



# OPA2544

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

### FEATURES

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

### DESCRIPTION

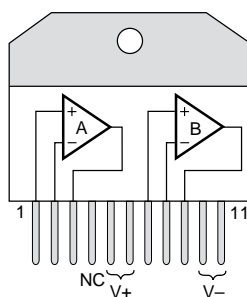
The OPA2544 is a dual high-voltage/high-current operational amplifier suitable for driving a wide variety of high power loads. It provides 2A output current and power supply voltage range extends to  $\pm 35\text{V}$ .

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 11-lead plastic packages and is specified for the  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$  temperature range.

### APPLICATIONS

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



Case  
connected  
to V- Supply.

# SPECIFICATIONS

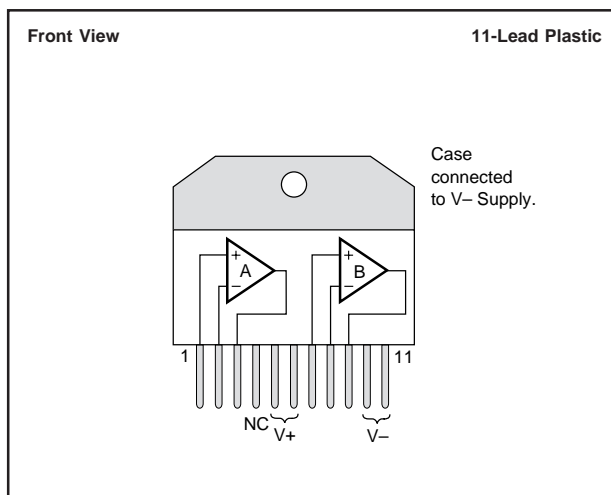
At  $T_{CASE} = +25^{\circ}\text{C}$  and  $V_S = \pm 35\text{V}$ , unless otherwise noted.

PARAMETER	CONDITIONS	OPA2544T			UNITS
		MIN	TYP	MAX	
<b>OFFSET VOLTAGE</b> Input Offset Voltage vs Temperature vs Power Supply	Specified Temp. Range $V_S = \pm 10\text{V}$ to $\pm 35\text{V}$		$\pm 1$ $\pm 10$ $\pm 10$	$\pm 5$  $\pm 100$	mV $\mu\text{V}/^{\circ}\text{C}$ $\mu\text{V}/\text{V}$
<b>INPUT BIAS CURRENT<sup>(1)</sup></b> Input Bias Current vs Temperature Input Offset Current	$V_{CM} = 0\text{V}$ $V_{CM} = 0\text{V}$		$\pm 15$ Doubles every $10^{\circ}\text{C}$ $\pm 10$	$\pm 50$  $\pm 50$	pA  pA
<b>NOISE</b> Input Voltage Noise Noise Density, $f = 1\text{kHz}$ Current Noise Density, $f = 1\text{kHz}$			36 3		$\text{nV}/\sqrt{\text{Hz}}$ $\text{fA}/\sqrt{\text{Hz}}$
<b>INPUT VOLTAGE RANGE</b> Common-Mode Input Range Positive Negative Common-Mode Rejection	Linear Operation Linear Operation $V_{CM} = \pm V_S - 6\text{V}$	(V+) $-6$ (V-) $+6$ 90	(V+) $-4$ (V-) $+4$ 106		V V dB
<b>INPUT IMPEDANCE</b> Differential Common-Mode			$10^{12} \parallel 8$ $10^{12} \parallel 10$		$\Omega \parallel \text{pF}$ $\Omega \parallel \text{pF}$
<b>OPEN-LOOP GAIN</b> Open-Loop Voltage Gain	$V_O = \pm 30\text{V}$ , $R_L = 15\Omega$	90	103		dB
<b>FREQUENCY RESPONSE</b> Gain-Bandwidth Product Slew Rate Full-Power Bandwidth Settling Time 0.1% Total Harmonic Distortion	$R_L = 15\Omega$ $60\text{Vp-p}$ , $R_L = 15\Omega$ $G = -10$ , $60\text{V}$ Step	5	1.4 8 See Typical Curve 25 See Typical Curve		MHz V/ $\mu\text{s}$ $\mu\text{s}$
<b>OUTPUT</b> Voltage Output: Positive Negative Positive Negative Current Output Short-Circuit Current	$I_O = 2\text{A}$ $I_O = 2\text{A}$ $I_O = 0.5\text{A}$ $I_O = 0.5\text{A}$	(V+) $-5$ (V-) $+5$ (V+) $-4.2$ (V-) $+4$	(V+) $-4.4$ (V-) $+3.8$ (V+) $-3.8$ (V-) $+3.1$ See SOA Curves $\pm 4$		V V V V A
<b>POWER SUPPLY</b> Specified Operating Voltage Operating Voltage Range Quiescent Current (total)	$I_O = 0$	$\pm 10$	$\pm 35$ $\pm 22$	$\pm 35$ $\pm 30$	V V mA
<b>TEMPERATURE RANGE</b> Operating Range Storage 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, $f > 50\text{Hz}$ Both Amplifiers, DC One Amplifier, $f > 50\text{Hz}$ One Amplifier, DC No Heat Sink	$-40$ $-40$	2 2.5 2.7 3 30	$+85$ $+125$	$^{\circ}\text{C}$ $^{\circ}\text{C}$ $^{\circ}\text{C}/\text{W}$ $^{\circ}\text{C}/\text{W}$ $^{\circ}\text{C}/\text{W}$

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

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## CONNECTION DIAGRAM



## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

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 .....	-40°C to +125°C
Junction Temperature .....	150°C
Lead Temperature (soldering, -10s) .....	300°C

NOTE: (1) Stresses above these ratings may cause permanent damage.

## PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>	TEMPERATURE RANGE
OPA2544T	11-Lead Plastic	242	-40°C to +85°C

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



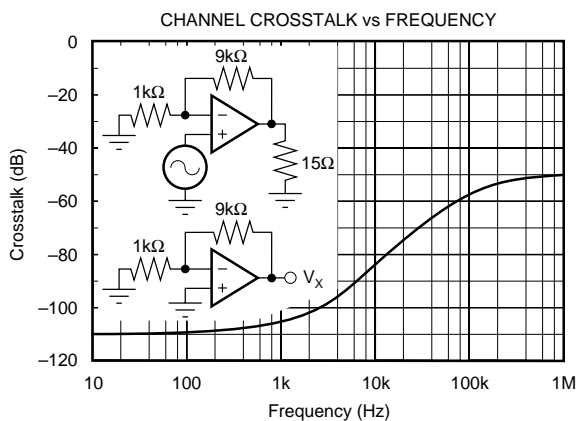
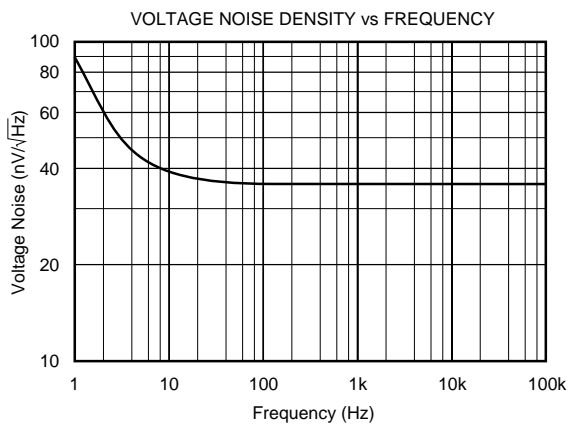
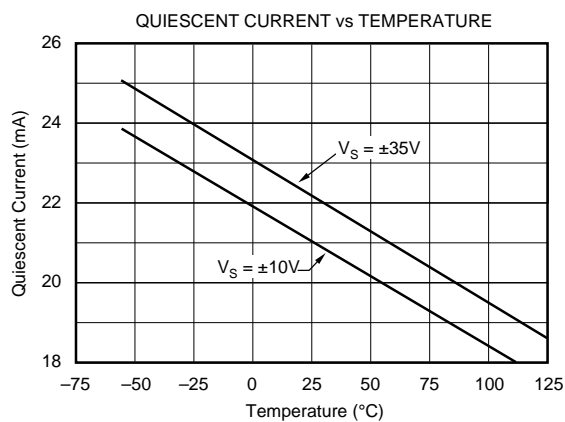
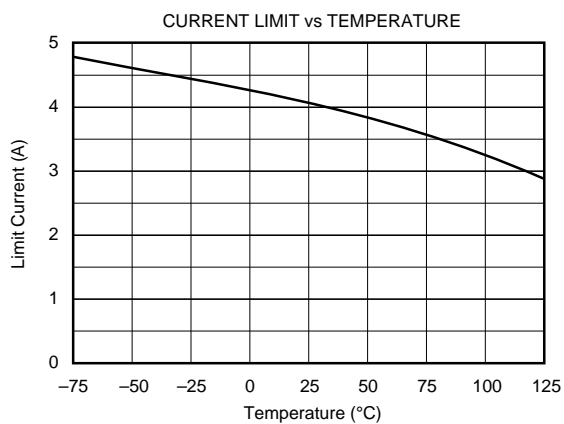
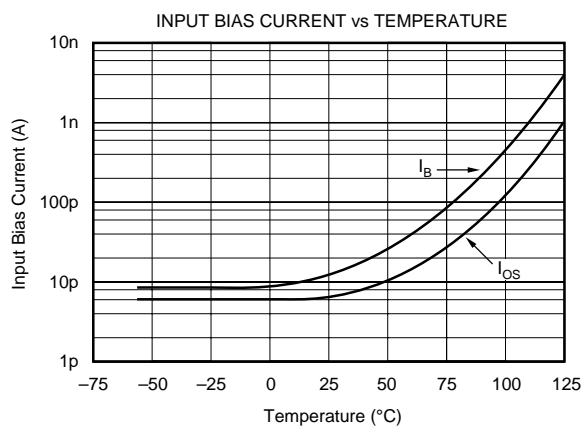
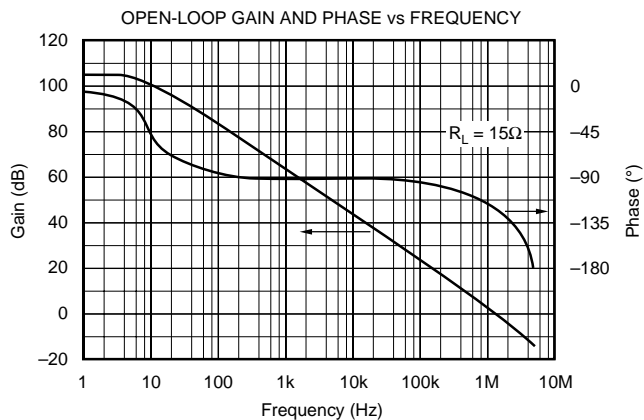
## ELECTROSTATIC DISCHARGE SENSITIVITY

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.

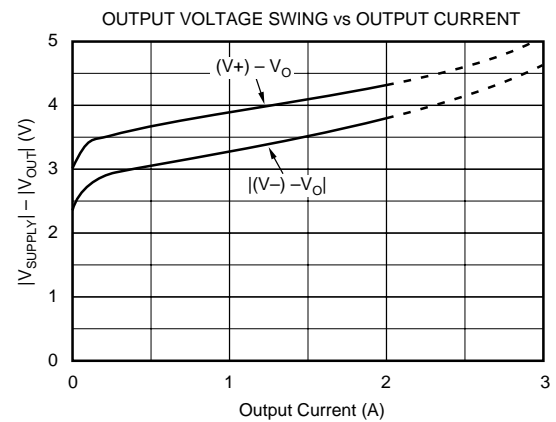
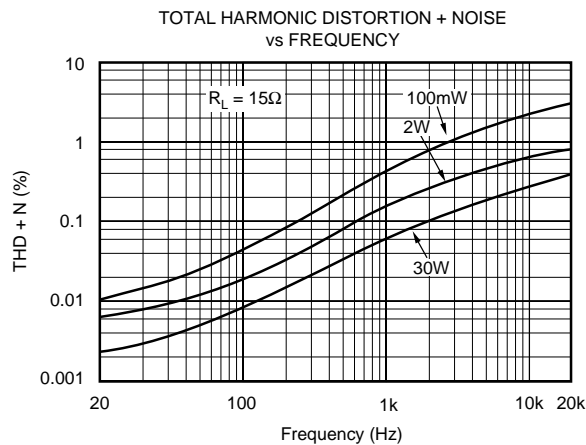
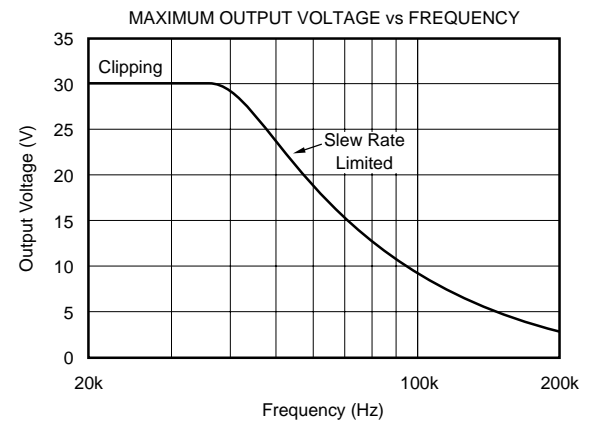
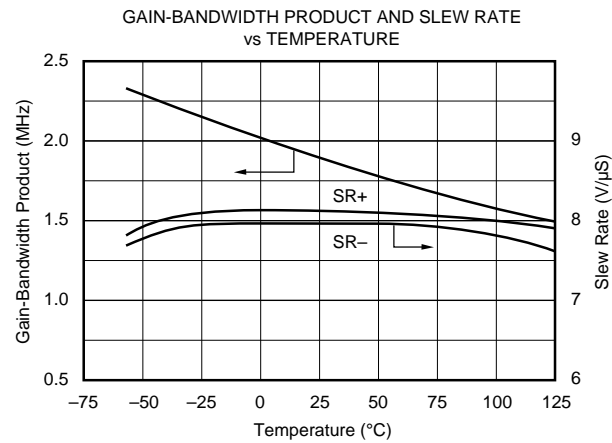
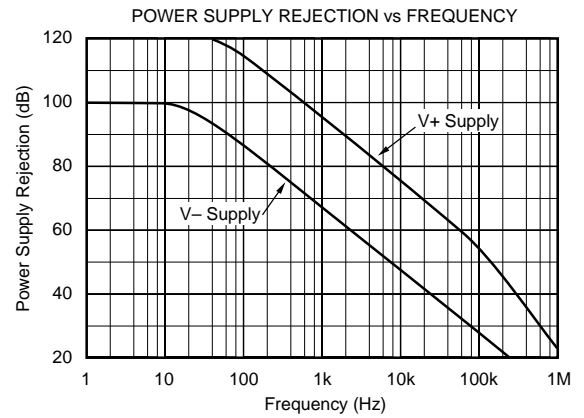
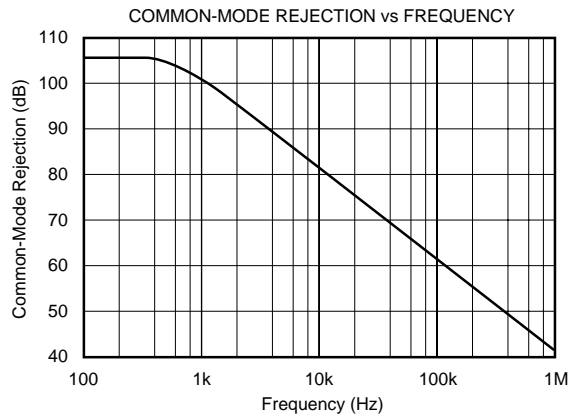
# TYPICAL PERFORMANCE CURVES

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



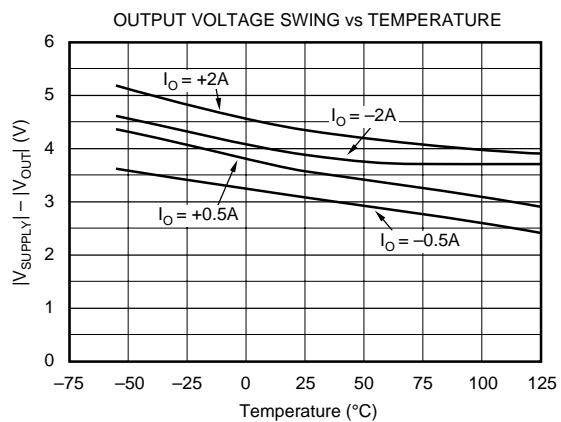
# TYPICAL PERFORMANCE CURVES (CONT)

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

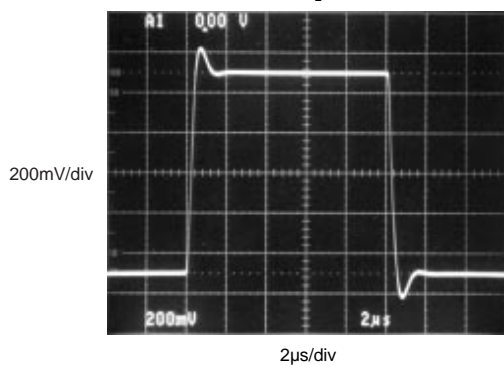


# TYPICAL PERFORMANCE CURVES (CONT)

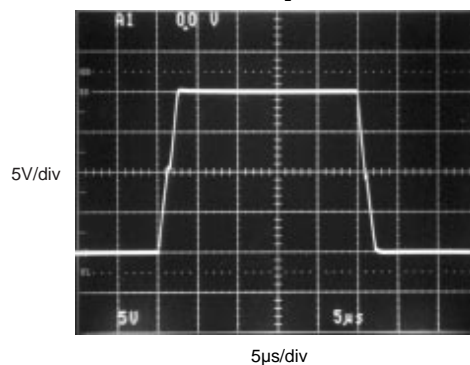
At  $T_{CASE} = +25^{\circ}\text{C}$  and  $V_S = \pm 35\text{V}$ , unless otherwise noted.



SMALL SIGNAL RESPONSE  
 $G = 3$ ,  $C_L = 1\text{nF}$



LARGE SIGNAL RESPONSE  
 $G = 3$ ,  $R_L = 15\Omega$



## 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.

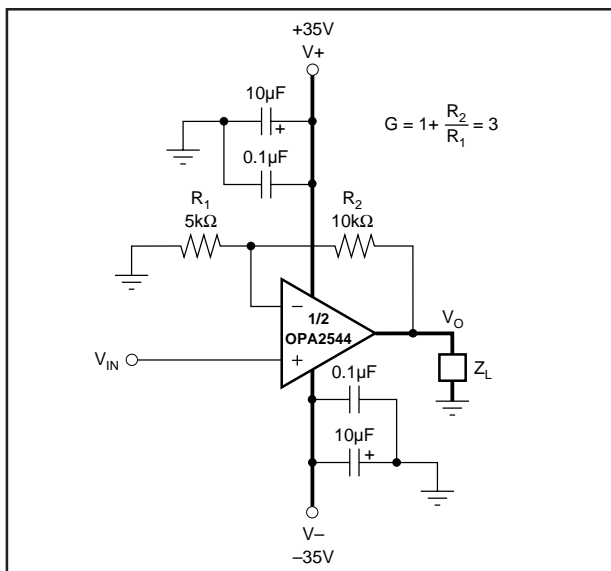


FIGURE 1. Basic Circuit Connections.

### 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.

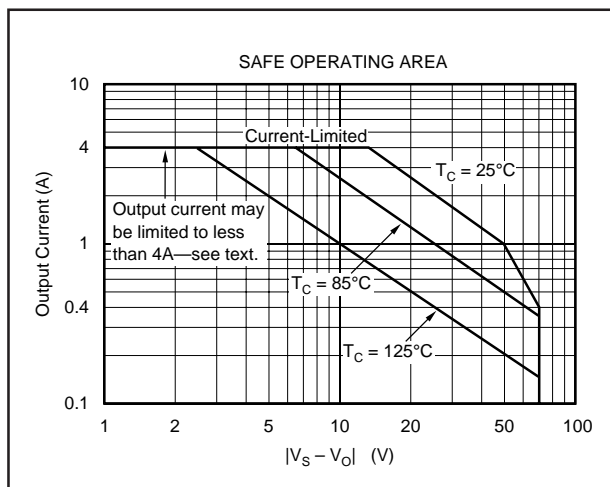


FIGURE 2. Safe Operating Area.

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 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 protec-

tion 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<sub>CE</sub> 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.

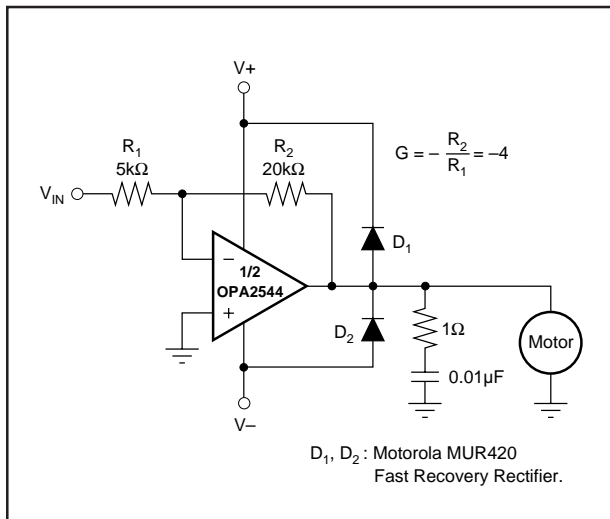


FIGURE 3. Motor Drive Circuit.

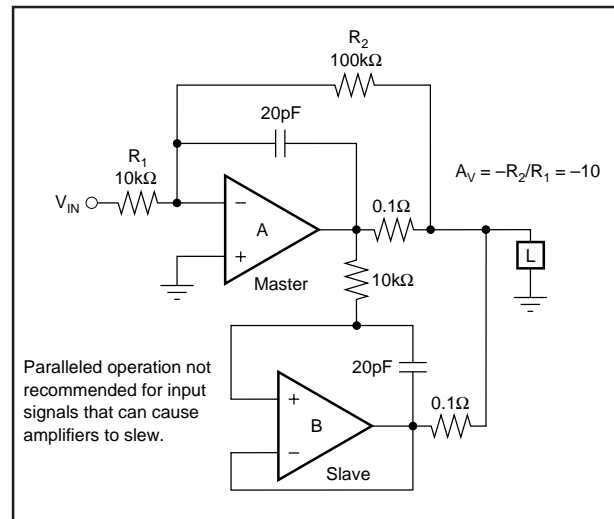


FIGURE 5. Paralleled Operation, Extended SOA.

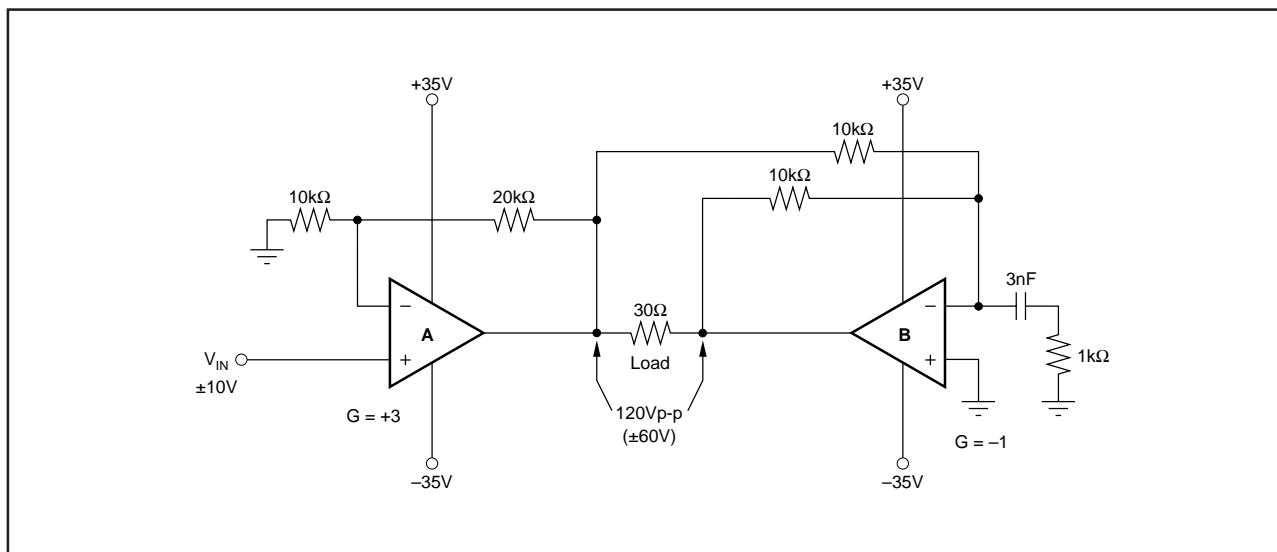


FIGURE 4. Bridge Drive Circuit.



## PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
OPA2544T	ACTIVE	TO-220	KV	11	25	RoHS & Green	SN	N / A for Pkg Type	-40 to 105	OPA2544T	<a href="#">Samples</a>
OPA2544TG3	ACTIVE	TO-220	KV	11	25	RoHS & Green	SN	N / A for Pkg Type	-40 to 105	OPA2544T	<a href="#">Samples</a>

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

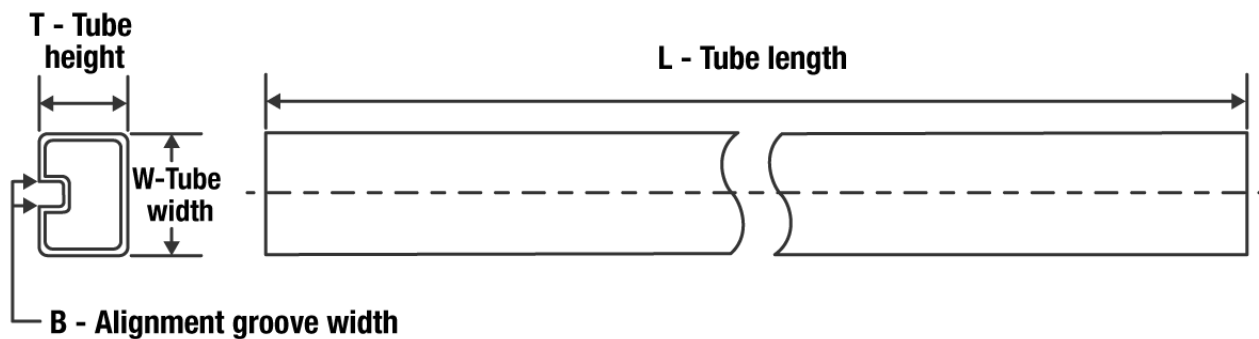
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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## TUBE



\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
OPA2544T	KV	TO-220	11	25	532.13	36.32	13340	NA
OPA2544TG3	KV	TO-220	11	25	532.13	36.32	13340	NA

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