Solitron DEVICES, INC.

OPERATIONAL AMPLIFIERS

HTL OP-07

HI-TECH LINEAR

ULTRA-LOW OFFSET VOLTAGE OPERATIONAL AMPLIFIER

GENERAL DESCRIPTION

The HTL OP-07 ultra-low offset voltage operational amplifier is designed with a special input stage to minimize offset voltage, input bias current and noise. It is internally trimmed at the factory to exhibit a typical offset voltage of 10μV (for HTL OP-07A). The low bias current of 2nA Max and the high open-loop gain of 109dB Min (for HTL OP-07A), as well as the low noise, make the HTL OP-07 op amp an ideal amplifier for precision and instrumentation applications.

The excellent stability of the offset voltage, gain and other parameters, as a function of temperature and time, combined with its supreme linearity, gain accuracy and common-mode rejection, make the HTL OP-07 a perfect choice for precision military and industrial systems where high performance is essential.

The HTL OP-07 is available in five performance grades. The HTL OP-07 and HTL OP-07A are specified for operation over the military temperature range of −55°C to +125°C and the HTL OP-07C, D, and E are specified for operation over a temperature range of 0°C to +70°C. It should also be mentioned that the HTL OP-07 directly replaces or fits in the sockets of LM725, LM108A, OP-05, OP-06, OP-27, LM741 and AD510. The HTL OP-07 op amp is available in hermetically-sealed TO-99 metal cans, ceramic 8-pin Mini-DIPs, Epoxy Mini-DIPS, small outline Epoxy 8-Pin SOICs and chip carriers (consult factory for additional chip carrier information).

FEATURES

- Ultra Low V_{OS} ..... 10μV Typ.
- Ultra Low V_{OS} Drift ..... 0.2μV/°C Typ.
- Ultra Stable V_{OS} vs Time ..... 0.2μV/Mo. Typ.
- Low Noise (0.1Hz to 10Hz) ..... 0.35$\mu V_{p\text{-}p}$ Typ.
- Wide Input Voltage Range ..... ±14V
- Wide Supply Voltage Range ..... ±3V to ±18V

ORDERING INFORMATION

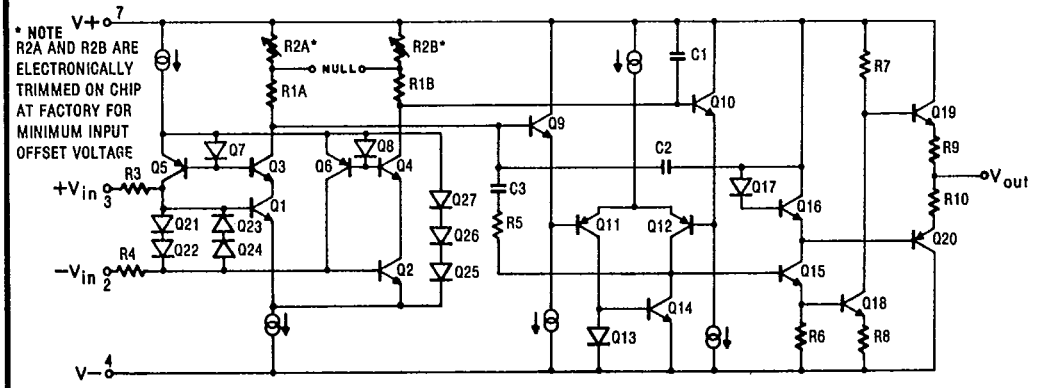
MAXIMUM OFFSET VOLTAGE (T_A = 25°C)	PACKAGE				OPERATING TEMPERATURE RANGE
	HERMETIC METAL TO-99 8-PIN	HERMETIC CERAMIC DIP 8-PIN	PLASTIC DIP 8-PIN	SMALL OUTLINE 8-PIN	
25 μV	OP07AJ*	OP07AZ*			MILITARY
75 μV	OP07EJ	OP07EZ	OP07EP	OP07ES	IND./COM'L
75 μV	OP07J*	OP07Z*			MILITARY
150 μV	OP07CJ	OP07CZ	OP07CP	OP07CS	IND./COM'L
150 μV	OP07DJ		OP07DP	OP07DS	IND./COM L

NOTES:

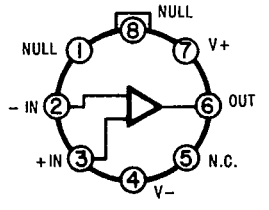
* Also available with MIL-STD 883B Processing. To order add /883B as a suffix to the part number. Consult factory for screening procedure.

* All commercial and industrial temperature range parts are available with burn-in per MIL-STD-883B.

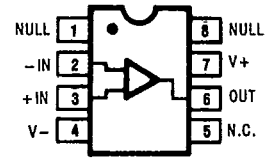
SCHEMATIC DIAGRAM



CONNECTION DIAGRAM



TO-99 (J-Suffix)



EPOXY MINI-DIP (P-Suffix)
8-PIN HERMETIC DIP (Z-Suffix)
8-PIN EPOXY SOIC (S-Suffix)

1177 Blue Heron Boulevard, Riviera Beach, Florida 33404
Telephone (305) 848-4311 • Toll Free WATS (800) 327-8462 • TWX (510) 952-7610 • Telex 51-3435 • Telefax (305) 863-5946

ABSOLUTE MAXIMUM RATINGS

Supply Voltage ..... ±22V
Differential Input Voltage ..... ±30V
Power Dissipation (Note 1) 500mW
Input Voltage (Note 2) ..... ±22V
Output Short-Circuit Duration ..... Indefinite
Operating Temperature Range
  OP-07A, OP-07 ..... −55°C to +125°C
  OP-07E, OP-07C, OP-07D ..... 0°C to +70°C
Storage Temperature Range
  P and S Packages ..... −65°C to +125°C
  J and Z Packages ..... −65°C to +150°C
Lead Temperature (Soldering, 60 sec) ..... 300°C

NOTES:

1. See table for maximum ambient temperature rating and derating factor.

PACKAGE TYPE	MAXIMUM AMBIENT TEMPERATURE FOR RATING	DERATE ABOVE MAXIMUM AMBIENT TEMPERATURE
TO-99 (J)	80°C	7.1mW/°C
8-Pin Hermetic DIP (Z)	75°C	6.7mW/°C
8-Pin Plastic DIP (P)	36°C	5.6mW/°C

2. For supply voltages less than ±22V, the maximum input voltage is equal to the supply voltage.

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

PARAMETER	SYMBOL	CONDITIONS	OP-07A			OP-07			OP-07E			OP-07C			OP-07D			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}	(Note 1)	—	10	25	—	30	75	—	30	75	—	60	150	—	60	150	µV
Long Term Input Offset Voltage Stability	ΔV_{OS}/Time	(Note 2)	—	0.2	1.0	—	0.2	1.0	—	0.3	1.5	—	0.4	2.0	—	0.5	3.0	µV/Mo
Input Offset Current	I_{OS}		—	0.3	2.0	—	0.4	2.8	—	0.5	3.8	—	0.8	6.0	—	0.8	6.0	nA
Input Bias Current	I_B		—	±0.7	±2.0	—	±1.0	±3.0	—	±1.2	±4.0	—	±1.8	±7.0	—	±2.0	±12	nA
Input Noise Voltage	e_{np-p}	0.1Hz to 10Hz (Note 3)	—	0.35	0.6	—	0.35	0.6	—	0.35	0.6	—	0.38	0.65	—	0.38	0.65	μV_{p-p}
Input Noise Voltage Density	e_n	f_o = 10Hz (Note 3) f_o = 100Hz (Note 3) f_o = 1000Hz (Note 3)	— — —	10.3 10.0 9.6	18.0 13.0 11.0	— — —	10.3 10.0 9.6	18.0 13.0 11.0	— — —	10.3 10.0 9.6	18.0 13.0 11.0	— — —	10.5 10.2 9.6	20.0 13.5 11.5	— — —	10.5 10.3 9.8	20.0 13.5 11.5	$nV/\sqrt{Hz}$
Input Noise Current	I_{np-p}	0.1Hz to 10Hz (Note 3)	—	14	30	—	14	30	—	14	30	—	15	35	—	15	35	pA_{p-p}
Input Noise Current Density	I_n	f_o = 10Hz (Note 3) f_o = 100Hz (Note 3) f_o = 1000Hz (Note 3)	— — —	0.32 0.14 0.12	0.80 0.23 0.17	— — —	0.32 0.14 0.12	0.80 0.23 0.17	— — —	0.32 0.14 0.12	0.80 0.23 0.17	— — —	0.35 0.15 0.13	0.90 0.27 0.18	— — —	0.35 0.15 0.13	0.90 0.27 0.18	$pA/\sqrt{Hz}$
Input Resistance Differential Mode	R_{IN}	(Note 4)	30	80	—	20	60	—	15	50	—	8	33	—	7	31	—	MΩ
Input Resistance Common Mode	R_{INCM}		—	200	—	—	200	—	—	160	—	—	120	—	—	120	—	GΩ
Input Voltage Range	IVR		±13	±14	—	±13	±14	—	±13	±14	—	±13	±14	—	±13	±14	—	V
Common Mode Rejection Ratio	CMRR	V_{CM} = ±13V	110	126	—	110	126	—	106	123	—	100	120	—	94	110	—	dB
Power Supply Rejection Ratio	PSRR	V_S = ±3V to ±18V	—	4	10	—	4	10	—	5	20	—	7	32	—	7	32	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 4)	300 150	500 400	— —	200 150	500 400	— —	200 150	500 400	— —	120 100	400 400	— —	120 —	400 400	— —	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	— — —	±12.5 ±12.0 ±10.5	±13.0 ±12.8 ±12.0	— — —	±12.0 ±11.5 —	±13.0 ±12.8 ±12.0	— — —	±12.0 ±11.5 —	±13.0 ±12.8 ±12.0	— — —	V
Slew Rate	SR	R_L≥2kΩ (Note 3)	0.1	0.3	—	0.1	0.3	—	0.1	0.3	—	0.1	0.3	—	0.1	0.3	—	V/µs
Closed Loop Bandwidth	BW	A_{VCL} = +1 (Note 3)	0.4	0.6	—	0.4	0.6	—	0.4	0.6	—	0.4	0.6	—	0.4	0.6	—	MHz
Open Loop Output Resistance	R_O	V_O = 0, I_O = 0	—	60	—	—	60	—	—	60	—	—	60	—	—	60	—	Ω
Power Consumption	P_d	V_S = ±15V, No Load V_S = ±3V, No Load	— —	75 4	120 6	— —	75 4	120 6	— —	75 4	120 6	— —	80 4	150 8	— —	80 4	150 8	mW
Offset Adjustment Range		R_p = 20kΩ	—	±4	—	—	±4	—	—	±4	—	—	±4	—	—	±4	—	mV

NOTES:

1. OP-07A grade V_{OS} is measured one minute after application of power. For all other grades V_{OS} is measured approximately 0.5 seconds after application of power.
2. 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 curves. Parameter is sample tested.
3. Sample tested.
4. Guaranteed by design.

ELECTRICAL CHARACTERISTICS (Continued)

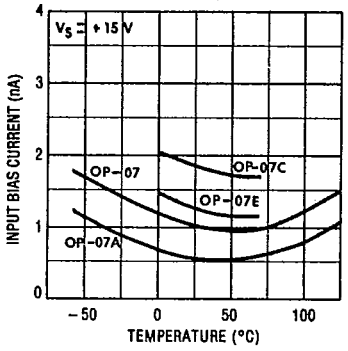
PARAMETER	SYMBOL	CONDITIONS	at V_S = ±15V, −55°C≤T_A≤+125°C, unless otherwise noted						at V_S = ±15V, 0°C≤T_A≤+70°C, unless otherwise noted									UNITS
			OP-07A			OP-07			OP-07E			OP-07C			OP-07D			
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	V_{OS}	(Note 1)	—	25	60	—	60	200	—	45	130	—	85	250	—	85	250	µV
Average Input Offset Voltage Drift Without External Trim	TCV_{OS}	(Note 3)	—	0.2	0.6	—	0.3	1.3	—	0.3	1.3	—	0.5	1.8	—	0.7	2.5	µV/°C
With External Trim	TCV_{OSn}	R_P = 20kΩ (Note 3)	—	0.2	0.6	—	0.3	1.3	—	0.3	1.3	—	0.4	1.6	—	0.7	2.5	µV/°C
Input Offset Current	I_{OS}		—	0.8	4	—	1.2	5.6	—	0.9	5.3	—	1.6	8.0	—	1.6	8.0	nA
Average Input Offset Current Drift	TCI_{OS}	(Note 2)	—	5	25	—	8	50	—	8	35	—	12	50	—	12	50	pA/°C
Input Bias Current	I_B		—	±1	±4	—	±2	±6	—	±1.5	±5.5	—	±2.2	±9.0	—	±3.0	±14	nA
Average Input Bias Current Drift	TCI_B	(Note 2)	—	8	25	—	13	50	—	13	35	—	18	50	—	18	50	pA/°C
Input Voltage Range	IVR		±13	±13.5	—	±13	±13.5	—	±13.0	±13.5	—	±13.0	±13.5	—	±13.0	±13.5	—	V
Common Mode Rejection Ratio	CMRR	V_{CM} = ±13V	106	123	—	106	123	—	103	123	—	97	120	—	94	106	—	dB
Power Supply Rejection Ratio	PSRR	V_S = ±3V to ±18V	—	5	20	—	5	20	—	7	32	—	10	51	—	10	51	µV/V
Large Signal Voltage Gain	A_{VO}	R_L≥2kΩ V_O = ±10V	200	400	—	150	400	—	180	450	—	100	400	—	100	400	—	V/mV
Output Voltage Swing	V_O	R_L≥2kΩ	±12	±12.6	—	±12	±12.6	—	±12	±12.6	—	±11	±12.6	—	±11	±12.6	—	V

NOTES:

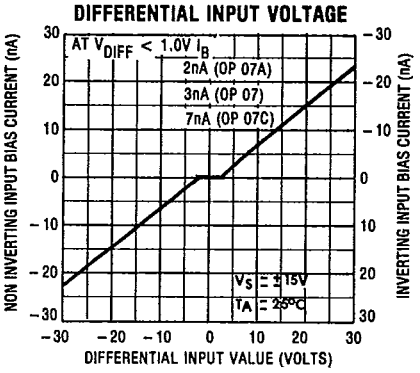
1. OP-07A grade V_{OS} is measured one minute after application of power. For all other grades V_{OS} is measured approximately 0.5 seconds after application of power.
2. Sample tested.
3. Guaranteed by design.

TYPICAL PERFORMANCE CHARACTERISTICS

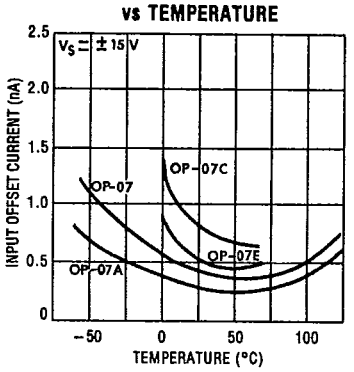
INPUT BIAS CURRENT vs TEMPERATURE



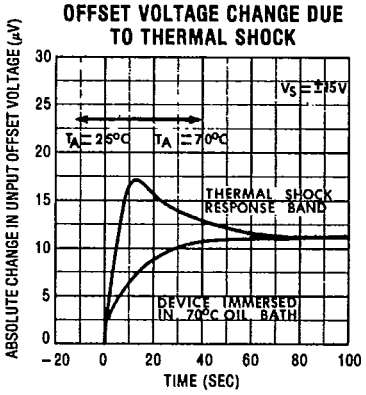
INPUT BIAS CURRENT vs DIFFERENTIAL INPUT VOLTAGE



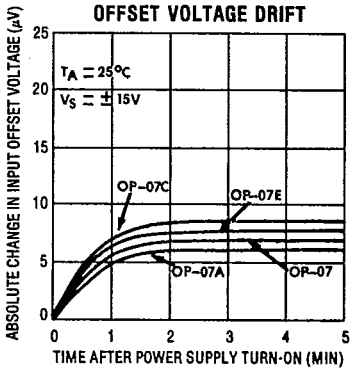
INPUT OFFSET CURRENT vs TEMPERATURE



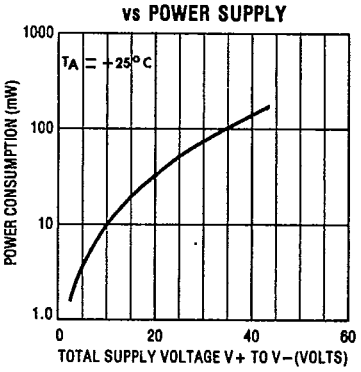
OFFSET VOLTAGE CHANGE DUE TO THERMAL SHOCK



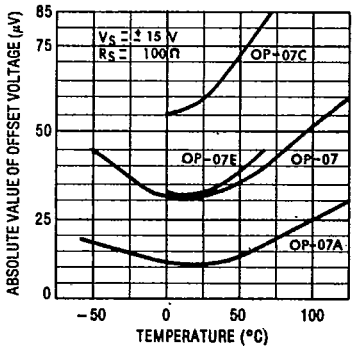
WARM-UP OFFSET VOLTAGE DRIFT



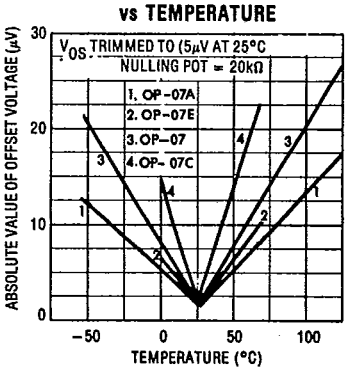
POWER CONSUMPTION vs POWER SUPPLY



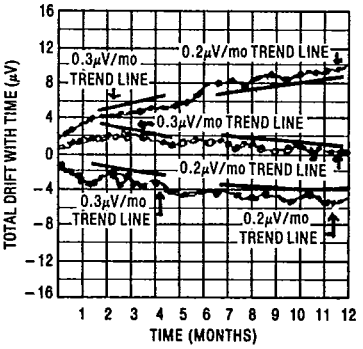
UNTRIMMED OFFSET VOLTAGE vs TEMPERATURE



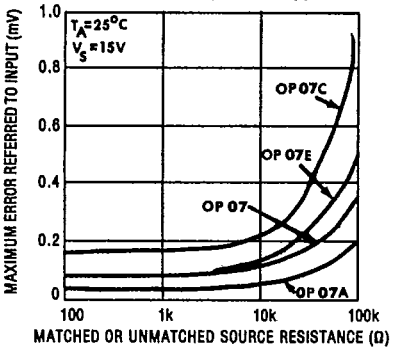
TRIMMED OFFSET VOLTAGE vs TEMPERATURE



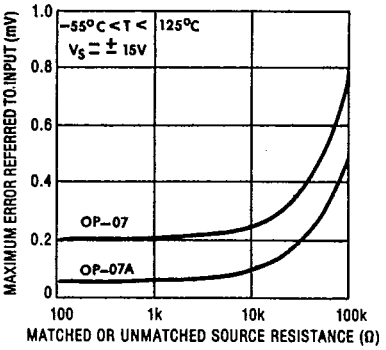
LONG-TERM OFFSET VOLTAGE DRIFT



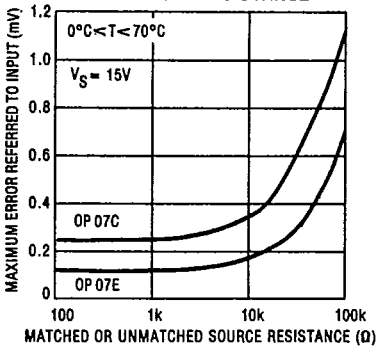
MAXIMUM ERROR vs SOURCE RESISTANCE



MAXIMUM ERROR vs SOURCE RESISTANCE

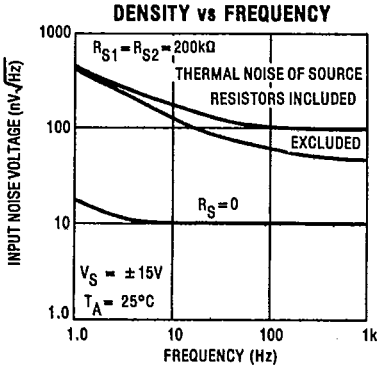


MAXIMUM ERROR vs SOURCE RESISTANCE

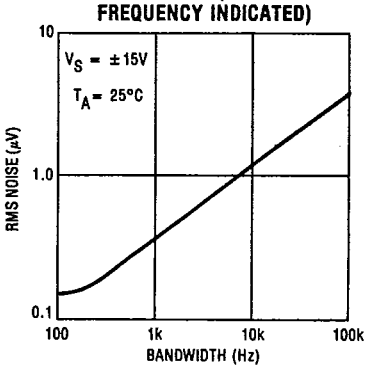


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

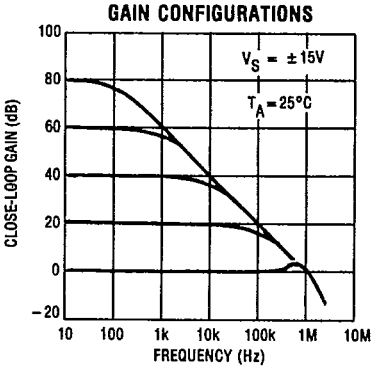
TOTAL INPUT VOLTAGE NOISE DENSITY vs FREQUENCY



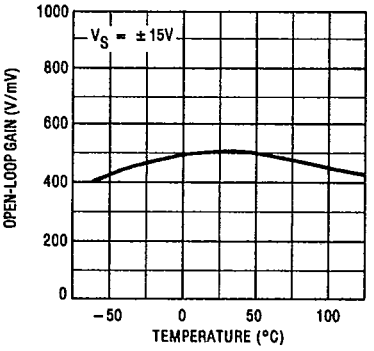
INPUT WIDEBAND NOISE vs BANDWIDTH (0.1Hz TO FREQUENCY INDICATED)



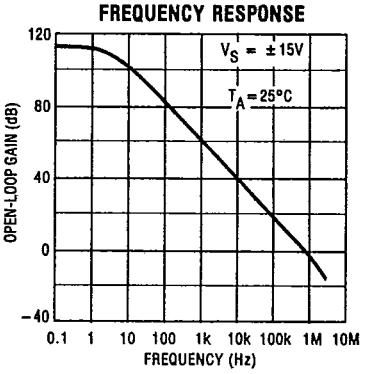
CLOSED-LOOP RESPONSE FOR VARIOUS GAIN CONFIGURATIONS



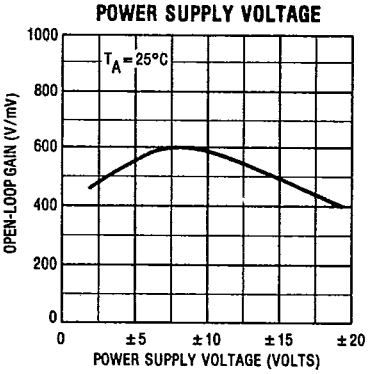
OPEN-LOOP GAIN vs TEMPERATURE



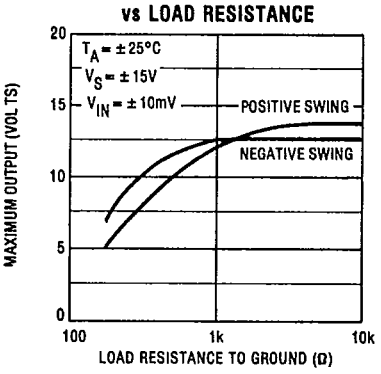
OPEN-LOOP FREQUENCY RESPONSE



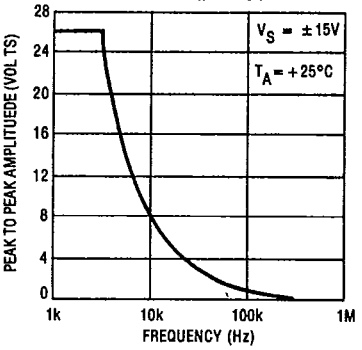
OPEN-LOOP GAIN vs POWER SUPPLY VOLTAGE



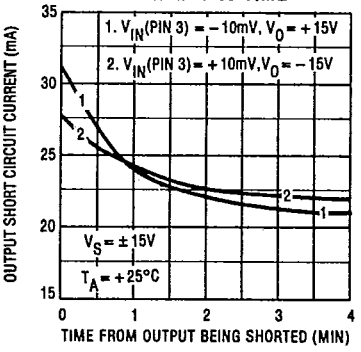
MAXIMUM OUTPUT VOLTAGE vs LOAD RESISTANCE



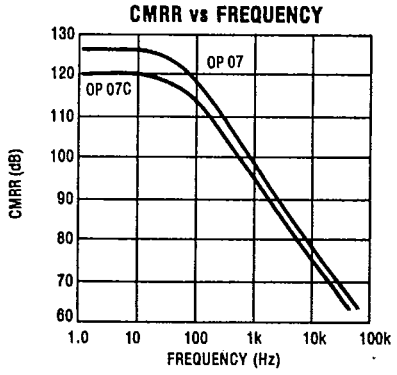
MAXIMUM OUTPUT SWING vs FREQUENCY



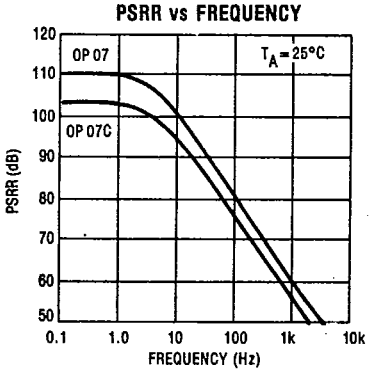
OUTPUT SHORT-CIRCUIT CURRENT vs TIME



CMRR vs FREQUENCY



PSRR vs FREQUENCY



APPLICATION HINTS

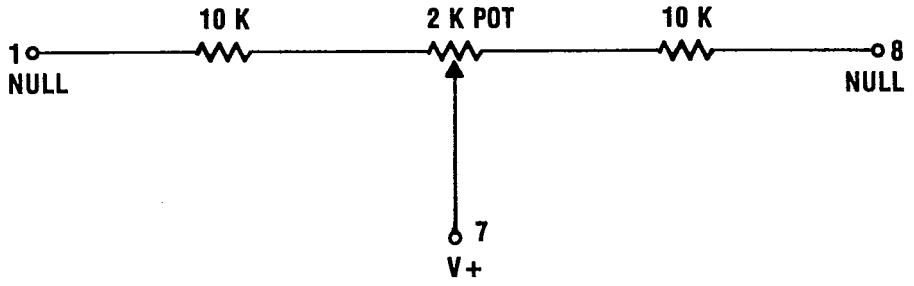
The HTL OP-07 operational amplifier may be inserted directly into the sockets of LM725, LM108A, OP-05, OP-06, OP-27 and other op amps. However, it may be necessary to remove the external compensation or nulling components.

The HTL OP-07 provides stable operation with load capacitances of up to 500pF and ±10V swings. If larger capacitors are used, they should be decoupled with a 50Ω resistor.

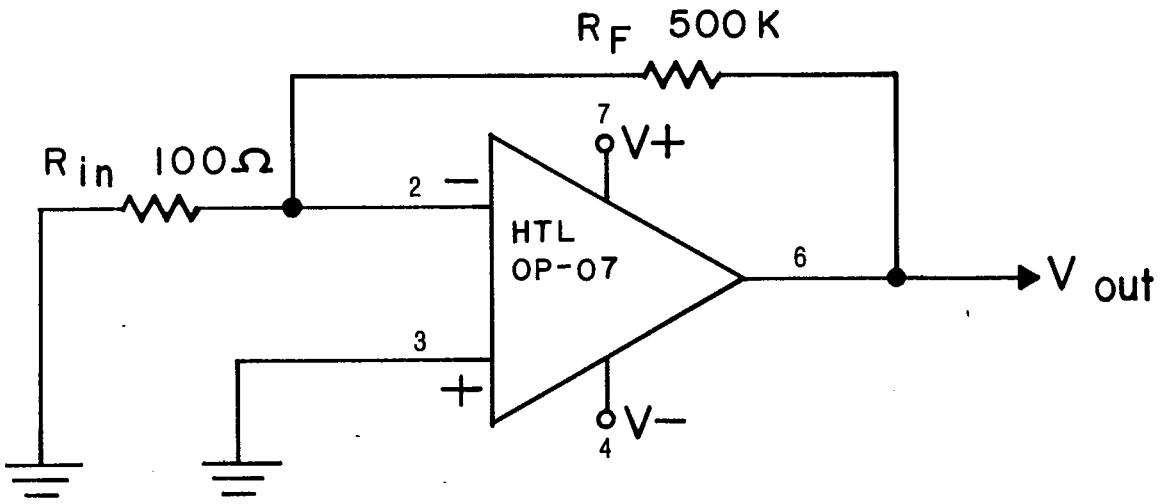
Thermoelectric voltages generated by dissimilar metals at the input terminals of the op amp can degrade the drift performance of the device. Therefore, it is desirable to maintain both input terminals at the same temperature, preferably the temperature of the op amp case.

OFFSET VOLTAGE ADJUSTMENT AND MEASUREMENT

The offset voltage of the HTL OP-07 operational amplifier, as low as it may be, may still be further reduced and nulled to zero or any other value if so desired. This may be done by using a potentiometer as shown below:



The offset voltage may be measured using a feedback configuration with a large R_F/R_{IN} resistor ratio, which amplifies the offset voltage to a value that can easily be measured. A typical offset voltage circuit is shown below:

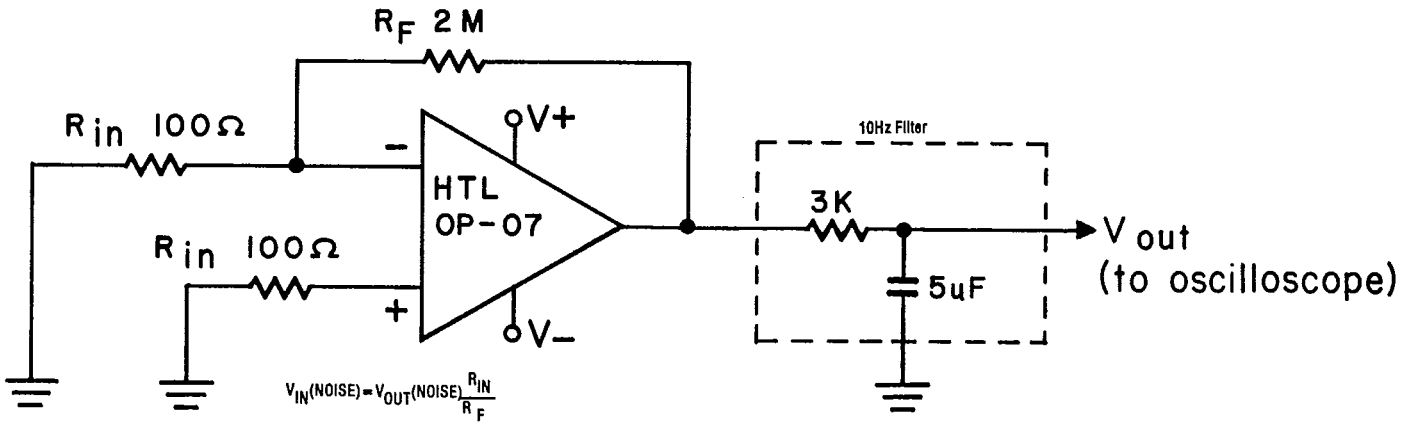


$$V_{OS}=V_{OUT}\frac{R_{IN}}{R_F}$$

NOISE MEASUREMENTS

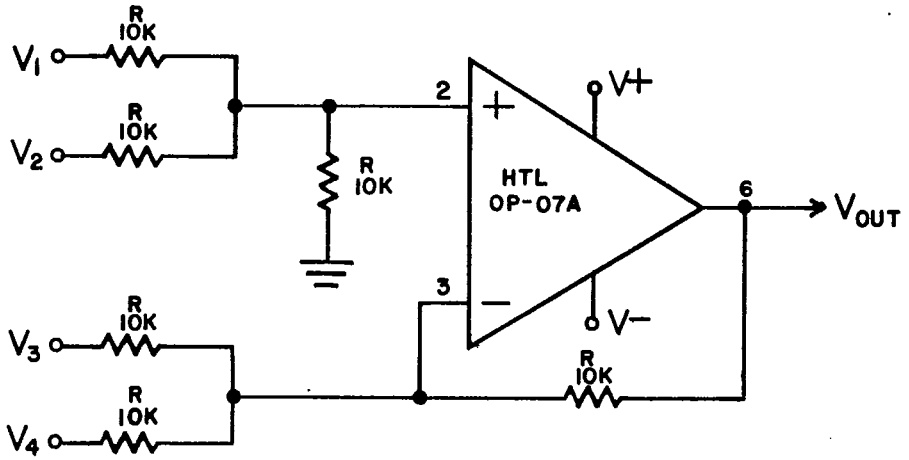
The noise of the HTL OP-07 op amp is very low, and when measured in the 0.1Hz to 10Hz range, may be confused with the DC drifts of the offset voltage due to temperature changes. It is therefore recommended to allow the device a warm-up time of about five to ten minutes as well as to mechanically shield it from air currents that can cause thermoelectric voltages, before any low frequency noise measurements are performed. Also, the test time should be kept below 10 seconds to eliminate the measurement of noise attributed to the frequency band below 0.1Hz.

A simple method of measuring the peak-to-peak low frequency noise, is achieved by employing the device itself as a gain stage and measuring the amplified noise using an oscilloscope. For example, if the op amp gain is set to 20,000 by proper choice of R_F/R_{IN}, and the oscilloscope is set to 1 sec/cm on the horizontal axis, and 5mV/cm on the vertical axis, then, each 1 cm division of peak-to-peak noise measured at the output of the op amp, corresponds to a 250mV of peak-to-peak noise referred to the input. A typical low frequency noise test circuit is shown below:



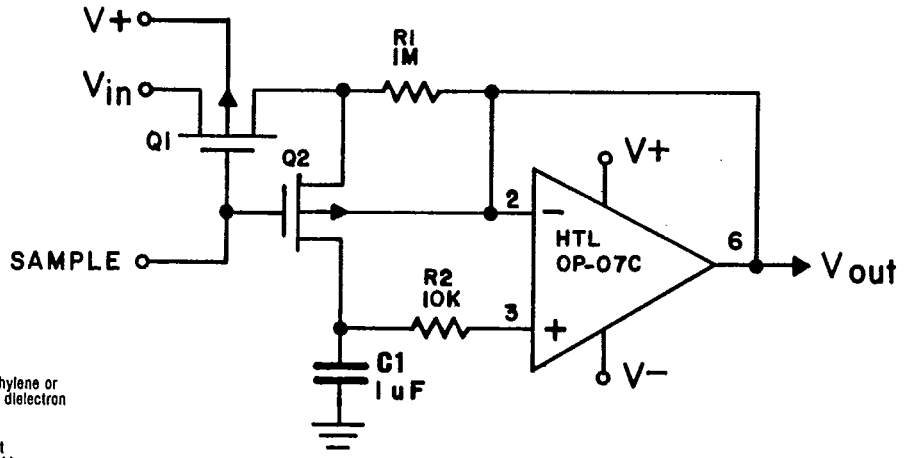
TYPICAL APPLICATIONS

PRECISION SUMMING AMPLIFIER



$V_{OUT} = V_1 + V_2 - V_3 - V_4$

SAMPLE AND HOLD

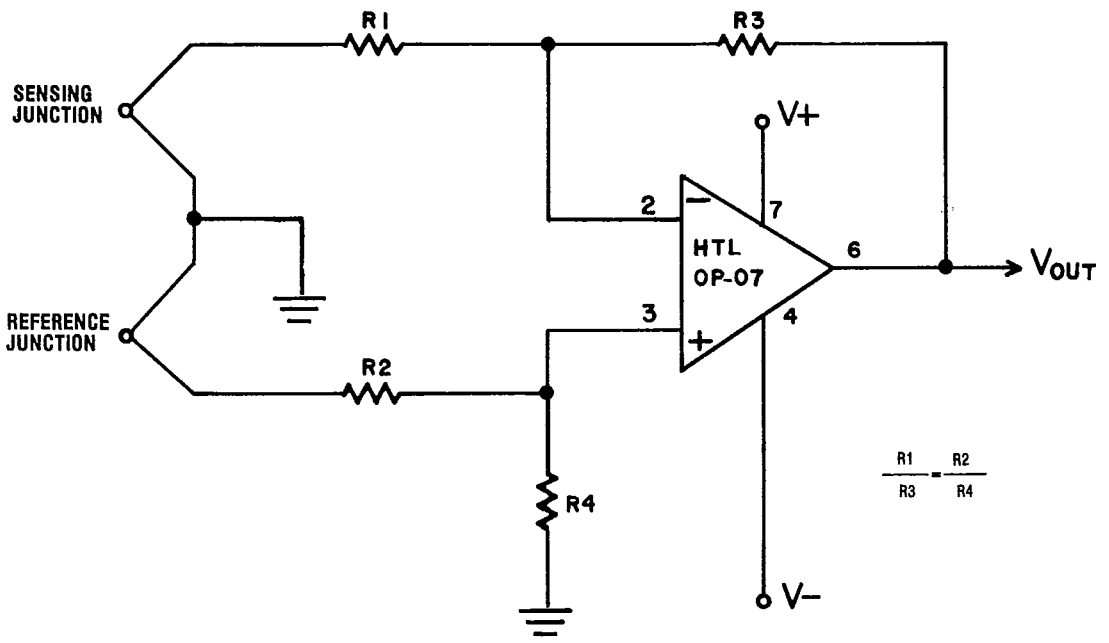


†Teflon, Polyethylene or polycarbonate dielectron capacitor

Worse case drift less than 2.5mV/sec

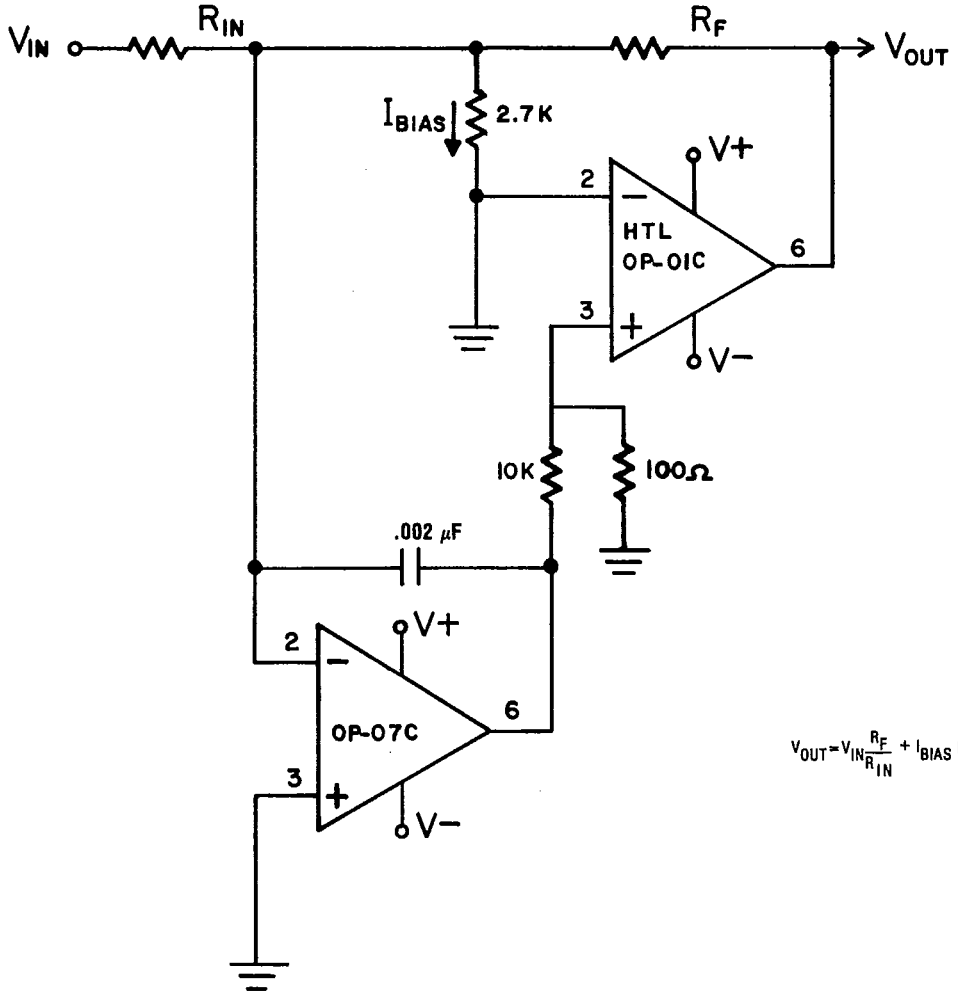
TYPICAL APPLICATIONS (Continued)

THERMOCOUPLE AMPLIFIER



$$\frac{R1}{R3} = \frac{R2}{R4}$$

HIGH SPEED AMPLIFIER WITH LOW DRIFT AND LOW INPUT CURRENT



$$V_{OUT} = V_{IN}\frac{R_F}{R_{IN}} + I_{BIAS}R_F$$