

High Current, High Power OPERATIONAL AMPLIFIER

FEATURES

- HIGH OUTPUT CURRENT: $\pm 10A$ Peak
- WIDE POWER SUPPLY RANGE: $\pm 10V$ to $\pm 40V$
- LOW QUIESCENT CURRENT: 2.6mA
- ISOLATED CASE TO-3 PACKAGE

DESCRIPTION

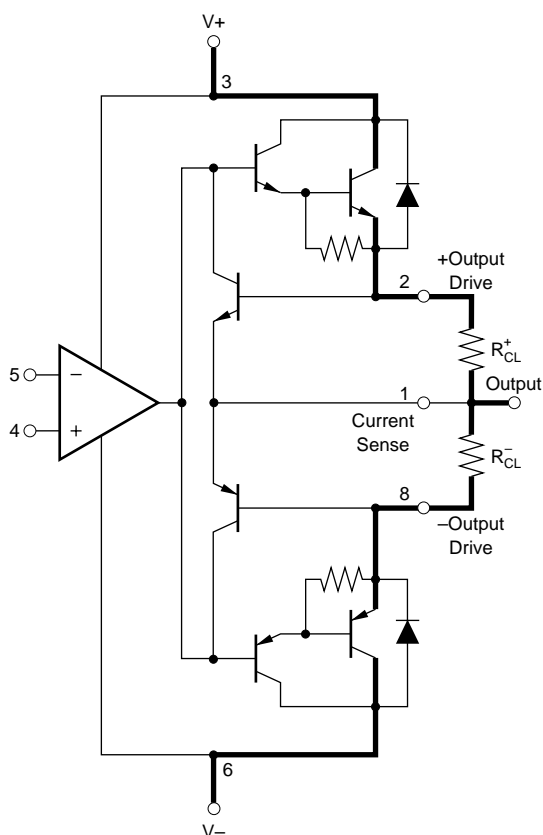
The OPA501 is a high output current operational amplifier. It can be used in virtually all common op amp circuits, yet is capable of output currents up to $\pm 10A$. Power-supply voltages up to $\pm 40V$ allow very high output power for driving motors or other electromechanical loads.

Safe operating area is fully specified, and user-set current limits provide protection for both the amplifier and load. The class-B (zero output stage bias) provides low quiescent current during small-signal conditions.

This rugged hybrid integrated circuit is packaged in a metal 8-pin TO-3 package and is specified over the industrial temperature range of $-40^{\circ}C$ to $+85^{\circ}C$.

APPLICATIONS

- MOTOR DRIVER
- SERVO AMPLIFIER
- VALVE ACTUATOR
- SYNCRO DRIVER
- PROGRAMMABLE POWER SUPPLY



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ABSOLUTE MAXIMUM RATINGS

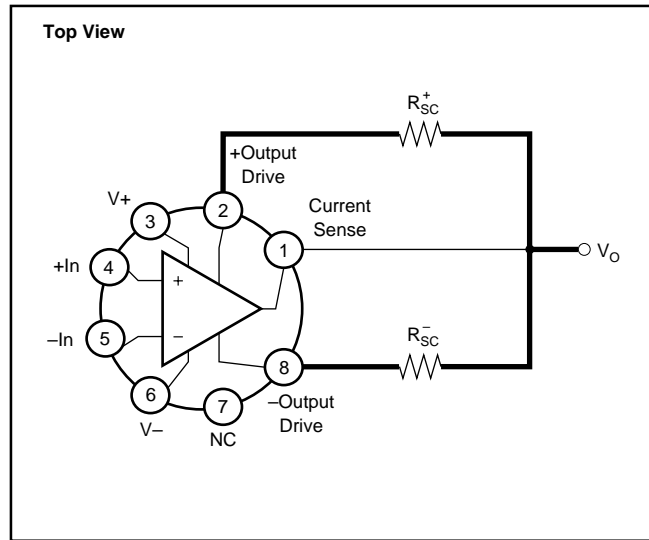
| | |
|--|---------------------------------|
| Power Supply Voltage (V_S) | $\pm 40V$ |
| Power Dissipation at $+25^\circ C$ ^(1, 2) | 79W |
| Differential Input Voltage | $\pm V_S - 3V$ |
| Common-Mode Input Voltage | $\pm V_S$ |
| Operating Temperature Range | $-55^\circ C$ to $+125^\circ C$ |
| Storage Temperature Range | $-65^\circ C$ to $+150^\circ C$ |
| Lead Temperature (soldering, 10s) | $+300^\circ C$ |
| Junction Temperature | $+200^\circ C$ |
| Output Short-Circuit Duration ⁽³⁾ | Continuous |

NOTES: (1) At case temperature of $+25^\circ C$. Derate at $2.2^\circ C/W$ above case temperature of $+25^\circ C$. (2) Average dissipation. (3) Within safe operating area and with appropriate derating.

PACKAGE/ORDERING INFORMATION

For the most current package and ordering information, see the Package Option Addendum located at the end of this data sheet.

CONNECTION DIAGRAM



ELECTRICAL CHARACTERISTICS

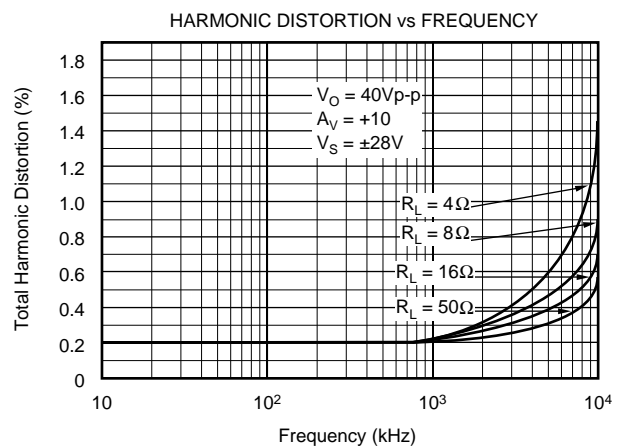
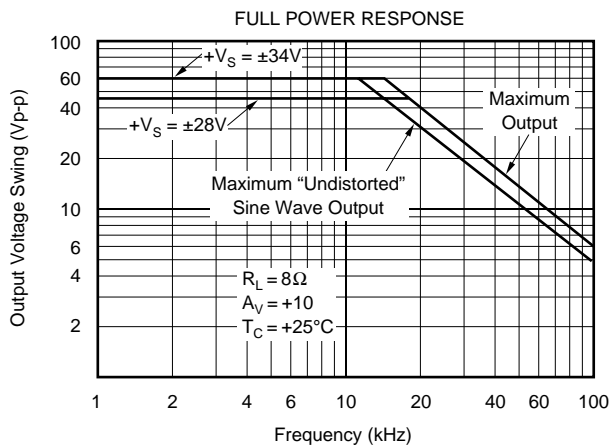
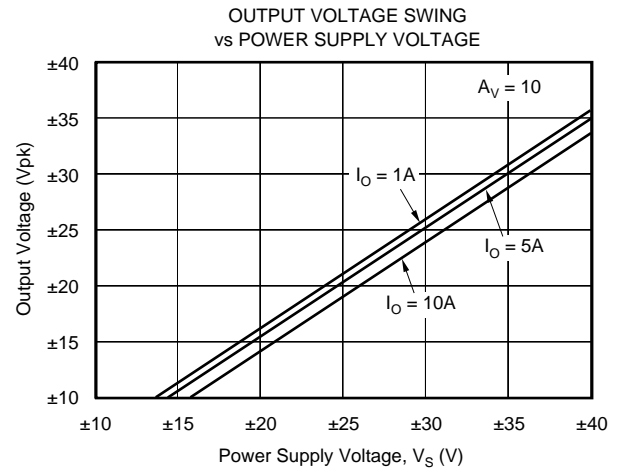
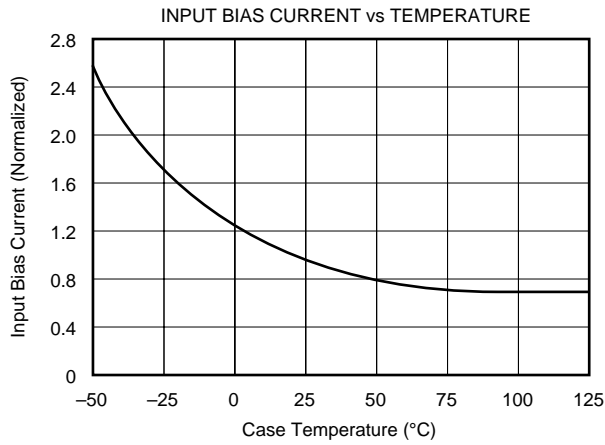
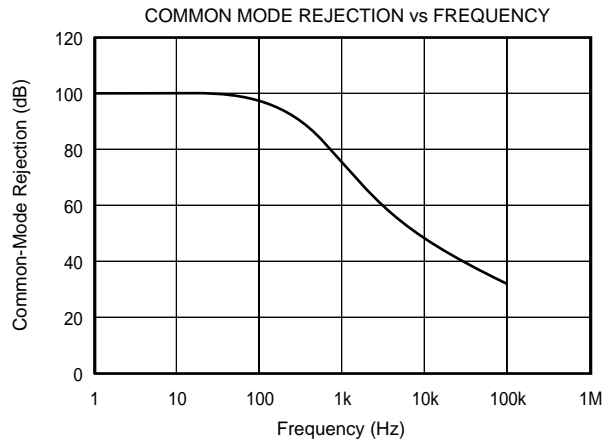
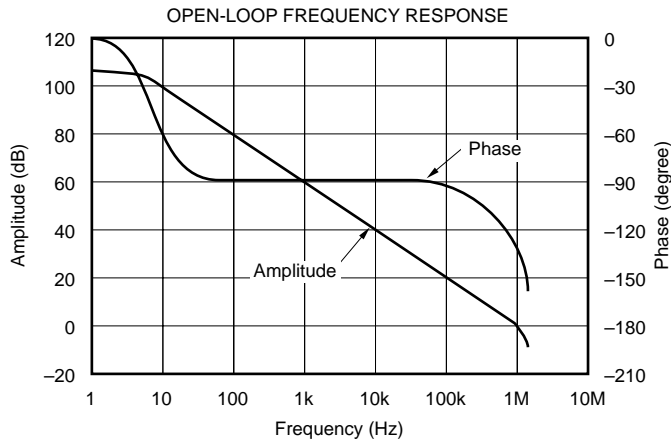
At $T_C = +25^\circ\text{C}$, and $V_S = \pm 28\text{V}$, unless otherwise noted.

| PARAMETER | CONDITIONS | OPA501AM | | | UNITS |
|--|--|----------------------------------|---------------------------------|----------------------|--|
| | | MIN | TYP | MAX | |
| RATED OUTPUT ^(1, 2) Output Current Continuous ⁽³⁾ Output Voltage ⁽³⁾ | $R_L = 2\Omega$ $R_L = 2.6\Omega$ $I_O = 10\text{A peak}$ | ± 10 ± 10 ± 20 | ± 23 | | A A V |
| DYNAMIC RESPONSE Bandwidth, Unity Gain Full Power Bandwidth Slew Rate | Small Signal $V_O = 40V_{PP}$, $R_L = 8\Omega$ $R_L = 5\Omega$ $R_L = 6.5\Omega$ | 10 1.35 1.35 | 1 16 | | MHz kHz V/ μs V/ μs |
| INPUT OFFSET VOLTAGE Initial Offset vs Temperature vs Supply Voltage | $-25^\circ\text{C} < T < +85^\circ\text{C}$ | | ± 5 ± 10 ± 35 | ± 10 ± 65 | mV $\mu\text{V}/^\circ\text{C}$ $\mu\text{V}/\text{V}$ |
| INPUT BIAS CURRENT Initial vs Temperature vs Supply Voltage | $T_{\text{CASE}} = +25^\circ\text{C}$ | | 15 ± 0.05 ± 0.02 | 40 | nA nA/ $^\circ\text{C}$ nA/V |
| INPUT DIFFERENCE CURRENT Initial vs Temperature | $T_{\text{CASE}} = +25^\circ\text{C}$ $-25^\circ\text{C} < T < +85^\circ\text{C}$ | | ± 5 ± 0.01 | ± 10 | nA nA/ $^\circ\text{C}$ |
| OPEN-LOOP GAIN, DC | $R_L = 5\Omega$ $R_L = 6.5\Omega$ | 94 98 | 115 115 | | dB dB |
| INPUT IMPEDANCE Differential Common-mode | | | 10 250 | | M Ω M Ω |
| INPUT NOISE Voltage Noise $f_n = 10\text{Hz to } 10\text{kHz}$ Current Noise $f_n = 10\text{Hz to } 10\text{kHz}$ | $f_n = 0.3\text{Hz to } 10\text{Hz}$ $f_n = 0.3\text{Hz to } 10\text{Hz}$ | 5 4.5 | 3 20 | | μV_{PP} μV_{RMS} pA $_{PP}$ pA $_{RMS}$ |
| INPUT VOLTAGE RANGE Common-Mode Voltage ⁽⁴⁾ Common-Mode Rejection | Linear Operation $f = \text{DC}$, $V_{CM} = \pm(V_S - 6)$ | $\pm(V_S - 6)$ 70 | $\pm(V_S - 3)$ 110 | | V dB |
| POWER SUPPLY Rated Voltage Operating Voltage Range Current, quiescent | | ± 10 | ± 28 ± 2.6 | ± 36 ± 10 | V V mA |
| TEMPERATURE RANGE Specification Operating, derated performance Storage | case | -25 -55 -65 | | +85 +125 +150 | $^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C}$ |
| THERMAL RESISTANCE | Steady State θ_{JC} | | 2.0 | 2.2 | $^\circ\text{C}/\text{W}$ |

NOTES: (1) Package must be derated based on a junction-to-case thermal resistance of $2.2^\circ\text{C}/\text{W}$ or a junction-to-ambient thermal resistance of $30^\circ\text{C}/\text{W}$. (2) Safe Operating Area and Power Derating Curves must be observed. (3) With $\pm R_{SC} = 0$. Peak output current is typically greater than 10A if duty cycle and pulse width limitations are observed. Output current greater than 10A is not guaranteed. (4) The absolute maximum voltage is 3V less than supply voltage.

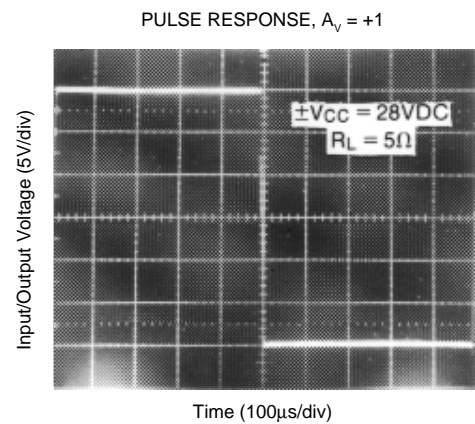
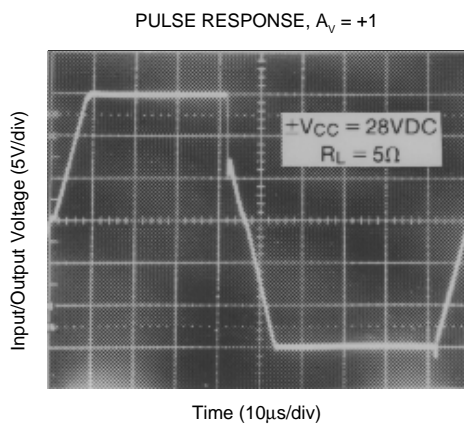
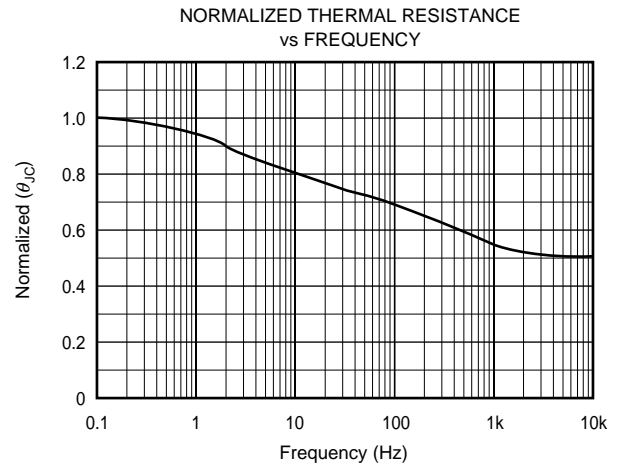
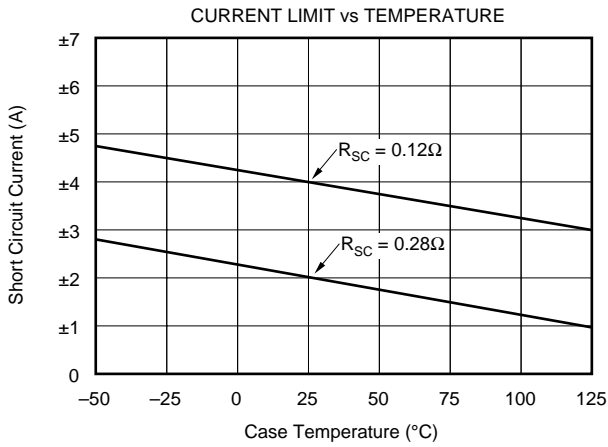
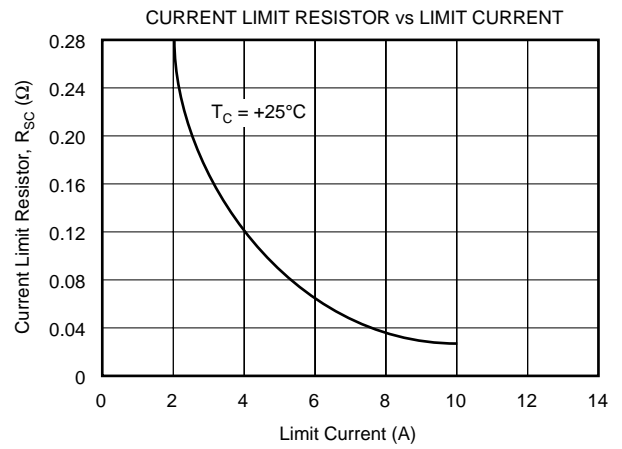
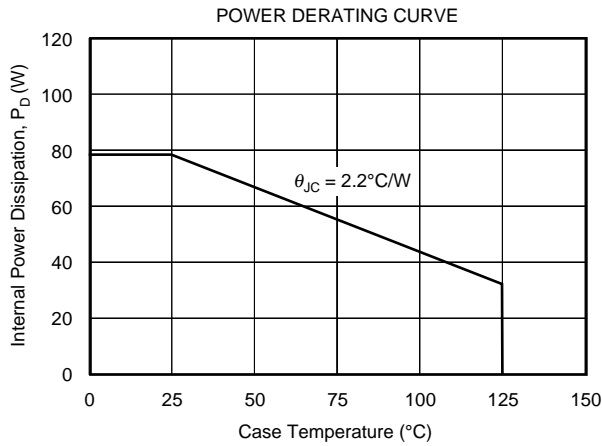
TYPICAL CHARACTERISTICS

Typical at +25°C case and $\pm V_S = 28\text{VDC}$, unless otherwise noted.



TYPICAL CHARACTERISTICS (Cont.)

Typical at +25°C case and $\pm V_S = 28\text{VDC}$, unless otherwise noted.



APPLICATIONS INFORMATION

Grounding techniques can greatly affect the performance of a power op amp. Figure 1 shows grounds connected so that load current does not flow through signal ground connections. Power supply and load connections should be physically separated from the amplifier input and signal connections.

Power supply connections to the amplifier should be bypassed with 10µF tantalum capacitors connected close to the device pins. The capacitors should be connected to load ground as shown.

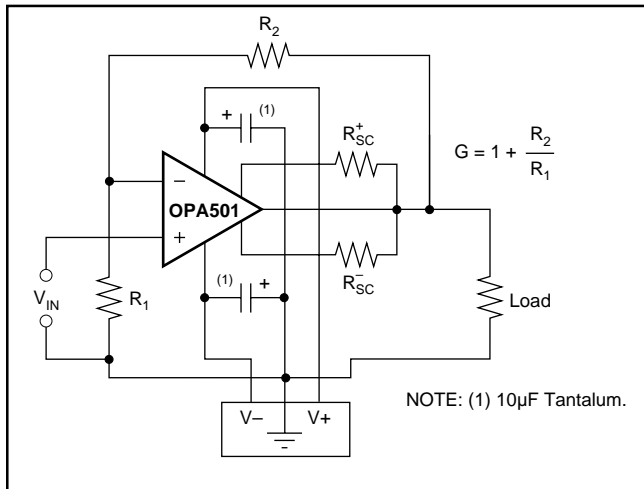


FIGURE 1. Basic Circuit Connections.

CURRENT LIMITS

The OPA501 has independent positive and negative current limit circuits. Current limits are set by the value of R_{SC}^+ and R_{SC}^- . The approximate value of these resistors is:

$$R_{SC} = \frac{0.65}{I_{LIMIT}} - 0.0437\Omega$$

I_{LIMIT} is the desired maximum current at room temperature in Amperes and R_{SC} is in ohms. The current limit value decreases with increasing temperature—see typical performance curves. The current limit resistors conduct the full amplifier output current. Power dissipation of the current limit resistors at maximum current is:

$$P_{MAX} = (I_{LIMIT})^2 R_{SC}$$

The current limit resistors can be chosen from a variety of types. Most wire-wound types are satisfactory, although some physically large resistors may have excessive inductance which can cause instability.

SAFE OPERATING AREA

Stress on the output transistor is determined by the output current and the voltage across the conducting output transistor. The power dissipated by the output transistor is equal to the product of the output current and the voltage across the conducting transistor, V_{CE} . The Safe Operating Area (SOA),

Figure 2, shows the permissible range of voltage and current. SOA is reduced at high operating temperature—see Figure 3.

The safe output current decreases as V_{CE} increases. Output short-circuits are very demanding. A short-circuit to ground forces the full power supply voltage (positive or negative side) across the conducting transistor. With $V_s = \pm 30V$, the current limit must be set for 2A to be safe for short-circuit to ground. For further information on SOA and evaluating signal and load conditions, consult Applications Bulletin AB-039.

HEAT SINKING

Most applications require a heat sink to assure that the maximum junction temperature of 200°C is not exceeded. The size of the heat sink required depends on the power dissipated by the amplifier and ambient temperature conditions. Application Bulletin AB-039 explains how to find maximum power dissipation for DC, AC, reactive loads, and other conditions. Applications Bulletin AB-038 shows how to determine heat sink requirements.

The case of the OPA501 is isolated from all circuitry and can be fastened directly to a heat sink. This eliminates cumbersome insulating hardware that degrades thermal performance. See Applications Bulletin AB-037 for information on mounting techniques and procedures.

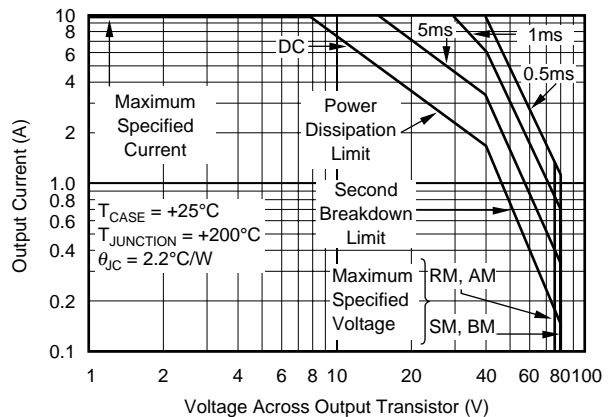


FIGURE 2. Transistor Safe Operating Area at +25°C Case Temperature.

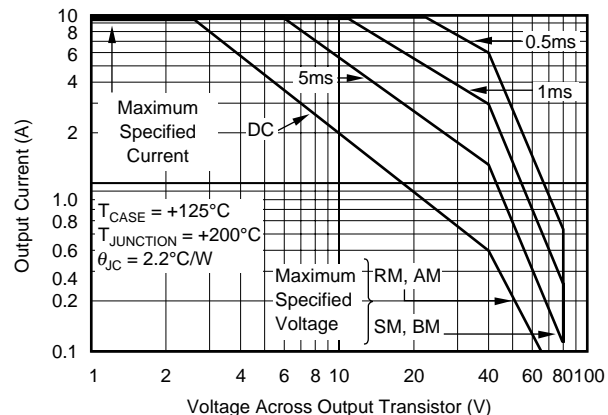


FIGURE 3. Transistor Safe Operating Area at +125°C Case Temperature.

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| OPA501AM | NRND | TO-3 | LMF | 8 | | TBD | Call TI | Call TI |

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

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Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

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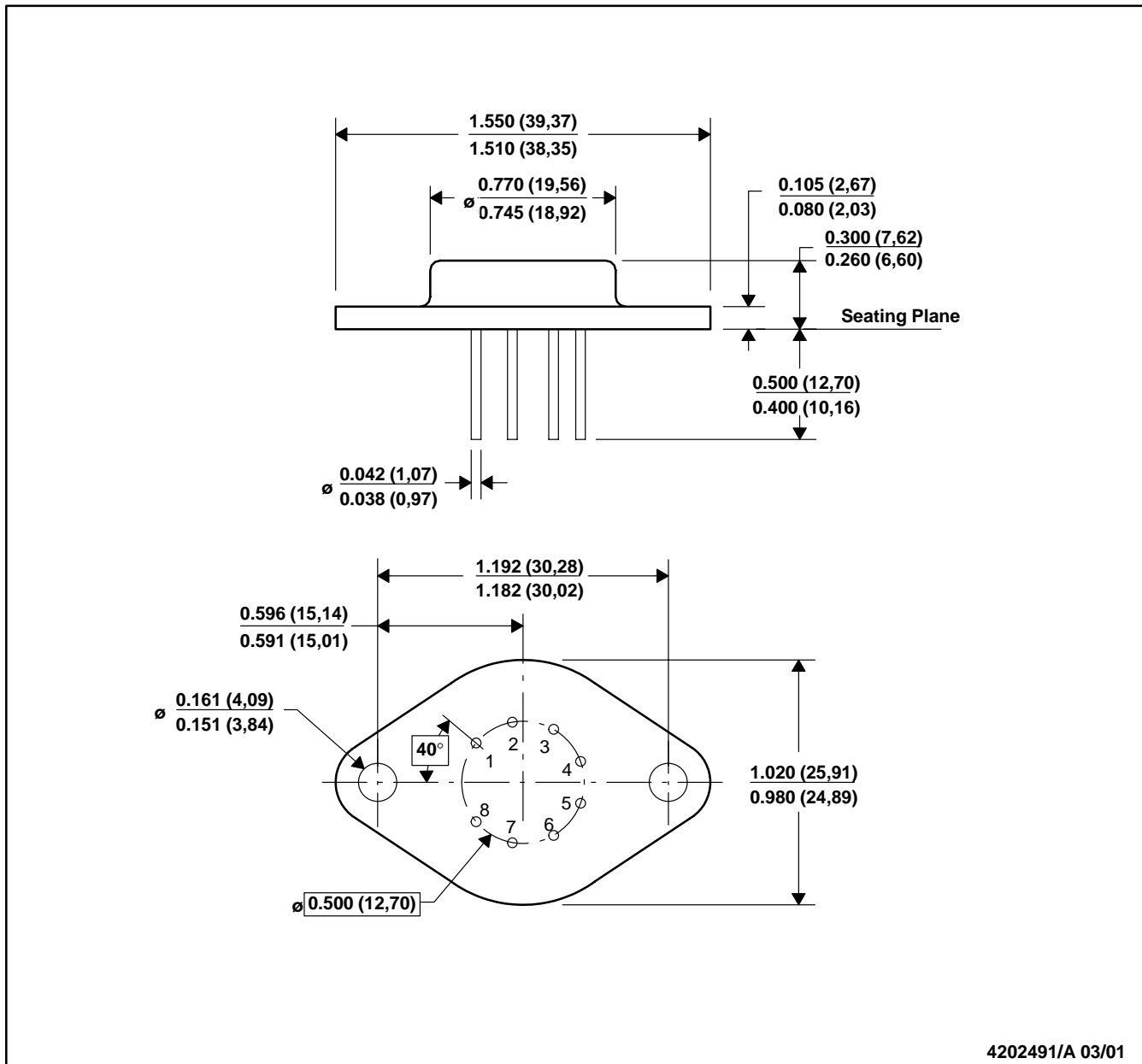
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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LMF (O-MBCY-W8)

METAL CYLINDRICAL PACKAGE



4202491/A 03/01

- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Leads in true position within 0.010 (0,25) R @ MMC at seating plane.
 - D. Pin numbers shown for reference only. Numbers may not be marked on package.

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