



# T-79-06-10 Ultralow Offset Voltage Op Amp

## AD OP-07

### FEATURES

Ultralow Offset Voltage:  $10\mu\text{V}$   
 Ultralow Offset Voltage Drift:  $0.2\mu\text{V}/^\circ\text{C}$   
 Ultrastable vs. Time:  $0.2\mu\text{V}/^\circ\text{C}$   
 Ultralow Noise:  $0.35\mu\text{V p-p}$   
 No External Components Required  
 Monolithic Construction  
 High Common-Mode Input Range:  $\pm 14.0\text{V}$   
 Wide Power Supply Voltage Range:  $\pm 3\text{V}$  to  $\pm 18\text{V}$   
 Fits 725, 108A/308A Sockets  
 Military Parts and Plus Parts Available  
 8-Pin Plastic Mini-DIP, Cerdip, TO-99 Hermetic Metal Can, or SOIC  
 Available in Wafer-Trimmed Chip Form  
 Available in Tape and Reel in Accordance with EIA-481A Standard  
 Surface Mount (SOIC)

### PRODUCT DESCRIPTION

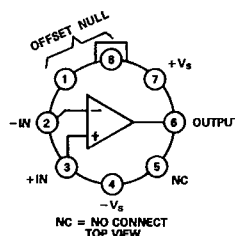
A guaranteed minimum open-loop voltage gain of 3,000,000 (AD OP-07A) represents an order of magnitude improvement over older designs; this affords increased accuracy in high closed-loop gain applications. Typical input offset voltages as low as  $10\mu\text{V}$ , typical bias currents of  $0.7\text{nA}$ , internal compensation and device protection eliminate the need for external components and adjustments. An input offset voltage temperature coefficient of  $0.2\mu\text{V}/^\circ\text{C}$  (typ) and long-term stability of  $0.2\mu\text{V}/\text{month}$  (typ) eliminate recalibration or loss of initial accuracy.

A true differential operational amplifier, the AD OP-07 has a high common-mode input voltage range ( $\pm 13\text{V}$  min) common-mode rejection ratio (typically up to  $126\text{dB}$ ) and high differential input impedance ( $50\text{M}\Omega$  typ); these features combine to assure high accuracy in noninverting configurations. Such applications include instrumentation amplifiers where the increased open-loop gain maintains high linearity at high closed-loop gains.

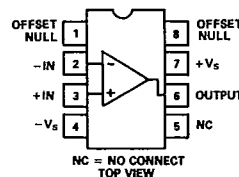
The AD OP-07 is available in five performance grades. The AD OP-07E, AD OP-07C and AD OP-07D are specified for operation over the  $0$  to  $+70^\circ\text{C}$  temperature range, while the AD OP-07A and AD OP-07 are specified for  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$  operation. All devices are available in either the TO-99 hermetically sealed metal cans or the hermetically sealed cerdip packages, while the commercial grades are also available in plastic 8-pin mini-DIP and plastic surface mount (SOIC) packages.

### CONNECTION DIAGRAMS

#### TO-99 (H) Package



#### Plastic Mini-DIP (N), Cerdip (Q) and SOIC (R) Packages



### PRODUCT HIGHLIGHTS

1. Increased open-loop voltage gain (3.0 million min) results in better accuracy and linearity in high closed-loop gain applications.
2. Ultralow offset voltage and offset voltage drift, combined with low input bias currents, allow the AD OP-07 to maintain high accuracy over the entire operating temperature range.
3. Internal frequency compensation, ultralow input offset voltage and full device protection eliminate the need for additional components. This reduces circuit size and complexity and increases reliability.
4. High input impedances, large common-mode input voltage range and high common-mode rejection ratio make the AD OP-07 ideal for noninverting and differential instrumentation applications.
5. Monolithic construction along with advanced circuit design and processing techniques result in low cost.
6. The input offset voltage is trimmed at the wafer stage. Unmounted chips are available for hybrid circuit applications.

# AD OP-07—SPECIFICATIONS ( $T_A = +25^\circ\text{C}$ , $V_S = \pm 15\text{ V}$ , unless otherwise specified)

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| Model<br>Parameter                                                                                 | Symbol                                           | AD OP-07E                                            |                                                           |                                                           | AD OP-07C                                            |                                                           |                                                            | AD OP-07D                                            |                                                           |                                                            |
|----------------------------------------------------------------------------------------------------|--------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------|
|                                                                                                    |                                                  | Min                                                  | Typ                                                       | Max                                                       | Min                                                  | Typ                                                       | Max                                                        | Min                                                  | Typ                                                       | Max                                                        |
| OPEN LOOP GAIN                                                                                     | $A_{VOL}$                                        | 2,000<br>1,800<br>300                                | 5,000<br>4,500<br>1,000                                   |                                                           | 1,200<br>1,000<br>300                                | 4,000<br>4,000<br>1,000                                   |                                                            | 1,200<br>1,000<br>300                                | 4,000<br>4,000<br>1,000                                   |                                                            |
| OUTPUT CHARACTERISTICS<br>Maximum Output Swing                                                     | $V_{OM}$                                         | $\pm 12.5$<br>$\pm 12.0$<br>$\pm 10.5$<br>$\pm 12.0$ | $\pm 13.0$<br>$\pm 12.8$<br>$\pm 12.0$<br>$\pm 12.6$      |                                                           | $\pm 12.0$<br>$\pm 11.5$<br>$\pm 12.0$<br>$\pm 11.0$ | $\pm 13.0$<br>$\pm 12.8$<br>$\pm 12.0$<br>$\pm 12.6$      |                                                            | $\pm 12.0$<br>$\pm 11.5$<br>$\pm 12.0$<br>$\pm 11.0$ | $\pm 13.0$<br>$\pm 12.8$<br>$\pm 12.0$<br>$\pm 12.6$      |                                                            |
| Open-Loop Output Resistance                                                                        | $R_{OL}$                                         |                                                      | 60                                                        |                                                           |                                                      | 60                                                        |                                                            |                                                      | 60                                                        |                                                            |
| FREQUENCY RESPONSE<br>Closed Loop Bandwidth<br>Slew Rate                                           | BW<br>SR                                         |                                                      | 0.6<br>0.17                                               |                                                           |                                                      | 0.6<br>0.17                                               |                                                            |                                                      | 0.6<br>0.17                                               |                                                            |
| INPUT OFFSET VOLTAGE<br>Initial                                                                    | $V_{OS}$                                         |                                                      | 30<br>45<br>+ 4                                           | 75<br>130                                                 |                                                      | 60<br>85<br>+ 4                                           | 150<br>250                                                 |                                                      | 60<br>85<br>+ 4                                           | 150<br>250                                                 |
| Adjustment Range<br>Average Drift<br>No External Trim<br>With External Trim<br>Long Term Stability | $TCV_{OS}$<br>$TCV_{OSN}$<br>$V_{OS\text{Time}}$ |                                                      | 0.3<br>0.3<br>0.3                                         | 1.3<br>1.3<br>1.5                                         |                                                      | 0.5<br>0.4<br>0.4                                         | 1.8<br>1.6<br>2.0                                          |                                                      | 0.7<br>0.7<br>0.5                                         | 2.5<br>2.5<br>3.0                                          |
| INPUT OFFSET CURRENT<br>Initial                                                                    | $I_{OS}$                                         |                                                      | 0.5<br>0.9<br>8                                           | 3.8<br>5.3<br>35                                          |                                                      | 0.8<br>1.6<br>12                                          | 6.0<br>8.0<br>50                                           |                                                      | 0.8<br>1.6<br>12                                          | 6.0<br>8.0<br>50                                           |
| Average Drift                                                                                      | $TCI_{OS}$                                       |                                                      |                                                           |                                                           |                                                      |                                                           |                                                            |                                                      |                                                           |                                                            |
| INPUT BIAS CURRENT<br>Initial                                                                      | $I_B$                                            |                                                      | + 1.2<br>+ 1.5<br>13                                      | $\pm 4.0$<br>$\pm 5.5$<br>35                              |                                                      | + 1.8<br>+ 2.2<br>18                                      | $\pm 7.0$<br>$\pm 9.0$<br>50                               |                                                      | + 2.0<br>+ 3.0<br>18                                      | $\pm 12$<br>$\pm 14$<br>50                                 |
| Average Drift                                                                                      | $TCI_B$                                          |                                                      |                                                           |                                                           |                                                      |                                                           |                                                            |                                                      |                                                           |                                                            |
| INPUT RESISTANCE<br>Differential<br>Common Mode                                                    | $R_{IN}$<br>$R_{INCM}$                           | 15                                                   | 50<br>160                                                 |                                                           | 8                                                    | 33<br>120                                                 |                                                            | 7                                                    | 31<br>120                                                 |                                                            |
| INPUT NOISE<br>Voltage<br>Voltage Density<br>Current<br>Current Density                            | $e_n$ P-P<br>$e_n$<br>$i_n$ P-P<br>$i_n$         |                                                      | 0.35<br>10.3<br>10.0<br>9.6<br>14<br>0.32<br>0.14<br>0.12 | 0.6<br>18.0<br>13.0<br>11.0<br>30<br>0.80<br>0.23<br>0.17 |                                                      | 0.38<br>10.5<br>10.2<br>9.8<br>15<br>0.35<br>0.15<br>0.13 | 0.65<br>20.0<br>13.5<br>11.5<br>35<br>0.90<br>0.27<br>0.18 |                                                      | 0.38<br>10.5<br>10.2<br>9.8<br>15<br>0.35<br>0.15<br>0.13 | 0.65<br>20.0<br>13.5<br>11.5<br>35<br>0.90<br>0.27<br>0.18 |
| INPUT VOLTAGE RANGE<br>Common Mode                                                                 | CMVR                                             | $\pm 13.0$<br>$\pm 13.0$                             | + 14.0<br>$\pm 13.5$                                      |                                                           | $\pm 13.0$<br>$\pm 13.0$                             | + 14.0<br>$\pm 13.5$                                      |                                                            | $\pm 13.0$<br>$\pm 13.0$                             | + 14.0<br>$\pm 13.5$                                      |                                                            |
| Common-Mode Rejection<br>Ratio                                                                     | CMRR                                             | 106<br>103                                           | 123<br>123                                                |                                                           | 100<br>97                                            | 120<br>120                                                |                                                            | 94<br>94                                             | 110<br>106                                                |                                                            |
| POWER SUPPLY<br>Current, Quiescent<br>Power Consumption<br>Rejection Ratio                         | $I_{Q2}$<br>$P_{D1}$<br>PSRR                     |                                                      | 3.0<br>90<br>6.0<br>94<br>90                              | 4.0<br>120<br>9.0                                         |                                                      | 3.5<br>105<br>6.0<br>90<br>86                             | 5.0<br>150<br>9.0                                          |                                                      | 3.5<br>105<br>6.0<br>90<br>86                             | 5.0<br>150<br>9.0                                          |
| OPERATING TEMPERATURE<br>RANGE                                                                     | $T_{min}$ , $T_{max}$                            | 0                                                    |                                                           | + 70                                                      | 0                                                    |                                                           | + 70                                                       | 0                                                    |                                                           | + 70                                                       |

## NOTES

<sup>1</sup>Input Offset Voltage measurements are performed by automated test equipment approximately 0.5 seconds after application of power. Additionally, the AD OP-07A offset voltage is guaranteed fully warmed up.

<sup>2</sup>Long-Term Input Offset Voltage Stability refers to the averaged trend line of  $V_{OS}$  vs. Time over extended periods of time and is extrapolated from high temperature test data. Excluding the initial hour of operation, changes in  $V_{OS}$  during the first 30 operating days are typically  $2.5\mu\text{V}$ . Parameter is not 100% tested: 90% of units meet this specification.

Specifications subject to change without notice.

## AD OP-07

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| AD OP-07A  |                 |     | AD OP-07   |                  |     | Test Conditions                                                   | Units             |
|------------|-----------------|-----|------------|------------------|-----|-------------------------------------------------------------------|-------------------|
| Min        | Typ             | Max | Min        | Typ              | Max |                                                                   |                   |
| 3,000      | 5,000           |     | 2,000      | 5,000            |     | $R_{f1} \geq 2k\Omega$ , $V_O = \pm 10V$                          | V/mV              |
| 2,000      | 4,000           |     | 1,500      | 4,000            |     | $R_{f1} \geq 2k\Omega$ , $V_O = \pm 10V$ , $T_{min}$ to $T_{max}$ | V/mV              |
| 300        | 1,000           |     | 300        | 1,000            |     | $R_{f1} = 500\Omega$ , $V_O = \pm 0.5V$ , $V_S = \pm 3V$          | V/mV              |
| $\pm 12.5$ | $\pm 13.0$      |     | $\pm 12.5$ | $\pm 13.0$       |     | $R_{f1} \geq 10k\Omega$                                           | V                 |
| $\pm 12.0$ | $\pm 12.8$      |     | $\pm 12.0$ | $\pm 12.8$       |     | $R_{f1} \geq 2k\Omega$                                            | V                 |
| $\pm 10.5$ | $\pm 12.0$      |     | $\pm 10.5$ | $\pm 12.0$       |     | $R_{f1} \geq 1k\Omega$                                            | V                 |
| $\pm 12.0$ | $\pm 12.6$      |     | $\pm 12.0$ | $\pm 12.6$       |     | $R_{f1} \geq 2k\Omega$ , $T_{min}$ to $T_{max}$                   | V                 |
| 60         |                 |     | 60         |                  |     | $V_O = 0$ , $I_O = 0$                                             | $\Omega$          |
| 0.6        |                 |     | 0.6        |                  |     | $A_{VCL} = +1.0$                                                  | MHz               |
| 0.17       |                 |     | 0.17       |                  |     | $R_{f1} \geq 2k$                                                  | V/ $\mu s$        |
| 10         | 25              |     | 30         | 75               |     | Note 1                                                            | $\mu V$           |
| 25         | 60 <sup>1</sup> |     | 60         | 200 <sup>1</sup> |     | $T_{min}$ to $T_{max}$                                            | $\mu V$           |
| $\pm 4$    |                 |     | $\pm 4$    |                  |     | $R_p = 20k\Omega$                                                 | mV                |
| 0.2        | 0.6             |     | 0.3        | 1.3              |     | $T_{min}$ to $T_{max}$                                            | $\mu V/^{\circ}C$ |
| 0.2        | 0.6             |     | 0.3        | 1.3              |     | $R_p = 20k\Omega$ , $T_{min}$ to $T_{max}$                        | $\mu V/^{\circ}C$ |
| 0.2        | 1.0             |     | 0.2        | 1.0              |     | Note 2                                                            | $\mu V/$ Month    |
| 0.3        | 2.0             |     | 0.4        | 2.8              |     | $T_{min}$ to $T_{max}$                                            | nA                |
| 0.8        | 4.0             |     | 1.2        | 5.6              |     | $T_{min}$ to $T_{max}$                                            | nA                |
| 5          | 25              |     | 8          | 50               |     |                                                                   | pA/^{\circ}C      |
| $\pm 0.7$  | $\pm 2.0$       |     | $\pm 1.0$  | $\pm 3.0$        |     | $T_{min}$ to $T_{max}$                                            | nA                |
| $\pm 1.0$  | $\pm 4.0$       |     | $\pm 2.0$  | $\pm 6.0$        |     | $T_{min}$ to $T_{max}$                                            | nA                |
| 8          | 25              |     | 13         | 50               |     |                                                                   | pA/^{\circ}C      |
| 30         | 80              |     | 20         | 60               |     |                                                                   | M $\Omega$        |
|            | 200             |     |            | 200              |     |                                                                   | G $\Omega$        |
| 0.35       | 0.6             |     | 0.35       | 0.6              |     | 0.1Hz to 10Hz                                                     | $\mu V$ p-p       |
| 10.3       | 18.0            |     | 10.3       | 18.0             |     | $f_O = 10Hz$                                                      | nV/ $\sqrt{Hz}$   |
| 10.0       | 13.0            |     | 10.0       | 13.0             |     | $f_O = 100Hz$                                                     | nV/ $\sqrt{Hz}$   |
| 9.6        | 11.0            |     | 9.6        | 11.0             |     | $f_O = 1kHz$                                                      | nV/ $\sqrt{Hz}$   |
| 14         | 30              |     | 14         | 30               |     | 0.1Hz to 10Hz                                                     | pA p-p            |
| 0.32       | 0.80            |     | 0.32       | 0.80             |     | $f_O = 10Hz$                                                      | pA/ $\sqrt{Hz}$   |
| 0.14       | 0.23            |     | 0.14       | 0.23             |     | $f_O = 100Hz$                                                     | pA/ $\sqrt{Hz}$   |
| 0.12       | 0.17            |     | 0.12       | 0.17             |     | $f_O = 1kHz$                                                      | pA/ $\sqrt{Hz}$   |
| $\pm 13.0$ | $\pm 14.0$      |     | $\pm 13.0$ | $\pm 14.0$       |     | $T_{min}$ to $T_{max}$                                            | V                 |
| $\pm 13.0$ | $\pm 13.5$      |     | $\pm 13.0$ | $\pm 13.5$       |     |                                                                   | V                 |
| 110        | 126             |     | 110        | 126              |     | $V_{CM} = \pm CMVR$                                               | dB                |
| 106        | 123             |     | 106        | 123              |     | $V_{CM} = \pm CMVR$ , $T_{min}$ to $T_{max}$                      | dB                |
| 3.0        | 4.0             |     | 30         | 4.0              |     | $V_S = \pm 15V$                                                   | mA                |
| 90         | 120             |     | 90         | 120              |     | $V_S = \pm 15V$                                                   | mW                |
| 6.0        | 8.4             |     | 6.0        | 8.4              |     | $V_S = \pm 3V$                                                    | mW                |
| 100        | 110             |     | 100        | 110              |     | $V_S = \pm 3V$ to $\pm 18V$                                       | dB                |
| 94         | 106             |     | 94         | 106              |     | $V_S = \pm 3V$ to $\pm 18V$ , $T_{min}$ to $T_{max}$              | dB                |
| -55        | +125            |     | -55        | +125             |     |                                                                   | $^{\circ}C$       |

Specifications shown in boldface are tested on all production units at final electrical test. Results from those tests are used to calculate outgoing quality levels. All min and max specifications are guaranteed, although only those shown in boldface are tested on all production units.

## AD OP-07

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## ABSOLUTE MAXIMUM RATINGS

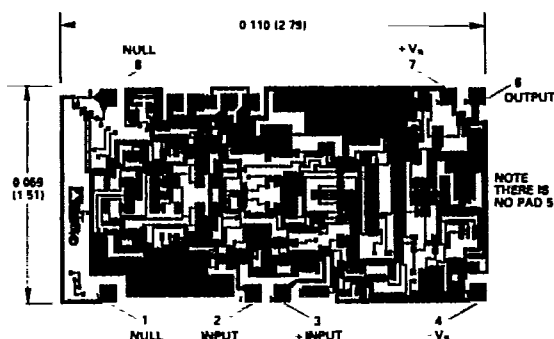
|                                          |                 |
|------------------------------------------|-----------------|
| Supply Voltage                           | ± 22V           |
| Internal Power Dissipation (Note 1)      | 500mW           |
| Differential Input Voltage               | ± 30V           |
| Input Voltage                            | ± $V_s$         |
| Output Short Circuit Duration            | Indefinite      |
| Storage Temperature Range                | -65°C to +150°C |
| Operating Temperature Range              |                 |
| AD OP-07A, AD OP-07                      | -55°C to +125°C |
| AD OP-07E, AD OP-07C, AD OP-07D          | 0 to +70°C      |
| Lead Temperature Range (Soldering 60sec) | +300°C          |

## NOTE

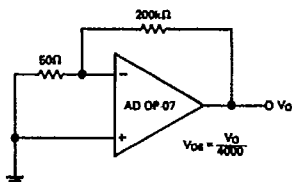
Note 1: Maximum package power dissipation vs. ambient temperature.

| Package Type | Maximum Ambient Temperature for Rating | Derate Above Maximum Ambient Temperature |
|--------------|----------------------------------------|------------------------------------------|
| TO-99(H)     | 80°C                                   | 7.1mW/°C                                 |
| Mini-DIP(N)  | 36°C                                   | 5.6mW/°C                                 |
| Cerdip(Q)    | 75°C                                   | 6.7mW/°C                                 |

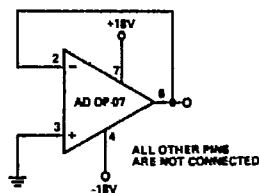
## CHIP DIMENSIONS AND BONDING DIAGRAM

Dimensions shown in inches and (mm).  
Contact factory for latest dimensions.

THE AD OP-07 IS AVAILABLE IN WAFER TRIMMED CHIP FORM FOR PRECISION HYBRIDS. CONSULT THE FACTORY FOR DETAILS.



Offset Voltage Test Circuit



Burn-In Circuit

ORDERING GUIDE<sup>1</sup>

| Model          | Temperature Range (°C) | Max Initial Offset (μV) | Max Offset Drift (μV/°C) | Package Description | Package Option <sup>2</sup> |
|----------------|------------------------|-------------------------|--------------------------|---------------------|-----------------------------|
| ADOP-07EH      | 0 to +70               | 75                      | 1.3                      | TO-99               | H-08A                       |
| ADOP-07EN      | 0 to +70               | 75                      | 1.3                      | Mini-DIP            | N-8                         |
| ADOP-07EQ      | 0 to +70               | 75                      | 1.3                      | Cerdip              | Q-8                         |
| ADOP-07CH      | 0 to +70               | 150                     | 1.8                      | TO-99               | H-08A                       |
| ADOP-07CN      | 0 to +70               | 150                     | 1.8                      | Mini-DIP            | N-8                         |
| ADOP-07CQ      | 0 to +70               | 150                     | 1.8                      | Cerdip              | Q-8                         |
| ADOP-07CR      | 0 to +70               | 150                     | 1.8                      | SOIC                | R-8                         |
| ADOP-07CR-REEL | 0 to +70               | 150                     | 1.8                      | SOIC                |                             |
| ADOP-07DH      | 0 to +70               | 150                     | 2.5                      | TO-99               | H-08A                       |
| ADOP-07DN      | 0 to +70               | 150                     | 2.5                      | Mini-DIP            | N-8                         |
| ADOP-07DQ      | 0 to +70               | 150                     | 2.5                      | Cerdip              | Q-8                         |
| ADOP-07AH      | -55 to +125            | 25                      | 0.6                      | TO-99               | H-08A                       |
| ADOP-07AQ      | -55 to +125            | 25                      | 0.6                      | Cerdip              | Q-8                         |
| ADOP-07H       | -55 to +125            | 75                      | 1.3                      | TO-99               | H-08A                       |
| ADOP-07Q       | -55 to +125            | 75                      | 1.3                      | Cerdip              | Q-8                         |

## NOTES

<sup>1</sup>A, C and D grade chips are also available.<sup>2</sup>For outline information see Package Information section.

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## Applying the AD OP-07

The AD OP-07 may be directly substituted for other OP-07s as well as 725, 108/208/308, 108A/208A/308A, 714, OP-05 or LM11 devices, with or without removal of external frequency compensation or offset nulling components. If used to replace 741 devices, offset nulling components must be removed (or

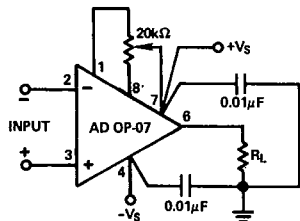


Figure 1. Optional Offset Nulling Circuit and Power Supply Bypassing

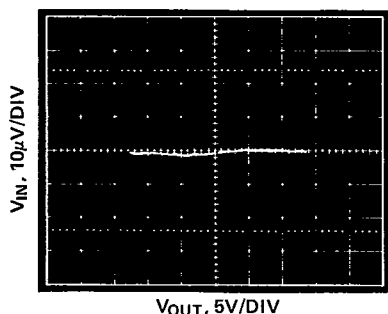
referenced to  $+V_S$ ). Input offset voltage of AD OP-07 is very low, but if additional nulling is required, the circuit shown in Figure 1 is recommended.

The AD OP-07 provides stable operation with load capacitances up to 500pF and  $\pm 10V$  swings; larger capacitances should be decoupled with 50Ω resistor.

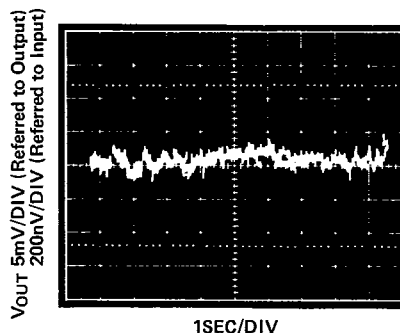
Stray thermoelectric voltages generated by dissimilar metals (thermocouples) at the contacts to the input terminals can prevent realization of the drift performance indicated. Best operation will be obtained when both input contacts are maintained at the same temperature, preferably close to the temperature of the device's package.

Although the AD OP-07 features high power supply rejection, the effects of noise on the power supplies may be minimized by bypassing the power supplies as close to Pins 4 and 7 of the AD OP-07 as possible, to load ground with a good-quality 0.01μF ceramic capacitor as shown in Figure 1.

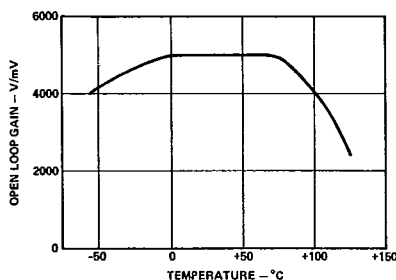
## Performance Curves (typical @ $T_A = +25^\circ\text{C}$ , $V_S = \pm 15V$ , AD OP-07 Grade Device unless otherwise noted)



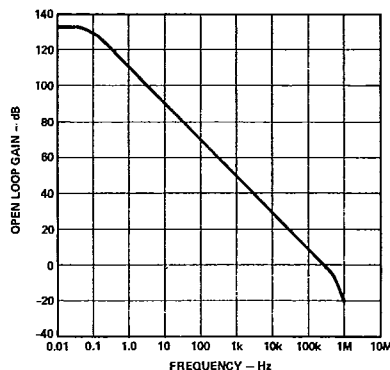
AD OP-07 Open-Loop Gain Curve



AD OP-07 Low Frequency Noise (See Test Circuit, on the Previous Page)



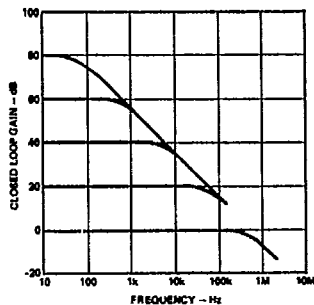
Open-Loop Gain vs. Temperature



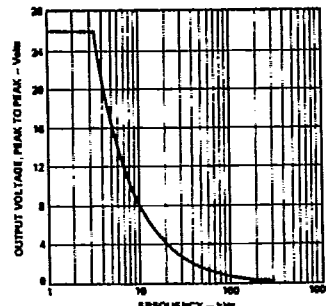
Open-Loop Frequency Response

## AD OP-07—Typical Performance Curves

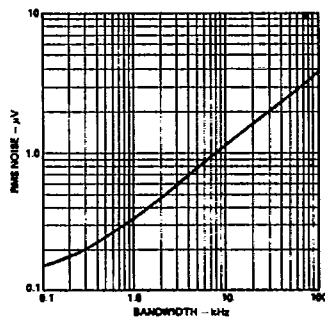
T-79-06-10



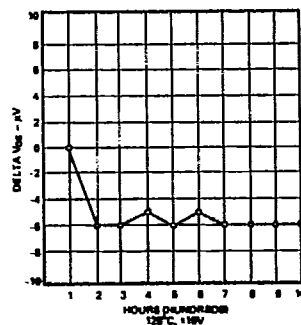
Closed-Loop Response for Various Gain Configurations



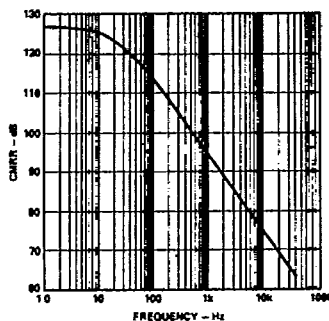
Maximum Undistorted Output vs. Frequency



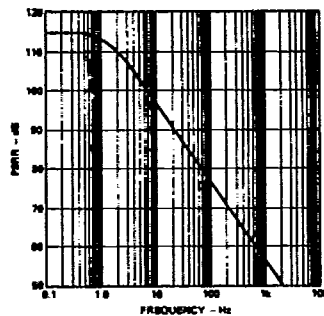
Input Wideband Noise vs. Bandwidth (0.1kHz to Frequency Indicated)



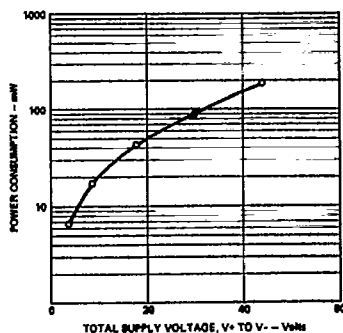
Offset Voltage vs. Time



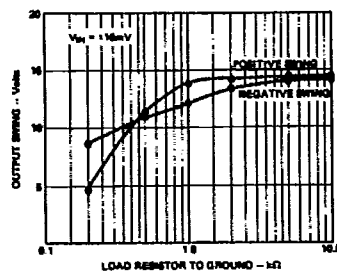
CMRR vs. Frequency



PSRR vs. Frequency



Power Consumption vs. Power Supply



Output Voltage vs. Load Resistance