

## OP-07 Low Offset, Low Drift Operational Amplifier

### General Description

The OP-07 has very low input offset voltage which is obtained by trimming at the wafer stage. These low offset voltages generally eliminate any need for external nulling. The OP-07 also features low input bias current and high open-loop gain. The low offsets and high open-loop gain make the OP-07 particularly useful for high-gain applications.

The wide input voltage range of  $\pm 13V$  minimum combined with high CMRR of 110 dB and high input impedance provide high accuracy in the non-inverting circuit configuration. Excellent linearity and gain accuracy can be maintained even at high closed-loop gains.

Stability of offsets and gain with time or variation in temperature is excellent.

The OP-07 is available in TO-99 metal can, ceramic or molded DIP.

For improved specifications, see the LM607.

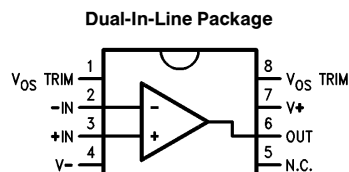
### Features

- Low  $V_{OS}$  75  $\mu V$  Max
- Low  $V_{OS}$  Drift 0.6  $\mu V/^{\circ}C$  Max
- Ultra-Stable vs Time 1.0  $\mu V$ /Month Max
- Low Noise 0.6  $\mu V$ p-p Max
- Wide Input Voltage Range  $\pm 14V$
- Wide Supply Voltage Range  $\pm 3V$  to  $\pm 18V$
- Fits 725/108A/308A, 741, AD510 Sockets
- Replaces the  $\mu A714$

### Applications

- Strain Gauge Amplifiers
- Thermocouple Amplifiers
- Precision Reference Buffer
- Analog Computing Functions

### Connection Diagram



See NS Package Number N08E

TL/H/10550-1

### Ordering Information

| $T_A = 25^{\circ}C$<br>$V_{OS}Max$<br>( $\mu V$ ) | N08E<br>Plastic | Operating<br>Temperature<br>Range |
|---------------------------------------------------|-----------------|-----------------------------------|
| 75                                                | OP07EP          | COM                               |
| 150                                               | OP07CP          | COM                               |
| 150                                               | OP07DP          | COM                               |

\*Also available per SMD #8203602

## Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

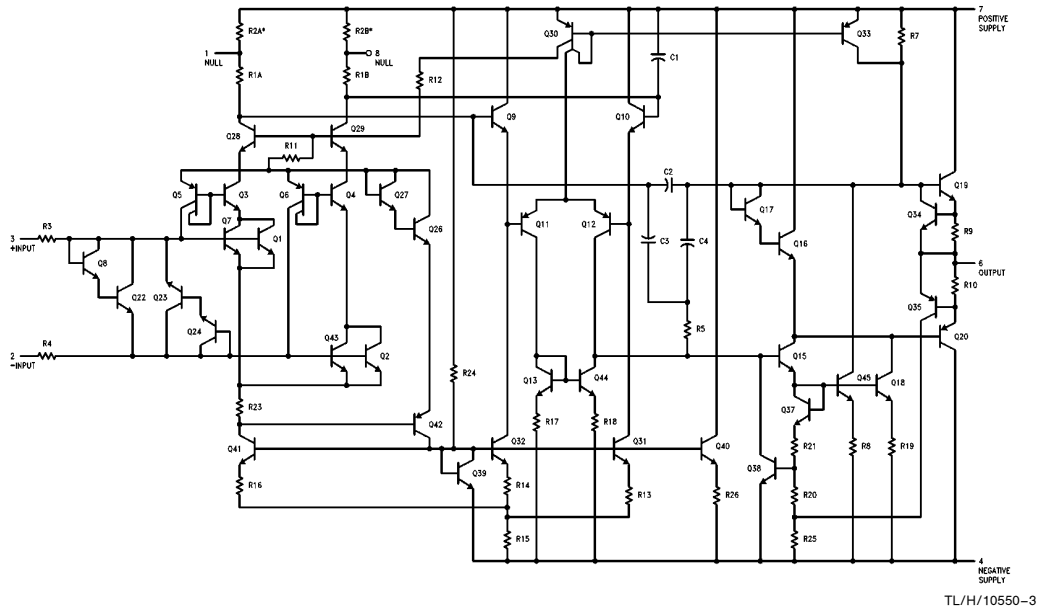
|                                     |                  |
|-------------------------------------|------------------|
| Supply Voltage                      | $\pm 22\text{V}$ |
| Internal Power Dissipation (Note 5) | 500 mW           |
| Differential Input Voltage          | $\pm 30\text{V}$ |
| Input Voltage (Note 6)              | $\pm 22\text{V}$ |
| Output Short-Circuit Duration       | Continuous       |

|                                       |                                                 |
|---------------------------------------|-------------------------------------------------|
| Storage Temperature Range             | $-65^{\circ}\text{C}$ to $+150^{\circ}\text{C}$ |
| Lead Temperature (Soldering, 60 sec.) | $260^{\circ}\text{C}$                           |
| Junction Temperature                  | $-65^{\circ}\text{C}$ to $+150^{\circ}\text{C}$ |

## Operating Temperature Range

|                        |                                              |
|------------------------|----------------------------------------------|
| OP-07E, OP-07C, OP-07D | $0^{\circ}\text{C}$ to $+70^{\circ}\text{C}$ |
|------------------------|----------------------------------------------|

## Simplified Schematic



\*R2A and R2B are electronically trimmed on chip at the factory for minimum offset voltage.

## Electrical Characteristics

Unless otherwise specified,  $V_S = \pm 15V$ ,  $T_A = 25^\circ C$ . **Boldface** type refers to limits over  $0^\circ C \leq T_A \leq 70^\circ C$

| Symbol             | Parameter                                                | Conditions                                                                                                                             | OP-07E                                                      |                                                             |                               | OP-07C                                        |                                                             |                               | Units            |
|--------------------|----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------|-------------------------------|-----------------------------------------------|-------------------------------------------------------------|-------------------------------|------------------|
|                    |                                                          |                                                                                                                                        | Min                                                         | Typ                                                         | Max                           | Min                                           | Typ                                                         | Max                           |                  |
| $V_{OS}$           | Input Offset Voltage                                     | (Note 1)                                                                                                                               |                                                             | 30<br><b>45</b>                                             | 75<br><b>130</b>              |                                               | 60<br><b>85</b>                                             | 150<br><b>250</b>             | $\mu V$          |
| $V_{OS/t}$         | Long-Term $V_{OS}$ Stability                             | (Note 2)                                                                                                                               |                                                             | 0.3                                                         | 1.5                           |                                               | 0.4                                                         | 2.0                           | $\mu V/Mo$       |
| $I_{OS}$           | Input Offset Current                                     |                                                                                                                                        |                                                             | 0.5<br><b>0.9</b>                                           | 3.8<br><b>5.3</b>             |                                               | 0.8<br><b>1.6</b>                                           | 6.0<br><b>8.0</b>             | nA               |
| $I_B$              | Input Bias Current                                       |                                                                                                                                        |                                                             | $\pm 1.2$<br>$\pm$ <b>1.5</b>                               | $\pm 4.0$<br>$\pm$ <b>5.5</b> |                                               | $\pm 1.8$<br>$\pm$ <b>2.2</b>                               | $\pm 7.0$<br>$\pm$ <b>9.0</b> | nA               |
| $e_{np-p}$         | Input Noise Voltage                                      | 0.1 Hz to 10 Hz (Note 3)                                                                                                               |                                                             | 0.35                                                        | 0.6                           |                                               | 0.38                                                        | 0.65                          | $\mu V_{p-p}$    |
| $e_n$              | Input Noise Voltage Density                              | $f_O = 10$ Hz<br>$f_O = 100$ Hz (Note 3)<br>$f_O = 1000$ Hz                                                                            |                                                             | 10.3<br>10.0<br>9.6                                         | 18.0<br>13.0<br>11.0          |                                               | 10.5<br>10.2<br>9.8                                         | 20.0<br>13.5<br>11.5          | $nV/\sqrt{Hz}$   |
| $i_{np-p}$         | Input Noise Current                                      | 0.1 Hz to 10 Hz (Note 3)                                                                                                               |                                                             | 14                                                          | 30                            |                                               | 15                                                          | 35                            | $pA_{p-p}$       |
| $i_n$              | Input Noise Current Density                              | $f_O = 10$ Hz<br>$f_O = 100$ Hz (Note 3)<br>$f_O = 1000$ Hz                                                                            |                                                             | 0.32<br>0.14<br>0.12                                        | 0.80<br>0.23<br>0.17          |                                               | 0.35<br>0.15<br>0.13                                        | 0.90<br>0.27<br>0.18          | $pA/\sqrt{Hz}$   |
| $R_{IN}$           | Input Resistance Differential-Mode                       | (Note 4)                                                                                                                               | 15                                                          | 50                                                          |                               | 8                                             | 33                                                          |                               | $M\Omega$        |
| $R_{INCM}$         | Input Resistance Common-Mode                             |                                                                                                                                        |                                                             | 160                                                         |                               |                                               | 120                                                         |                               | $G\Omega$        |
| IVR                | Input Voltage Range                                      |                                                                                                                                        | $\pm 13.0$                                                  | $\pm 14.0$                                                  |                               | $\pm 13$                                      | $\pm 14$                                                    |                               | V                |
| CMRR               | Common-Mode Rejection Ratio                              | $V_{CM} = \pm 13V$                                                                                                                     | 106<br><b>103</b>                                           | 123<br><b>123</b>                                           |                               | 100<br><b>97</b>                              | 120<br><b>120</b>                                           |                               | dB               |
| PSRR               | Power Supply Rejection Ratio                             | $V_S = \pm 3V$ to $\pm 18V$<br>$V_S = \pm 3V$ to $\pm 18V$                                                                             |                                                             | 5<br><b>7</b>                                               | 20<br><b>32</b>               |                                               | 7<br><b>10</b>                                              | 32<br><b>51</b>               | $\mu V/V$        |
| $A_{VO}$           | Large Signal Voltage Gain                                | $R_L \geq 2 k\Omega$ , $V_O = \pm 10V$<br>$R_L \geq 2 k\Omega$<br>$R_L \geq 500\Omega$ , $V_O = \pm 0.5V$ ,<br>$V_S = \pm 3V$ (Note 4) | 200<br><b>180</b><br>150                                    | 500<br><b>450</b><br>400                                    |                               | 120<br><b>100</b><br>100                      | 400<br><b>400</b><br>400                                    |                               | V/mV             |
| $V_O$              | Output Voltage Swing                                     | $R_L \geq 10 k\Omega$<br>$R_L \geq 2 k\Omega$<br>$R_L \geq 2 k\Omega$<br>$R_L \geq 1 k\Omega$                                          | $\pm 12.5$<br>$\pm 12.0$<br>$\pm$ <b>12.0</b><br>$\pm 10.5$ | $\pm 13.0$<br>$\pm 12.8$<br>$\pm$ <b>12.6</b><br>$\pm 12.0$ |                               | $\pm 12.0$<br>$\pm 11.5$<br>$\pm$ <b>11.0</b> | $\pm 13.0$<br>$\pm 12.8$<br>$\pm$ <b>12.6</b><br>$\pm 12.0$ |                               | V                |
| SR                 | Slew Rate                                                | $R_L \geq 2 k\Omega$ (Note 3)                                                                                                          | 0.1                                                         | 0.3                                                         |                               | 0.1                                           | 0.3                                                         |                               | $V/\mu s$        |
| BW                 | Closed-Loop Bandwidth                                    | $A_{VCL} = +1$ (Note 3)                                                                                                                | 0.4                                                         | 0.6                                                         |                               | 0.4                                           | 0.6                                                         |                               | MHz              |
| $R_O$              | Output Resistance                                        | $V_O = 0$ , $I_O = 0$                                                                                                                  |                                                             | 60                                                          |                               |                                               | 60                                                          |                               | $\Omega$         |
| $P_d$              | Power Consumption                                        | $V_S = \pm 15V$ , No Load<br>$V_S = \pm 3V$ , No Load                                                                                  |                                                             | 75<br>4                                                     | 120<br>6                      |                                               | 80<br>4                                                     | 150<br>8                      | mW               |
|                    | Offset Adj. Range                                        | $R_P = 20 k\Omega$                                                                                                                     |                                                             | $\pm 4$                                                     |                               |                                               | $\pm 4$                                                     |                               | mV               |
| TCV <sub>OS</sub>  | Average Input Offset Voltage Drift Without External Trim | (Note 4)                                                                                                                               |                                                             | <b>0.3</b>                                                  | <b>1.3</b>                    |                                               | <b>0.5</b>                                                  | <b>1.8</b>                    | $\mu V/^\circ C$ |
| TCV <sub>OSn</sub> | With External Trim                                       | $R_P = 20 k\Omega$ (Note 4)                                                                                                            |                                                             | <b>0.3</b>                                                  | <b>1.3</b>                    |                                               | <b>0.4</b>                                                  | <b>1.6</b>                    |                  |
| TCI <sub>OS</sub>  | Average Input Offset Current Drift                       | (Note 3)                                                                                                                               |                                                             | <b>8</b>                                                    | <b>35</b>                     |                                               | <b>12</b>                                                   | <b>50</b>                     | $pA/^\circ C$    |
| TCI <sub>B</sub>   | Average Input Bias Current Drift                         | (Note 3)                                                                                                                               |                                                             | <b>13</b>                                                   | <b>35</b>                     |                                               | <b>18</b>                                                   | <b>50</b>                     | $pA/^\circ C$    |

## Electrical Characteristics

Unless otherwise specified,  $V_S = \pm 15V$ ,  $T_A = 25^\circ C$ . **Boldface** type refers to limits over  $0^\circ C \leq T_A \leq +70^\circ C$

| Symbol      | Parameter                                                | Conditions                                                                                                                                          | OP-07D                                        |                                                             |                                 | Units            |
|-------------|----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|-------------------------------------------------------------|---------------------------------|------------------|
|             |                                                          |                                                                                                                                                     | Min                                           | Typ                                                         | Max                             |                  |
| $V_{OS}$    | Input Offset Voltage                                     | (Note 1)                                                                                                                                            |                                               | 60<br><b>85</b>                                             | 150<br><b>250</b>               | $\mu V$          |
| $V_{OS}/t$  | Long-Term $V_{OS}$ Stability                             | (Note 2)                                                                                                                                            |                                               | 0.5                                                         | 3.0                             | $\mu V/Mo$       |
| $I_{OS}$    | Input Offset Current                                     |                                                                                                                                                     |                                               | 0.8<br><b>1.6</b>                                           | 6.0<br><b>8.0</b>               | nA               |
| $I_B$       | Input Bias Current                                       |                                                                                                                                                     |                                               | $\pm 2.0$<br>$\pm$ <b>3.0</b>                               | $\pm 12.0$<br>$\pm$ <b>14.0</b> | nA               |
| $e_{np-p}$  | Input Noise Voltage                                      | 0.1 Hz to 10 Hz (Note 3)                                                                                                                            |                                               | 0.38                                                        | 0.65                            | $\mu Vp-p$       |
| $e_n$       | Input Noise Voltage Density                              | $f_O = 10$ Hz<br>$f_O = 100$ Hz (Note 3)<br>$f_O = 1000$ Hz                                                                                         |                                               | 10.5<br>10.3<br>9.8                                         | 20.0<br>13.5<br>11.5            | $nV/\sqrt{Hz}$   |
| $i_{np-p}$  | Input Noise Current                                      | 0.1 Hz to 10 Hz (Note 3)                                                                                                                            |                                               | 15                                                          | 35                              | $pAp-p$          |
| $i_n$       | Input Noise Current Density                              | $f_O = 10$ Hz<br>$f_O = 100$ Hz (Note 3)<br>$f_O = 1000$ Hz                                                                                         |                                               | 0.35<br>0.15<br>0.13                                        | 0.90<br>0.27<br>0.18            | $pA/\sqrt{Hz}$   |
| $R_{IN}$    | Input Resistance Differential-Mode                       | (Note 4)                                                                                                                                            | 7                                             | 31                                                          |                                 | $M\Omega$        |
| $R_{INCM}$  | Input Resistance Common-Mode                             |                                                                                                                                                     |                                               | 120                                                         |                                 | $G\Omega$        |
| IVR         | Input Voltage Range                                      |                                                                                                                                                     | $\pm 13$                                      | $\pm 14$                                                    |                                 | V                |
| CMRR        | Common-Mode Rejection Ratio                              | $V_{CM} = \pm 13V$                                                                                                                                  | 94<br><b>94</b>                               | 110<br><b>106</b>                                           |                                 | dB               |
| PSRR        | Power Supply Rejection Ratio                             | $V_S = \pm 3V$ to $\pm 18V$                                                                                                                         |                                               | 7<br><b>10</b>                                              | 32<br><b>51</b>                 | $\mu V/V$        |
| $A_{VO}$    | Large Signal Voltage Gain                                | $R_L \leq 2 k\Omega$ , $V_O = \pm 10V$<br>$R_L = 2 k\Omega$ , $V_O = \pm 10V$<br>$R_L \geq 500\Omega$ , $V_O = \pm 0.5V$ ,<br>$V_S \pm 3V$ (Note 4) | 120<br><b>100</b>                             | 400<br><b>400</b><br>400                                    |                                 | V/mV             |
| $V_O$       | Output Voltage Swing                                     | $R_L \geq 10 k\Omega$<br>$R_L \geq 2 k\Omega$<br>$R_L \geq 2 k\Omega$<br>$R_L \geq 1 k\Omega$                                                       | $\pm 12.0$<br>$\pm 11.5$<br>$\pm$ <b>11.0</b> | $\pm 13.0$<br>$\pm 12.8$<br>$\pm$ <b>12.6</b><br>$\pm 12.0$ |                                 | V                |
| SR          | Slew Rate                                                | $R_L \geq 2 k\Omega$ (Note 3)                                                                                                                       | 0.1                                           | 0.3                                                         |                                 | $V/\mu s$        |
| BW          | Closed-Loop Bandwidth                                    | $A_{VCL} = +1$ (Note 3)                                                                                                                             | 0.4                                           | 0.6                                                         |                                 | MHz              |
| RO          | Output Resistance                                        | $V_O = 0$ , $I_O = 0$                                                                                                                               |                                               | 60                                                          |                                 | $\Omega$         |
| $P_d$       | Power Consumption                                        | $V_S = \pm 15V$ , No Load<br>$V_S = \pm 3V$ , No Load                                                                                               |                                               | 80<br>4                                                     | 150<br>8                        | mW               |
|             | Offset Adj. Range                                        | $R_P = 20 k\Omega$                                                                                                                                  |                                               | $\pm 4$                                                     |                                 | mV               |
| $TCV_{OS}$  | Average Input Offset Voltage Drift Without External Trim | (Note 4)                                                                                                                                            |                                               | <b>0.7</b>                                                  | <b>2.5</b>                      | $\mu V/^\circ C$ |
| $TCV_{OSn}$ | With External Trim                                       | $R_P = 20 k\Omega$ (Note 4)                                                                                                                         |                                               | <b>0.7</b>                                                  | <b>2.5</b>                      | $\mu V/^\circ C$ |
| $TCI_{OS}$  | Average Input Offset Current Drift                       | (Note 3)                                                                                                                                            |                                               | <b>12</b>                                                   | <b>50</b>                       | $pA/^\circ C$    |
| $TCI_B$     | Average Input Bias Current Drift                         | (Note 3)                                                                                                                                            |                                               | <b>18</b>                                                   | <b>50</b>                       | $pA/^\circ C$    |

**Note 1:**  $V_{OS}$  is measured approximately 0.5 second after application of power.

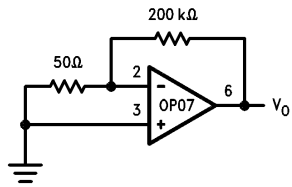
**Note 2:** Long-Term Offset Voltage Stability refers to the averaged trend line of  $V_{OS}$  vs Time over extended periods after the first 30 days of operation. Excluding the initial hour of operation, changes in  $V_{OS}$  during the first 30 operating days are typically  $2.5 \mu V$ . Parameter is sample tested.

**Note 3:** Sample Tested.

**Note 4:** Guaranteed by design.

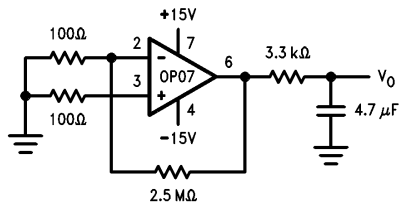
## Test Circuits

Offset Voltage Test Circuit



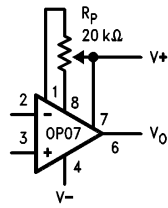
TL/H/10550-4

Low Frequency Noise Test Circuit



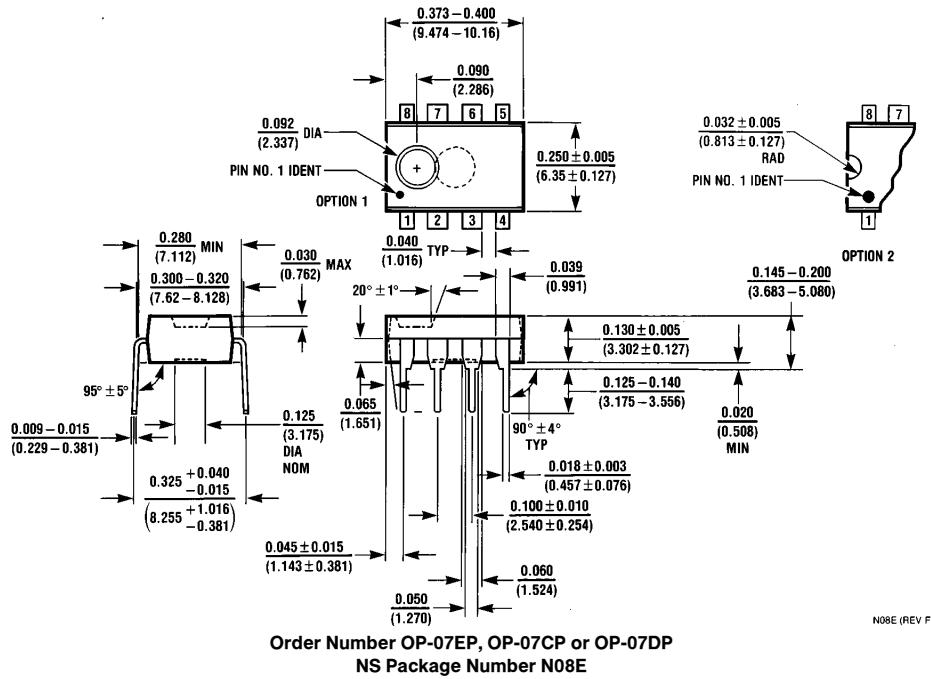
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Optional Offset Nulling Circuit



TL/H/10550-6

## Physical Dimensions inches (millimeters) (Continued)



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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



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