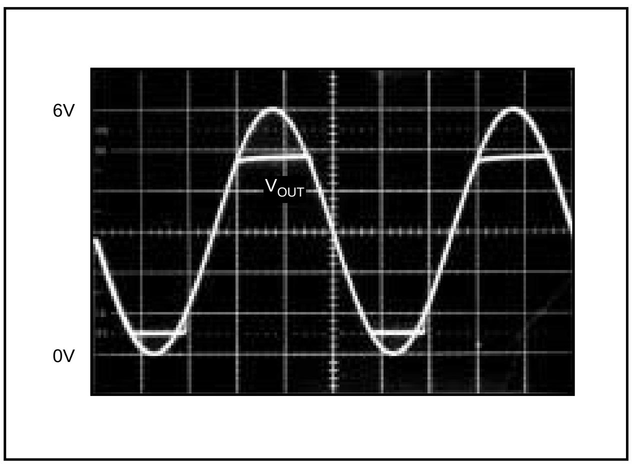


FIGURE 1. No Phase Inversion with Inputs Greater than the Power-Supply Voltage.

Normally, input bias current is approximately 1pA. However, input voltages exceeding the power supplies can cause excessive current to flow in or out of the input pins. Momentary voltages greater than the power supply can be tolerated as long as the current on the input pins is limited to 10mA. This is easily accomplished with an input resistor, as shown in Figure 2.

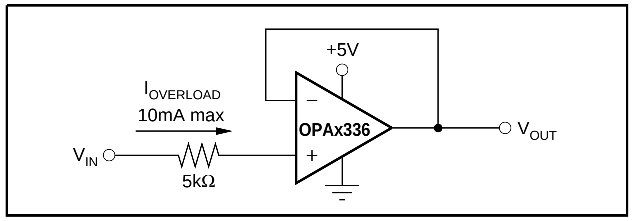


FIGURE 2. Input Current Protection for Voltages Exceeding the Supply Voltage.

CAPACITIVE LOAD AND STABILITY

OPA336 series op amps can drive a wide range of capacitive loads. However, all op amps under certain conditions may become unstable. Op-amp configuration, gain, and load value are just a few of the factors to consider when determining stability.

When properly configured, OPA336 series op amps can drive approximately 10,000pF. An op amp in unity-gain configuration is the most vulnerable to capacitive load. The capacitive load reacts with the op amp's output resistance, along with any additional load resistance, to create a pole in the response which degrades the phase margin. In unity gain, OPA336 series op amps perform well with a pure capacitive load up to about 300pF. Increasing gain enhances the amplifier's ability to drive loads beyond this level.

One method of improving capacitive load drive in the unity-gain configuration is to insert a 50Ω to 100Ω resistor inside the feedback loop, as shown in Figure 3. This reduces ringing with large capacitive loads while maintaining DC

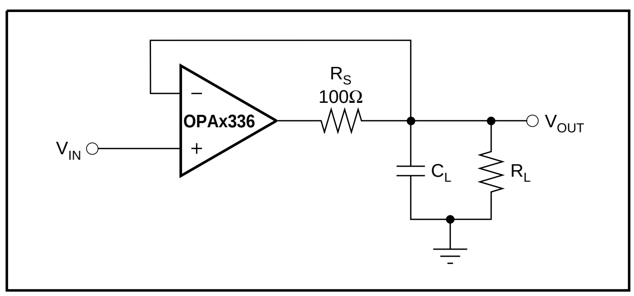


FIGURE 3. Series Resistor in Unity-Gain Configuration Improves Capacitive Load Drive.

accuracy. For example, with R_L = 25kΩ, OPA336 series op amps perform well with capacitive loads in excess of 1000pF, as shown in Figure 4. Without R_S, capacitive load drive is typically 350pF for these conditions, as shown in Figure 5.

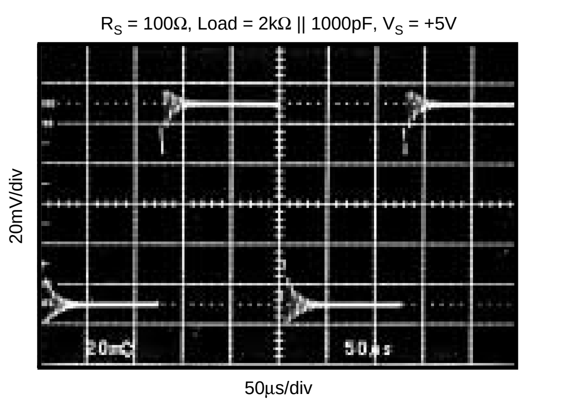


FIGURE 4. Small-Signal Step Response Using Series Resistor to Improve Capacitive Load Drive.

Alternatively, the resistor may be connected in series with the output outside of the feedback loop. However, if there is a resistive load parallel to the capacitive load, it and the series resistor create a voltage divider. This introduces a Direct Current (DC) error at the output, however, this error may be insignificant. For instance, with R_L = 100kΩ and R_S = 100Ω, there is only about a 0.1% error at the output.

Figure 5 shows the recommended operating regions for the OPA336. Decreasing the load resistance generally improves capacitive load drive. Figure 5 also illustrates how stability differs depending on where the resistive load is connected. With G = +1 and R_L = 10kΩ connected to V_S/2, the OPA336 can typically drive 500pF. Connecting the same load to ground improves capacitive load drive to 1000pF.

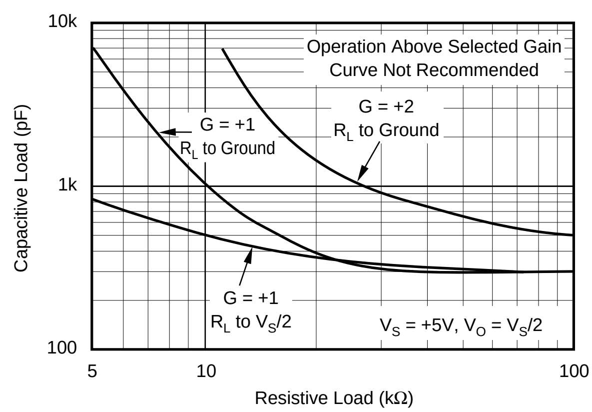


FIGURE 5. Stability—Capacitive Load vs Resistive Load.