ANALOG DEVICES

Instrumentation Operational Amplifier

OP-05

FEATURES

- Low Noise ..... $0.6\mu V_{p-p}$ Max, 0.1 to 10Hz
- Low Drift vs. Temperature ..... $0.5\mu V/°C$ Max
- Low Drift vs. Time ..... $0.2\mu V$/Month Typ
- Low Bias Current ..... 2.0nA Max
- High CMRR ..... 114dB Min
- High PSRR ..... 100dB Min
- High Gain ..... 300,000 Min
- High R_{IN} Differential ..... 30MΩ Min
- High R_{IN} CM ..... 200GΩ Typ
- Internally Compensated ..... Stable to 500pF Load
- Fits 725, 108A and 741 Sockets
- 125° C Temperature Tested Dice
- Available in Die Form

GENERAL DESCRIPTION

The OP-05 series of monolithic instrumentation operational amplifiers combine excellent performance in low-signal-level applications with the simplicity of use of a fully-protected, internally-compensated op amp. The OP-05 has low input offset voltage and bias current combined with very high levels of gain, input impedance, CMRR, and PSRR.

The OP-05 is a direct replacement in 725, 108A, and unnulled 741 sockets allowing instant system performance improvement without redesign. The OP-05 is an excellent choice for a wide variety of applications including strain gauge and thermocouple bridges, high-gain active filters, buffers, integrators, and sample-and-hold amplifiers. For dual-matched versions, refer to the OP-207 and OP-10 data sheets.

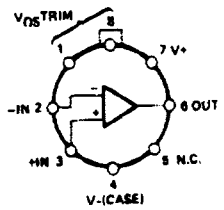
ORDERING INFORMATION †

T_A = 25°C V_{OS} MAX (mV)	PACKAGE TO-99	PACKAGE CERDIP 8-PIN	PACKAGE PLASTIC 8-PIN	OPERATING TEMPERATURE RANGE
0.15	OP05AJ*	OP05AZ*	–	MIL
0.5	OP05J*	–	–	MIL
0.5	OP05EJ	OP05EZ	OP05EP	COM
1.3	OP05CJ	OP05CZ	OP05CP	COM

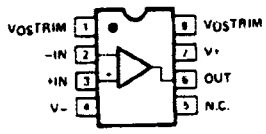
* For devices processed in total compliance to MIL-STD-883, add /883 after part number. Consult factory for 883 data sheet.

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

PIN CONNECTIONS



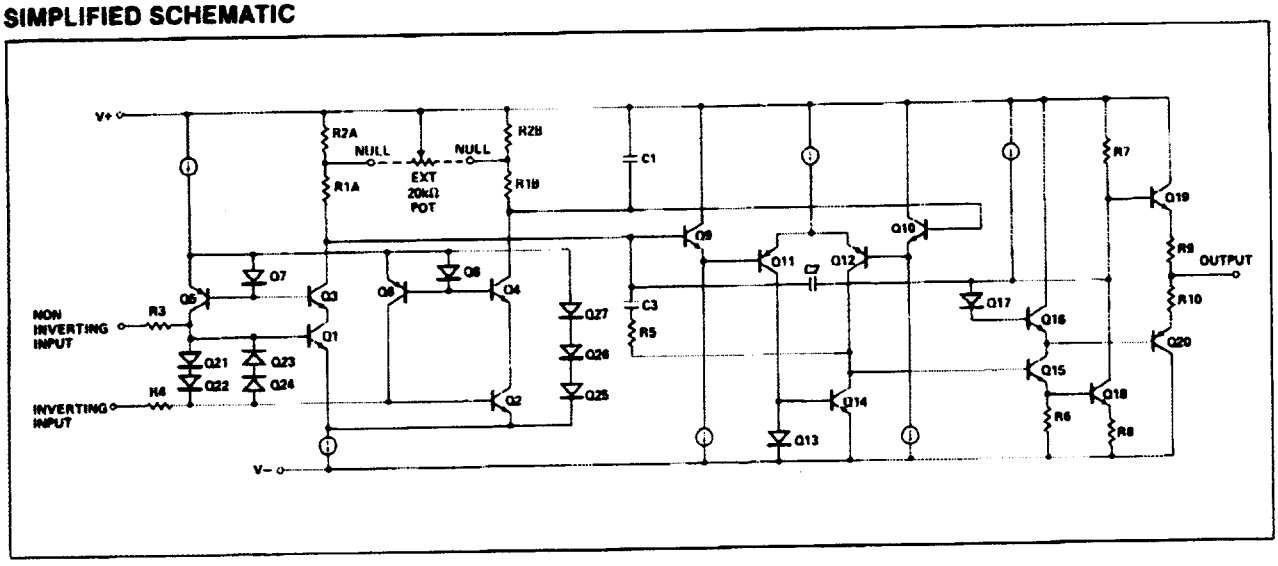
TO-99
(J-Suffix)



EPOXY MINI-DIP
(P-Suffix)

8-PIN HERMETIC DIP
(Z-Suffix)

SIMPLIFIED SCHEMATIC



OP-05

ABSOLUTE MAXIMUM RATINGS (Note 3)

Supply Voltage ..... ±22V
Differential Input Voltage ..... ±30V
Input Voltage (Note 1) ..... ±22V
Output Short-Circuit Duration ..... Indefinite
Storage Temperature Range
  J and Z Packages ..... –65°C to +150°C
  P Package ..... –65°C to +125°C
Operating Temperature Range
  OP-05A, OP-05 ..... –55°C to +125°C
  OP-05E, OP-05C ..... 0°C to +70°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
TO-99 (J)	150	18	°C/W
8-Pin Hermetic DIP (Z)	148	16	°C/W
8-Pin Plastic DIP (P)	103	43	°C/W

NOTES:
1. For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.
2. Θ_{JA} is specified for worst case mounting conditions, i.e., Θ_{JA} is specified for device in socket for TO, CerDIP, P-DIP, and LCC packages; Θ_{JA} is specified for device soldered to printed circuit board for SO and PLCC packages.
3. Absolute maximum ratings apply to both DICE and packaged parts, unless otherwise noted.

ELECTRICAL CHARACTERISTICS at V_S = ±15V, T_A = 25°C, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	OP-05A MIN	OP-05A TYP	OP-05A MAX	OP-05 MIN	OP-05 TYP	OP-05 MAX	UNITS
Input Offset Voltage	V_{OS}		—	0.07	0.15	—	0.2	0.5	mV
Long-Term Input Offset Voltage Stability	ΔV_{OS}/Time	(Note 1)	—	0.2	1.0	—	0.2	1.0	µV/Mo
Input Offset Current	I_{OS}		—	0.7	2.0	—	1.0	2.8	nA
Input Bias Current	I_B		—	±0.7	±2.0	—	±1.0	±3.0	nA
Input Noise Voltage (Note 2)	e_{np-p}	0.1Hz to 10Hz	—	0.35	0.6	—	0.35	0.6	μV_{p-p}
Input Noise Voltage Density (Note 2)	e_n	f_O = 10Hz f_O = 100Hz 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	$nV/\sqrt{Hz}$
Input Noise Current (Note 2)	i_{np-p}	0.1Hz to 10Hz	—	14	30	—	14	30	pA_{p-p}
Input Noise Current Density (Note 2)	i_n	f_O = 10Hz f_O = 100Hz 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	$pA/\sqrt{Hz}$
Input Resistance — Differential-Mode	R_{IN}	(Note 3)	30	80	—	20	60	—	MΩ
Input Resistance — Common-Mode	R_{INCM}		—	200	—	—	200	—	GΩ
Input Voltage Range	IVR		±13.5	±14.0	—	±13.5	±14.0	—	V
Common-Mode Rejection Ratio	CMRR	V_{CM} = ±13.5V	114	126	—	114	126	—	dB
Power Supply Rejection Ratio	PSRR	V_S = ±3V to ±18V	—	4	10	—	4	10	µV/V
Large-Signal Voltage Gain	A_{VO}	R_L ≥ 2kΩ, V_O = ±10V R_L ≥ 500Ω, V_O = ±0.5V V_S = ±3V (Note 3)	300 150	500 500	— —	200 150	500 500	— —	V/mV
Output Voltage Swing	V_O	R_L ≥ 10kΩ R_L ≥ 2kΩ R_L ≥ 1kΩ	±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
Slew Rate (Note 2)	SR	R_L ≥ 2kΩ	0.1	0.3	—	0.1	0.3	—	V/µs
Closed-Loop Bandwidth (Note 2)	BW	A_{VCL} = +1.0	0.4	0.6	—	0.4	0.6	—	MHz
Open-Loop Output Resistance	R_O	V_O = 0, I_O = 0	—	60	—	—	60	—	Ω
Power Consumption	P_d	No load V_S = ±3V, No load	— —	90 4	120 6	— —	90 4	120 6	mW
Offset Adjustment Range		R_P = 20kΩ	—	4	—	—	4	—	mV

NOTES:
1. Long-term input offset voltage stability refers to the averaged trend line of V_{OS} vs. Time over extended periods after the first 30 days of operation. Excluding the initial hour of operation, changes in V_{OS} during the first 30 operating days are typically 2.5µV. Refer to typical performance curve.
2. Sample tested.
3. Guaranteed by design.

ELECTRICAL CHARACTERISTICS at $V_S = \pm 15V$, $-55°C \le T_A \le +125°C$, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	OP-05A MIN	OP-05A TYP	OP-05A MAX	OP-05 MIN	OP-05 TYP	OP-05 MAX	UNITS
Input Offset Voltage	V_{OS}		—	0.10	0.24	—	0.3	0.7	mV
Average Input Offset Voltage Drift Without External Trim	TCV_{OS}	(Note 2)	—	0.3	0.9	—	0.7	2.0	µV/°C
With External Trim	TCV_{OSn}	$R_P = 20k\Omega$ (Note 3)	—	0.2	0.5	—	0.3	1.0	
Input Offset Current	I_{OS}		—	1.0	4.0	—	1.8	5.6	nA
Average Input Offset Current Drift	TCI_{OS}	(Note 2)	—	5	25	—	8	50	pA/°C
Input Bias Current	I_B		—	±1	±4	—	±2	±6	nA
Average Input Bias Current Drift	TCI_B	(Note 2)	—	8	25	—	13	50	pA/°C
Input Voltage Range	IVR		±13.0	±13.5	—	±13.0	±13.5	—	V
Common-Mode Rejection Ratio	CMRR	$V_{CM} = \pm 13.0V$	110	123	—	110	123	—	dB
Power Supply Rejection Ratio	PSRR	$V_S = \pm 3V$ to $\pm 18V$	—	5	20	—	5	20	µV/V
Large-Signal Voltage Gain	A_{VO}	$R_L \ge 2k\Omega$, $V_O = \pm 10V$	200	400	—	150	400	—	V/mV
Output Voltage Swing	V_O	$R_L \ge 2k\Omega$	±12.0	±12.6	—	±12.0	±12.6	—	V

ELECTRICAL CHARACTERISTICS at $V_S = \pm 15V$, $T_A = 25°C$, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	OP-05E MIN	OP-05E TYP	OP-05E MAX	OP-05C MIN	OP-05C TYP	OP-05C MAX	UNITS
Input Offset Voltage	V_{OS}		—	0.2	0.5	—	0.3	1.3	mV
Long-Term Input Offset Voltage Stability	$\Delta V_{OS}/Time$	(Notes 1, 2)	—	0.3	1.5	—	0.4	2.0	µV/Mo
Input Offset Current	I_{OS}		—	1.2	3.8	—	1.8	6.0	nA
Input Bias Current	I_B		—	±1.2	±4.0	—	±1.8	±7.0	nA
Input Noise Voltage (Note 2)	e_{np-p}	0.1Hz to 10Hz	—	0.35	0.6	—	0.38	0.65	μV_{p-p}
Input Noise Voltage Density (Note 2)	e_n	$f_O = 10Hz$	—	10.3	18.0	—	10.5	20.0	$nV/\sqrt{Hz}$
		$f_O = 100Hz$	—	10.0	13.0	—	10.2	13.5	
		$f_O = 1000Hz$	—	9.6	11.0	—	9.8	11.5	
Input Noise Current (Note 2)	i_{np-p}	0.1Hz to 10Hz	—	14	30	—	15	35	pA_{p-p}
Input Noise Current Density (Note 2)	i_n	$f_O = 10Hz$	—	0.32	0.80	—	0.35	0.90	$pA/\sqrt{Hz}$
		$f_O = 100Hz$	—	0.14	0.23	—	0.15	0.27	
		$f_O = 1000Hz$	—	0.12	0.17	—	0.13	0.18	
Input Resistance — Differential-Mode	R_{IN}	(Note 3)	15	50	—	8	33	—	MΩ
Input Resistance — Common-Mode	R_{INCM}		—	160	—	—	120	—	GΩ
Input Voltage Range	IVR		±13.5	±14.0	—	±13.0	±14.0	—	V
Common-Mode Rejection Ratio	CMRR	$V_{CM} = \pm 13.5V$	110	123	—	100	120	—	dB
Power Supply Rejection Ratio	PSRR	$V_S = \pm 3V$ to $\pm 18V$	—	5	20	—	7	32	µV/V
Large-Signal Voltage Gain	A_{VO}	$R_L \ge 2k\Omega$, $V_O = \pm 10V$	200	500	—	180	400	—	V/mV
		$R_L \ge 500\Omega$, $V_O = \pm 0.5V$ $V_S = \pm 3V$ (Note 3)	150	500	—	100	400	—	
Output Voltage Swing	V_O	$R_L \ge 10k\Omega$	±12.5	±13.0	—	±12.0	±13.0	—	V
		$R_L \ge 2k\Omega$	±12.0	±12.8	—	±11.5	±12.8	—	
		$R_L \ge 1k\Omega$	±10.5	±12.0	—	—	±12.0	—	
Slew Rate (Note 2)	SR	$R_L = \ge 2k\Omega$	0.1	0.3	—	0.1	0.3	—	V/µs
Closed-Loop Bandwidth (Note 2)	BW	$A_{VCL} = +1.0$	0.4	0.6	—	0.4	0.6	—	MHz
Open-Loop Output Resistance	R_O	$V_O = 0$, $I_O = 0$		60	—	—	60	—	Ω
Power Consumption	P_d	No load	—	90	120	—	95	150	mW
		$V_S = \pm 3V$, No load	—	4	6	—	4	8	
Offset Adjustment Range		$R_P = 20k\Omega$	—	4	—	—	4	—	mV

NOTE: See notes on previous page.

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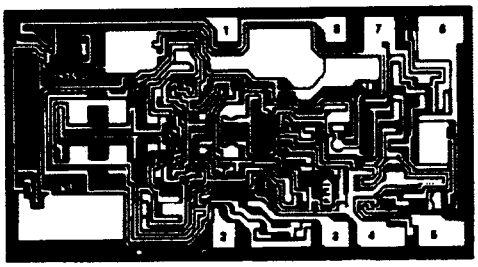
ELECTRICAL CHARACTERISTICS at $V_S = \pm 15V$, $0°C \le T_A \le +70°C$, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	OP-05E MIN	OP-05E TYP	OP-05E MAX	OP-05C MIN	OP-05C TYP	OP-05C MAX	UNITS
Input Offset Voltage	V_{OS}		—	0.25	0.6	—	0.35	1.8	mV
Average Input Offset Voltage Drift Without External Trim	TCV_{OS}	(Note 2)	—	0.7	2.0	—	1.3	4.5	µV/°C
With External Trim	TCV_{OSn}	$R_P = 20k\Omega$ (Note 3)	—	0.2	0.6	—	0.4	1.5	µV/°C
Input Offset Current	I_{OS}		—	1.4	5.3	—	2.0	8.0	nA
Average Input Offset Current Drift	TCI_{OS}	(Note 2)	—	8	35	—	12	50	pA/°C
Input Bias Current	I_B		—	±1.5	±5.5	—	±2.2	±9.0	nA
Average Input Bias Current Drift	TCI_B	(Note 2)	—	13	35	—	18	50	pA/°C
Input Voltage Range	IVR		±13.0	±13.5	—	±13.0	±13.5	—	V
Common-Mode Rejection Ratio	CMRR	$V_{CM} = \pm 13.0V$	107	123	—	97	120	—	dB
Power Supply Rejection Ratio	PSRR	$V_S = \pm 3V$ to $\pm 18V$	—	7	32	—	10	51	µV/V
Large-Signal Voltage Gain	A_{VO}	$R_L \ge 2k\Omega$, $V_O = \pm 10V$	180	450	—	100	400	—	V/mV
Output Voltage Swing	V_O	$R_L \ge 2k\Omega$	±12.0	±12.6	—	±11.0	±12.6	—	V

NOTES:

1. Long-Term Input Offset Voltage Stability refers to the averaged trend line of V_{OS} vs. Time over extended periods after the first 30 days of operation. Excluding the initial hour of operation, changes in V_{OS} during the first 30 operating days are typically 2.5µV. Refer to typical performance curve.
2. Sample tested.
3. Guaranteed by design.

DICE CHARACTERISTICS (125°C TESTED DICE AVAILABLE)



DIE SIZE 0.101 × 0.052 inch, 5300 sq. mils
(2.57 × 1.32 mm, 3.34 sq. mm)

1. BALANCE
2. INVERTING INPUT
3. NONINVERTING INPUT
4. V-
5. NO CONNECTION
6. OUTPUT
7. V+
8. BALANCE

WAFER TEST LIMITS at $V_S = \pm 15V$, $T_A = 25°C$ for OP-05N, OP-05G and OP-05GR devices; $T_A = 125°C$ for OP-05NT and OP-05GT devices, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	OP-05NT LIMIT	OP-05N LIMIT	OP-05GT LIMIT	OP-05G LIMIT	OP-05GR LIMIT	UNITS
Input Offset Voltage	V_{OS}		0.25	0.15	0.7	0.5	1.3	mV MAX
Input Offset Current	I_{OS}		4.0	2.0	5.7	3.8	6.0	nA MAX
Input Bias Current	I_B		±4	±2	±6	±4	±7	nA MAX
Input Resistance Differential Mode	R_{IN}	(Note 2)	—	20	—	15	8	MΩ MIN
Input Voltage Range	IVR		±13.0	±13.5	±13.0	±13.5	±13.0	V MIN
Common-Mode Rejection Ratio	CMRR	$V_{CM} = \pm 13.5V$ at +25°C $V_{CM} = \pm 13.0$ at +125°C	110	114	110	110	100	dB MIN
Power Supply Rejection Ratio	PSRR	$V_S = \pm 3V$ to $\pm 18V$	20	10	20	20	30	µV/V MAX
Output Voltage Swing	V_O	$R_L = 10k\Omega$ $R_L = 2k\Omega$ $R_L = 1k\Omega$	— ±12.0 —	±12.5 ±12.0 ±10.5	— ±12.0 —	±12.5 ±12.0 ±10.5	±12.0 ±11.5 —	V MIN
Large-Signal Voltage Gain	A_{VO}	$R_L = 2k\Omega$ $V_O = \pm 10V$	200	200	150	200	120	V/mV MIN
Differential Input Voltage			±30	±30	±30	±30	±30	V MAX
Power Consumption	P_d	$V_{OUT} = 0V$	—	120	—	120	150	mW MAX

NOTES:
1. For 25°C characteristics of NT & GT devices see N & G characteristics respectively.
2. Guaranteed by design.

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.

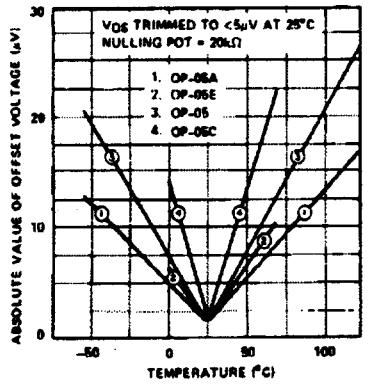
TYPICAL ELECTRICAL CHARACTERISTICS at $V_S = \pm 15V$, $T_A = +25°C$, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	OP-05NT TYPICAL	OP-05N TYPICAL	OP-05GT TYPICAL	OP-05G TYPICAL	OP-05GR TYPICAL	UNITS
Average Input Offset Voltage Drift	TCV_{OS}	$R_S \leq 50\Omega$	0.3	0.3	0.7	0.7	1.2	µV/°C
Nulled Input Offset Voltage Drift	TCV_{OSn}	$R_S \leq 50\Omega$, $R_p = 20k\Omega$	0.2	0.2	0.3	0.3	0.4	µV/°C
Average Input Offset Current Drift	TCI_{OS}		5	5	8	8	12	pA/°C
Slew Rate	SR	$R_L \geq 2k\Omega$	0.3	0.3	0.3	0.3	0.3	V/µs
Closed-Loop Bandwidth	BW	$A_{VCL} = +1$	0.6	0.6	0.6	0.6	0.6	MHz

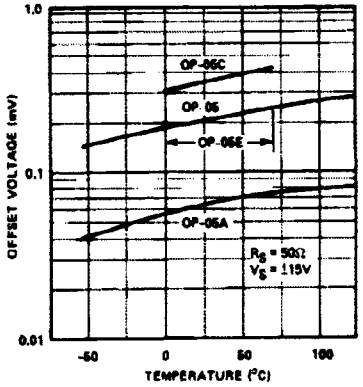
OP-05

TYPICAL PERFORMANCE CHARACTERISTICS

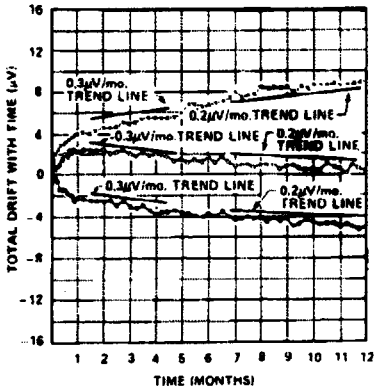
TRIMMED OFFSET VOLTAGE vs TEMPERATURE



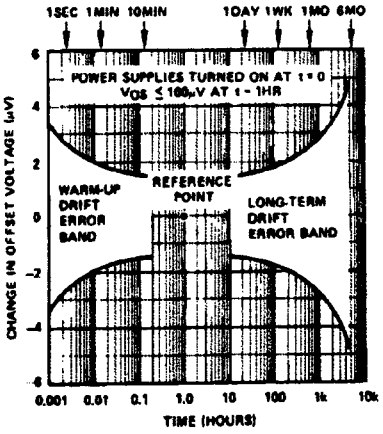
UNTRIMMED OFFSET VOLTAGE vs TEMPERATURE



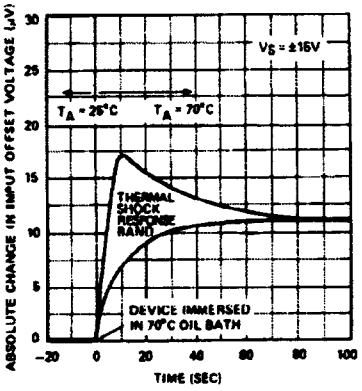
TYPICAL OFFSET VOLTAGE STABILITY vs TIME



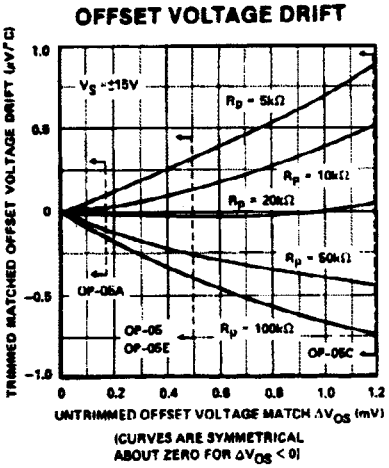
OFFSET VOLTAGE DRIFT WITH TIME



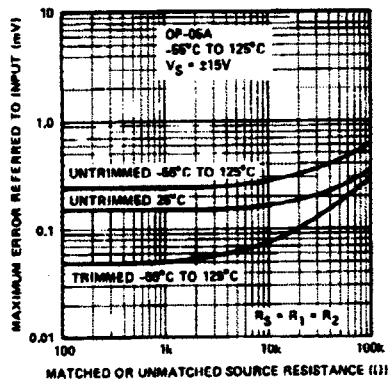
OFFSET VOLTAGE CHANGE DUE TO THERMAL SHOCK



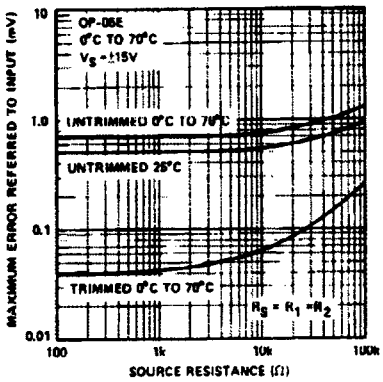
TRIMMED OFFSET VOLTAGE DRIFT



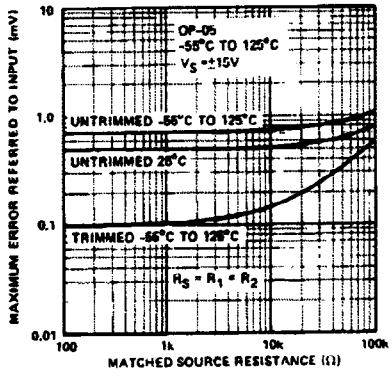
MAXIMUM ERROR vs SOURCE RESISTANCE



MAXIMUM ERROR vs SOURCE RESISTANCE

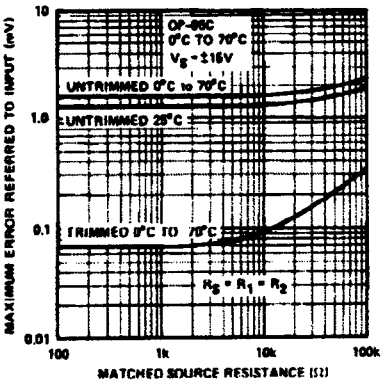


MAXIMUM ERROR vs SOURCE RESISTANCE

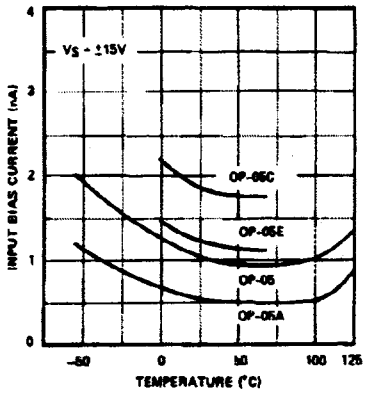


TYPICAL PERFORMANCE CHARACTERISTICS

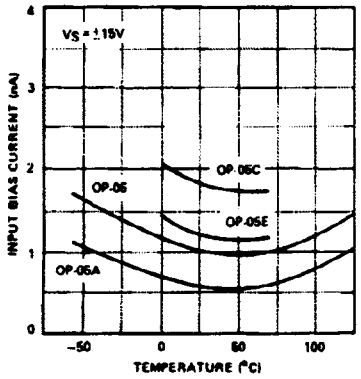
MAXIMUM ERROR vs SOURCE RESISTANCE



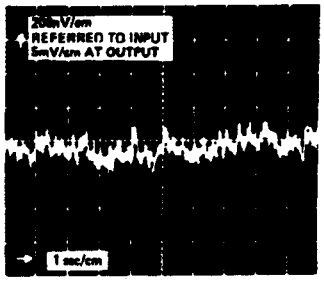
INPUT BIAS CURRENT vs TEMPERATURE



INPUT OFFSET CURRENT vs TEMPERATURE

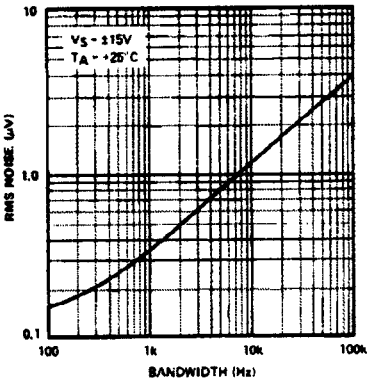


OP-05 LOW FREQUENCY NOISE

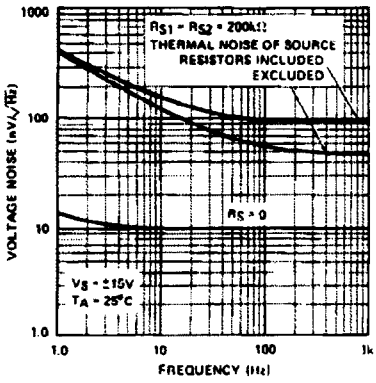


(SEE NOISE TEST CIRCUIT)

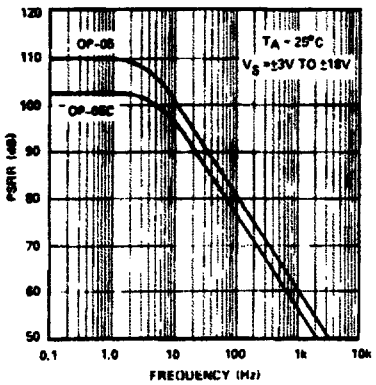
INPUT WIDEBAND NOISE vs BANDWIDTH (0.1Hz TO FREQUENCY INDICATED)



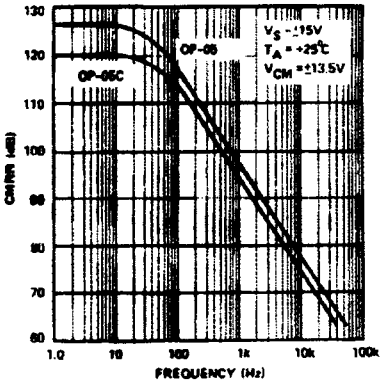
VOLTAGE NOISE DENSITY vs FREQUENCY



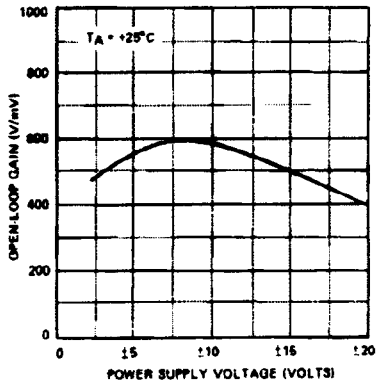
PSRR vs FREQUENCY



CMRR vs FREQUENCY



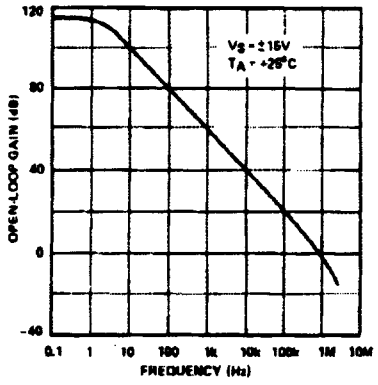
OPEN-LOOP GAIN vs POWER SUPPLY VOLTAGE



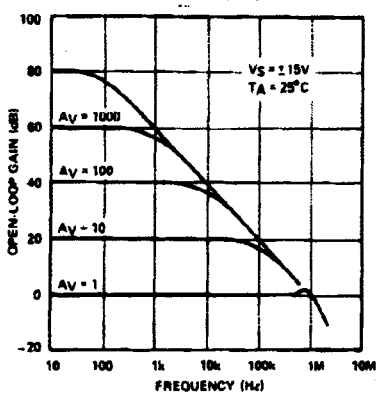
OP-05

TYPICAL PERFORMANCE CHARACTERISTICS

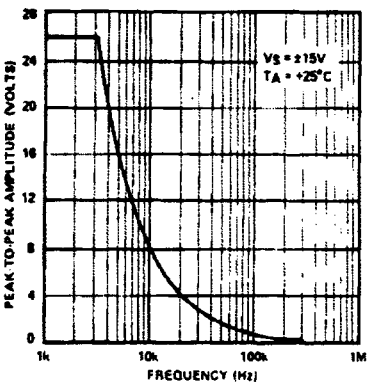
OPEN-LOOP GAIN vs FREQUENCY



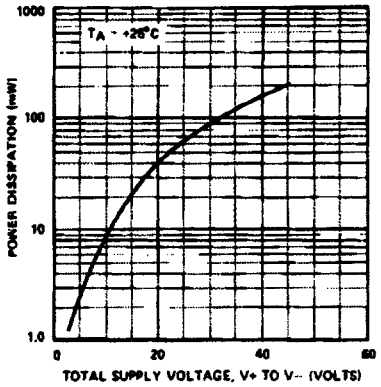
CLOSED-LOOP GAIN vs FREQUENCY



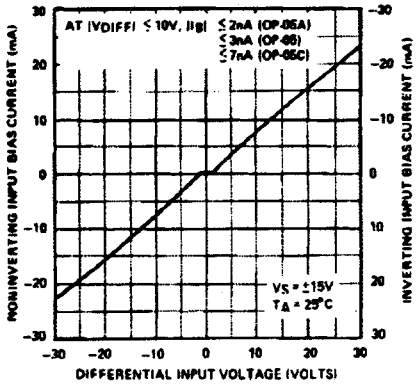
MAXIMUM OUTPUT SWING vs FREQUENCY



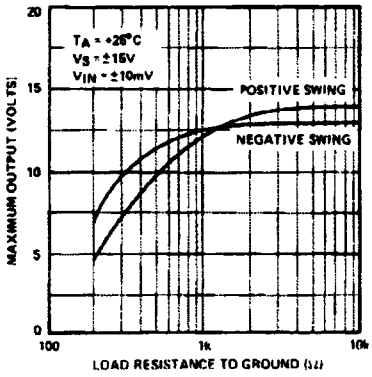
POWER CONSUMPTION vs POWER SUPPLY



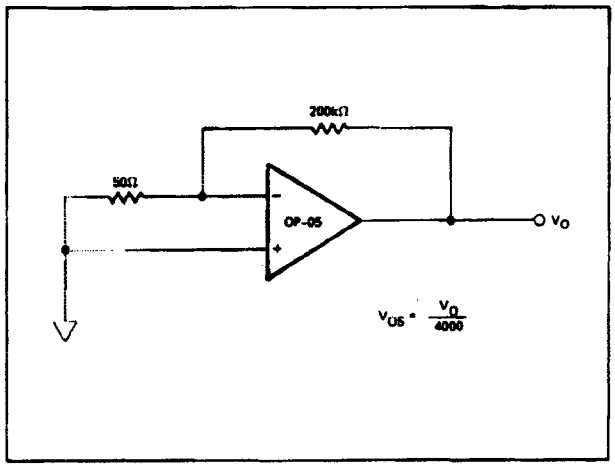
INPUT BIAS CURRENT vs DIFFERENTIAL INPUT VOLTAGE



MAXIMUM OUTPUT VOLTAGE vs LOAD RESISTANCE



TYPICAL OFFSET VOLTAGE TEST CIRCUIT



TYPICAL LOW-FREQUENCY NOISE TEST CIRCUIT*