

## FEATURES

- *Guaranteed max.*  $0.5\mu\text{V}/^\circ\text{C}$  Drift
- *Guaranteed max.*  $0.6\mu\text{V}$  pk-pk Noise
- *Guaranteed max.*  $2\text{nA}$  Bias Current
- *Guaranteed minimum*  $114\text{dB}$  CMRR

## APPLICATIONS

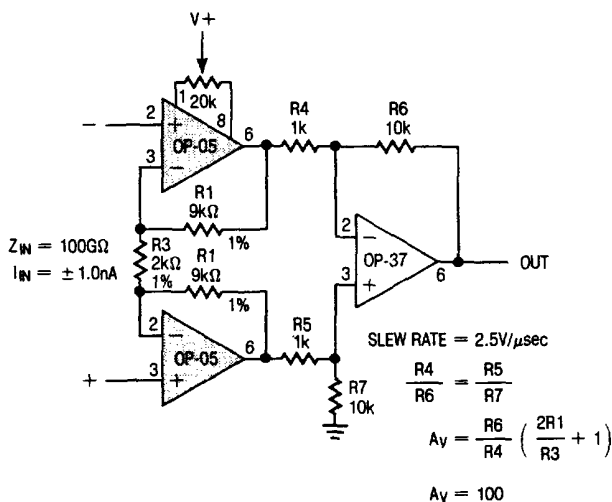
- Strain Gauges
- Thermocouple Amplifiers
- Instrumentation Amplifiers
- Medical Instruments

## DESCRIPTION

The OP-05 is an internally compensated op-amp which provides excellent input offset voltage, low bias current, very high common mode rejection, and low offset voltage drift with temperature when the input offset voltage is externally trimmed to zero. Direct replacement of similar devices in existing systems can result in significant system performance improvement without redesign. The OP-05 is particularly well suited for instrumentation and low signal level applications where precision and stability over time and temperature are important. Internal frequency compensation enhances the OP-05's versatility for a wide variety of precision op-amp uses. Linear's advanced design, process and test techniques ensure device performance as well as reliability. An instrumentation amplifier application is shown below. For higher performance requirements see the LT1001 single precision op amp and the LT1002 dual matched precision op amp series.

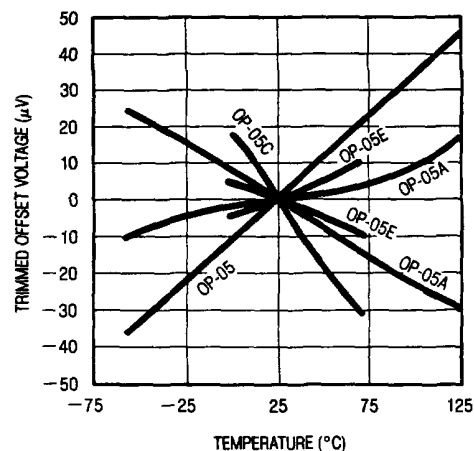
**2**

### Instrumentation Amplifier



### Trimmed Offset Voltage with Temperature of Six Representative Units

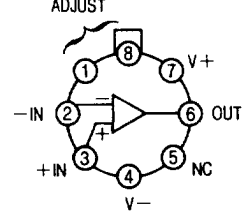
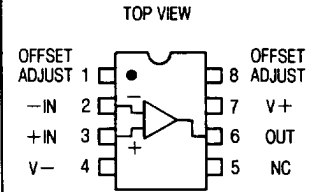
(Offset Trimmed to Zero at  $25^\circ\text{C}$  with  $20\text{k}\Omega$  Pot)



## ABSOLUTE MAXIMUM RATINGS

Supply Voltage	± 22V
Differential Input Voltage	± 30V
Input Voltage Equal to Supply Voltage	
Output Short Circuit Duration	Indefinite
Operating Temperature Range	
OP-05/OP-05A	-55°C to 125°C
OP-05E/OP-05C	0°C to 70°C
Storage Temperature Range	
All Devices	-65°C to 150°C
Lead Temperature (Soldering, 10 sec.)	300°C

## PACKAGE/ORDER INFORMATION

TOP VIEW OFFSET ADJUST	ORDER PART NO.	OFFSET VOLTAGE MAX
 <p>METAL CAN H PACKAGE</p>	OP-05AH OP-05H OP-05EH OP-05CH	0.15mV 0.5mV 0.5mV 1.3mV
 <p>HERMETIC J8 PACKAGE</p>	OP-05AJ8 OP-05J8 OP-05EJ8 OP-05CJ8 OP-05EN8 OP-05CN8	0.15mV 0.5mV 0.5mV 1.3mV 0.5mV 1.3mV

## ELECTRICAL CHARACTERISTICS $V_S = \pm 15V, T_A = 25^\circ C$ , unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	OP-05A			OP-05			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{OS}$	Input Offset Voltage			0.07	0.15		0.2	0.5	mV
$\frac{\Delta V_{OS}}{\Delta Time}$	Long Term Input Offset Voltage Stability	(Notes 1 and 2)		0.2	1.0		0.2	1.0	$\mu V/$ Month
$I_{OS}$	Input Offset Current			0.7	2.0		1.0	2.8	nA
$I_B$	Input Bias Current			± 0.7	± 2.0		± 1.0	± 3.0	nA
$e_n$	Input Noise Voltage	0.1Hz to 10Hz (Note 2)		0.35	0.6		0.35	0.6	$\mu V_{p-p}$
	Input Noise Voltage Density	$f_o = 10Hz$ $f_o = 100Hz$ (Note 2) $f_o = 1000Hz$		10.3 10.0 9.6	18.0 13.0 11.0		10.3 10.0 9.6	18.0 13.0 11.0	$nV/\sqrt{Hz}$
$i_n$	Input Noise Current	0.1Hz to 10Hz (Note 2)		14	30		14	30	$pA_{p-p}$
	Input Noise Current Density	$f_o = 10Hz$ $f_o = 100Hz$ (Note 2) $f_o = 1000Hz$		0.32 0.14 0.12	0.80 0.23 0.17		0.32 0.14 0.12	0.80 0.23 0.17	$pA/\sqrt{Hz}$
$R_{in}$	Input Resistance Differential Mode	(Note 3)	30	80		20	60		M $\Omega$
	Input Resistance Common Mode			200			200		G $\Omega$
	Input Voltage Range		± 13.5	± 14.0		± 13.5	± 14.0		V
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 13.5V$	114	126		114	126		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 3V$ to $\pm 18V$	100	108		100	108		dB
$A_{VOL}$	Large Signal Voltage Gain	$R_L \geq 2k\Omega, V_o = \pm 10V$ $R_L \geq 500\Omega, V_o = \pm 0.5V$ $V_S = \pm 3V$ (Note 3)	300 150	500 500		200 150	500 500		V/mV
$V_{OUT}$	Maximum Output Voltage Swing	$R_L \geq 10k\Omega$ $R_L \geq 2k\Omega$ $R_L \geq 1k\Omega$	± 12.5 ± 12.0 ± 10.5	± 13.0 ± 12.8 ± 12.0		± 12.5 ± 12.0 ± 10.5	± 13.0 ± 12.8 ± 12.0		V
SR	Slew Rate	$R_L \geq 2k\Omega$ (Note 2)	0.1	0.3		0.1	0.3		V/ $\mu S$
GBW	Closed Loop Bandwidth	$A_{VCL} = +1$ (Note 2)	0.4	0.6		0.4	0.6		MHz
$Z_o$	Open Loop Output Impedance	$V_o = 0, I_o = 0, f = 10Hz$		60			60		$\Omega$
$P_d$	Power Dissipation	No load $V_S = \pm 3V$ , No load		90 4	120 6		90 4	120 6	mW
	Offset Adjustment Range	Null Pot = 20k $\Omega$		± 4			± 4		mV

See Notes on page 2-324

## ELECTRICAL CHARACTERISTICS $V_S = \pm 15V$ , $-55^\circ C \leq T_A \leq 125^\circ C$ , unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	OP-05A			OP-05			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{OS}$	Input Offset Voltage			0.10	0.24		0.3	0.7	mV
$\frac{\Delta V_{OS}}{\Delta Temp}$	Average Input Offset Voltage Drift Without External Trim With External Trim	Null Pot = 20k $\Omega$ (Note 2)		0.3 0.2	0.9 0.5		0.7 0.3	2.0 1.0	$\mu V/^\circ C$
$I_{OS}$	Input Offset Current			1.0	4.0		1.8	5.6	nA
$\frac{\Delta I_{OS}}{\Delta Temp}$	Average Input Offset Current Drift	(Note 2)		5	25		8	50	pA/°C
$I_B$	Input Bias Current			$\pm 1.0$	$\pm 4.0$		$\pm 2.0$	$\pm 6.0$	nA
$\frac{\Delta I_B}{\Delta Temp}$	Average Input Bias Current Drift	(Note 2)		8	25		13	50	pA/°C
	Input Voltage Range		$\pm 13.0$	$\pm 13.5$		$\pm 13.0$	$\pm 13.5$		V
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 13V$	110	123		110	123		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 3V$ to $\pm 18V$	94	106		94	106		dB
$A_{VOL}$	Large Signal Voltage Gain	$R_L \geq 2k\Omega$ , $V_o = \pm 10V$	200	400		150	400		V/mV
$V_{OUT}$	Output Voltage Swing	$R_L \geq 2k\Omega$	$\pm 12.0$	$\pm 12.6$		$\pm 12.0$	$\pm 12.6$		V

## ELECTRICAL CHARACTERISTICS $V_S = \pm 15V$ , $T_A = 25^\circ C$ , unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	OP-05E			OP-05C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{OS}$	Input Offset Voltage			0.2	0.5		0.3	1.3	mV
$\frac{\Delta V_{OS}}{\Delta Time}$	Long Term Input Offset Voltage Stability	(Notes 1 and 2)		0.3	1.5		0.4	2.0	$\mu V/Month$
$I_{OS}$	Input Offset Current			1.2	3.8		1.8	6.0	nA
$I_B$	Input Bias Current			$\pm 1.2$	$\pm 4.0$		$\pm 1.8$	$\pm 7.0$	nA
$e_n$	Input Noise Voltage	0.1Hz to 10Hz (Note 2)		0.35	0.6		0.38	0.65	$\mu V_{p-p}$
	Input Noise Voltage Density	$f_o = 10Hz$ $f_o = 100Hz$ (Note 2) $f_o = 1000Hz$		10.3 10.0 9.6	18.0 13.0 11.0		10.5 10.2 9.8	20.0 13.5 11.5	nV/ $\sqrt{Hz}$
$i_n$	Input Noise Current	0.1Hz to 10Hz (Note 2)		14	30		15	35	pA $_{p-p}$
	Input Noise Current Density	$f_o = 10Hz$ $f_o = 100Hz$ (Note 2) $f_o = 1000Hz$		0.32 0.14 0.12	0.80 0.23 0.17		0.35 0.15 0.13	0.90 0.27 0.18	pA/ $\sqrt{Hz}$
$R_{in}$	Input Resistance Differential Mode	(Note 3)	15	50		8	33		M $\Omega$
	Input Resistance Common Mode			160			120		G $\Omega$
	Input Voltage Range		$\pm 13.5$	$\pm 14.0$		$\pm 13.5$	$\pm 14.0$		V
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 13.5V$	110	123		100	120		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 3V$ to $\pm 18V$	94	106		90	104		dB
$A_{VOL}$	Large Signal Voltage Gain	$R_L \geq 2k\Omega$ , $V_o = \pm 10V$ $R_L \geq 500\Omega$ , $V_o = \pm 0.5V$ $V_S = \pm 3V$ (Note 3)	200 150	500 500		120 100	400 400		V/mV
$V_{OUT}$	Maximum Output Voltage Swing	$R_L \geq 10k\Omega$ $R_L \geq 2k\Omega$ $R_L \geq 1k\Omega$	$\pm 12.5$ $\pm 12.0$ $\pm 10.5$	$\pm 13.0$ $\pm 12.8$ $\pm 12.0$		$\pm 12.0$ $\pm 11.5$ $\pm 12.0$	$\pm 13.0$ $\pm 12.8$ $\pm 12.0$		V
SR	Slew Rate	$R_L \geq 2k\Omega$ (Note 2)	0.1	0.3		0.1	0.3		V/ $\mu S$
GBW	Closed Loop Bandwidth	$A_{VCL} = +1$ (Note 2)	0.4	0.6		0.4	0.6		MHz
$Z_o$	Open Loop Output Impedance	$V_o = 0$ , $I_o = 0$ , $f = 10Hz$		60			60		$\Omega$
$P_d$	Power Dissipation	No load $V_S = \pm 3V$ , No load	90 4	120 6		95 4	150 8		mW
	Offset Adjustment Range	Null Pot = 20k $\Omega$		$\pm 4$			$\pm 4$		mW

See Notes on page 2-324

**ELECTRICAL CHARACTERISTICS**  $V_S = \pm 15V, 0^\circ C \leq T_A \leq 70^\circ C.$ 

SYMBOL	PARAMETER	CONDITIONS	OP-05E			OP-05C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{OS}$	Input Offset Voltage		●	0.25	0.6		0.35	1.6	mV
$\frac{\Delta V_{OS}}{\Delta Temp}$	Average Input Offset Voltage Drift Without External Trim With External Trim	Null Pot = 20k $\Omega$ (Note 2)	●	0.7	2.0		1.3	4.5	$\mu V/^\circ C$
			●	0.2	0.6		0.4	1.5	
$I_{OS}$	Input Offset Current		●	1.4	5.3		2.0	8.0	nA
$\frac{\Delta I_{OS}}{\Delta Temp}$	Average Input Offset Current Drift	(Note 2)	●	8	35		12	50	$\mu A/^\circ C$
$I_B$	Input Bias Current		●	$\pm 1.5$	$\pm 5.5$		$\pm 2.2$	$\pm 9.0$	nA
$\frac{\Delta I_B}{\Delta Temp}$	Average Input Bias Current Drift	(Note 2)	●	13	35		18	50	$\mu A/^\circ C$
	Input Voltage Range		●	$\pm 13.0$	$\pm 13.5$		$\pm 13.0$	$\pm 13.5$	V
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 13V$	●	107	123		97	120	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 3V$ to $\pm 18V$	●	90	103		86	100	dB
$A_{VOL}$	Large Signal Voltage Gain	$R_L \geq 2k\Omega, V_o = \pm 10V$	●	180	450		100	400	V/mV
$V_{OUT}$	Output Voltage Swing	$R_L \geq 2k\Omega$	●	$\pm 12.0$	$\pm 12.6$		$\pm 11.0$	$\pm 12.6$	V

The ● denotes the specifications which apply over the full operating temperature range.

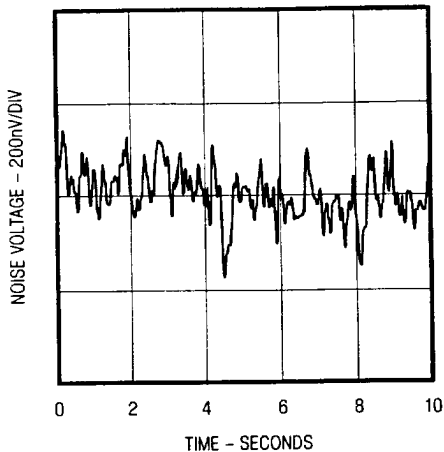
**Note 1:** Long term offset voltage stability is the average value of offset voltage vs. time plotted over extended periods following 30 days of operation. Values for time under 30 days of operation are typically 2.5 $\mu V$  following the first hour of operation.

**Note 2:** This parameter is sample tested.

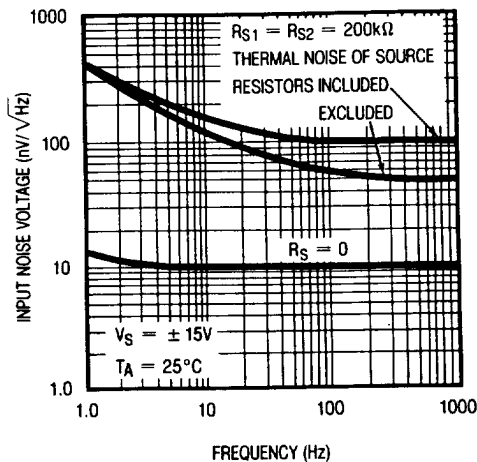
**Note 3:** This parameter is guaranteed by design.

# TYPICAL PERFORMANCE CHARACTERISTICS

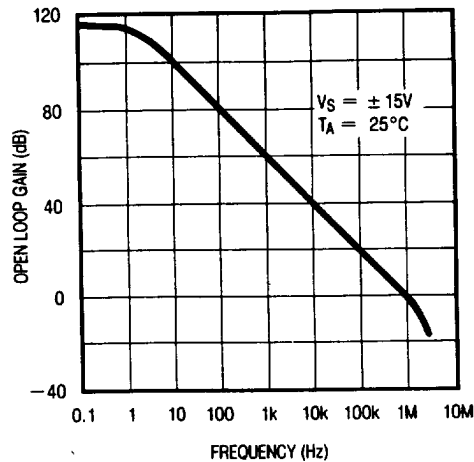
**Low Frequency Noise**  
(Closed Loop Gain = 25,000)



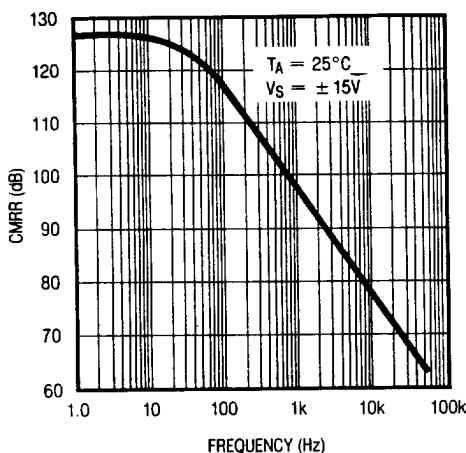
**Total Input Noise Voltage vs Frequency**



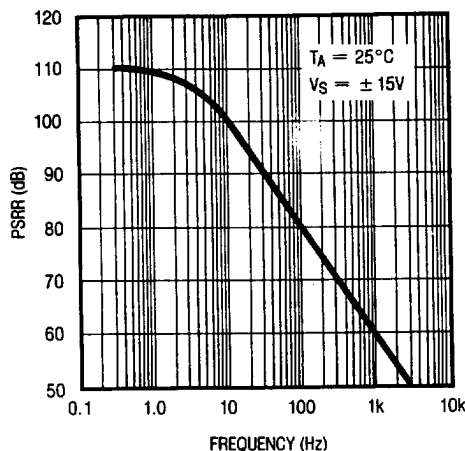
**Open-Loop Frequency Response**



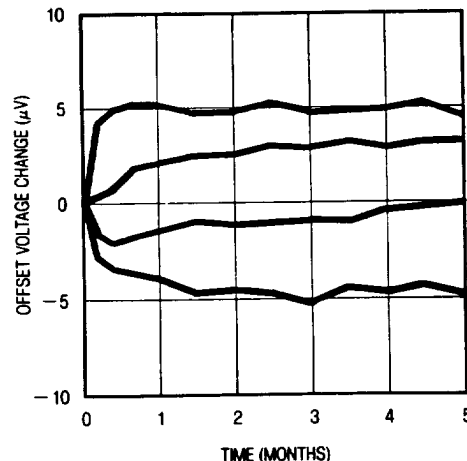
**Common Mode Rejection Ratio vs Frequency**



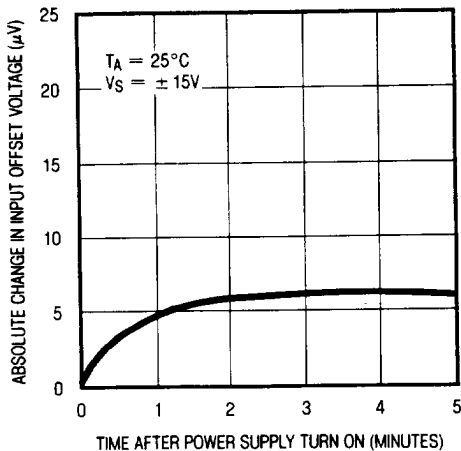
**Power Supply Rejection Ratio vs Frequency**



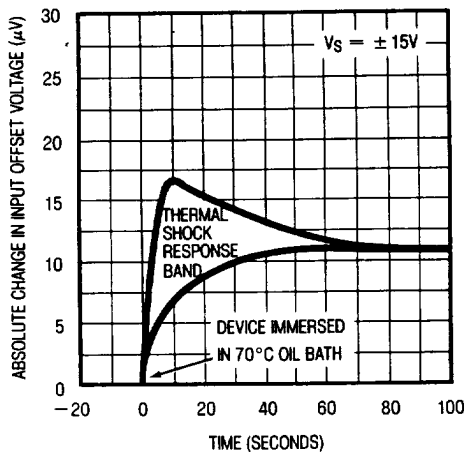
**Long Term Stability of Four Representative Units**



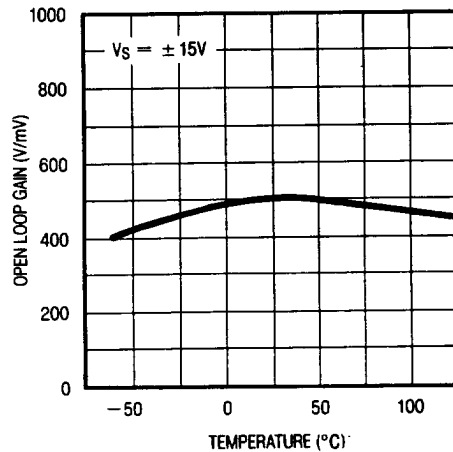
**Warm-Up Drift**



**Offset Voltage Change Due to Thermal Shock**



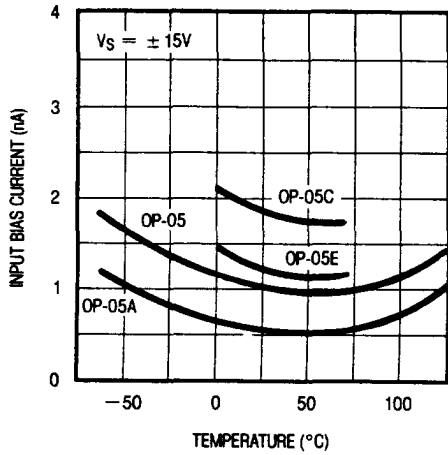
**Open-Loop Gain vs Temperature**



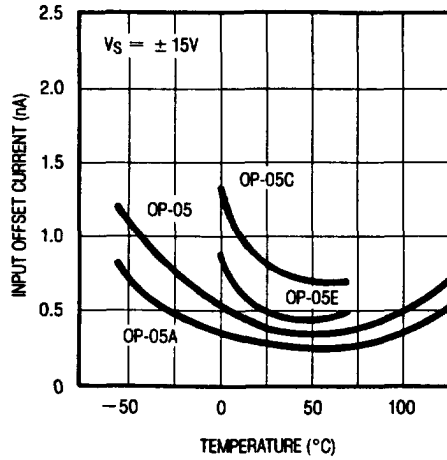
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# TYPICAL PERFORMANCE CHARACTERISTICS

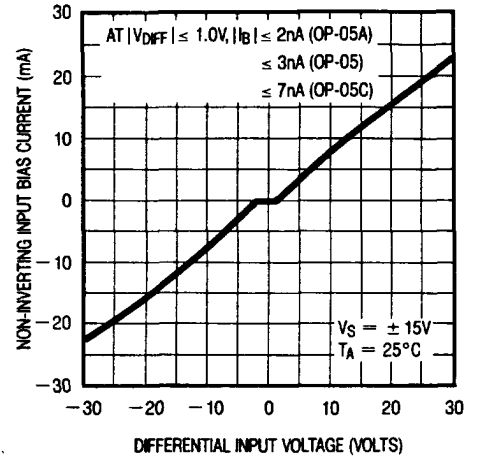
**Input Bias Current vs Temperature**



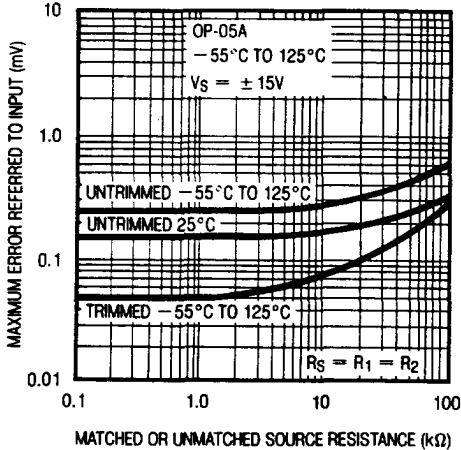
**Input Offset Current vs Temperature**



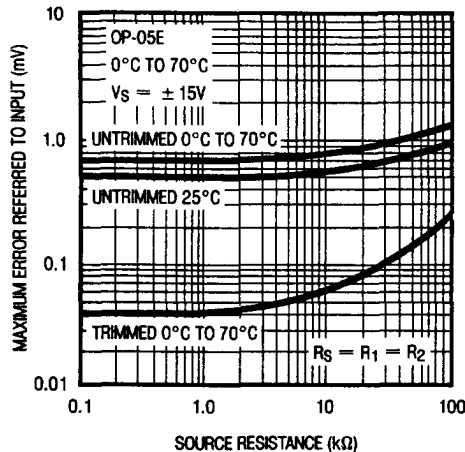
**Input Bias Current vs Differential Input Voltage**



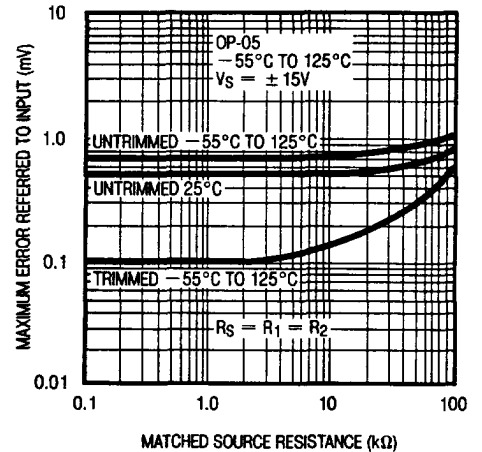
**Maximum Error vs Source Resistance**



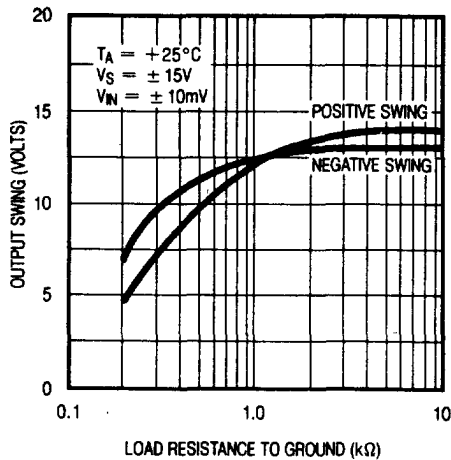
**Maximum Error vs Source Resistance**



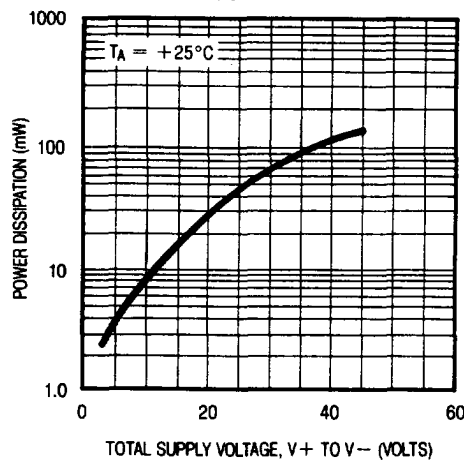
**Maximum Error vs Source Resistance**



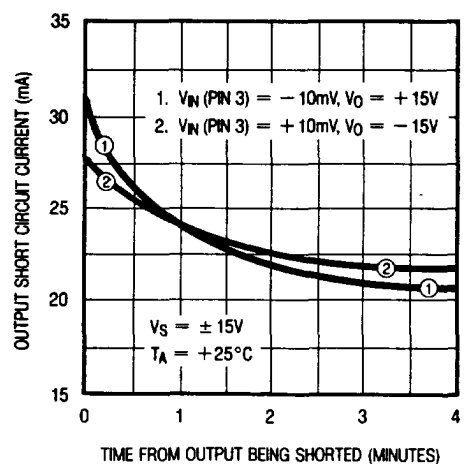
**Output Voltage vs Load Resistance**



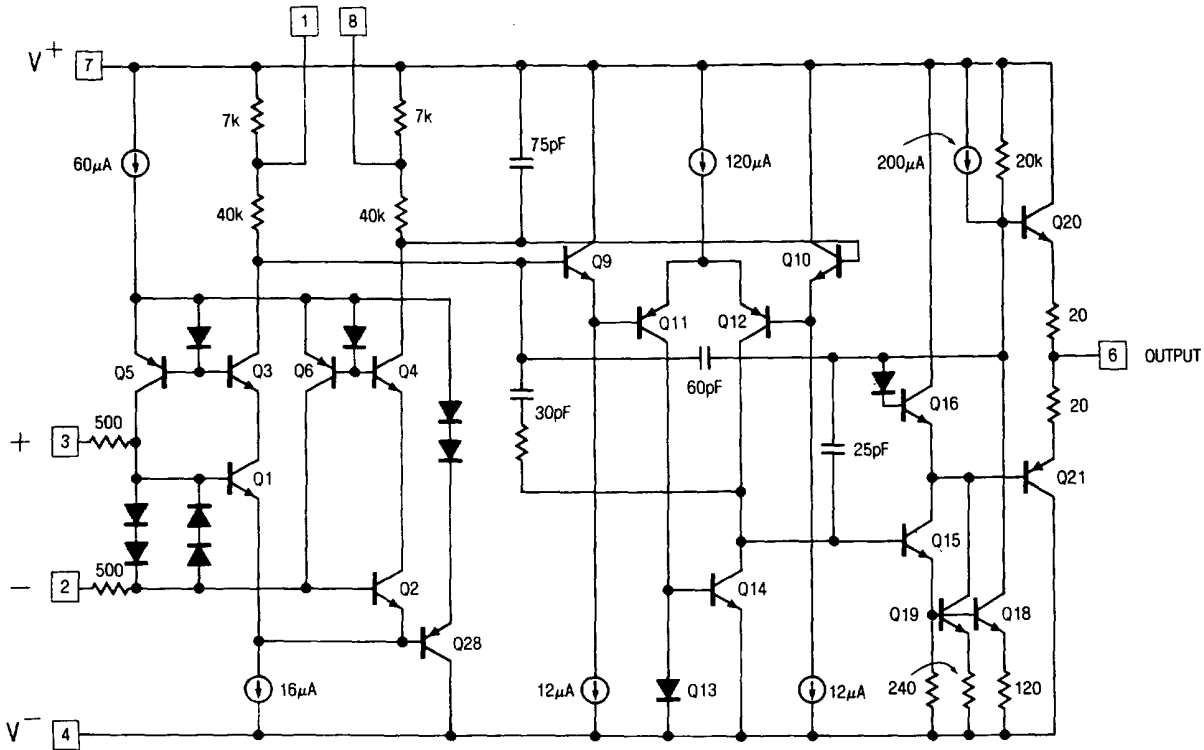
**Power Consumption vs Power Supply**



**Output Short-Circuit Current vs Time**



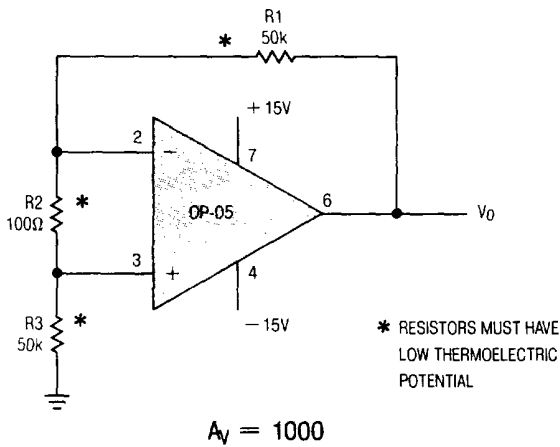
# SCHEMATIC DIAGRAM



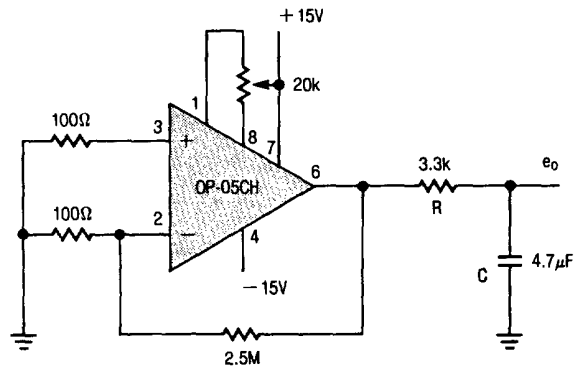
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# TEST CIRCUIT DIAGRAMS

Offset Voltage Test Circuit †



Offset Nulling and Low Frequency Noise Test Circuit



NOTES:

- 1) RC APPROXIMATELY 10Hz FILTER
  - 2) OBSERVE OUTPUT FOR 10 SECONDS
- $A_V = 25000$

Application Tip

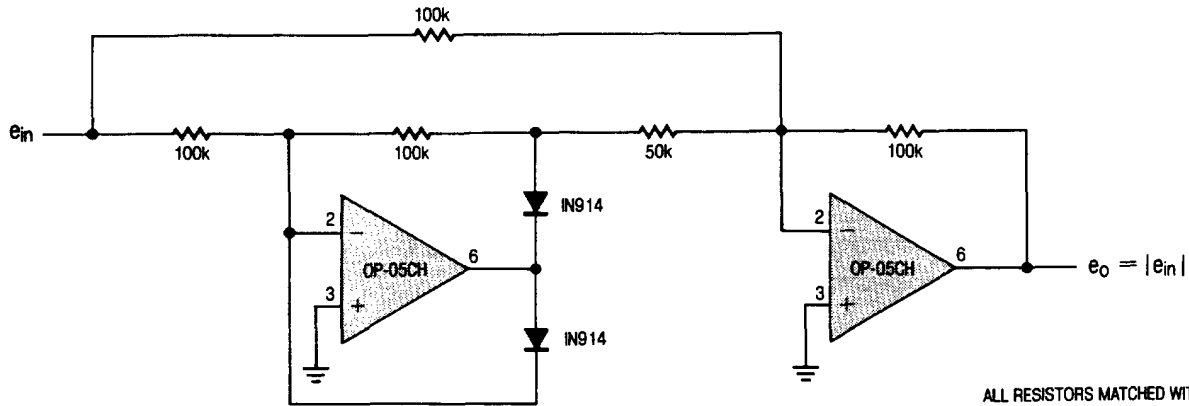
When the OP-05 is used as a replacement in 725, 108/108A, 308/308A applications, removal of external compensation is optional. For conventionally nulled 741 type applications, external trimming should be removed. Care should be taken to avoid thermocouple voltages caused by temperature variations between the input terminals or dissimilar metals.

† This circuit is also used as the burn-in configuration with supply voltages changed to  $\pm 20V$ ,  $R1 = R3 = 10k$ ,  $R2 = 200\Omega$ ,  $A_V = 100$ .

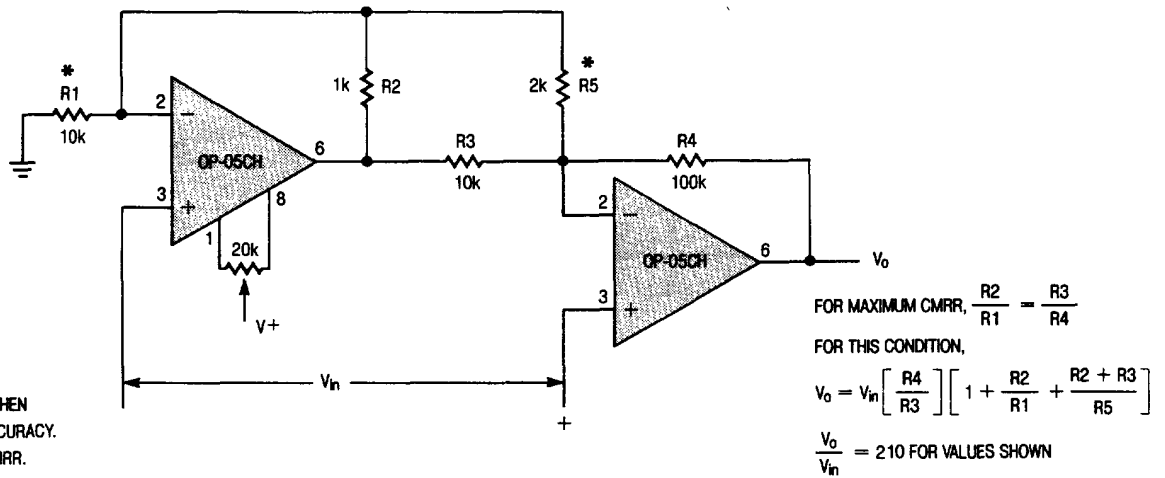


# TYPICAL APPLICATIONS

Precision Absolute Value Circuit



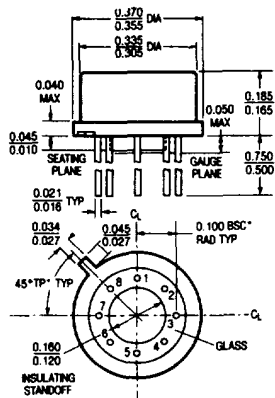
Two Op-Amp Instrumentation Amplifier



\* ADJUST R1 FOR CMRR, THEN  
ADJUST R5 FOR GAIN ACCURACY.  
R5 DOES NOT AFFECT CMRR.

## PACKAGE DESCRIPTION

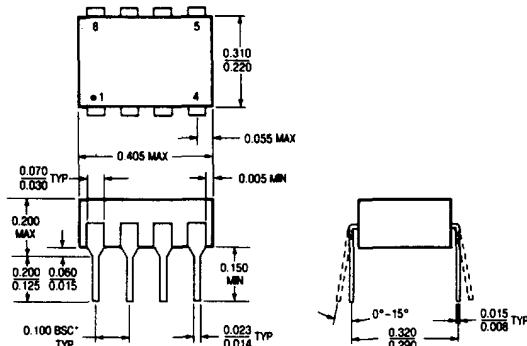
H Package  
Metal Can



NOTE: DIMENSIONS IN INCHES

$T_j$ max	$\theta_{ja}$	$\theta_{jc}$
150°C	150°C/W	45°C/W

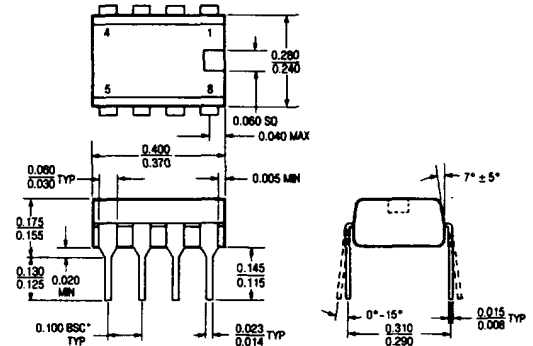
J8 Package  
8 Lead Hermetic Dip



NOTE: DIMENSIONS IN INCHES UNLESS OTHERWISE NOTED.  
\*LEADS WITHIN 0.007 OF TRUE POSITION (TP) AT GAUGE PLANE

$T_j$ max	$\theta_{ja}$
150°C	100°C/W

N8 Package  
8 Lead Plastic



NOTE: DIMENSIONS IN INCHES UNLESS OTHERWISE NOTED.  
\*LEADS WITHIN 0.007 OF TRUE POSITION (TP) AT GAUGE PLANE

$T_j$ max	$\theta_{ja}$
100°C	130°C/W