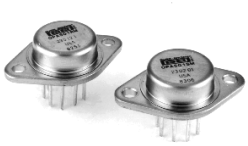


SBOS136A – JANUARY 1983 – REVISED DECEMBER 2003

High Current, High Power OPERATIONAL AMPLIFIER

FEATURES

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

APPLICATIONS

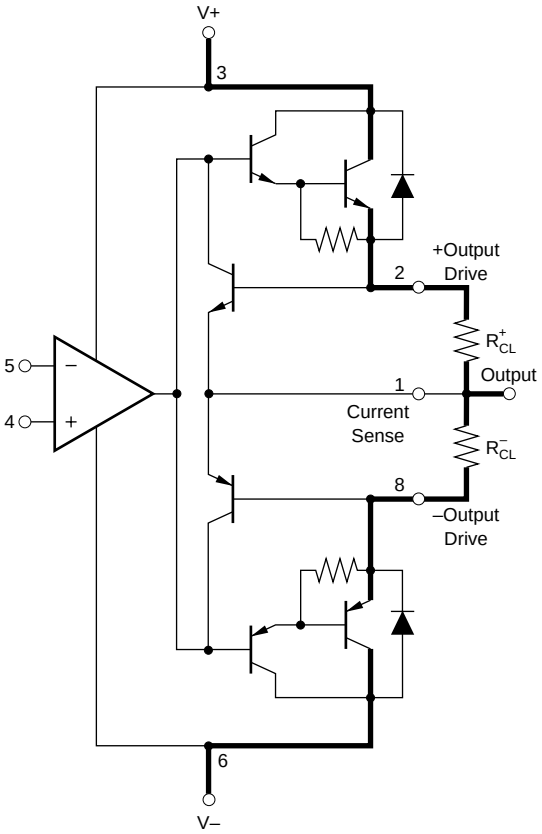
- **MOTOR DRIVER**
- **SERVO AMPLIFIER**
- **VALVE ACTUATOR**
- **SYNCRO DRIVER**
- **PROGRAMMABLE POWER SUPPLY**

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 ±10A. Power-supply voltages up to ±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°C to +85°C .



ABSOLUTE MAXIMUM RATINGS

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

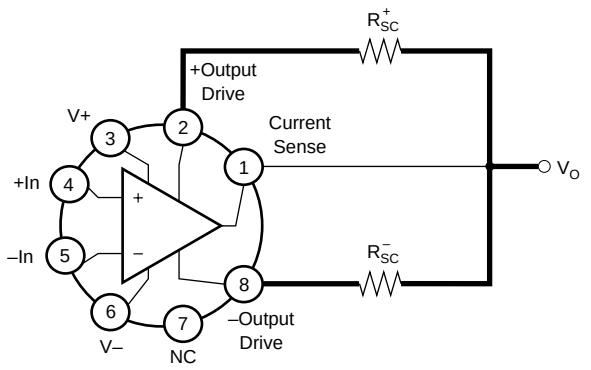
NOTES: (1) At case temperature of +25°C. Derate at 2.2°C/W above case temperature of +25°C. (2) Average dissipation. (3) Within safe operating area and with appropriate derating.

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

Top View



ELECTRICAL CHARACTERISTICS

At T_C = +25°C, and V_S = ±28V, unless otherwise noted.

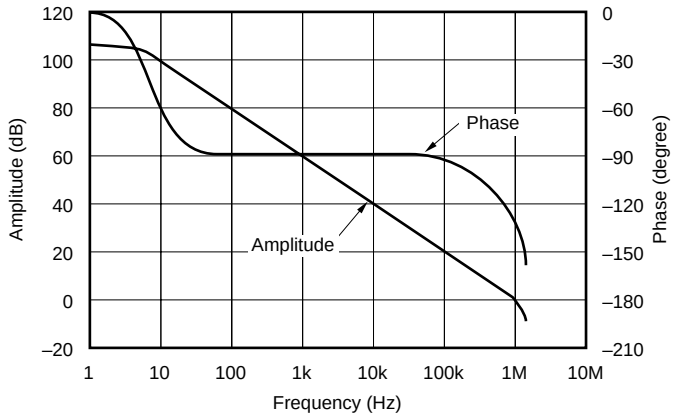
PARAMETER	CONDITIONS	OPA501AM			UNITS
		MIN	TYP	MAX	
RATED OUTPUT(1, 2)					
Output Current	R_L = 2Ω	±10			A
Continuous(3)	R_L = 2.6Ω	±10			A
Output Voltage(3)	I_O = 10A peak	±20	±23		V
DYNAMIC RESPONSE					
Bandwidth, Unity Gain	Small Signal		1		MHz
Full Power Bandwidth	V_O = 40V_{PP}, R_L = 8Ω	10	16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

NOTES: (1) Package must be derated based on a junction-to-case thermal resistance of 2.2°C/W or a junction-to-ambient thermal resistance of 30°C/W. (2) Safe Operating Area and Power Derating Curves must be observed. (3) With ±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.

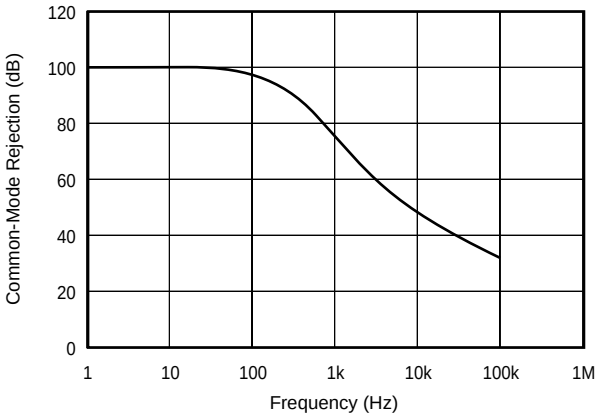
TYPICAL CHARACTERISTICS

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

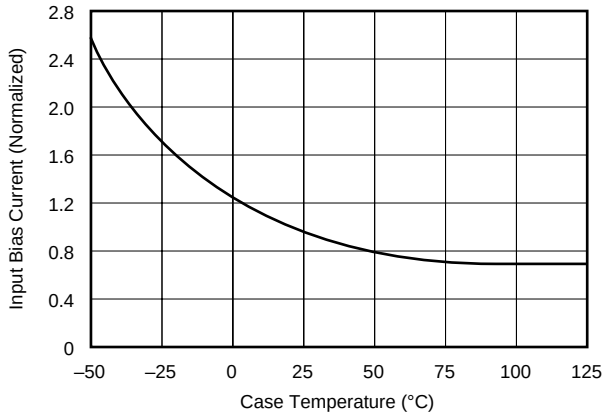
OPEN-LOOP FREQUENCY RESPONSE



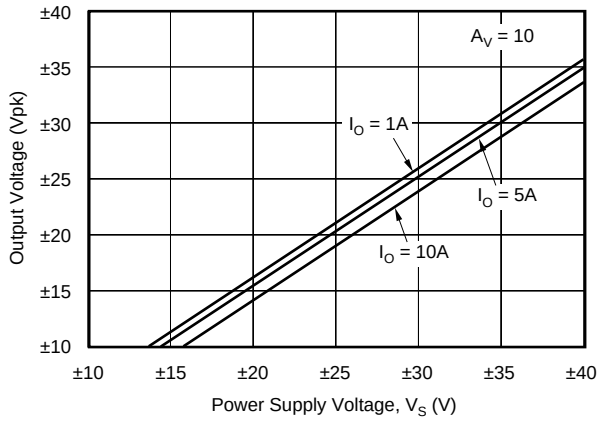
COMMON MODE REJECTION vs FREQUENCY



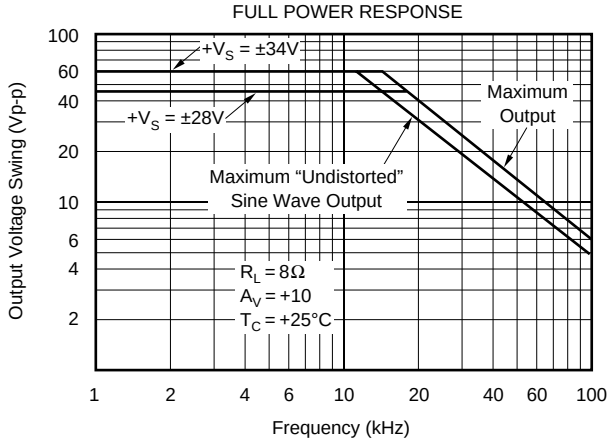
INPUT BIAS CURRENT vs TEMPERATURE



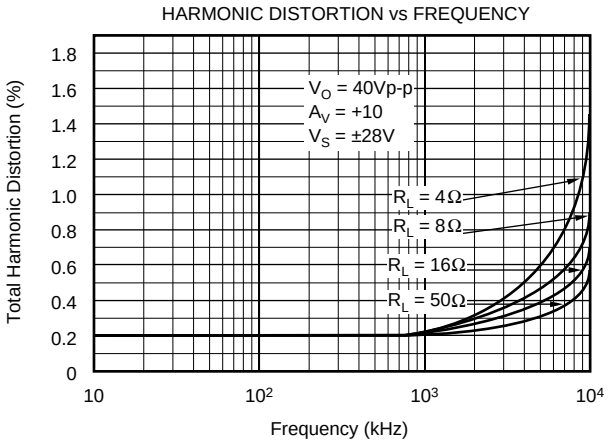
OUTPUT VOLTAGE SWING
vs POWER SUPPLY VOLTAGE



FULL POWER RESPONSE



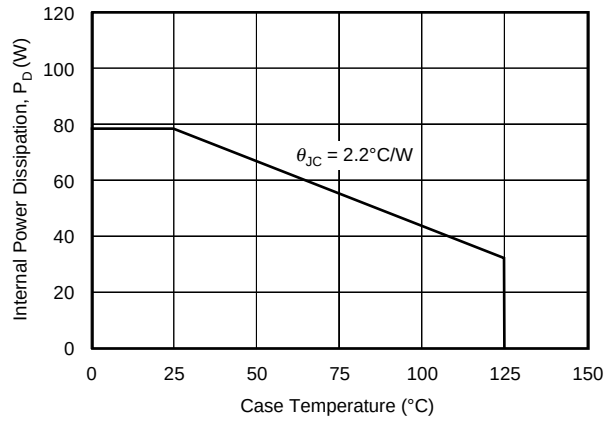
HARMONIC DISTORTION vs FREQUENCY



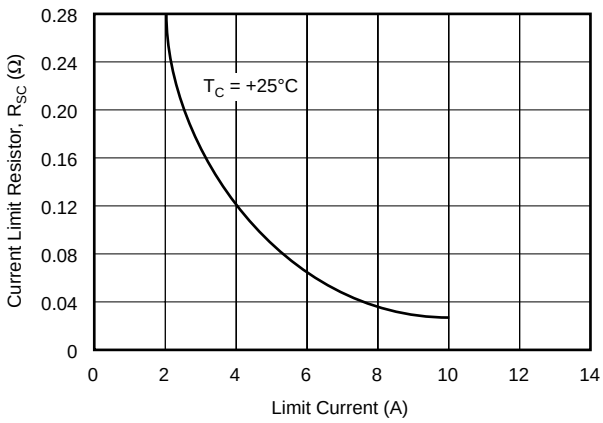
TYPICAL CHARACTERISTICS (Cont.)

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

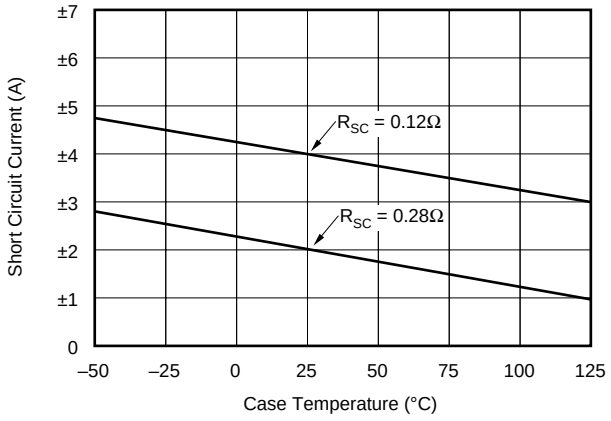
POWER DERATING CURVE



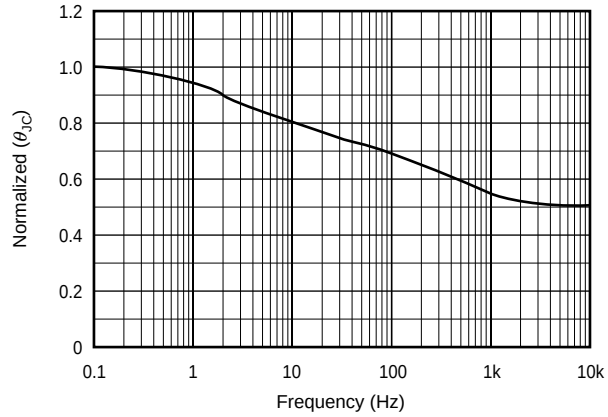
CURRENT LIMIT RESISTOR vs LIMIT CURRENT



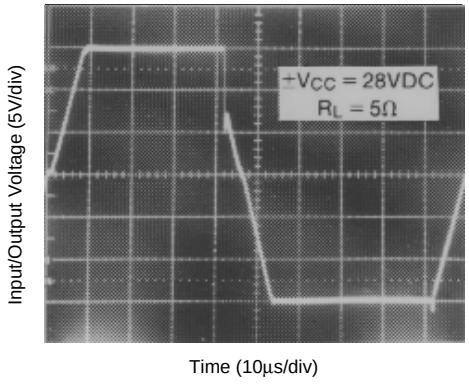
CURRENT LIMIT vs TEMPERATURE



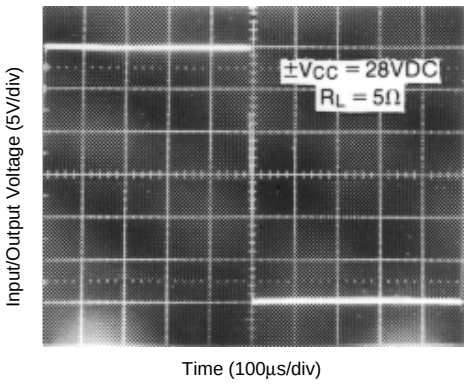
NORMALIZED THERMAL RESISTANCE vs FREQUENCY



PULSE RESPONSE, A_V = +1



PULSE RESPONSE, A_V = +1



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.

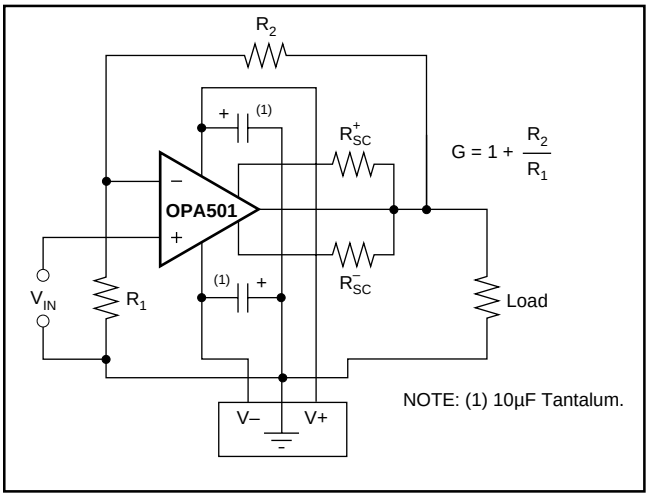


FIGURE 1. Basic Circuit Connections.

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.

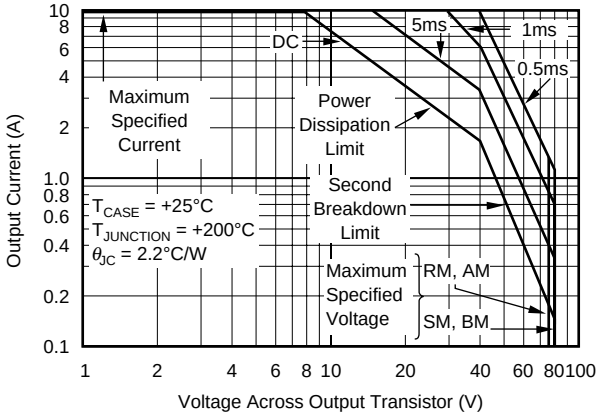


FIGURE 2. Transistor Safe Operating Area at +25°C Case Temperature.

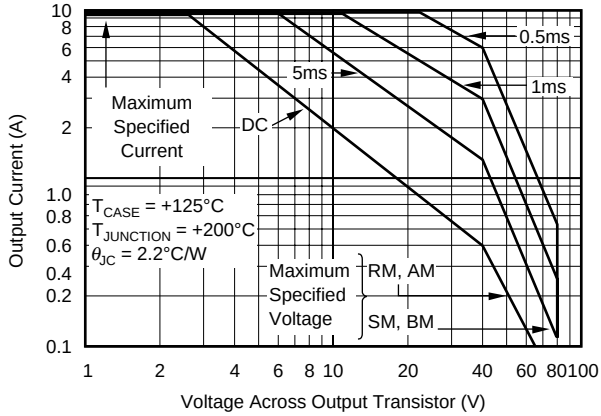


FIGURE 3. Transistor Safe Operating Area at +125°C Case Temperature.

PACKAGING INFORMATION

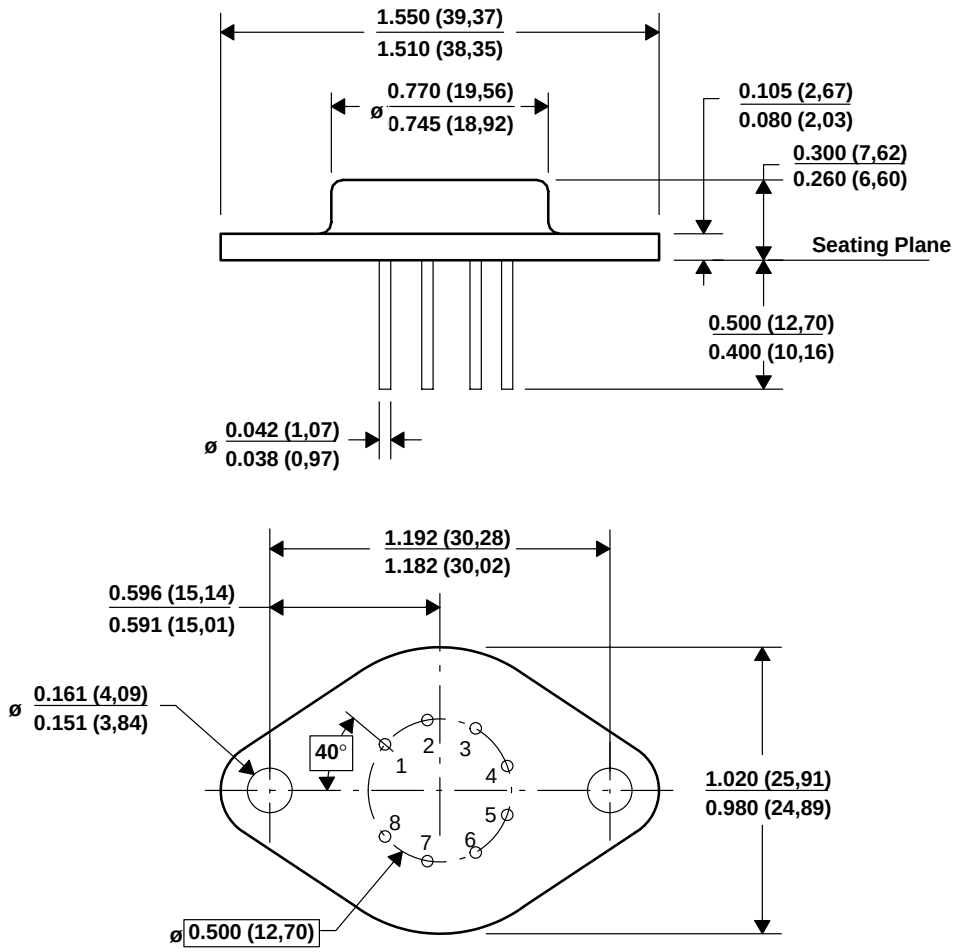
Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
OPA501AM	NRND	TO-3	LMF	8	18	Pb-Free (RoHS Exempt)	Call TI	N / A for Pkg Type

(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.
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)

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

LMF (O–MBCY–W8) **METAL CYLINDRICAL PACKAGE**



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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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