High-Speed ($A_{VCL} \geq 10$) Programmable Micropower Operational Amplifier

OP-32

FEATURES

- Programmable Supply Current ..... 500nA to 2mA
- Single Supply Operation ..... +3V to +30V
- Dual Supply Operation ..... ±1.5V to ±15V
- Low Input Offset Voltage 100μV
- Low Input Offset Voltage Drift ..... 0.5μV/°C
- High Common-Mode Input Range ..... V– to V+ (–1.5V)
- High CMRR and PSRR 115dB
- High Open-Loop Gain 2000V/mV
- ±30V Input Overvoltage Protection
- Fast ..... 1V/μs @ I_{SY} = 300μA
- LM4250 Pinout
- Compensated for Minimum Gain of 10
- Available in Die Form

ORDERING INFORMATION †

T_A = 25°C V_{OS} MAX (μV)	PACKAGE CERDIP 8-PIN	PACKAGE PLASTIC 8-PIN	OPERATING TEMPERATURE RANGE
300	–	OP32AZ*	MIL
300	OP32EP	OP32EZ	IND
500	OP32FP	OP32FZ	IND
1000	OP32GP	OP32GZ	IND

* For devices processed in total compliance to MIL-STD-883, add /883 after part number. Consult factory for 883 data sheet.

† Burn-in is available on commercial and industrial temperature range parts in CerDIP, plastic DIP, and TO-can packages.

GENERAL DESCRIPTION

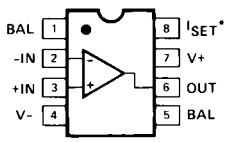
The OP-32 is a high-speed, high-gain programmable operational amplifier. Both offset voltage and offset current are low, and both are stable with changes in temperature, supply voltage, and set current. High CMRR and PSRR ensure precision performance when the OP-32 is used with an unregulated battery or vehicular electrical system.

The wide input voltage range, including the negative supply or ground, allows use in single-battery applications. The OP-32 is characterized over a wide supply range of ±1.5V to ±15V. This guarantees predictable performance with any commonly available supply.

The ability to operate at relatively high speed with low power consumption makes this amplifier ideal for remote applications where power is limited. The programmability allows each amplifier in a system to be set for the minimum power consumption necessary for each specific application. Programmability also makes it possible to adjust the bandwidth and phase shift.

The OP-32 pinout is identical to the LM4250 and many other micropower operational amplifiers. This allows easy upgrading of system performance.

PIN CONNECTIONS

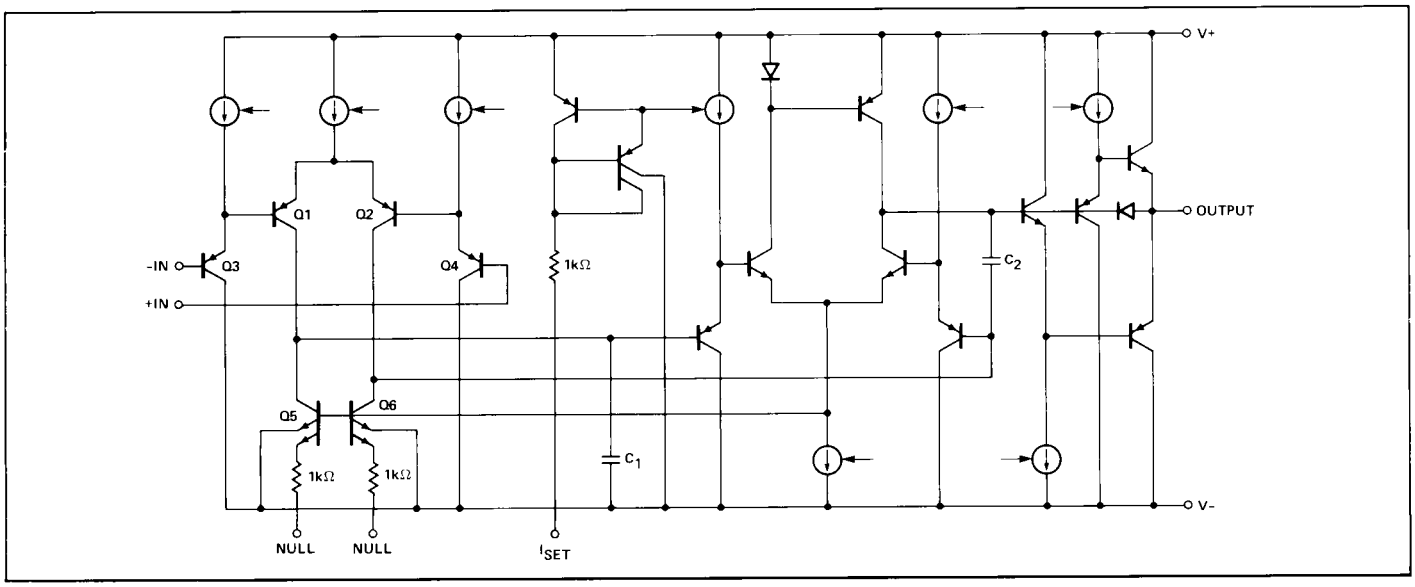


8-PIN EPOXY DIP (P-Suffix)

8-PIN HERMETIC DIP (Z-Suffix)

* DO **NOT** SHORT I_{SET} TO V- OR GROUND. SEE APPLICATIONS INFORMATION.

SIMPLIFIED SCHEMATIC



ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage ..... ±18V
Differential Input Voltage ..... ±30
Input Voltage ..... Supply Voltage
Storage Temperature Range
  Z Package ..... –65°C to +150°C
  P Package ..... –55°C to +125°C
Operating Temperature Range
  OP-32A ..... –55°C to +125°C
  OP-32E, F, G ..... –25°C to +85°C
Lead Temperature Range (Soldering, 60 sec) ..... 300°C
Junction Temperature ..... –65°C to +150°C

PACKAGE TYPE	Θ_{JA} (Note 2)	Θ_{JC}	UNITS
8-Pin Hermetic DIP (Z)	148	16	°C/W
8-Pin Plastic DIP (P)	103	43	°C/W

NOTES:
1. Absolute maximum ratings apply to both DICE and packaged parts, unless otherwise noted.
2. Θ_{JA} is specified for worst case mounting conditions, i.e., Θ_{JA} is specified for device in socket for CerDIP and P-DIP packages.

ELECTRICAL CHARACTERISTICS at $V_S = \pm 1.5V$ to $\pm 15V$, $15\mu A \le I_{SY} \le 450\mu A$, $T_A = +25°C$, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	OP-32A/E MIN	OP-32A/E TYP	OP-32A/E MAX	OP-32F MIN	OP-32F TYP	OP-32F MAX	OP-32G MIN	OP-32G TYP	OP-32G MAX	UNITS
Input Offset Voltage	V_{OS}		—	100	300	—	200	500	—	400	1000	μV
Input Offset current	I_{OS}	$V_{CM} = 0$	—	—	2	—	—	2	—	—	3	nA
Input Bias Current (Note 1)	I_B	$I_{SY} = 15\mu A$	—	3	5	—	5	7.5	—	5	10	nA
		$I_{SY} = 150\mu A$	—	20	35	—	24	35	—	30	50	
		$I_{SY} = 450\mu A$	—	60	90	—	70	100	—	80	125	
Input Voltage Range	IVR	$V_S = \pm 15V$	-15.0/13.5	—	—	-15.0/13.5	—	—	-15.0/13.5	—	—	V
Common-Mode Rejection Ratio (Note 2)	CMRR	$V_S = \pm 15V$ $-15V \le V_{CM} \le +13.5V$	100	115	—	95	110	—	85	100	—	dB
Power Supply Rejection Ratio (Note 2)	PSRR	$V_S = \pm 1.5V$ to $\pm 15V$; and V− = 0V, V+ = 3V to 30V.	—	1	6	—	3	12	—	10	25	μV/V
Large-Signal Voltage Gain	A_{VO}	$V_S = \pm 15V$, $R_L = 100k\Omega$, $I_{SY} = 15\mu A$ $R_L = 10k\Omega$, $150\mu A \le I_{SY} \le 450\mu A$	1000	2000	—	750	1500	—	500	1000	—	V/mV
Output Voltage Swing	V_O	$V_S = \pm 1.5V$ $R_L = 100k\Omega$, $I_{SY} = 15\mu A$ $R_L = 10k\Omega$, $150\mu A \le I_{SY} \le 450\mu A$	±0.8	±0.88	—	±0.8	±0.88	—	±0.75	±0.85	—	V
		$V_S \pm 15V$ $R_L = 100k\Omega$, $I_{SY} = 15\mu A$ $R_L = 10k\Omega$, $150\mu A \le I_{SY} \le 450\mu A$	±14	±14.2	—	±14	±14.2	—	±13.8	±14.2	—	V
Gain-Bandwidth Product		$I_{SY} = 15\mu A$, $R_L = 100k\Omega$	—	100	—	—	100	—	—	100	—	kHz
		$I_{SY} = 450\mu A$, $R_L = 10k\Omega$	—	4500	—	—	4500	—	—	4500	—	
Slew Rate	SR	$V_S = \pm 15V$, $I_{SY} = 450\mu A$, $R_L = 10k\Omega$	—	1.5	—	—	1.5	—	—	1.5	—	V/μs
Supply Current No Load (Note 3)	I_{SY}	$V_S = \pm 15V$, $I_{SET} = 1\mu A$	—	15	17	—	15	19	—	15	21	μA
		$I_{SET} = 10\mu A$	—	150	170	—	150	190	—	150	200	
		$I_{SET} = 30\mu A$	—	450	525	—	450	600	—	450	650	
		$V_S = \pm 1.5V$, $I_{SET} = 1\mu A$	—	10.5	12.5	—	11	15	—	11	18	μA
		$I_{SET} = 10\mu A$	—	105	125	—	110	150	—	110	180	
		$I_{SET} = 30\mu A$	—	350	400	—	350	450	—	350	500	

NOTES:
1. I_B and I_{OS} are measured at $V_{CM} = 0$.
2. PSRR and CMRR measured with V_{OS} unnulled and I_{SET} held constant.
3. The supply current (I_{SY}) is dependent on the set current (I_{SET}) and supply voltage as follows:

$$\frac{I_{SY}}{I_{SET}} \simeq 10 + \frac{(V+) - (V-)}{6}$$

The range of I_{SY}/I_{SET} is approximately 10.5 to 15 over the specified operating range of $V_S = \pm 1.5V$ to $V_S = \pm 15V$.

ELECTRICAL CHARACTERISTICS at $V_S = \pm 1.5V$ to $\pm 15V$, $15\mu A \le I_{SY} \le 450\mu A$, $-55°C \le T_A \le +125°C$, unless otherwise noted.

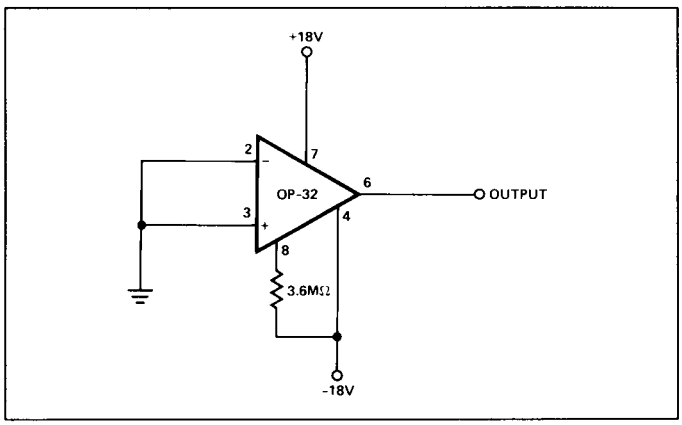
PARAMETER	SYMBOL	CONDITIONS	OP-32A MIN	OP-32A TYP	OP-32A MAX	UNITS
Average Input Offset Voltage Drift (Note 1)	TCV_{OS}	Unnulled	–	0.5	2.0	µV/°C
Input Offset Voltage	V_{OS}		–	175	400	µV
Input Offset Current	I_{OS}	$V_{CM} = 0$	–	–	2	nA
Average Input Offset Current Drift	TCI_{OS}	(Notes 1, 2)	–	1	10	pA/°C
Input Bias Current (Note 2)	I_B	$I_{SY} = 15\mu A$ $I_{SY} = 150\mu A$ $I_{SY} = 450\mu A$	– – –	3 20 60	5 35 90	nA
Input Voltage Range	IVR	$V_S = \pm 15V$	−15.0/13.5	–	–	V
Common-Mode Rejection Ratio (Note 3)	CMRR	$V_S = \pm 15V$ $-15V \le V_{CM} \le +13.5$ $I_{SET} = 10\mu A$ $I_{SET} = 1\mu A$	 90 80	 110 90	 – –	dB
Power Supply Rejection Ratio (Note 3)	PSRR	$V_S = \pm 1.5V$ to $\pm 15V$ & V− = 0V, V+ = 3V to 30V (V_{CM} = 1.5V)	–	2	10	µV/V
Large-Signal Voltage Gain	A_{VO}	$V_S = \pm 15V$, $R_L = 100k\Omega$, $I_{SY} = 15\mu A$ $R_L = 10k\Omega$, $150\mu A \le I_{SY} \le 450\mu A$	 200 500	 400 1000	 – –	V/mV
Output Voltage Swing	V_O	$V_S = \pm 1.5V$ $R_L = 100k\Omega$, $I_{SY} = 15\mu A$ $R_L = 10k\Omega$, $150\mu A \le I_{SY} \le 450\mu A$	±0.65	±0.75	–	V
		$V_S = \pm 15V$ $R_L = 100k\Omega$, $I_{SY} = 15\mu A$ $R_L = 10k\Omega$, $150\mu A \le I_{SY} \le 450\mu A$	±13.6	±14.0	–	V
Supply Current No Load (Note 4)	I_{SY}	$V_S = \pm 15V$ $I_{SET} = 1\mu A$ $I_{SET} = 10\mu A$ $I_{SET} = 30\mu A$	 – – –	 16 160 450	 18 180 550	µA
		$V_S = \pm 1.5V$ $I_{SET} = 1\mu A$ $I_{SET} = 10\mu A$ $I_{SET} = 30\mu A$	 – – –	 12 120 360	 14 140 450	µA

NOTES:

1. Sample tested.
2. I_B and I_{OS} are measured at $V_{CM} = 0$.
3. PSRR and CMRR measured with V_{OS} unnulled and I_{SET} held constant.
4. The supply current (I_{SY}) is dependent on the set current (I_{SET}) and supply voltage as follows:

$$\frac{I_{SY}}{I_{SET}} \simeq 10 + \frac{(V+) - (V-)}{6}$$

BURN-IN CIRCUIT*



*Other circuits may apply at ADI's discretion.

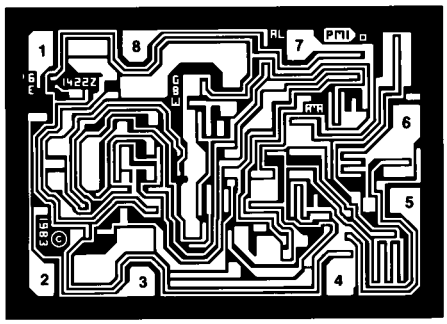
ELECTRICAL CHARACTERISTICS at $V_S = \pm 1.5V$ to $\pm 15V$, $15\mu A \le I_{SY} \le 450\mu A$, $-25°C \le T_A \le +85°C$, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	OP-32E MIN	OP-32E TYP	OP-32E MAX	OP-32F MIN	OP-32F TYP	OP-32F MAX	OP-32G MIN	OP-32G TYP	OP-32G MAX	UNITS
Average Input Offset Voltage Drift (Note 1)	TCV_{OS}	Unnulled	—	0.5	1.5	—	1.0	2.0	—	1.5	3.0	μV/°C
Input Offset Voltage	V_{OS}		—	100	400	—	200	600	—	500	1200	μV
Input Offset Current	I_{OS}	$V_{CM} = 0$	—	—	2	—	—	2	—	—	3	nA
Average Input Offset Current Drift	TCI_{OS}	(Notes 1, 2)	—	2	10	—	3	15	—	5	25	pA/°C
Input Bias Current (Note 2)	I_B	$I_{SY} = 15\mu A$	—	3	5	—	5	7.5	—	5	10	nA
		$I_{SY} = 150\mu A$	—	20	35	—	24	35	—	30	50	
		$I_{SY} = 450\mu A$	—	60	90	—	70	100	—	80	125	
Input Voltage Range	IVR	$V_S = \pm 15V$	−15.0/13.5	—	—	−15.0/13.5	—	—	−15.0/13.5	—	—	V
Common-Mode Rejection Ratio (Note 3)	CMRR	$V_S = \pm 15V$ & $-15V \le V_{CM} \le +13.5V$	95	110	—	90	105	—	80	100	—	dB
Power Supply Rejection Ratio (Note 3)	PSRR	$V_S = \pm 1.5V$ to $\pm 15V$ & $V- = 0V$, $V+ = 3V$ to $30V$	—	3.2	10	—	10	32	—	32	56	μV/V
Large-Signal Voltage Gain	A_{VO}	$V_S = \pm 15V$, $R_L = 100k\Omega$, $I_{SY} = 15\mu A$	750	1000	—	500	1000	—	400	1000	—	V/mV
		$R_L = 10k\Omega$, $150\mu A \le I_{SY} \le 450\mu A$	750	1000	—	500	1000	—	400	1000	—	
Output Voltage Swing	V_O	$V_S = \pm 1.5V$, $R_L = 100k\Omega$, $I_{SY} = 15\mu A$	±0.70	±0.75	—	±0.65	±0.75	—	±0.6	±0.7	—	V
		$V_S = \pm 1.5V$, $R_L = 10k\Omega$, $150\mu A \le I_{SY} \le 450\mu A$	±0.70	±0.75	—	±0.65	±0.75	—	±0.6	±0.7	—	
		$V_S = \pm 15V$, $R_L = 100k\Omega$, $I_{SY} = 15\mu A$	±13.8	±14.1	—	±13.6	±14.1	—	±13.0	±14.0	—	V
		$V_S = \pm 15V$, $R_L = 10k\Omega$, $150\mu A \le I_{SY} \le 450\mu A$	±13.8	±14.1	—	±13.6	±14.1	—	±13.0	±14.0	—	
Supply Current No Load (Note 4)	I_{SY}	$V_S = \pm 15V$, $I_{SET} = 1\mu A$	—	16	18	—	16	20	—	16	25	μA
		$I_{SET} = 10\mu A$	—	160	180	—	160	200	—	160	250	
		$I_{SET} = 30\mu A$	—	450	550	—	450	600	—	450	650	
		$V_S = \pm 1.5V$, $I_{SET} = 1\mu A$	—	12	14	—	12	17	—	12	25	μA
		$I_{SET} = 10\mu A$	—	120	140	—	120	170	—	120	200	
		$I_{SET} = 30\mu A$	—	360	450	—	360	500	—	360	550	

NOTES:
1. Sample tested.
2. I_B and I_{OS} are measured at $V_{CM} = 0$.
3. PSRR and CMRR measured with V_{OS} unnulled and I_{SET} held constant.
4. The supply current (I_{SY}) is dependent on the set current (I_{SET}) and supply voltage as follows:

$$\frac{I_{SY}}{I_{SET}} \simeq 10 + \frac{(V+) - (V-)}{6}$$

DICE CHARACTERISTICS



DIE SIZE 0.070 X 0.050 inch, 3500 sq. mils
(1.78 X 1.27 mm, 2.26 sq. mm)

1. BALANCE
2. INVERTING INPUT
3. NONINVERTING INPUT
4. V–
5. BALANCE
6. OUTPUT
7. V+
8. I_{SET}

WAFER TEST LIMITS at V_S = ±1.5V to ±15V, 15µA ≤ I_{SY} ≤ 450µA, T_A = 25°C, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	OP-32N LIMIT	OP-32G LIMIT	OP-32GR LIMIT	UNITS
Input Offset Voltage	V_{OS}		300	500	1000	µV MAX
Input Offset Current	I_{OS}	V_{CM} = 0	2	2	3	nA MAX
Input Bias Current (Note 1)	I_B	I_{SY} = 15µA	5	7.5	10	nA MAX
		I_{SY} = 150µA	35	35	50	
		I_{SY} = 450µA	90	100	125	
Input Voltage Range	IVR	V_S = ±15V	−15/13.5	−15/13.5	−15/13.5	V MIN
Common-Mode Rejection Ratio (Note 2)	CMRR	V_S = ±15V, −15V ≤ V_{CM} ≤ +13.5V	100	95	85	dB MIN
Power Supply Rejection Ratio (Note 2)	PSRR	V_S = ±1.5V to ±15V & V− = 0V, V+ = 3V to 30V	6	12	25	µV/V MAX
Large-Signal Voltage Gain	A_{VO}	V_S = ±15V, R_L = 100kΩ, I_{SY} = 15µA	1000	750	500	V/mV MIN
		R_L = 10kΩ, 150µA ≤ I_{SY} ≤ 450µA	1000	750	500	
Output Voltage Swing	V_O	V_S = ±1.5V, R_L = 100kΩ, I_{SY} = 15µA, R_L = 100kΩ, 150µA ≤ I_{SY} ≤ 450µA	±0.8	±0.8	±0.75	V MIN
		V_S = ±15V, R_L = 100kΩ, I_{SY} = 15µA, R_L = 10kΩ, 150µA ≤ I_{SY} ≤ 450µA	±14	±14	±13.8	V MIN
Supply Current No Load (Note 3)	I_{SY}	V_S = ±1.5V, I_{SET} = 1µA	12.5	15	18	µA MAX
		I_{SET} = 10µA	125	150	180	
		I_{SET} = 30µA	400	450	500	
		V_S = ±15V, I_{SET} = 1µA	17	19	21	µA MAX
		I_{SET} = 10µA	170	190	200	
		I_{SET} = 30µA	525	600	650	

NOTES:

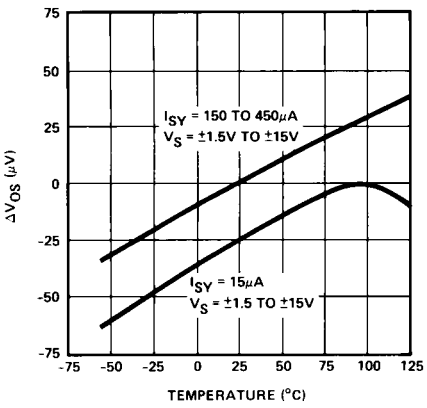
1. I_B and I_{OS} are measured at V_{CM} = 0.
2. PSRR and CMRR measured with V_{OS} unnulled and I_{SET} held constant.
3. The supply current (I_{SY}) is dependent on the set current (I_{SET}) and supply voltage as follows:

$$\frac{I_{SY}}{I_{SET}} \simeq 10 + \frac{(V+) - (V-)}{6}$$

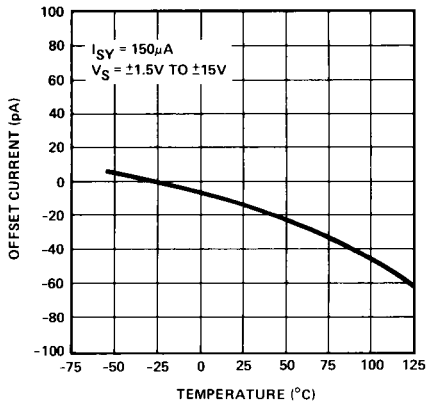
Electrical tests are performed at wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualification through sample lot assembly and testing.

TYPICAL DC PERFORMANCE CHARACTERISTICS

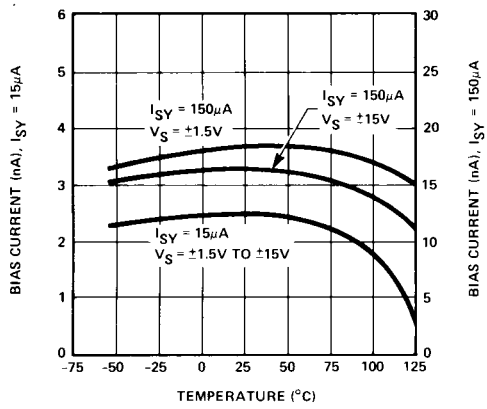
OFFSET VOLTAGE vs TEMPERATURE



OFFSET CURRENT vs TEMPERATURE

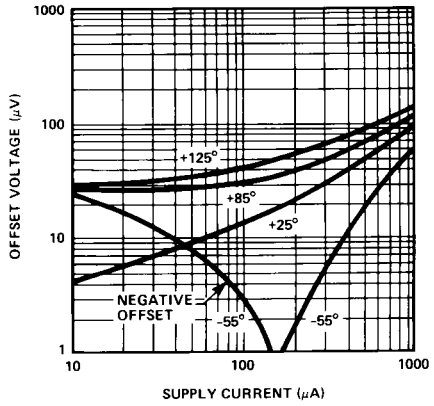


BIAS CURRENT vs TEMPERATURE

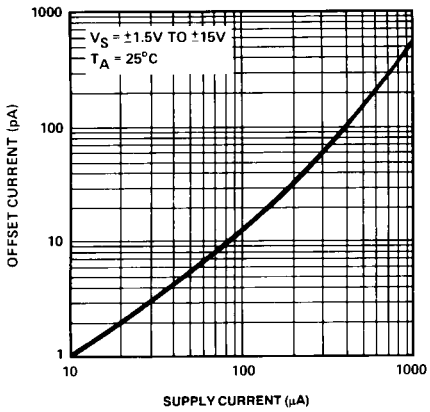


TYPICAL DC PERFORMANCE CHARACTERISTICS

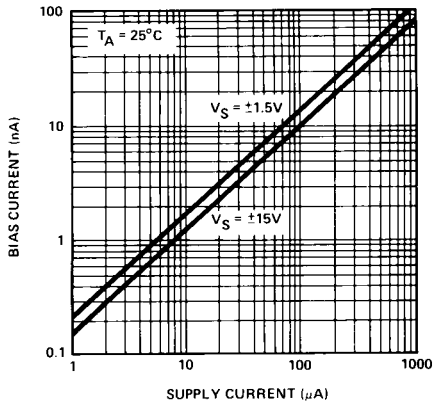
OFFSET VOLTAGE vs SUPPLY CURRENT



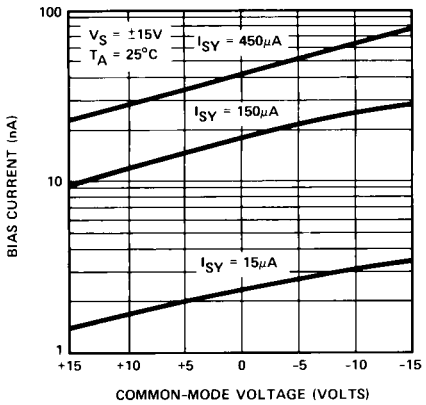
OFFSET CURRENT vs SUPPLY CURRENT



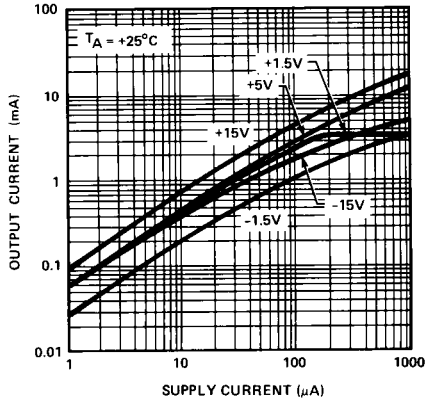
BIAS CURRENT vs SUPPLY CURRENT



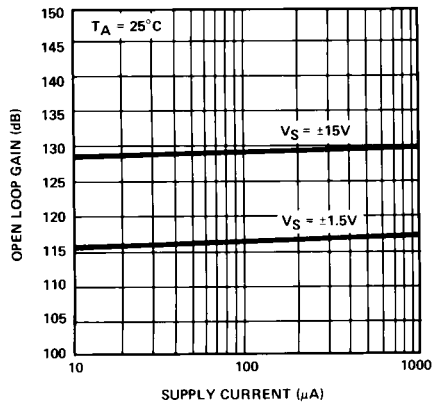
BIAS CURRENT vs COMMON-MODE VOLTAGE



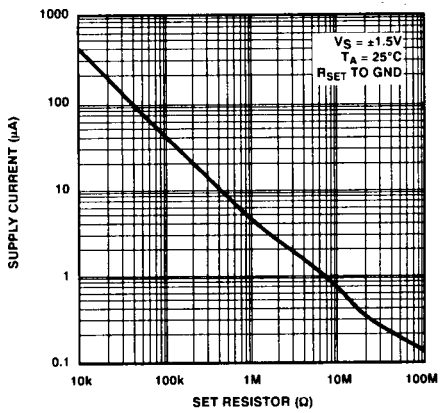
MAXIMUM OUTPUT CURRENT vs SUPPLY CURRENT AT $V_S = \pm 15V$, +5V AND ±1.5V



OPEN-LOOP GAIN vs SUPPLY CURRENT

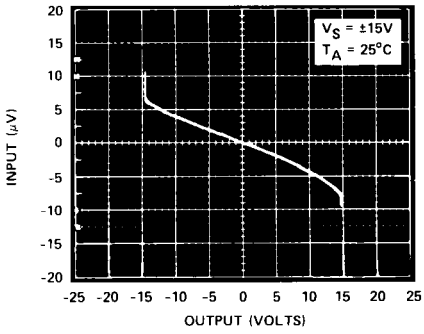


SUPPLY CURRENT vs SET RESISTOR

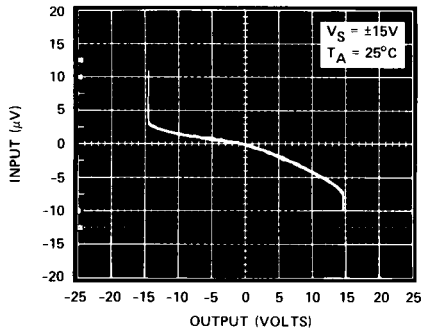


TYPICAL DC OPEN-LOOP INPUT-OUTPUT CHARACTERISTICS

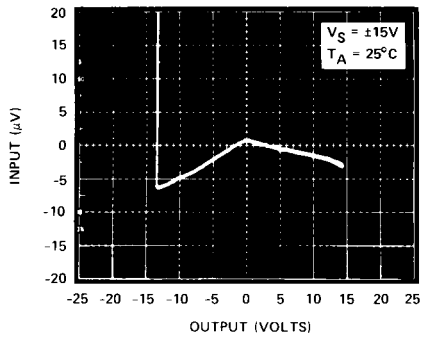
I_{SY} = 1mA, R_L = 100kΩ



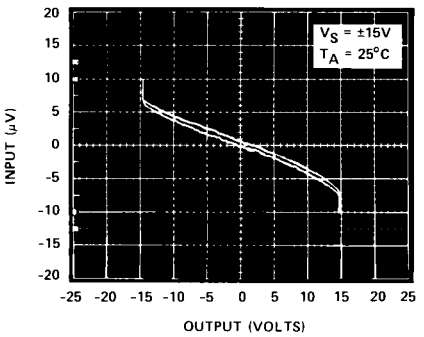
I_{SY} = 1mA, R_L = 10kΩ



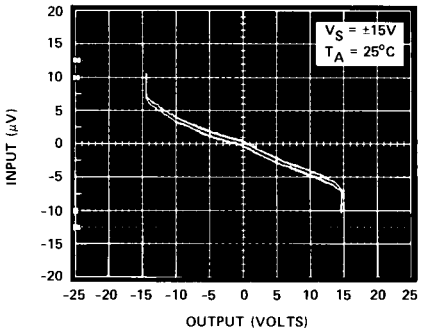
I_{SY} = 1mA, R_L = 2kΩ



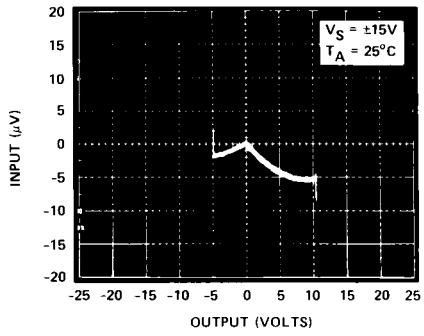
I_{SY} = 100μA, R_L = 100kΩ



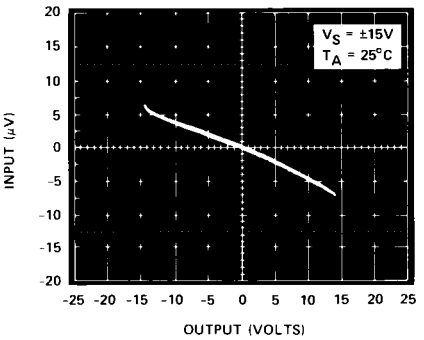
I_{SY} = 100μA, R_L = 10kΩ



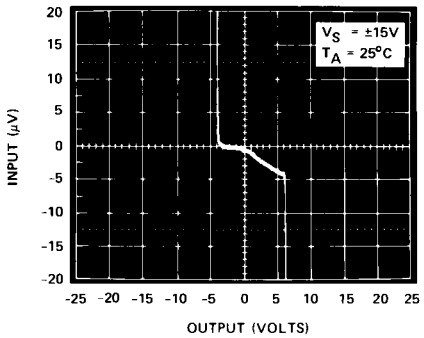
I_{SY} = 100μA, R_L = 2kΩ



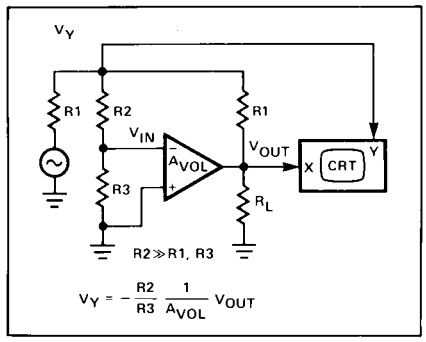
I_{SY} = 10μA, R_L = 100kΩ



I_{SY} = 10μA, R_L = 10kΩ



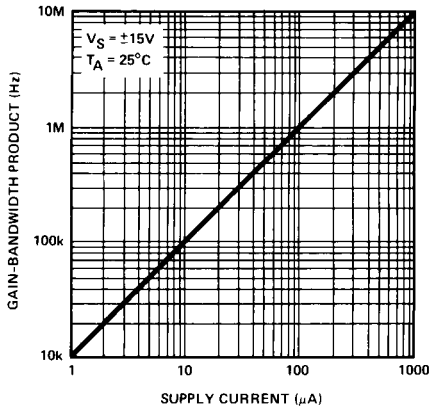
TEST CIRCUIT



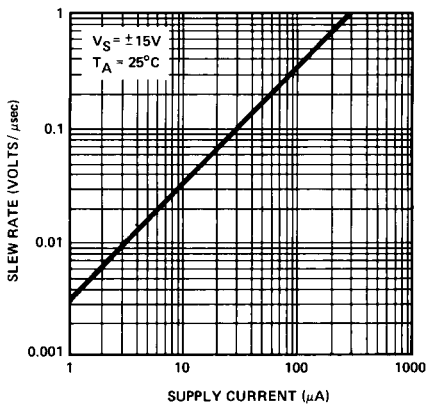
OP-32

TYPICAL AC PERFORMANCE CHARACTERISTICS

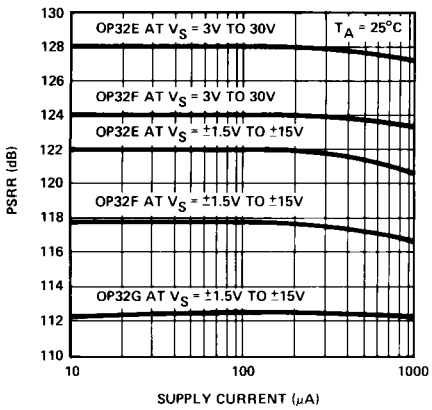
GAIN-BANDWIDTH PRODUCT vs SUPPLY CURRENT



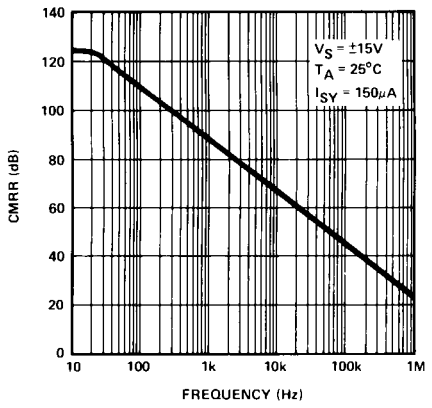
SLEW RATE vs SUPPLY CURRENT



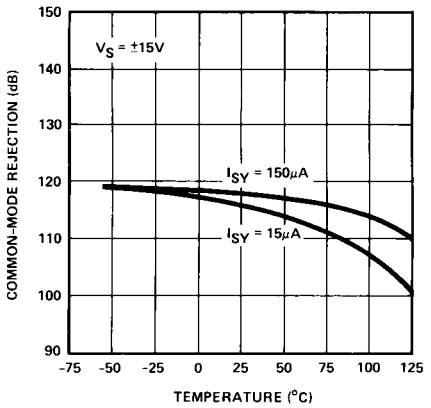
POWER SUPPLY REJECTION vs SUPPLY CURRENT



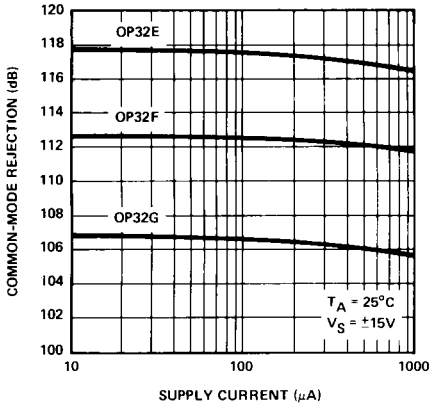
COMMON-MODE REJECTION vs FREQUENCY



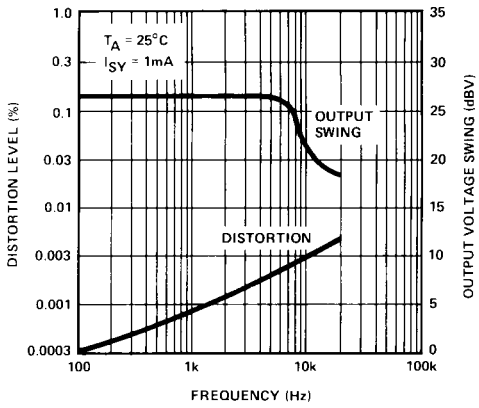
COMMON-MODE REJECTION vs TEMPERATURE



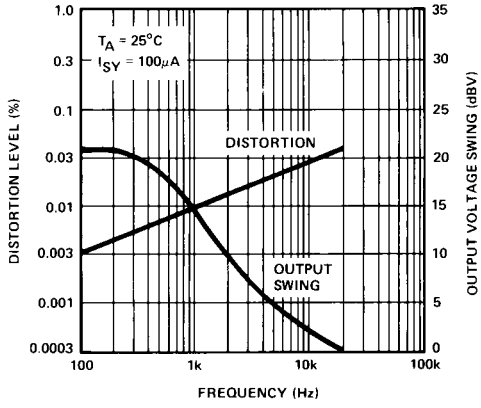
COMMON-MODE REJECTION vs SUPPLY CURRENT



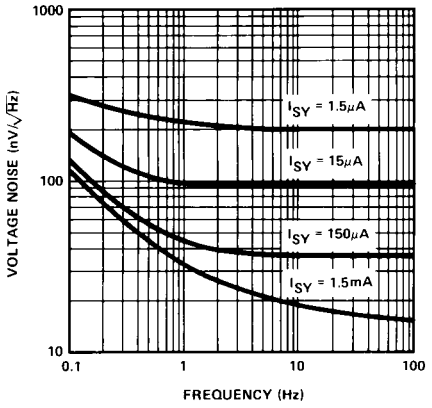
TOTAL HARMONIC DISTORTION vs FREQUENCY



TOTAL HARMONIC DISTORTION vs FREQUENCY



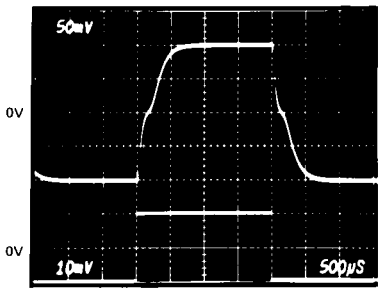
VOLTAGE NOISE vs FREQUENCY



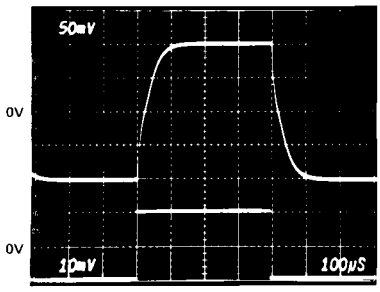
TYPICAL AC PERFORMANCE CHARACTERISTICS

SMALL-SIGNAL TRANSIENT RESPONSE vs SUPPLY CURRENT

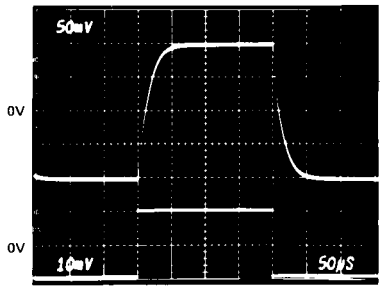
$I_{SY} = 1.5\mu A$



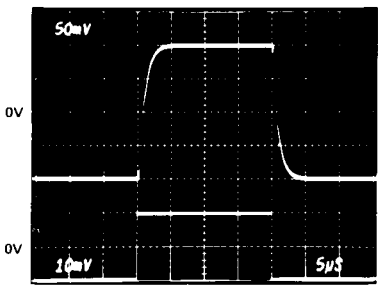
$I_{SY} = 7.5\mu A$



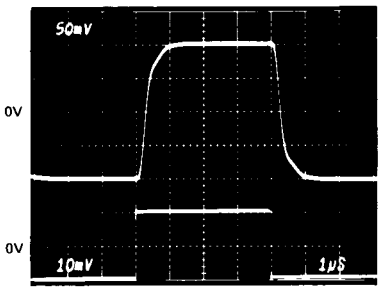
$I_{SY} = 15\mu A$



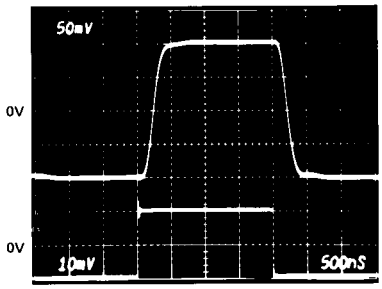
$I_{SY} = 150\mu A$



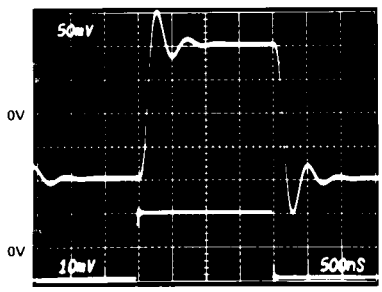
$I_{SY} = 450\mu A$



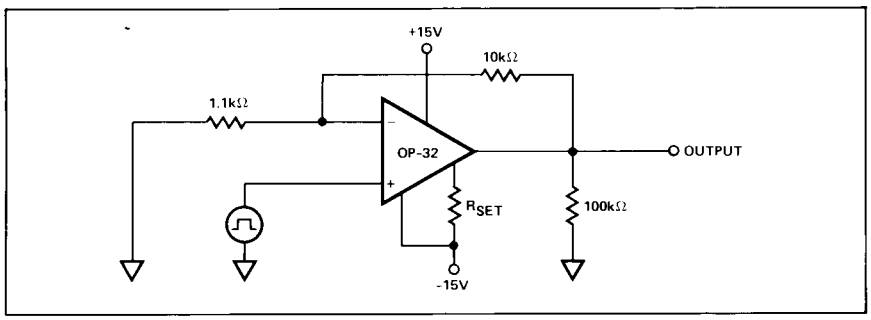
$I_{SY} = 750\mu A$



$I_{SY} = 1.5mA$



TEST CIRCUIT

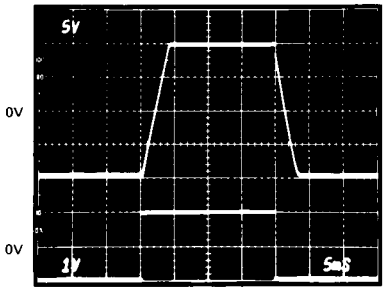


OP-32

TYPICAL AC PERFORMANCE CHARACTERISTICS

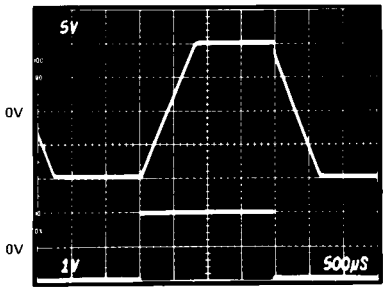
LARGE-SIGNAL TRANSIENT RESPONSE vs SUPPLY CURRENT

$I_{SY} = 1.5\mu A$



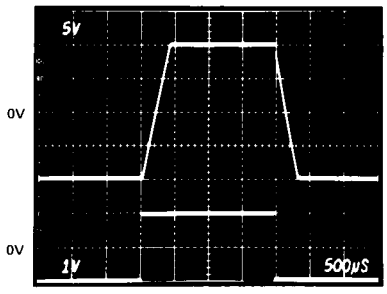
R_{F1} = 110kΩ, R_{F2} = 1MΩ, R_L = OPEN

$I_{SY} = 7.5\mu A$



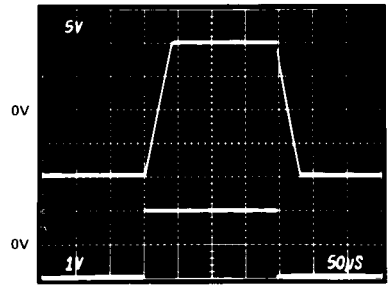
R_{F1} = 11kΩ, R_{F2} = 100kΩ, R_L = 1MΩ

$I_{SY} = 15\mu A$



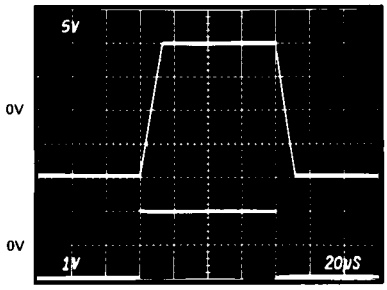
R_{F1} = 11kΩ, R_{F2} = 100kΩ, R_L = 1MΩ

$I_{SY} = 150\mu A$



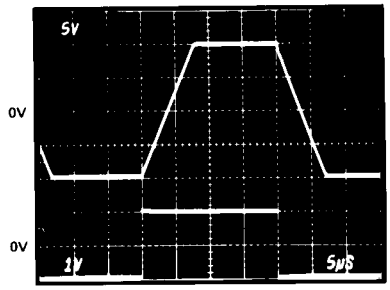
R_{F1} = 1.1kΩ, R_{F2} = 10kΩ, R_L = 100kΩ

$I_{SY} = 450\mu A$



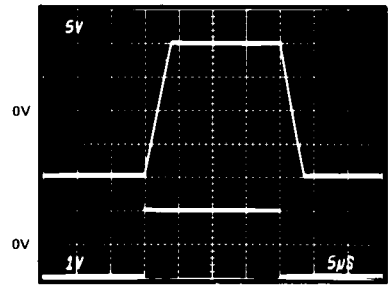
R_{F1} = 1.1kΩ, R_{F2} = 10kΩ, R_L = 100kΩ

$I_{SY} = 750\mu A$



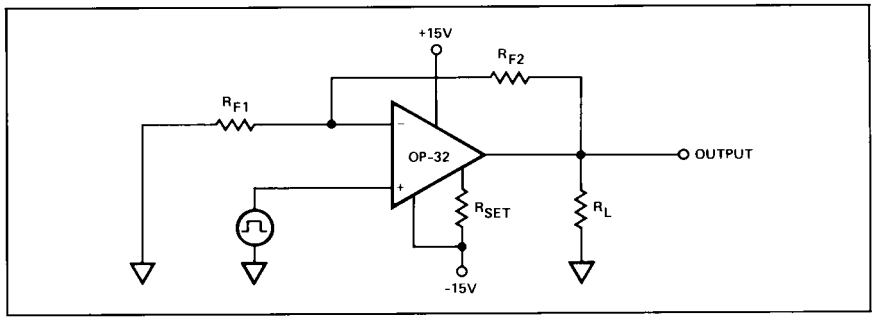
R_{F1} = 1.1kΩ, R_{F2} = 10kΩ, R_L = 100kΩ

$I_{SY} = 1.5mA$



R_{F1} = 1.1kΩ, R_{F2} = 10kΩ, R_L = 100kΩ

TEST CIRCUIT



APPLICATIONS INFORMATION

SETTING SUPPLY CURRENT

The op amp power supply current is determined by the current flowing out of pin 8. Pin 8 is at the V+ voltage less two diode drops, which is approximately V+ minus 1.1V. Do not connect pin 8 to ground or V− without a set resistor in series or excessive supply current will be drawn which may damage the OP-32.

The set resistor value is selected to make the power supply current optimum for the specific application. Adjusting the OP-32 power supply current determines the slew-rate, bandwidth, and the output current limits (see Performance Characteristics). The supply current is nominally 15 times the set current and the set resistor value is calculated from:

$$R_S = \frac{(V_{SUPPLY} - 1.1V)}{I_{SET}}, \text{ where } I_{SY} \simeq 15\, I_{SET}$$

(See graph below)

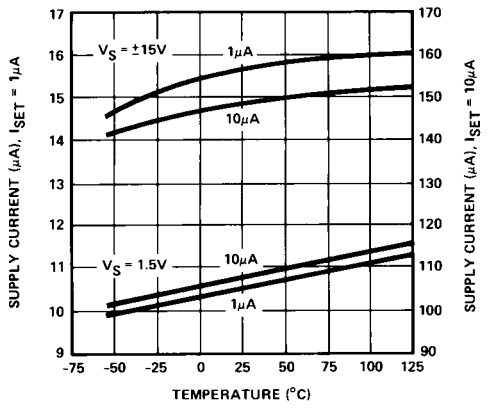
Note that the set resistor can go to either negative supply or to ground. If the set resistor goes to negative supply, then $V_{SUPPLY} = (V+) - (V-)$. For a single-supply circuit, V_{SUPPLY} is simply (V+). If the supply voltage varies widely, set current can be stabilized with circuits (a), (b), or (c).

The relationship between supply voltage, supply current and set current can be approximated by:

$$\frac{I_{SY}}{I_{SET}} \simeq 10 + \frac{(V+) - (V-)}{6} \quad (T_A = 25°C)$$

The ratio $\frac{I_{SY}}{I_{SET}}$ increases with temperature by approximately 0.05%/°C.

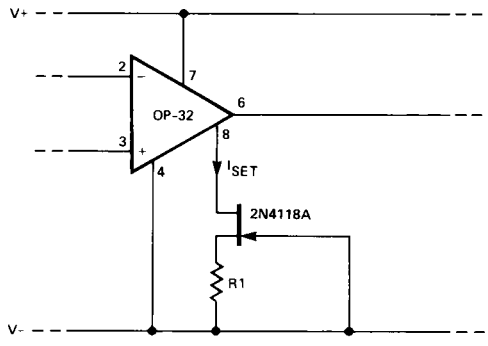
SUPPLY CURRENT vs TEMPERATURE



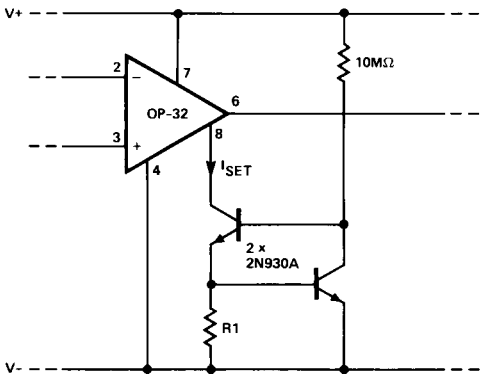
INPUT BIAS CURRENT

Input bias current varies directly with set current. The set current required for a given supply current ranges from $I_{SY}/10.5$ at ±1.5V supply voltage to $I_{SY}/15$ at ±15V. Therefore, I_B will be highest at the minimum supply voltage condition of ±1.5V (or 3V) for any given supply current.

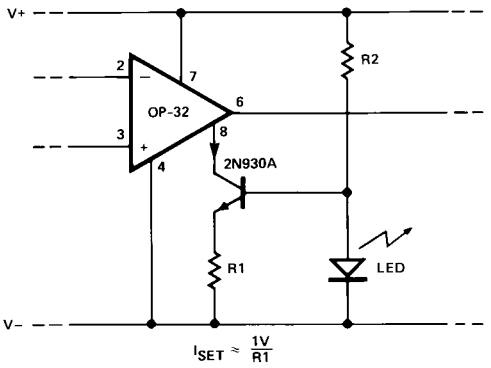
CURRENT SETTING CIRCUITS



(a) $I_{SET} \simeq \frac{V_p}{1.5R1}$, $I_{DSS} \gg I_{SET}$

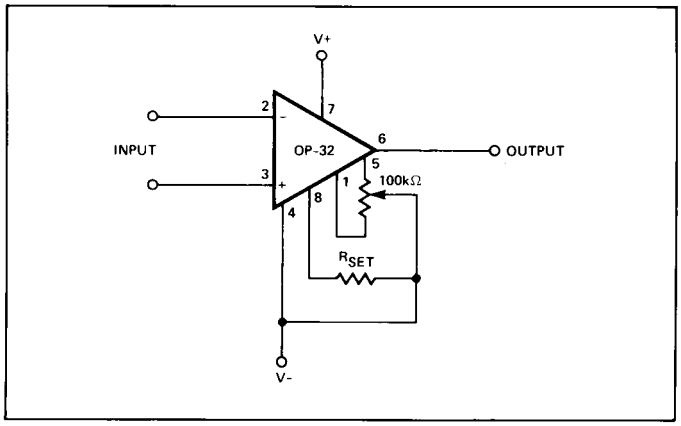


(b) $I_{SET} \simeq \frac{V_{BE}}{R1}$



(c) $I_{SET} \simeq \frac{1V}{R1}$

OFFSET NULLING CIRCUIT



BATTERY-POWERED, GAIN-OF-100 AMPLIFIER

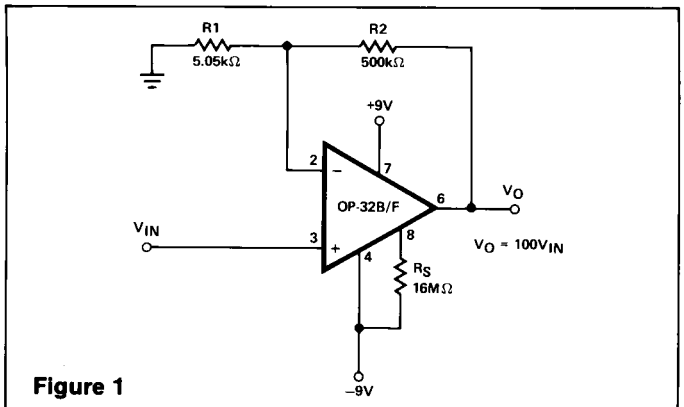


Figure 1

OFFSET VOLTAGE ADJUSTMENT

The offset voltage can be trimmed to zero using a 100kΩ potentiometer (see offset nulling circuit). Adjusting the pot wiper towards pin 5 causes the output to go positive. Adjustment range is approximately ±5mV at $V_S = \pm 15V$. The V_{OS} adjust range is proportional to supply voltage. Resolution of the nulling can be increased by using a smaller pot in conjunction with fixed resistors.

If power supply voltages vary widely and the set current is established by a resistor, the op amp supply currents will vary in proportion to the supply voltage changes. V_{OS} will remain almost constant with supply current changes if the null pins (1 and 5) are not used. If a V_{OS} adjust pot is used, current variations may flow through the offset pot causing an apparent V_{OS} change. If a V_{OS} adjust pot is used in combination with widely-varying supply voltages, a set-current stabilizer circuit as shown in (a), (b), or (c) is recommended.

APPLICATIONS EXAMPLE

BATTERY-POWERED, GAIN-OF-100 AMPLIFIER

The simple noninverting amplifier circuit shown in Figure 1 provides an accurate gain-of-100 while operating from a pair of 9V batteries. The circuit requires only 15μA of supply current. Slew-rate is approximately 0.06V/μsec and output swing is ±8V.

A value of 500kΩ was chosen for R_2. For a gain of 100, R_1 is calculated as:

$$A_{VCL} = 1 + \frac{R_2}{R_1}$$

$$100 = 1 + \frac{500k\Omega}{R_1}$$

$$\therefore R_1 = 5.05k\Omega$$

Using an OP-32B/F, we can expect an $I_B + I_{OS}/2$ of less than 8.5nA when operating at I_{SY} of 15μA, so the input offset caused by $I_B R_1$ will be negligible (8.5nA × 5.05kΩ ~ 43μV).

The set resistor R_S needed for a supply current of 15μA is calculated from:

$$R_S = \frac{V_{SUPPLY} - 1.1V}{I_{SY}/15} = \frac{18V - 1.1V}{1\mu A}$$

$$\therefore R_S = 16.9M\Omega$$

Offset voltage adjustment is optional. An OP-32B/F has maximum input offset voltage of 500μV which would cause an output offset voltage of 50mV. Drift over temperature is very low, typically less than 1.0μV/°C, and is guaranteed to be less than 2.0μV/°C. PSRR is also low, only 6μV/V, so battery voltage change has negligible effect on offset.

Most micropower programmable op amps lose open-loop gain and CMRR at low supply currents. The OP-32 design overcomes these limitations so accuracy is maintained at supply currents of only a few microamps. The OP-32B/F used in this example has a minimum open-loop gain of over 117dB. Gain error due to finite open-loop gain will be less than 100/750,000, which is only 133 PPM. CMRR will typically be 110dB, an error of 3 PPM. Gain accuracy of the circuit is almost entirely dependent on the accuracy of the R_1/R_2 ratio; the op amp contributes less than 0.015% gain error.

Considering all error sources, this simple ×100 battery-powered circuit using an OP-32B/F is capable of achieving excellent accuracy. Without external adjustments of any kind, output offset will be less than 54mV and gain accuracy will be better than ±0.015% (exclusive of R_2/R_1 error). Gain linearity, slew-rate symmetry, and stability over temperature are all excellent with the OP-32, making circuit performance very predictable.