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OPA2544

## High-Voltage, High-Current DUAL OPERATIONAL AMPLIFIER

### FEATURES

- HIGH OUTPUT CURRENT: 2A min
- WIDE POWER SUPPLY RANGE:  
 $\pm 10V$  to  $\pm 35V$
- SLEW RATE:  $8V/\mu s$
- INTERNAL CURRENT LIMIT
- THERMAL SHUTDOWN PROTECTION
- FET INPUT:  $I_B = 50pA$  max
- 8-PIN HERMETIC TO-3 AND 11-LEAD PLASTIC PACKAGES

### APPLICATIONS

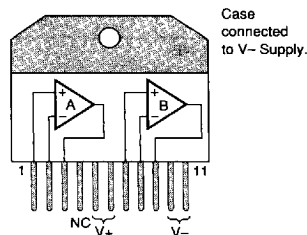
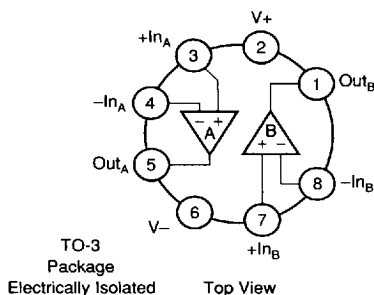
- MOTOR DRIVER
- PROGRAMMABLE POWER SUPPLY
- SERVO AMPLIFIER
- VALVES, ACTUATOR DRIVER
- MAGNETIC DEFLECTION COIL DRIVER
- AUDIO AMPLIFIER

### DESCRIPTION

The OPA2544 is a dual high-voltage/high-current operational amplifier suitable for driving a wide variety of high power loads. It provides 2A output current and power supply voltage range extends to  $\pm 35V$ .

The OPA2544 integrates two high performance FET op amps with high power output stages on a single monolithic chip. Internal current limit and thermal shutdown protect the amplifier and load from damage.

The OPA2544 is available in a hermetic 8-pin metal TO-3, and 11-lead plastic packages. Models are available in  $-40^\circ C$  to  $+85^\circ C$ , and  $-55^\circ C$  to  $+125^\circ C$  temperature ranges.



International Airport Industrial Park • Mailing Address: PO Box 11400 • Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd. • Tucson, AZ 85706  
Tel: (520) 746-1111 • Twx: 910-952-1111 • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132



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# SPECIFICATIONS

At  $T_{CASE} = +25^{\circ}C$  and  $V_S = \pm 35V$ , unless otherwise noted.

PARAMETER	CONDITIONS	OPA2544T OPA2544BM			OPA2544SM			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>OFFSET VOLTAGE</b> Input Offset Voltage vs Temperature vs Power Supply	Specified Temp. Range $V_S = \pm 10V$ to $\pm 35V$		$\pm 1$ $\pm 10$ $\pm 10$	$\pm 5$  $\pm 100$		*	*	mV $\mu V/^{\circ}C$ $\mu V/V$
<b>INPUT BIAS CURRENT<sup>(1)</sup></b> Input Bias Current vs Temperature Input Offset Current	$V_{CM} = 0V$  $V_{CM} = 0V$		$\pm 15$  $\pm 10$	$\pm 50$  $\pm 50$		*	*	pA  pA
<b>NOISE</b> Input Voltage Noise Noise Density, $f = 1kHz$ Current Noise Density, $f = 1kHz$			36 3			*	*	$nV/\sqrt{Hz}$ $fA/\sqrt{Hz}$
<b>INPUT VOLTAGE RANGE</b> Common-Mode Input Range Positive Negative Common-Mode Rejection	Linear Operation Linear Operation $V_{CM} = \pm V_S/6V$	(V+) -6 (V-) +6 90	(V+) -4 (V-) +4 106			*	*	V V dB
<b>INPUT IMPEDANCE</b> Differential Common-Mode			$10^{12} \parallel 8$ $10^{12} \parallel 10$			*	*	$\Omega \parallel pF$ $\Omega \parallel pF$
<b>OPEN-LOOP GAIN</b> Open-Loop Voltage Gain	$V_O = \pm 30V$ , $R_L = 15\Omega$	90	103			*	*	dB
<b>FREQUENCY RESPONSE</b> Gain-Bandwidth Product Slew Rate Full-Power Bandwidth Settling Time 0.1% Total Harmonic Distortion	$R_L = 15\Omega$ $60Vp-p$ , $R_L = 15\Omega$  $G = -10$ , 60V Step	5	1.4 8 See Typical Curve 25 See Typical Curve			*	*	MHz V/ $\mu s$  $\mu s$
<b>OUTPUT</b> Voltage Output: Positive Negative Positive Negative Current Output Short-Circuit Current	$I_O = 2A$ $I_O = 2A$ $I_O = 0.5A$ $I_O = 0.5A$	(V+) -5 (V-) +5 (V+) -4.2 (V-) +4	(V+) -4.4 (V-) +3.8 (V+) -3.8 (V-) +3.1			*	*	V V V V A
<b>POWER SUPPLY</b> Specified Operating Voltage Operating Voltage Range Quiescent Current (total)	$I_O = 0$	$\pm 10$	$\pm 35$  $\pm 22$  $\pm 30$			*	*	V V mA
<b>TEMPERATURE RANGE</b> Operating Range Storage, Metal TO-3 Package Plastic Package Thermal Resistance, $\theta_{JC}^2$ Thermal Resistance, $\theta_{JC}^2$ Thermal Resistance, $\theta_{JC}^2$ Thermal Resistance, $\theta_{JC}^2$ Thermal Resistance, $\theta_{JA}^2$	Both Amplifiers, $f > 50Hz$ Both Amplifiers, DC One Amplifier, $f > 50Hz$ One Amplifier, DC No Heat Sink	-40 -65 -40		+85 +125 +125		-55 *	+125 *	$^{\circ}C$ $^{\circ}C$ $^{\circ}C$ $^{\circ}C/W$ $^{\circ}C/W$ $^{\circ}C/W$ $^{\circ}C/W$ $^{\circ}C/W$

\* Specifications same as OPA2544BM.

NOTES: (1) High-speed test at  $T_J = 25^{\circ}C$ . (2) Calculated from total power dissipation of both amplifiers.

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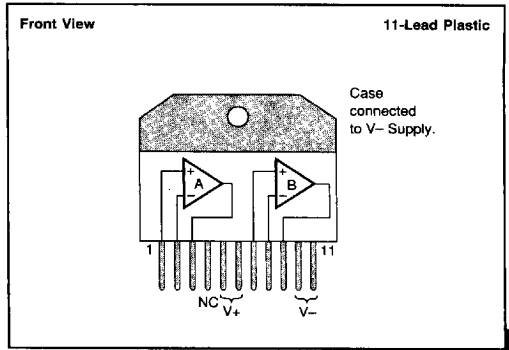
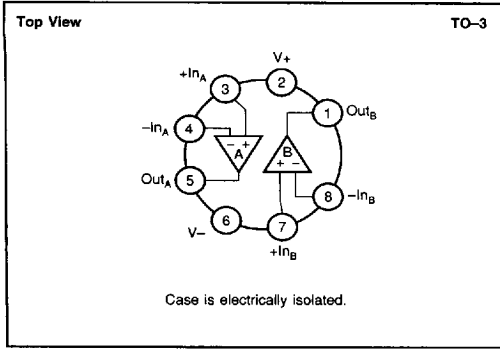
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**CONNECTION DIAGRAMS**



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**ORDERING INFORMATION**

MODEL	PACKAGE	TEMPERATURE RANGE
OPA2544T	11-Lead Plastic	-40°C to +85°C
OPA2544BM	8-Pin Metal TO-3	-40°C to +85°C
OPA2544SM	8-Pin Metal TO-3	-55°C to +125°C

**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage, V+ to V-	70V
Output Current	See SOA Curve
Input Voltage (V-) -0.7V to (V+) +0.7V	
Operating Temperature	-55°C to +125°C
Storage Temperature, Metal TO-3 Package	-55°C to +125°C
Plastic Package	-40°C to +125°C
Junction Temperature	150°C
Lead Temperature (soldering, -10s)	300°C

**PACKAGE INFORMATION**

MODEL	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>
OPA2544T	11-Lead Plastic	242
OPA2544BM	8-Pin Metal TO-3	030
OPA2544SM	8-Pin Metal TO-3	030

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book.



**ELECTROSTATIC DISCHARGE SENSITIVITY**

This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

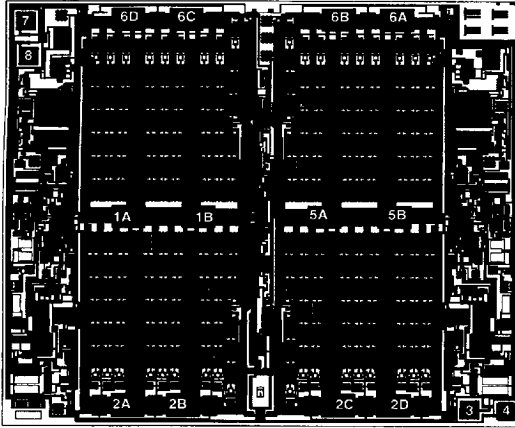
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

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DICE INFORMATION



OPA2544 DIE TOPOGRAPHY

PAD	FUNCTION
1A, 1B	Out <sub>B</sub>
2A, 2B, 2C, 2D	V+
3	+In <sub>A</sub>
4	-In <sub>A</sub>
5A, 5B	Out <sub>A</sub>
6A, 6B, 6C, 6D	V-
7	+In <sub>B</sub>
8	-In <sub>B</sub>

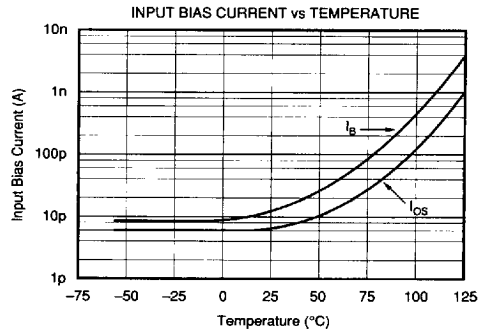
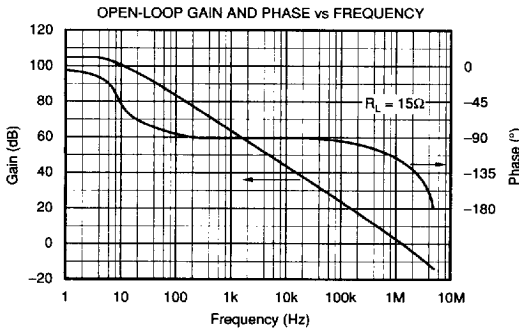
Substrate Bias: Internally connected to V- power supply.

MECHANICAL INFORMATION

	MILS (0.001")	MILLIMETERS
Die Size	218 x 252 ±5	8.58 x 9.92 ±0.13
Die Thickness	20 ±3	0.51 ±0.08
Min. Pad Size	4 x 4	0.1 x 0.1
Backing	Chromium-Silver	

TYPICAL PERFORMANCE CURVES

T<sub>CASE</sub> = +25°C, V<sub>S</sub> = ±35V unless otherwise noted.



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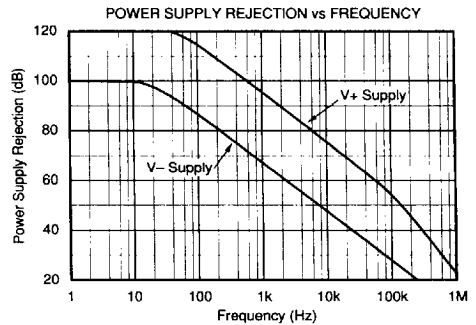
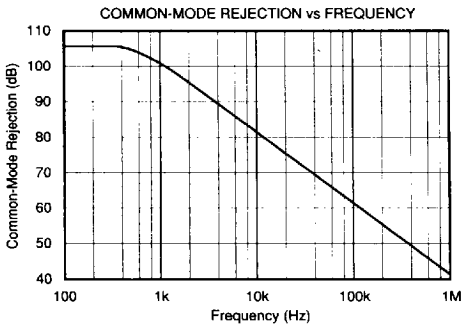
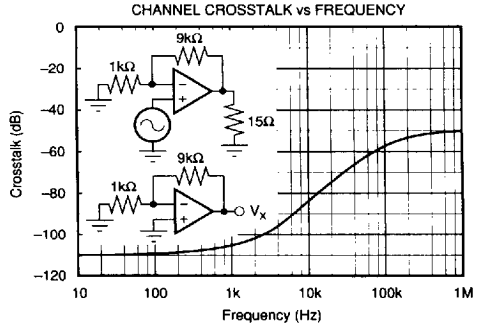
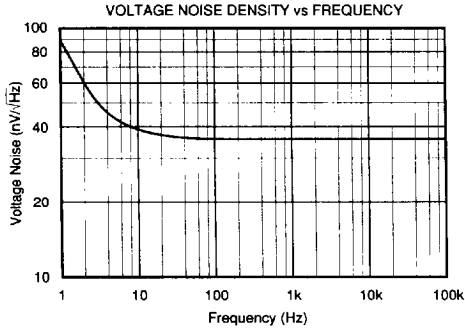
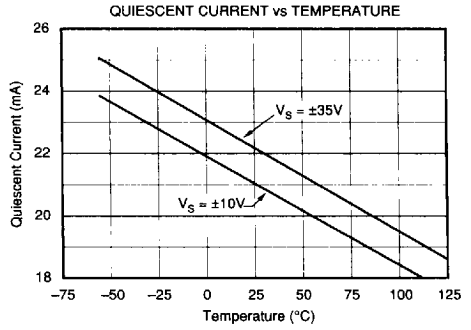
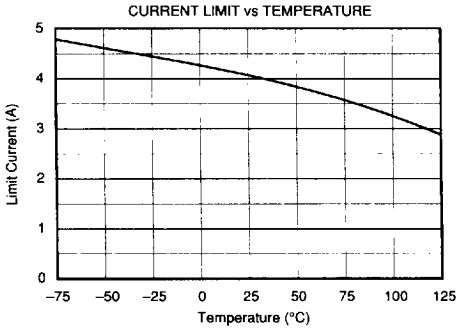
## TYPICAL PERFORMANCE CURVES (CONT)

At  $T_{CASE} = +25^{\circ}C$  and  $V_S = \pm 35V$ , unless otherwise noted.

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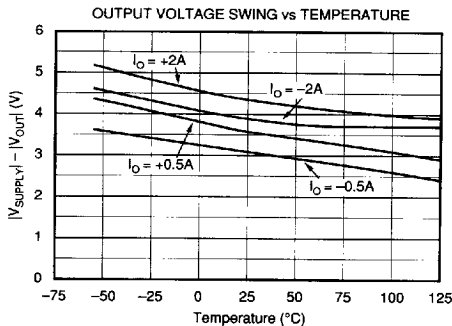
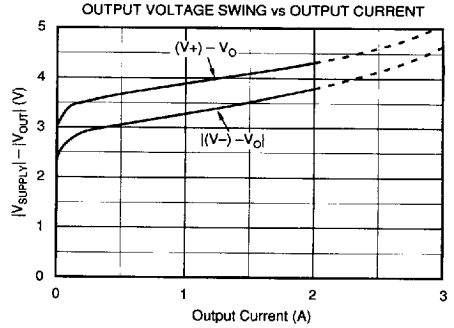
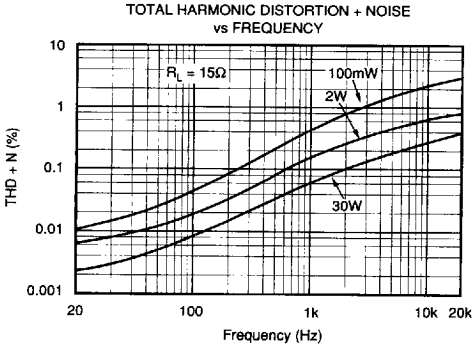
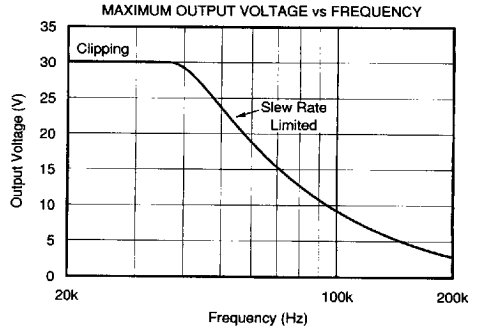
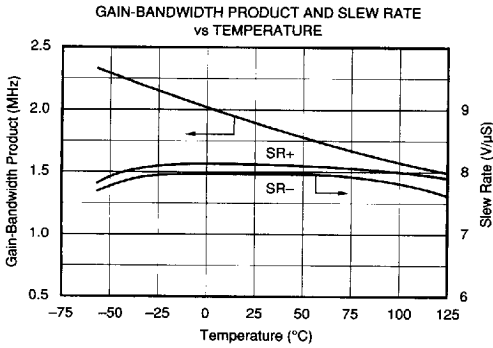
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## TYPICAL PERFORMANCE CURVES (CONT)

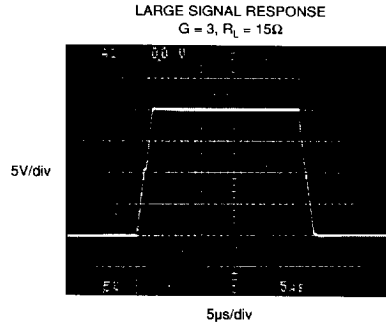
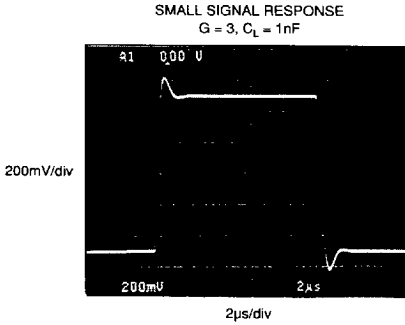
At  $T_{CASE} = +25^{\circ}C$  and  $V_S = \pm 35V$ , unless otherwise noted.



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## TYPICAL PERFORMANCE CURVES (CONT)

At  $T_{CASE} = +25^{\circ}C$  and  $V_S = \pm 35V$ , unless otherwise noted.



## APPLICATIONS INFORMATION

Figure 1 shows the OPA2544 connected as a basic non-inverting amplifier. The OPA2544 can be used in virtually any op amp configuration. Power supply terminals should be bypassed with low series impedance capacitors. The technique shown, using a ceramic and tantalum type in parallel, is recommended. Power supply wiring should have low series impedance and inductance.

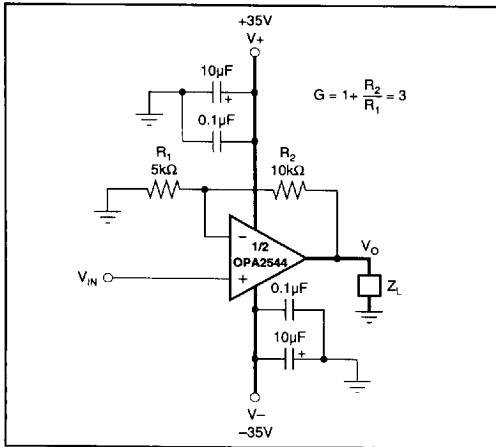


FIGURE 1. Basic Circuit Connections.

## SAFE OPERATING AREA

Stress on the output transistors is determined by the output current and the voltage across the conducting output transistor,  $V_{CE}$ . 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 curve, Figure 2) shows the permissible range of voltage and current.

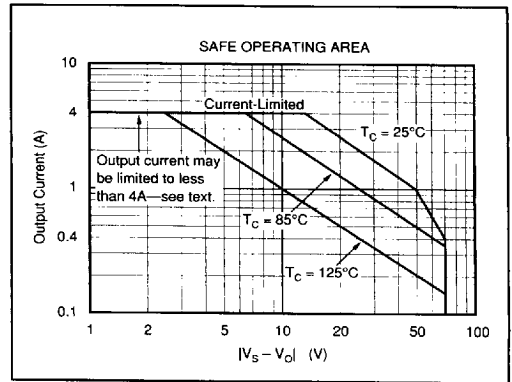


FIGURE 2. Safe Operating Area.



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The safe output current decreases as  $V_{CE}$  increases. Output short-circuit is a very demanding case for SOA. A short-circuit to ground forces the full power supply voltage ( $V_+$  or  $V_-$ ) across the conducting transistor. With  $V_S = \pm 35V$  the safe output current is 1.5A (at 25°C). The short-circuit current is approximately 4A which exceeds the SOA. This situation will activate the thermal shutdown circuit in the OPA2544. For further insight on SOA, consult AB-039.

### CURRENT LIMIT

The OPA2544 has an internal current limit set for approximately 4A. This current limit decreases with increasing junction temperature as shown in the typical curve, Current Limit versus Temperature. This, in combination with the thermal shutdown circuit, provides protection from many types of overload. It may not, however, protect for short-circuit to ground, depending on the power supply voltage, ambient temperature, heat sink and signal conditions.

### POWER DISSIPATION

Power dissipation depends on power supply, signal and load conditions. For DC signals, power dissipation is equal to the product of output current times the voltage across the conducting output transistor. Power dissipation can be minimized by using the lowest possible power supply voltage necessary to assure the required output voltage swing.

For resistive loads, the maximum power dissipation occurs at a DC output voltage of one-half the power supply voltage. Dissipation with AC signals is lower. Application Bulletin AB-039 explains how to calculate or measure power dissipation with unusual signals and loads.

### HEATSINKING

Most applications require a heat sink to assure that the maximum junction temperature is not exceeded. The heat sink required depends on the power dissipated and on ambient conditions. Consult Application Bulletin AB-038 for information on determining heat sink requirements.

The case of the metal TO-3 model of the OPA2544 is electrically isolated from all circuitry and can be connected directly to a heat sink. This eliminates cumbersome insulating hardware that increases thermal resistance. Consult Application Bulletin AB-037 for proper mounting techniques and procedures for TO-3 power products.

The heat sink tab of the plastic package is connected to the  $V_-$  power supply terminal. Lowest thermal resistance can be achieved by mounting the tab directly to a heat sink. If the heat sink cannot be electrically "hot" at  $V_-$  power supply potential, insulating hardware must be used.

### THERMAL PROTECTION

The OPA2544 has thermal shutdown that protects the amplifier from damage. Any tendency to activate the thermal shutdown circuit during normal operation is indication of excessive power dissipation or an inadequate heat sink.

The thermal protection activates at a junction temperature of approximately 155°C. For reliable operation, junction temperature should be limited to 150°C, maximum. To estimate the margin of safety in a complete design (including heat sink), increase the ambient temperature until the thermal protection is activated. Use worst-case load and signal conditions. For good reliability, the thermal protection should trigger more than 25°C above the maximum expected ambient condition of your application. This produces a junction temperature of 125°C at the maximum expected ambient condition.

Depending on load and signal conditions, the thermal protection circuit may produce a duty-cycle modulated output signal. This limits the dissipation in the amplifier, but the rapidly varying output waveform may be damaging to some loads. The thermal protection may behave differently depending on whether internal dissipation is produced by sourcing or sinking output current.

### UNBALANCED POWER SUPPLIES

Some applications do not require equal positive and negative output voltage swing. The power supply voltages of the OPA2544 do not need to be equal. For example, a -7V negative power supply voltage assures that the inputs of the OPA2544 are operated within their linear common-mode range, and that the output can swing to 0V. The  $V_+$  power supply could range from 15V to 63V. The total voltage ( $V_-$  to  $V_+$ ) can range from 20V to 70V. With a 63V positive supply voltage, the device may not be protected from damage during short-circuits because of the larger  $V_{CE}$  during this condition.

### OUTPUT PROTECTION

Reactive and EMF-generating loads can return load current to the amplifier, causing the output voltage to exceed the power supply voltage. This damaging condition can be avoided with clamp diodes from the output terminal to the power supplies as shown in Figure 2. Fast-recovery rectifier diodes with a 4A or greater continuous rating are recommended.

### SOCKET

An 8-pin TO-3 socket, Burr-Brown model 0804MC is available. Although not required, this socket makes mounting and interchanging parts easy, especially during design and testing.



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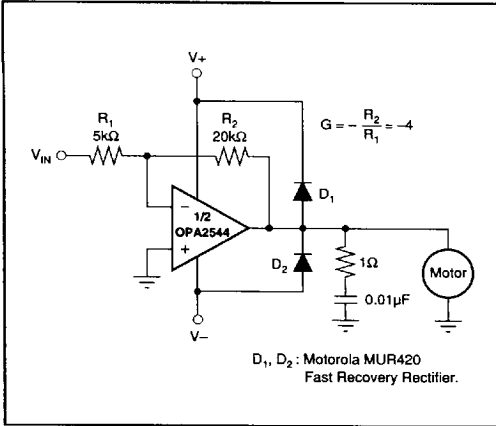


FIGURE 3. Motor Drive Circuit.

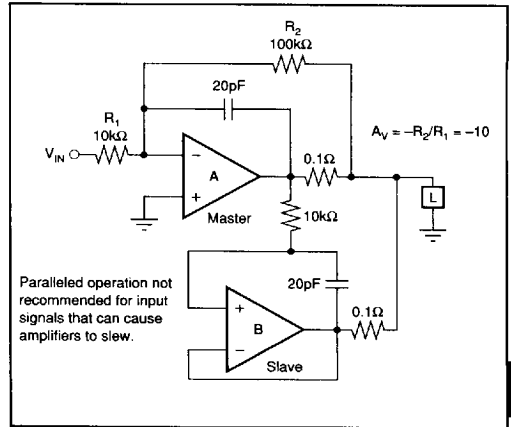


FIGURE 5. Paralleled Operation, Extended SOA.

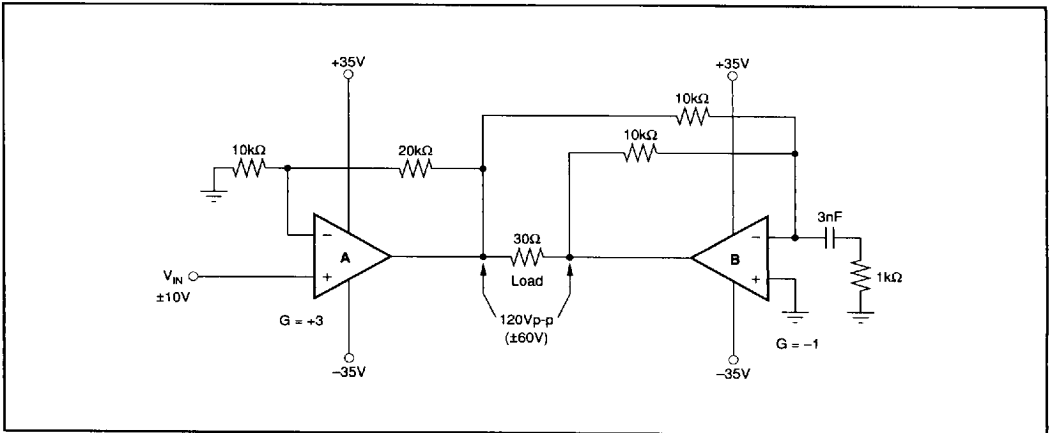


FIGURE 4. Bridge Drive Circuit.

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