

# 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

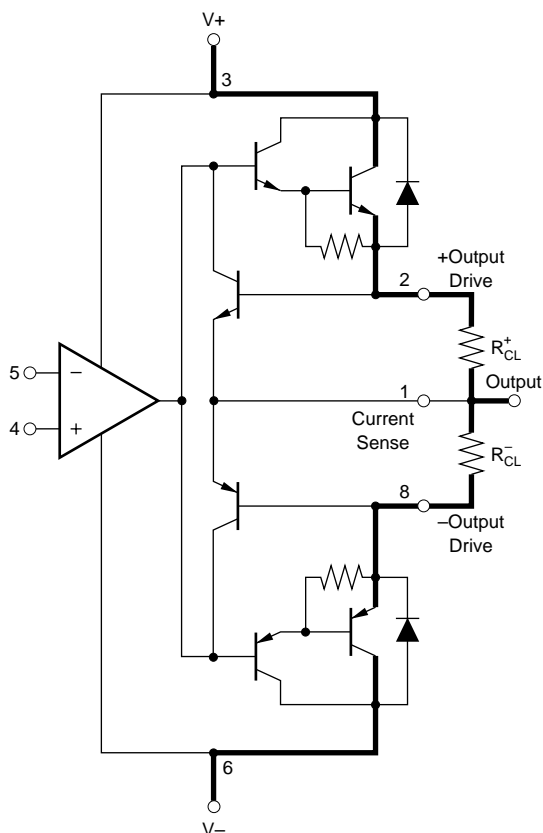
The OPA501 is a high output current operational amplifier. It can be used in virtually all common op amp circuits, yet is capable of output currents up to  $\pm 10A$ . Power-supply voltages up to  $\pm 40V$  allow very high output power for driving motors or other electromechanical loads.

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



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.

## ABSOLUTE MAXIMUM RATINGS

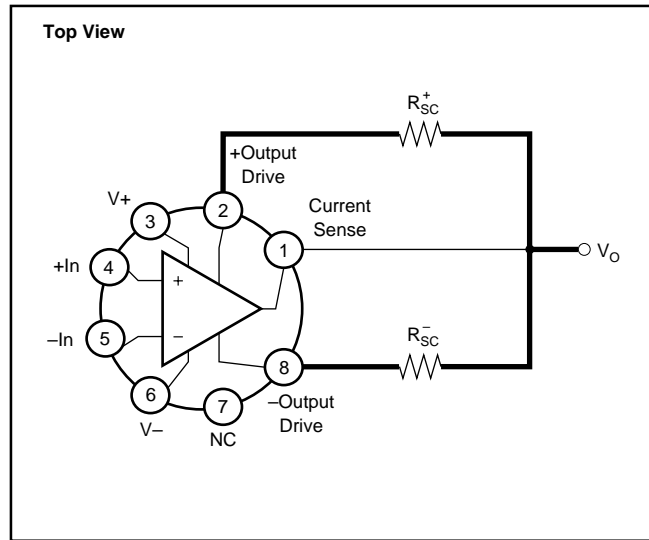
Power Supply Voltage ( $V_S$ )	$\pm 40V$
Power Dissipation at $+25^\circ C$ <sup>(1, 2)</sup>	79W
Differential Input Voltage	$\pm V_S - 3V$
Common-Mode Input Voltage	$\pm V_S$
Operating Temperature Range	$-55^\circ C$ to $+125^\circ C$
Storage Temperature Range	$-65^\circ C$ to $+150^\circ C$
Lead Temperature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

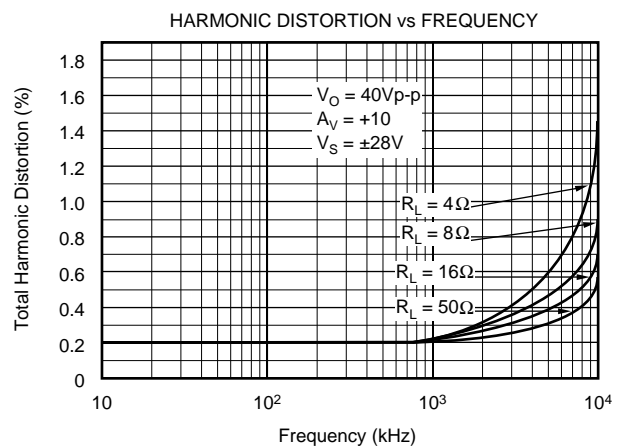
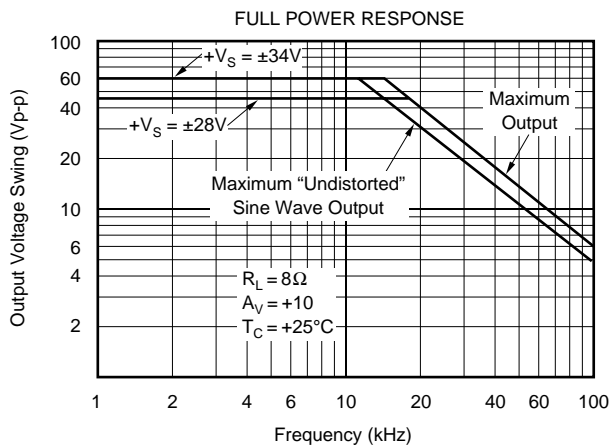
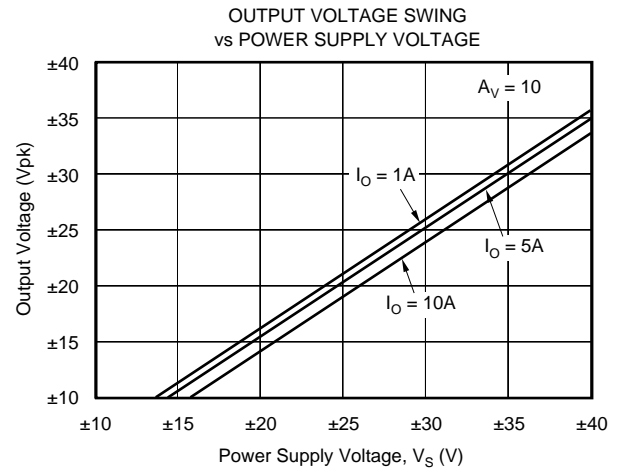
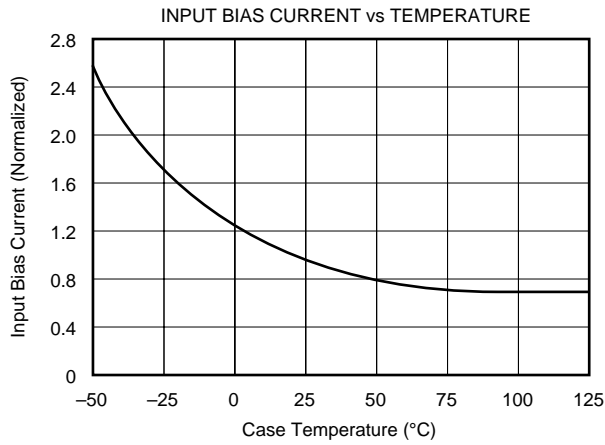
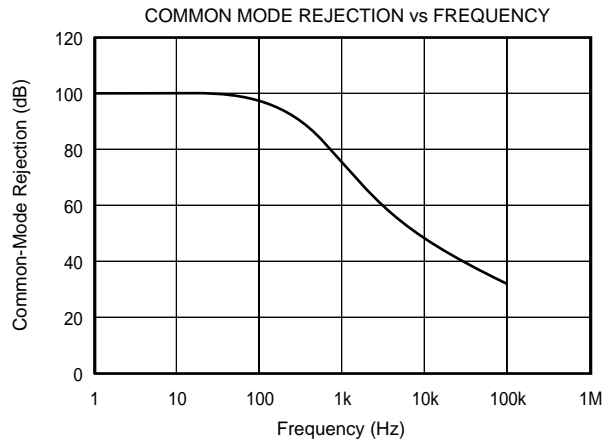
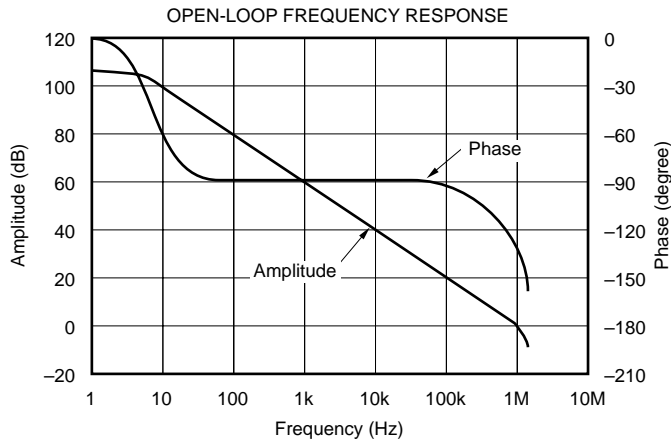
At  $T_C = +25^\circ\text{C}$ , and  $V_S = \pm 28\text{V}$ , unless otherwise noted.

PARAMETER	CONDITIONS	OPA501AM			UNITS
		MIN	TYP	MAX	
<b>RATED OUTPUT</b> <sup>(1, 2)</sup> Output Current Continuous <sup>(3)</sup> Output Voltage <sup>(3)</sup>	$R_L = 2\Omega$ $R_L = 2.6\Omega$ $I_O = 10\text{A peak}$	$\pm 10$ $\pm 10$ $\pm 20$	$\pm 23$		A A V
<b>DYNAMIC RESPONSE</b> 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/ $\mu\text{s}$ V/ $\mu\text{s}$
<b>INPUT OFFSET VOLTAGE</b> Initial Offset vs Temperature vs Supply Voltage	$-25^\circ\text{C} < T < +85^\circ\text{C}$		$\pm 5$ $\pm 10$ $\pm 35$	$\pm 10$ $\pm 65$	mV $\mu\text{V}/^\circ\text{C}$ $\mu\text{V}/\text{V}$
<b>INPUT BIAS CURRENT</b> Initial vs Temperature vs Supply Voltage	$T_{\text{CASE}} = +25^\circ\text{C}$		15 $\pm 0.05$ $\pm 0.02$	40	nA nA/ $^\circ\text{C}$ nA/V
<b>INPUT DIFFERENCE CURRENT</b> Initial vs Temperature	$T_{\text{CASE}} = +25^\circ\text{C}$ $-25^\circ\text{C} < T < +85^\circ\text{C}$		$\pm 5$ $\pm 0.01$	$\pm 10$	nA nA/ $^\circ\text{C}$
<b>OPEN-LOOP GAIN, DC</b>	$R_L = 5\Omega$ $R_L = 6.5\Omega$	94 98	115 115		dB dB
<b>INPUT IMPEDANCE</b> Differential Common-mode			10 250		$\text{M}\Omega$ $\text{M}\Omega$
<b>INPUT NOISE</b> 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		$\mu\text{V}_{PP}$ $\mu\text{V}_{RMS}$ $\text{pA}_{PP}$ $\text{pA}_{RMS}$
<b>INPUT VOLTAGE RANGE</b> Common-Mode Voltage <sup>(4)</sup> 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
<b>POWER SUPPLY</b> Rated Voltage Operating Voltage Range Current, quiescent		$\pm 10$	$\pm 28$ $\pm 2.6$	$\pm 36$ $\pm 10$	V V mA
<b>TEMPERATURE RANGE</b> Specification Operating, derated performance Storage	case	-25 -55 -65		+85 +125 +150	$^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C}$
<b>THERMAL RESISTANCE</b>	Steady State $\theta_{JC}$		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.

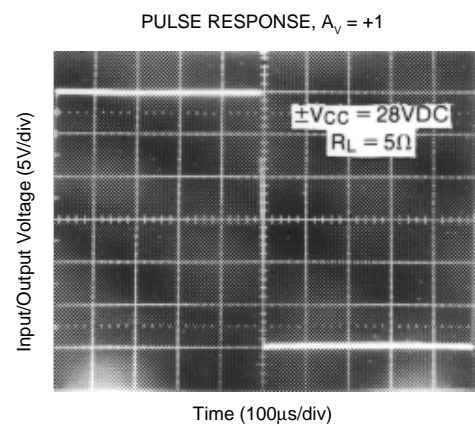
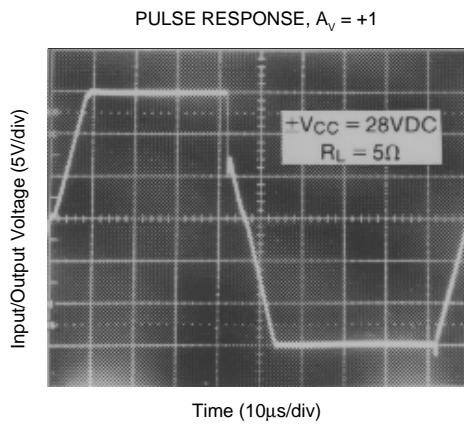
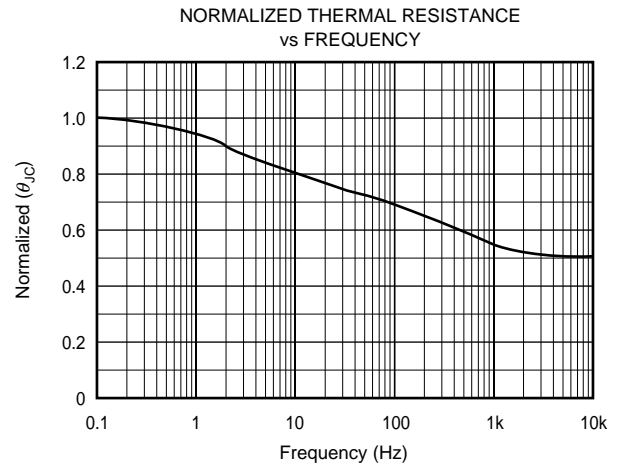
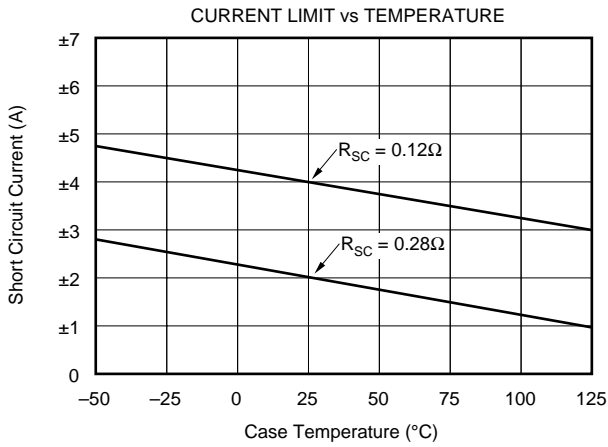
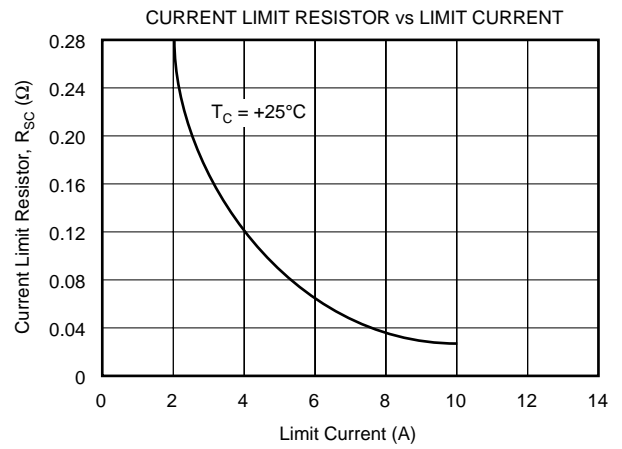
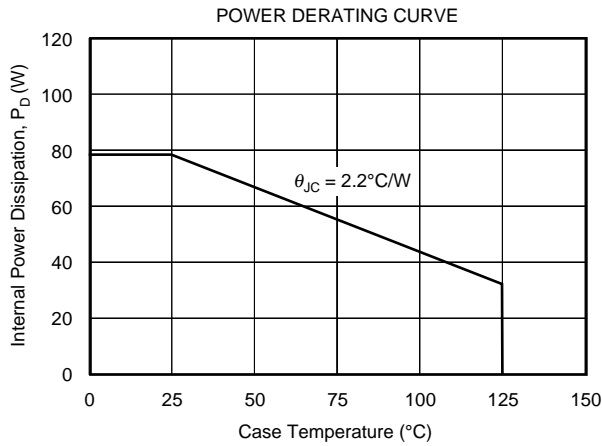
# TYPICAL CHARACTERISTICS

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.

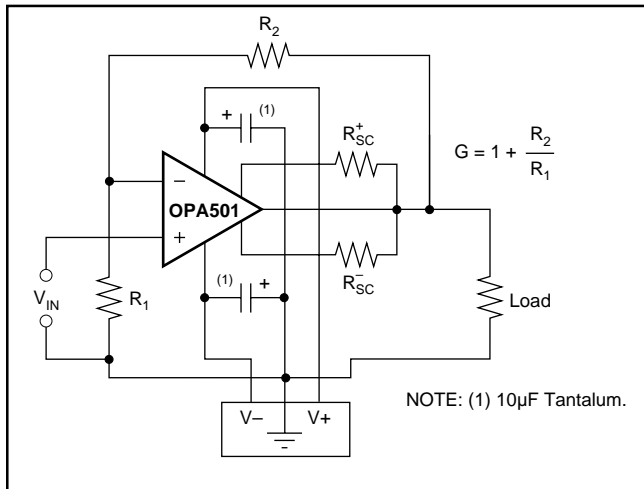


FIGURE 1. Basic Circuit Connections.

## 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.

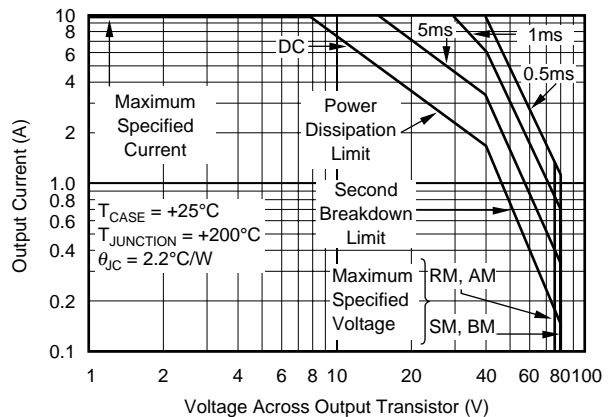


FIGURE 2. Transistor Safe Operating Area at +25°C Case Temperature.

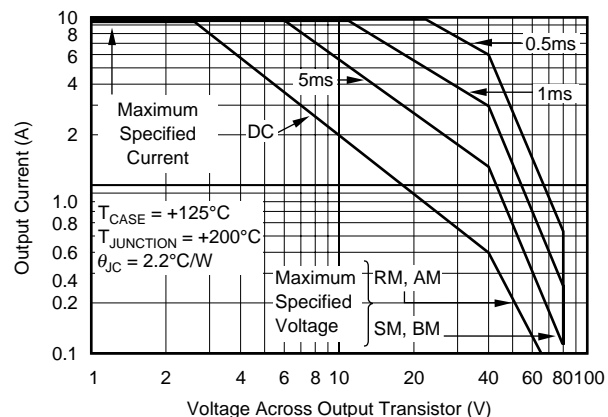


FIGURE 3. Transistor Safe Operating Area at +125°C Case Temperature.

**PACKAGING INFORMATION**

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

<sup>(1)</sup> 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.

<sup>(2)</sup> 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.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**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.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

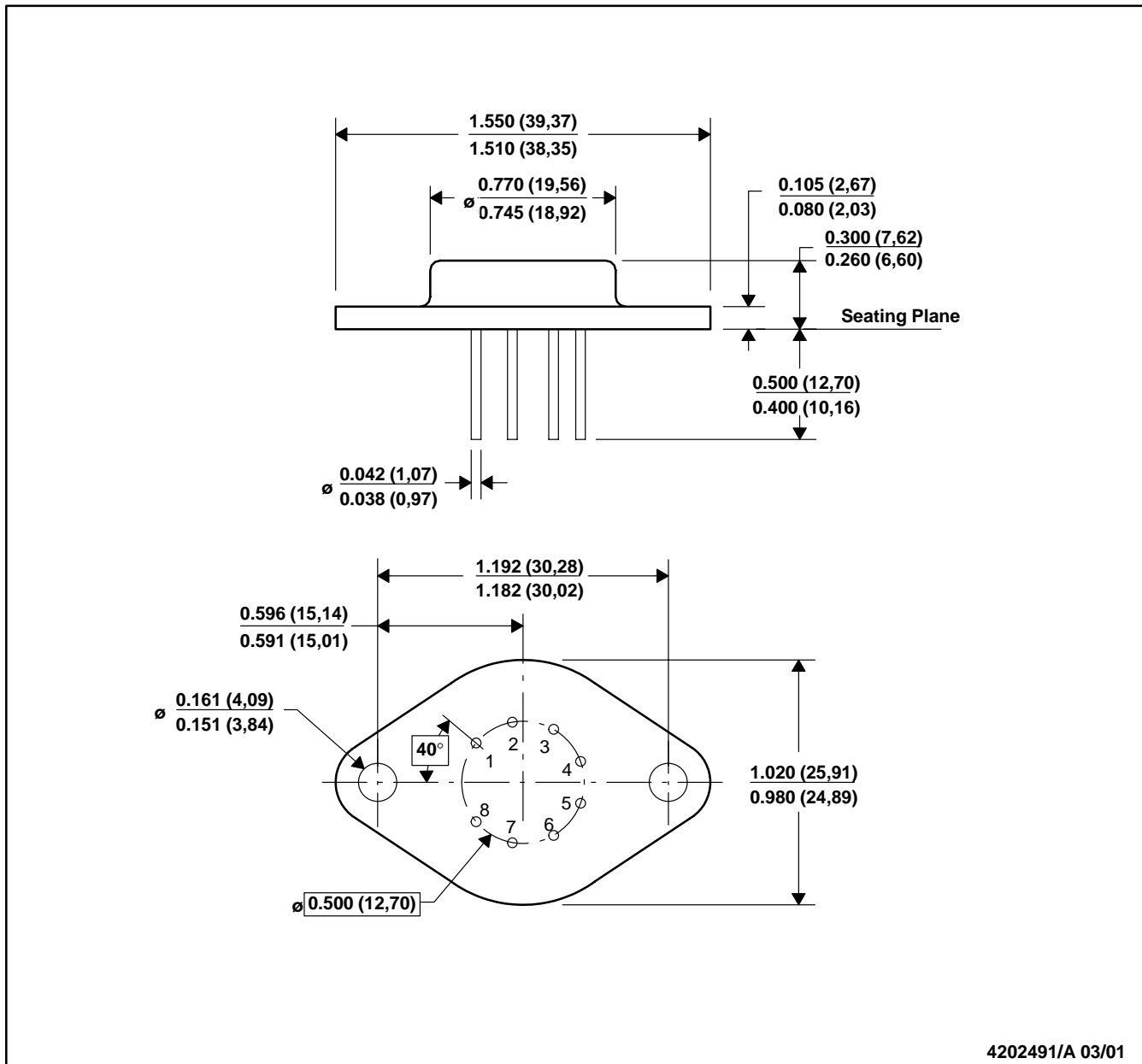
<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

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.



## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2009, Texas Instruments Incorporated