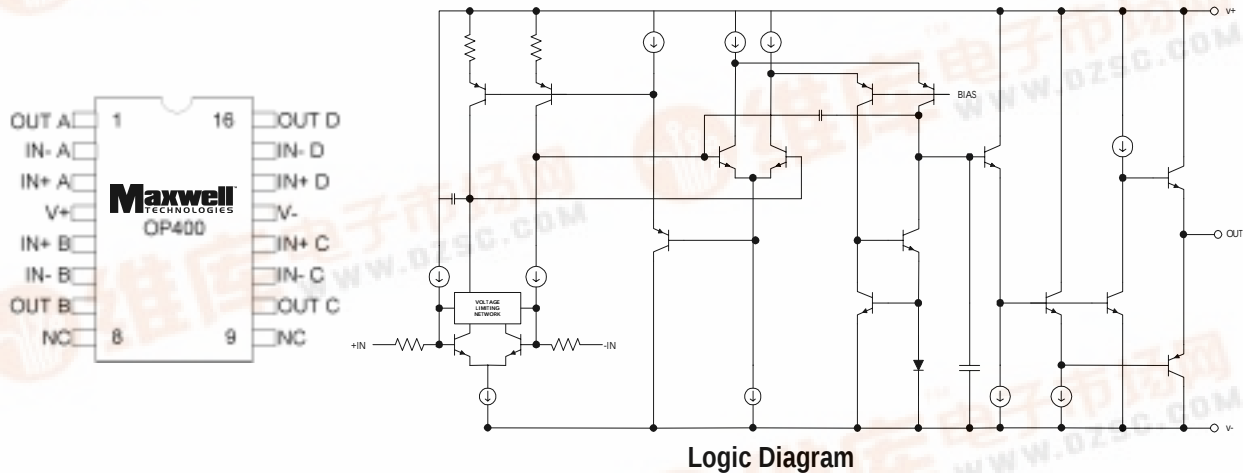




# OP400

## Quad Low-Offset, Low-Power Operational Amplifier



### FEATURES:

- RAD-PAK® technology-hardened against natural space radiation
- Total dose hardness:
  - > 100 krad (Si), depending upon space mission
- Package:
  - 16 pin Rad-Pak® flat package
- Low input offset voltage 150 $\mu$ V max
- Low offset voltage drift
  - +1.2 $\mu$ V/ $^{\circ}$ C max (over -55 to +125 $^{\circ}$ C)
- Low supply current (per amplifier) 725  $\mu$ A max
- High open-loop gain 5000V/mV min
- Input bias current 3 nA Max
- Low noise voltage density 11 nV per (Hz) $^{1/2}$  at 1 kHz
- Stable with large capacitive loads 10 nF typ

### DESCRIPTION:

Maxwell Technologies' OP400 monolithic quad operational amplifier microcircuit features a greater than 100 krad (Si) typical total dose tolerance, depending upon space mission. Using Maxwell's radiation-hardened RAD-PAK® packaging technology, the OP400 has an extremely low input offset voltage no less than 150 mV with a drift of under 1.2 mV/ $^{\circ}$ C, guaranteed over the full military temperature range. The OP400 features low power consumption, drawing less than 725  $\mu$ A per amplifier.

Maxwell Technologies' patented RAD-PAK packaging technology incorporates radiation shielding in the microcircuit package. It eliminates the need for box shielding while providing the required radiation shielding for a lifetime in orbit or space mission. In a GEO orbit, RAD-PAK provides greater than 100 krad (Si) radiation dose tolerance. This product is available with screening up to Class S.

TABLE 1. PINOUT DESCRIPTION

| PIN          | SYMBOL    | DESCRIPTION           |
|--------------|-----------|-----------------------|
| 1, 7, 10, 16 | OUT A - D | Output Signal         |
| 2, 6, 11, 15 | -IN A - D | Negative Input Signal |
| 3, 5, 12, 14 | +IN A - D | Positive Input Signal |
| 8, 9         | NC        | Not Connected         |
| 4            | V+        | Positive Voltage      |
| 13           | V-        | Negative Voltage      |

TABLE 2. OP400 ABSOLUTE MAXIMUM RATINGS

| PARAMETER                     | SYMBOL   | MIN | MAX      | UNIT               |
|-------------------------------|----------|-----|----------|--------------------|
| Supply Voltage                | $V_{CC}$ |     | $\pm 20$ | V                  |
| Differential Input Voltage    |          |     | $\pm 30$ | V                  |
| Input Voltage                 |          |     |          | Supply Voltage     |
| Output Short-Circuit Duration |          |     |          | Continuous         |
| Storage Temperature Range     | $T_S$    | -65 | 150      | $^{\circ}\text{C}$ |
| Operating Temperature Range   | $T_A$    | -55 | 125      | $^{\circ}\text{C}$ |

TABLE 3. DELTA LIMITS

| PARAMETER | VARIATION                                |
|-----------|------------------------------------------|
| ICC       | $\pm 10\%$ of specified value in Table 4 |

TABLE 4. OP400 DC ELECTRICAL CHARACTERISTICS

( $V_S = \pm 15\text{V}$ ,  $T_A = -55$  TO  $125^{\circ}\text{C}$ , UNLESS OTHERWISE SPECIFIED)

| PARAMETER                         | SYMBOL   | TEST CONDITIONS                | SUBGROUPS                      | MIN  | TYP | MAX  | UNITS                   |
|-----------------------------------|----------|--------------------------------|--------------------------------|------|-----|------|-------------------------|
| Input Offset Voltage              | $V_{OS}$ | $+25^{\circ}\text{C}$          | 1                              | ---  | 40  | 150  | $\mu\text{V}$           |
|                                   |          | $-55$ TO $125^{\circ}\text{C}$ | 2, 3                           | --   | 70  | 270  |                         |
| Long Term Input Voltage Stability | ---      |                                | 1, 2, 3                        | ---  | 0.1 | ---  | $\mu\text{V}/\text{mo}$ |
| Input Offset Current              | $I_{OS}$ | $V_{CM} = 0\text{V}$           | $+25^{\circ}\text{C}$          | 1    | --- | 0.1  | nA                      |
|                                   |          |                                | $-55$ TO $125^{\circ}\text{C}$ | 2, 3 |     | 0.1  |                         |
| Input Bias Current                | $I_B$    | $V_{CM} = 0\text{V}$           | $+25^{\circ}\text{C}$          | 1    | --- | 0.75 | nA                      |
|                                   |          |                                | $-55$ TO $125^{\circ}\text{C}$ | 2, 3 |     | 1.30 |                         |

# Quad Low-Offset, Low-Power Operational Amplifier

# OP400

TABLE 4. OP400 DC ELECTRICAL CHARACTERISTICS

( $V_S = \pm 15V$ ,  $T_A = -55$  TO  $125^\circ C$ , UNLESS OTHERWISE SPECIFIED)

| PARAMETER                          | SYMBOL     | TEST CONDITIONS                       |                                      | SUBGROUPS | MIN      | TYP        | MAX | UNITS     |
|------------------------------------|------------|---------------------------------------|--------------------------------------|-----------|----------|------------|-----|-----------|
| Input Resistance Differential Mode | $R_{IN}$   | +25°C                                 | +25E = Engineering (testing @ +25°C) | 1         | ---      | 10         | --- | $M\Omega$ |
| Input Resistance Common Mode       | $R_{INCM}$ |                                       |                                      | 1, 2, 3   | ---      | 200        | --- | $G\Omega$ |
| Large Signal Voltage Gain          | $A_{VO}$   | $V_O = \pm 10V$<br>$R_L = 10 k\Omega$ | +25°C                                | 1         | 5000     | 12000      | --- | V/mV      |
|                                    |            |                                       | -55 to 125°C                         | 2, 3      | 3000     | 9000       | --  |           |
|                                    |            | $R_L = 2 k\Omega$                     | +25°C                                | 1         | 2000     | 3500       | --- |           |
|                                    |            |                                       | -55 to 125°C                         | 2, 3      | 1000     | 2300       | --  |           |
| Input Voltage Range <sup>1</sup>   | IVR        | 3/                                    | +25°C                                | 1         | $\pm 12$ | $\pm 13$   | --- | V         |
|                                    |            |                                       | -55 to 125°C                         | 2, 3      | $\pm 12$ | $\pm 12.5$ | --  |           |
| Common Mode Rejection              | CMR        | $V_{CM} = \pm 12V$                    | +25°C                                | 4         | 120      | 140        | --- | dB        |
|                                    |            |                                       | -55 to 125°C                         | 5, 6      | 115      | 130        | --  |           |
| Power Supply Rejection Ratio       | PSRR       | $V_S = \pm 3V$<br>to $\pm 18V$        | +25°C                                | 1         | ---      | 0.1        | 1.8 | $\mu V/V$ |
|                                    |            |                                       | -55 to 125°C                         | 2, 31     | --       | 0.2        | 3.2 |           |
| Output Voltage Swing               | $V_O$      | $R_L = 10 k\Omega$                    |                                      | 1, 2, 3   | $\pm 12$ | $\pm 12.6$ | --- | V         |
|                                    |            | $R_L = 2 k\Omega$                     |                                      | 1, 2, 3   | $\pm 11$ | $\pm 12.4$ | --- |           |
| Supply Current Per Amplifier       | $I_{SV}$   | No Load                               | +25°C                                | 1         | ---      | 600        | 725 | $\mu A$   |
|                                    |            |                                       | -55 to 125°C                         | 2, 3      | --       | 600        | 775 |           |
| Input Capacitance                  | $C_{IN}$   |                                       | +25°C                                | 1         | ---      | 3.2        | --- | pF        |
| Capacitive Load Stability          |            | $A_V = +1$<br>No Oscillations         | +25°C                                | 1         | ---      | 10         | --- | nF        |

1. Guaranteed by CMR test.

TABLE 5. OP400 AC Electrical Characteristics

( $V_S = \pm 15V$ ,  $T_A = -55$  TO  $125^\circ C$ , UNLESS OTHERWISE SPECIFIED.)

| PARAMETER                   | SYMBOL       | Test Conditions |              | SUBGROUP | MIN | TYP  | MAX | UNIT           |
|-----------------------------|--------------|-----------------|--------------|----------|-----|------|-----|----------------|
| Input Noise Voltage         | $e_{n\ p-p}$ | 0.1 Hz to 10 Hz | +25°C        | 1        | --- | 0.5  | --- | $\mu V_{p-p}$  |
| Input Noise Voltage Density | $e_n$        | $f_o = 10$ Hz   | +25°C        | 1        | --- | 22   | --  | $nV/\sqrt{Hz}$ |
|                             |              | $f_o = 1$ KHz   | +25°C        | 1        | --- | 11   | --  |                |
| Input Noise Current         | $i_{n\ p-p}$ | 0.1 Hz to 10 Hz | +25°C        | 1        | --- | 15   | --- | $pA_{p-p}$     |
| Input Noise Current Density | $i_n$        | $f_o = 10$ Hz   | +25°C        | 1        | --- | 0.6  | --- | $nV/\sqrt{Hz}$ |
| Slew Rate                   | SR           |                 | -55 to 125°C | 1, 2, 3  | 0.1 | 0.15 | --- | V/ $\mu s$     |
| Gain Bandwidth Product      | GBWP         | $A_V = +1$      | -55 to 125°C | 1, 2, 3  | --- | 500  | --- | kHz            |

TABLE 5. OP400 AC Electrical Characteristics

( $V_S = \pm 15V$ ,  $T_A = -55$  TO  $125^\circ C$ , UNLESS OTHERWISE SPECIFIED.)

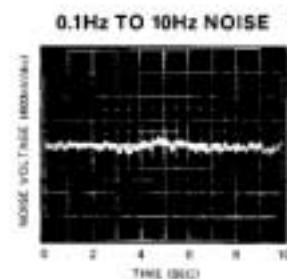
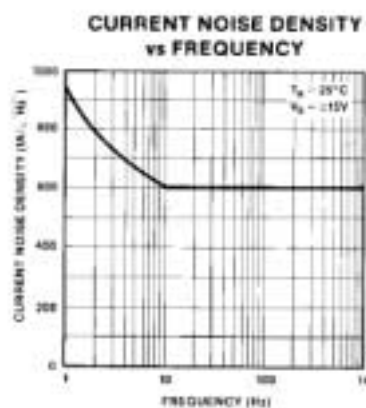
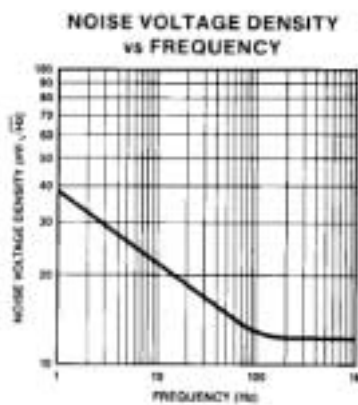
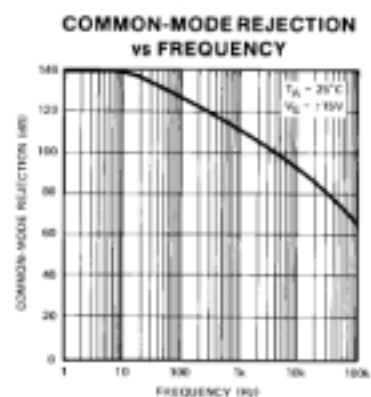
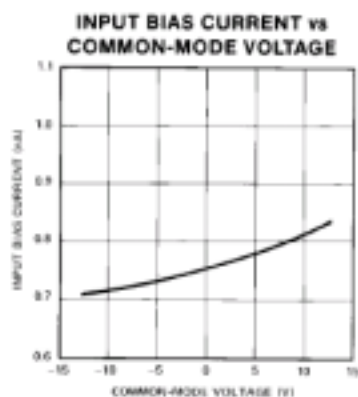
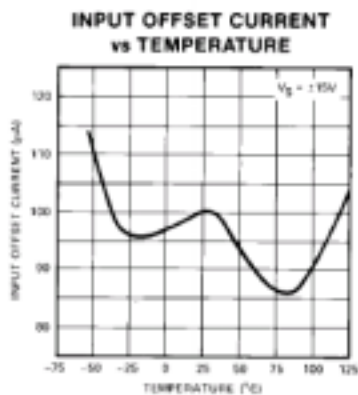
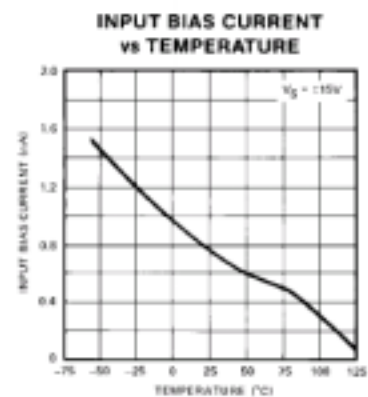
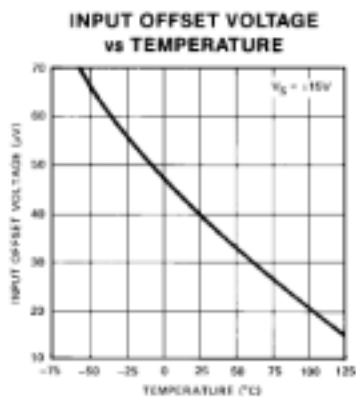
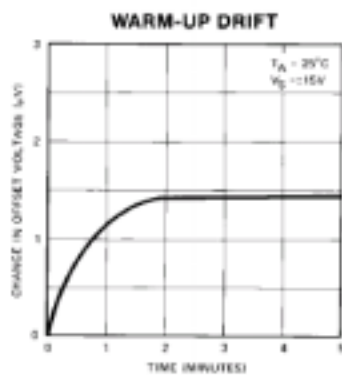
| PARAMETER          | SYMBOL | Test Conditions                               |               | SUBGROUP | MIN | TYP | MAX | UNIT |
|--------------------|--------|-----------------------------------------------|---------------|----------|-----|-----|-----|------|
| Channel Separation | CS     | $V_O = 20 V_{p-p}$<br>$f_O = 10 \text{ Hz}^1$ | $+25^\circ C$ | 4        | 123 | 135 | --- | dB   |

1. Guaranteed by design.

# Quad Low-Offset, Low-Power Operational Amplifier

# OP400

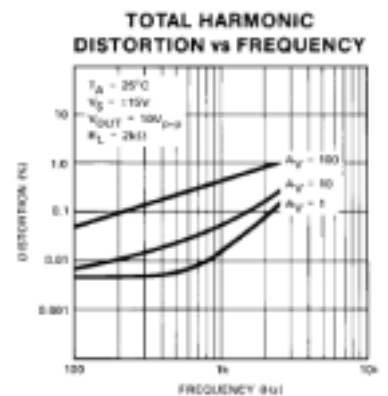
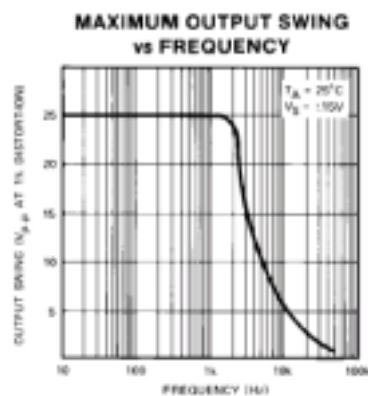
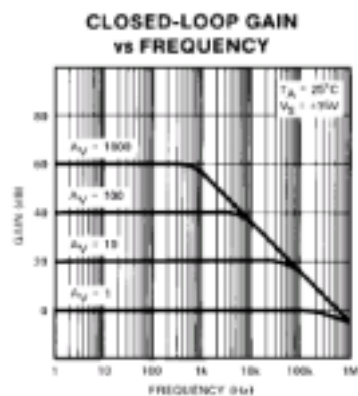
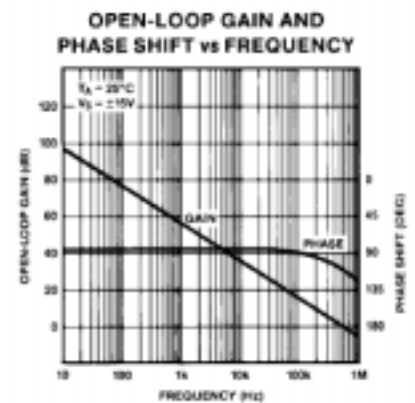
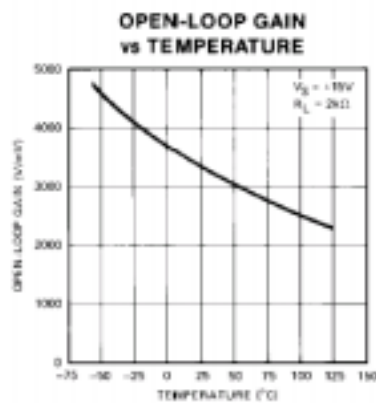
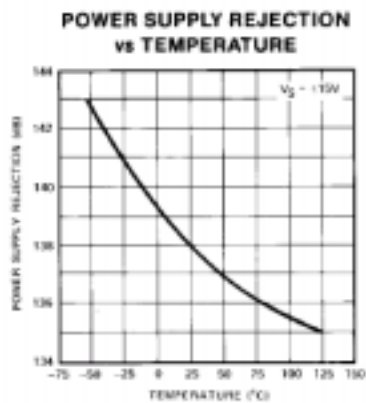
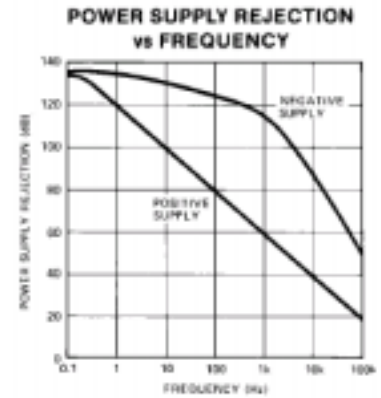
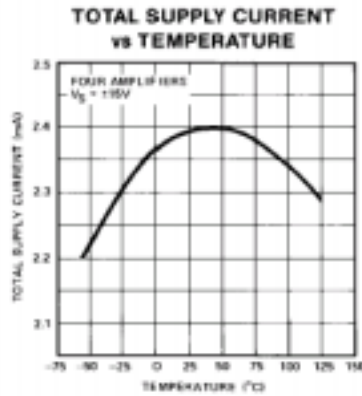
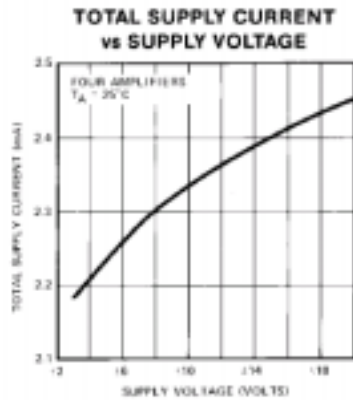
## OP400 TYPICAL OPERATING CHARACTERISTICS



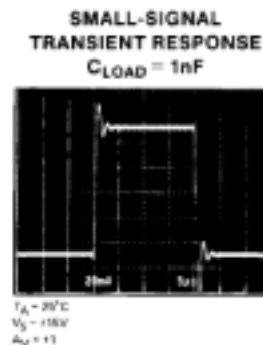
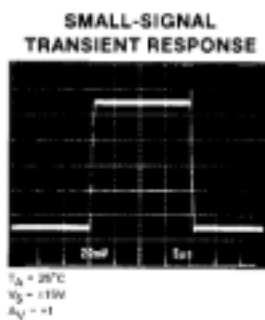
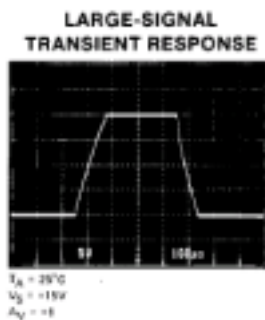
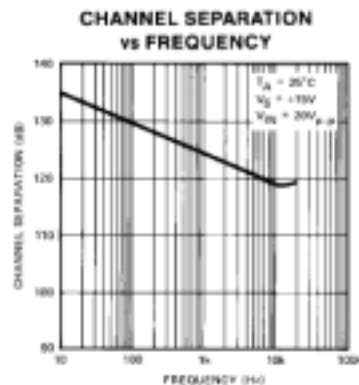
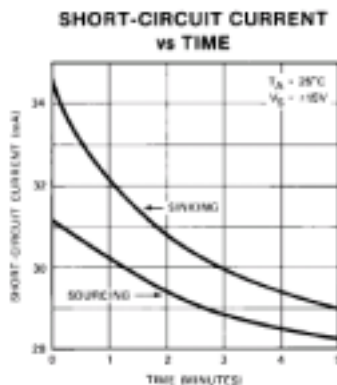
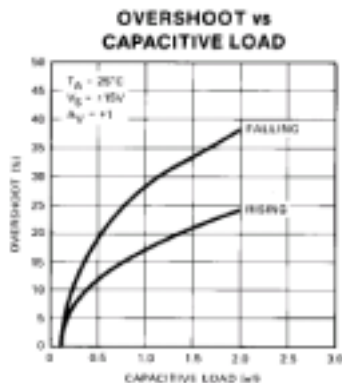
# Quad Low-Offset, Low-Power Operational Amplifier

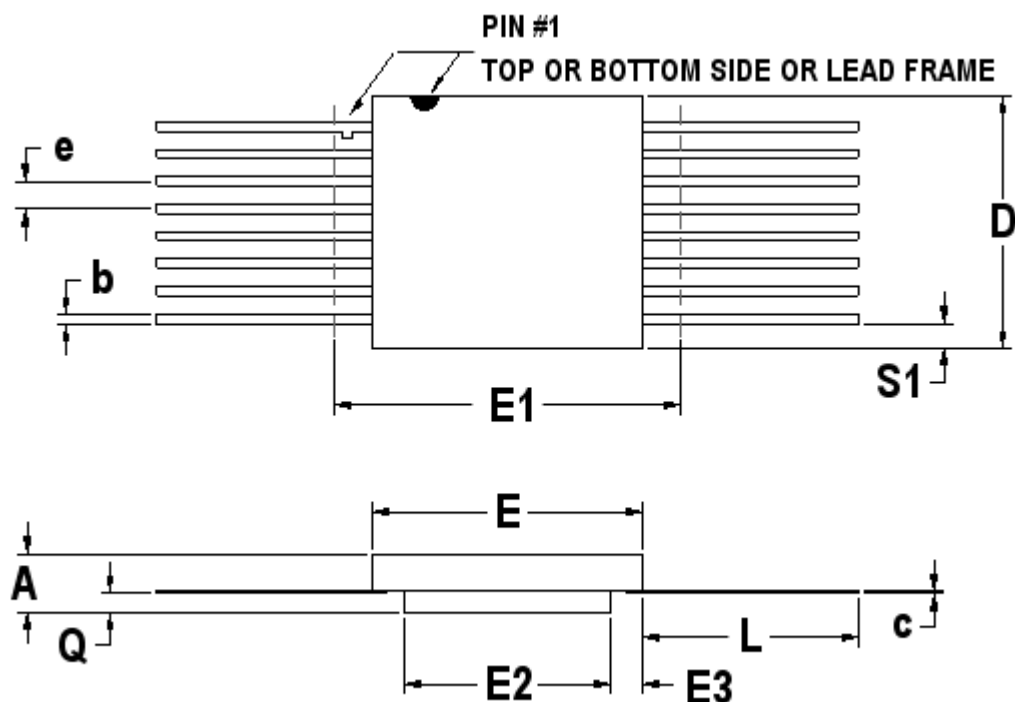
# OP400

## OP400 TYPICAL OPERATING CHARACTERISTICS (CONTINUED)



## OP400 TYPICAL OPERATING CHARACTERISTICS (CONTINUED)





16-PIN RAK-PAK® FLAT PACKAGE

| SYMBOL | DIMENSION |       |       |
|--------|-----------|-------|-------|
|        | MIN       | NOM   | MAX   |
| A      | 0.115     | 0.135 | 0.150 |
| b      | 0.015     | 0.017 | 0.019 |
| c      | 0.004     | 0.005 | 0.007 |
| D      | 0.407     | 0.415 | 0.423 |
| E      | 0.275     | 0.280 | 0.285 |
| E1     | --        | --    | 0.500 |
| E2     | 0.150     | 0.156 | 0.162 |
| E3     | 0.030     | 0.062 | --    |
| e      | 0.050 BSC |       |       |
| L      | 0.325     | 0.335 | 0.345 |
| Q      | 0.020     | 0.033 | 0.045 |
| S1     | 0.005     | 0.024 | 0.045 |
| N      | 16        |       |       |

Note: All dimensions in inches.

# Quad Low-Offset, Low-Power Operational Amplifier

# OP400

## Important Notice:

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# Quad Low-Offset, Low-Power Operational Amplifier

OP400

## Product Ordering Options

