

## Power Operational Amplifiers

RoHS  
COMPLIANT

### FEATURES

- High Internal Dissipation — 400W
- High Current — 40A Continuous, 80A Peak
- High Slew Rate — 50V/ $\mu$ s
- Optional Boost Voltage Inputs

### APPLICATIONS

- Semi-conductor Testing
- Brushless DC Motor Drive
- Voltage Controlled Current Source
- Electromagnetic Driver

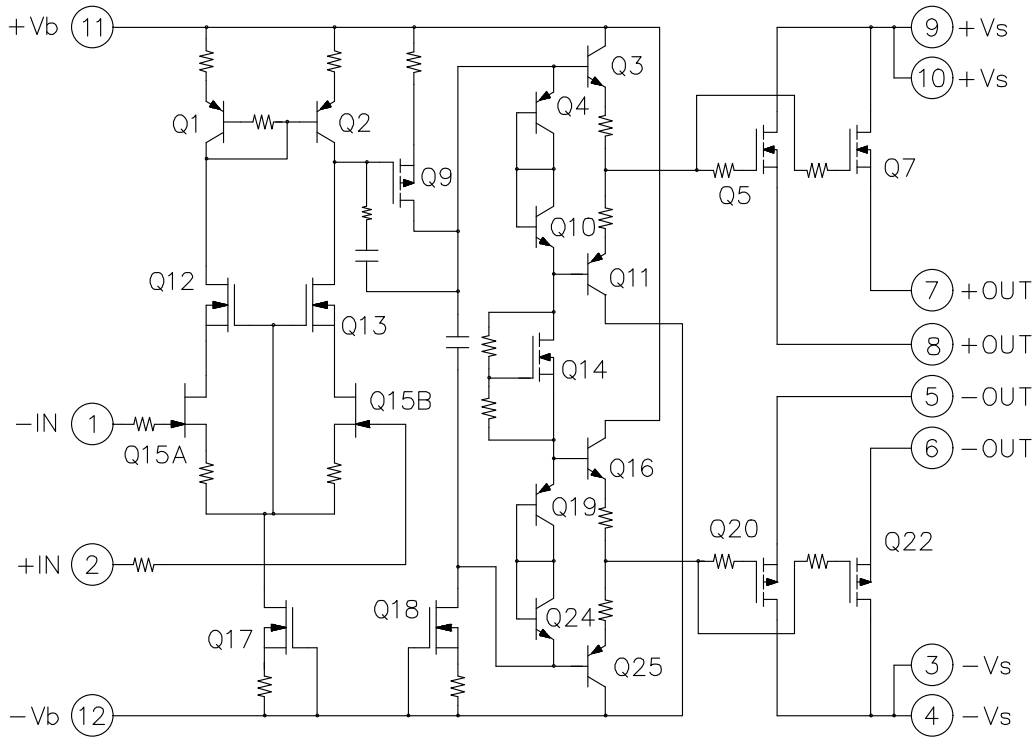


### DESCRIPTION

The PA52 is a MOSFET power operational amplifier that extends the performance limits of power amplifiers in slew rate and power bandwidth, while maintaining high current and power dissipation ratings. Boost voltage inputs allow the small signal portion of the amplifier to operate at a higher voltage than the high current output stage. The amplifier is then biased to achieve close linear swings to the supply rails at high currents for extra efficient operation.

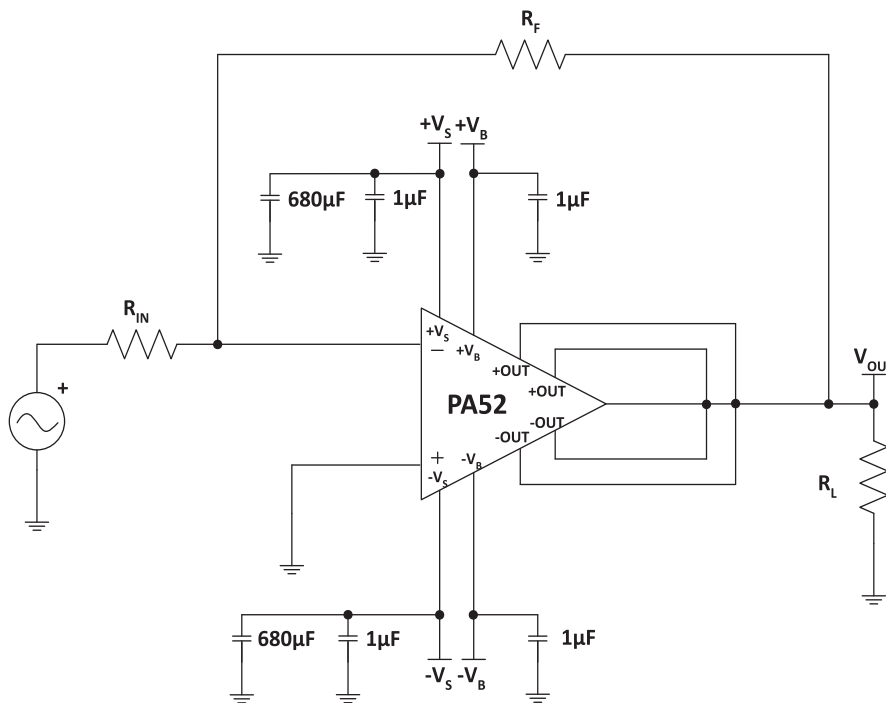
The JEDEC MO-127 12-pin Power Dip™ package (see Package Outlines) is hermetically sealed and isolated from the internal circuits. The use of compressible thermal washers and/or improper mounting torque will void the product warranty. Please see Application Note 1, “General Operating Considerations”.

Figure 1: Equivalent Schematic



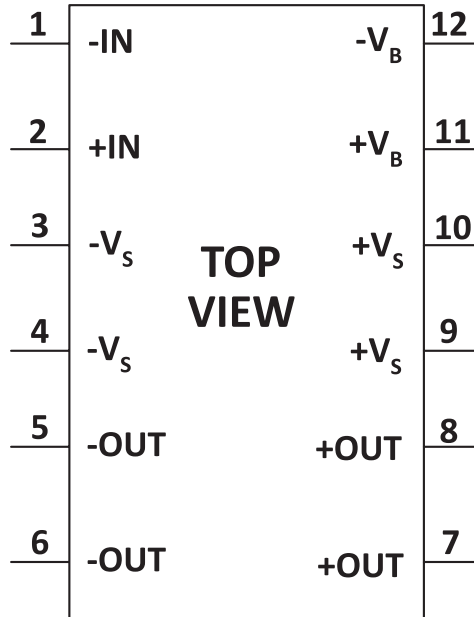
TYPICAL CONNECTION

Figure 2: Typical Connection



**PINOUT AND DESCRIPTION TABLE**

Figure 3: External Connections



Pin Number	Name	Description
1	-IN	The inverting input.
2	+IN	The non-inverting input.
3, 4	-V <sub>S</sub>	The negative supply rail. Pins 3 and 4 are internally connected.
5, 6	-OUT	The negative output. Pins 5 and 6 are not internally connected. Short pins 5, 6, 7, and 8.
7, 8	+OUT	The positive output. Pins 7 and 8 are not internally connected. Short pins 5, 6, 7, and 8.
9, 10	+V <sub>S</sub>	The positive supply rail. Pins 9 and 10 are internally connected.
11	+V <sub>B</sub>	The positive boost supply rail. Short to +V <sub>S</sub> if unused. See applicable section.
12	-V <sub>B</sub>	The negative boost supply rail. Short to -V <sub>S</sub> if unused. See applicable section.

**SPECIFICATIONS**

Unless otherwise noted:  $T_C = 25^\circ\text{C}$ , DC input specifications are  $\pm$  value given. Power supply voltage is typical rating.  $\pm V_B = \pm V_S$ .

**ABSOLUTE MAXIMUM RATINGS**

Parameter	Symbol	Min	Max	Units
Supply Voltage, $+V_S$ To $-V_S$	$+V_S$ to $-V_S$		200	V
Boost Voltage, $+V_B$ To $-V_B$			230	V
Output Current, within SOA	$I_{OUT}$		80	A
Power Dissipation, internal	$P_D$		400	W
Input Voltage, differential	$V_{IN (Diff)}$	-20	20	V
Input Voltage, common mode	$V_{CM}$	$-V_B$	$+V_B$	V
Temperature, pin solder, 10s			350	$^\circ\text{C}$
Temperature, junction <sup>1</sup>	$T_J$		150	$^\circ\text{C}$
Temperature, storage		-65	+150	$^\circ\text{C}$
Operating Temperature Range, case	$T_C$	-55	+125	$^\circ\text{C}$

1. Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTTF. For guidance, refer to the heatsink data sheet.

**CAUTION**

The PA52 is constructed from MOSFET transistors. ESD handling procedures must be observed. The internal substrate contains beryllia (BeO). Do not break the seal. If accidentally broken, do not crush, machine, or subject to temperatures in excess of  $850^\circ\text{C}$  to avoid generating toxic fumes.

**INPUT**

Parameter	Test Conditions	PA52			PA52A			Units
		Min	Typ	Max	Min	Typ	Max	
Offset Voltage, initial			5	10		2	5	mV
Offset Voltage vs. temperature	Full temp range		20	50		*	*	$\mu\text{V}/^\circ\text{C}$
Offset Voltage vs. supply			10	30		*	*	$\mu\text{V}/\text{V}$
Bias Current, initial			10	50		*	*	pA
Bias Current vs. supply			0.01			*		pA/V
Offset Current, initial			10	50		*	*	pA
Input Impedance, DC			$10^{11}$			*		$\Omega$
Input Capacitance			13			*		pF
Common Mode Voltage Range	Full temp range	$-V_B + 12$ $+V_B - 14$			*			V
Common Mode Rejection, DC	Full temp range, $V_{CM} = \pm 20\text{V}$	90	100			*	*	dB
Input Noise	100 kHz BW, $R_S = 1\text{ k}\Omega$		10			*		$\mu\text{V}_{\text{rms}}$

**GAIN**

Parameter	Test Conditions	PA52			PA52A			Units
		Min	Typ	Max	Min	Typ	Max	
Open Loop, @ 15 Hz	Full temp range	94	102		*	*		dB
Gain Bandwidth Product	$R_L = 10\ \Omega$		3			*		MHz
Power Bandwidth	$R_L = 4\ \Omega$ , $V_{OUT} = 180\text{V}_{\text{P-P}}$ , $A_V = -10$ Full temp range		90			*		kHz

**OUTPUT**

Parameter	Test Conditions	PA52			PA52A			Units
		Min	Typ	Max	Min	Typ	Max	
Voltage Swing	$I_{OUT} = 40A$	$\pm V_S \pm 9.5$	$\pm V_S \pm 8.0$		*	*		V
Voltage Swing, PA52	$\pm V_B = \pm V_S \pm 10V$ , $I_{OUT} = 40A$	$\pm V_S \pm 5.8$	$\pm V_S \pm 4.0$					V
Voltage Swing, PA52A	$\pm V_B = \pm V_S \pm 10V$ , $I_{OUT} = 50A$				$\pm V_S \pm 5.8$	$\pm V_S \pm 5.0$		V
Current, peak	3ms 10% Duty Cycle	80			*			A
Settling Time to 0.1%	$A_V = -10$ , 10V Step, $R_L = 4 \Omega$		1			*		$\mu s$
Slew Rate	$A_V = -10$	50			*			V/ $\mu s$
Resistance	$I_{OUT} = 0$ , No Load, 2 MHz		2.5			*		$\Omega$

**POWER SUPPLY**

Parameter	Test Conditions	PA52			PA52A			Units
		Min	Typ	Max	Min	Typ	Max	
Voltage, $\pm V_B$	Full temp range	+14,-12	$\pm 30$	$\pm 115$	*	*	*	V
Voltage, $\pm V_S$	Full temp range	$\pm 3$		$\pm 100$	*		*	V
Current, quiescent, boost supply			26	32		*	*	mA
Current, quiescent, total			30	36		*	*	mA

**THERMAL**

Parameter	Test Conditions	PA52			PA52A			Units
		Min	Typ	Max	Min	Typ	Max	
Resistance, AC, junction to case <sup>1</sup>	Full temp range, $F > 60 \text{ Hz}$		0.2	0.25		*	*	$^{\circ}C/W$
Resistance, DC, junction to case	Full temp range, $F > 60 \text{ Hz}$		0.25	0.31		*	*	$^{\circ}C/W$
Resistance, junction to air	Full temp range		12			*		$^{\circ}C/W$
Temperature Range, case	Meets full range specification	-25		85	*		*	$^{\circ}C$

1. Rating applies if the output current alternates between both output transistors at a rate faster than 60 Hz.

**Note:** \*The specification of PA52A is identical to the specification for PA52 in applicable column to the left

TYPICAL PERFORMANCE GRAPHS

Figure 4: Power Derating

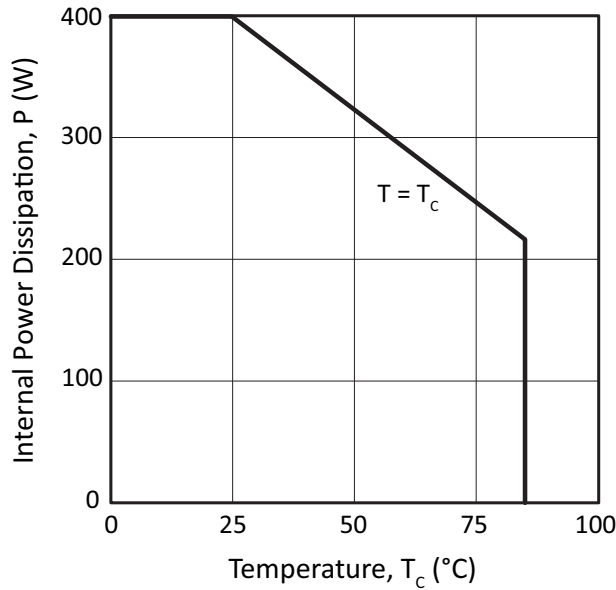


Figure 5: Power Supply Rejection

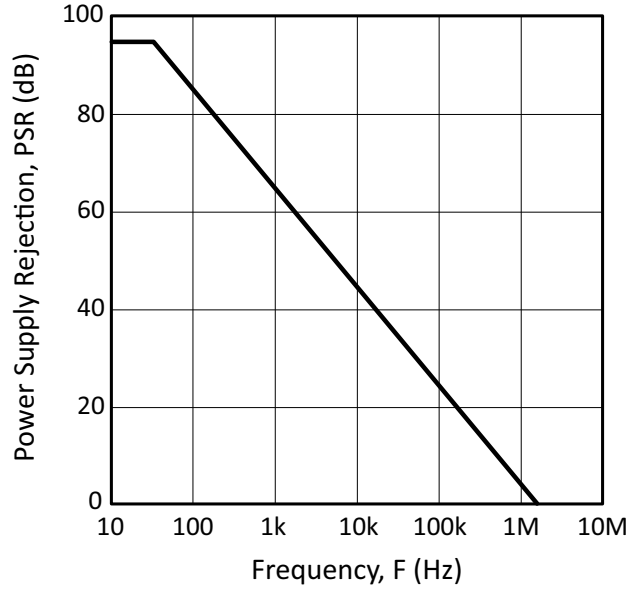


Figure 6: Small Signal Gain

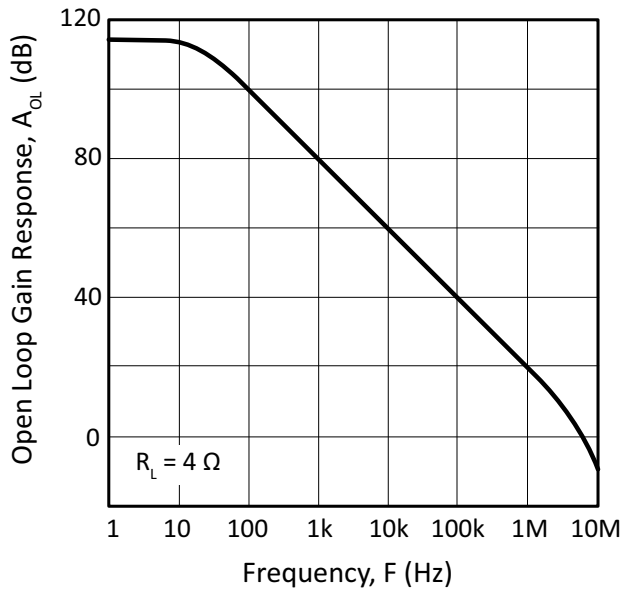


Figure 7: Small Signal Phase

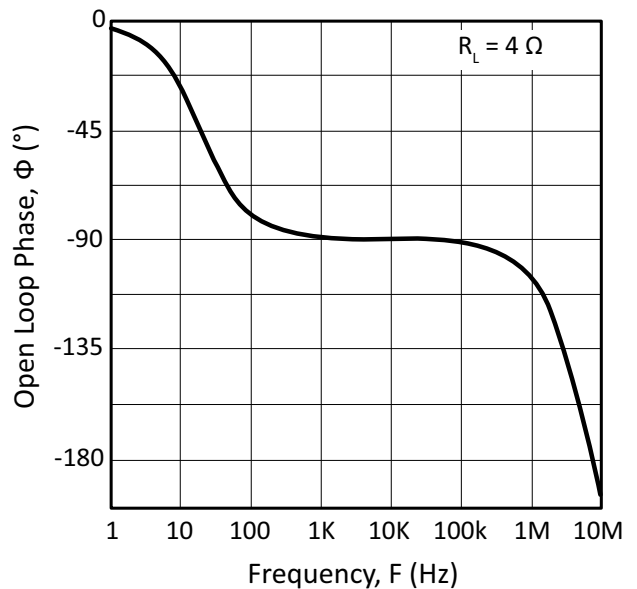


Figure 8: Output Voltage Swing

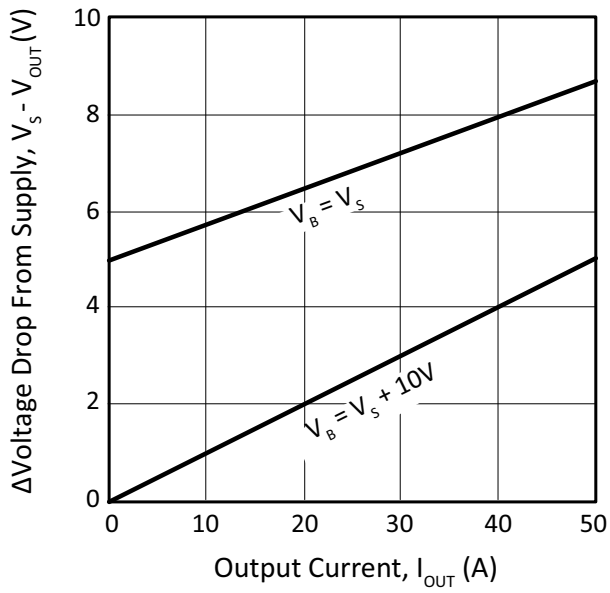


Figure 10: Power Response

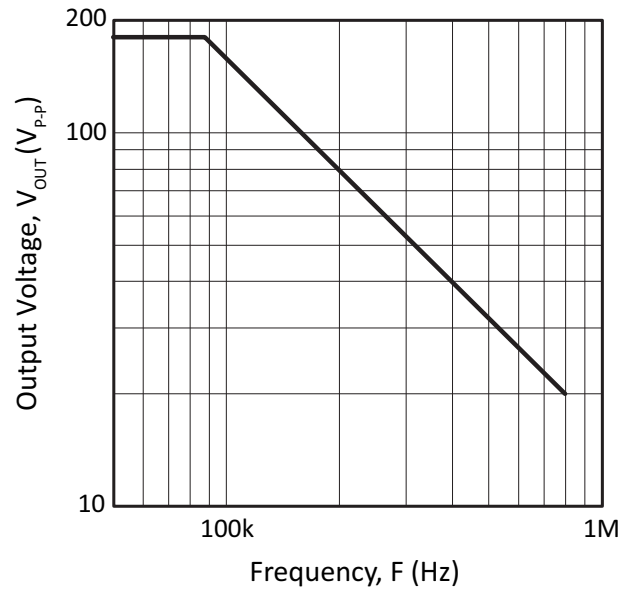


Figure 9:

Figure 11: Common Mode Rejection

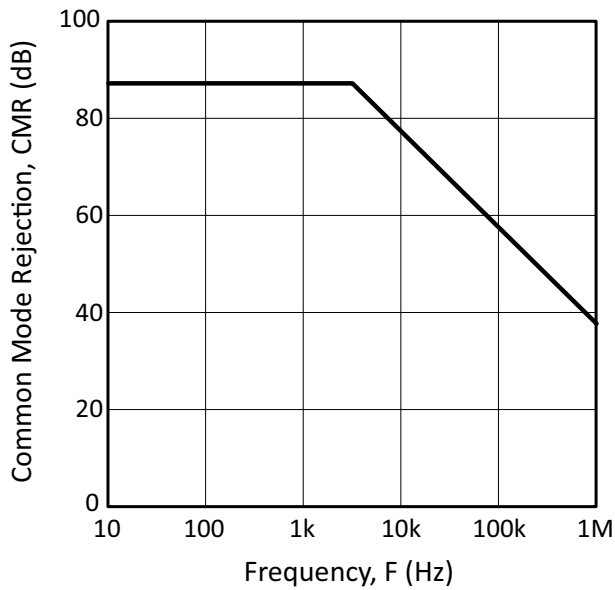
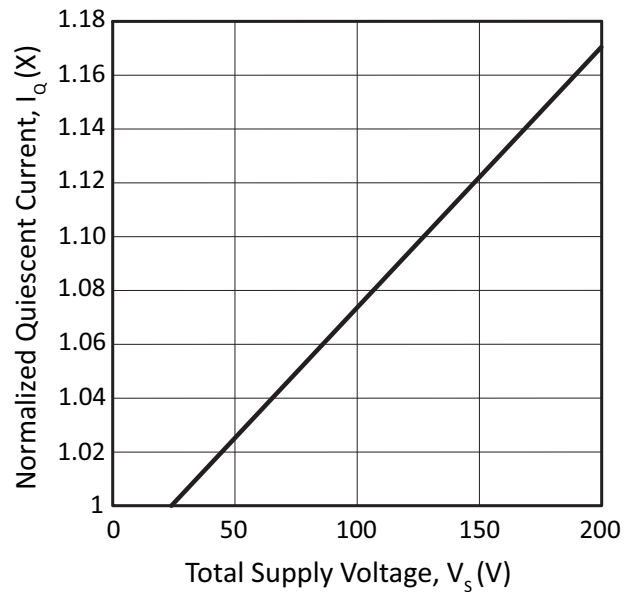


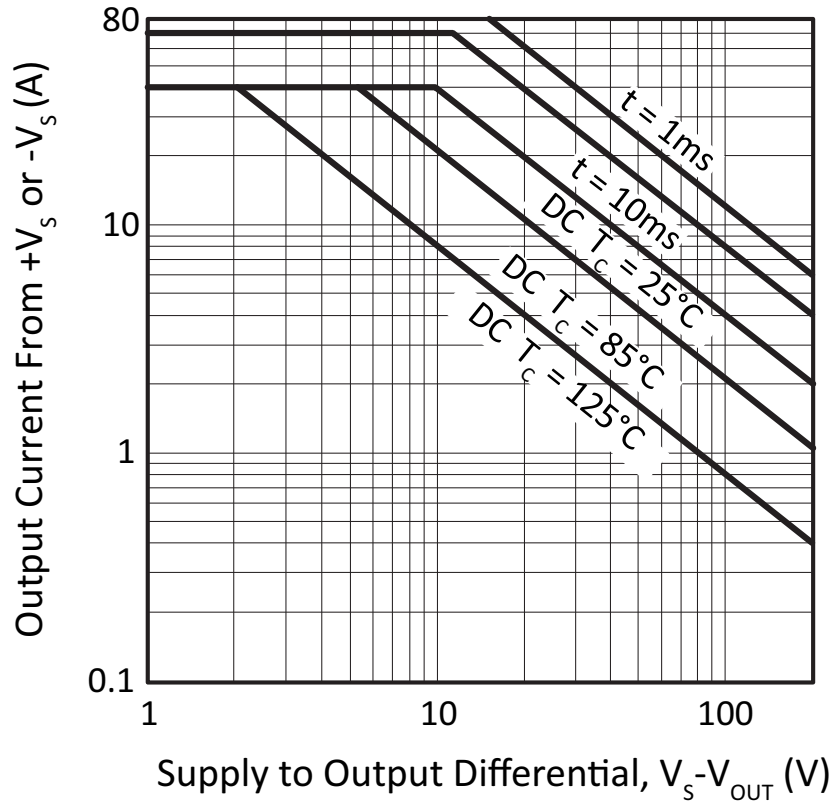
Figure 12: Quiescent Current





**SAFE OPERATING AREA (SOA)**

Figure 13: SOA



**GENERAL**

Please read Application Note 1 “General Operating Considerations” which covers stability, supplies, heat sinking, mounting, current limit, SOA interpretation, and specification interpretation. Visit [www.apexanalog.com](http://www.apexanalog.com) for Apex Microtechnology’s complete Application Notes library, Technical Seminar Workbook, and Evaluation Kits.

**CURRENT LIMIT**

There is no internal circuit provision for current limit in the PA52. However, the PA52 circuit board in the PA52 evaluation kit does provide a means whereby the output current can be sensed. An external circuit current limit can thereby be implemented if needed.

**BOOST OPERATION**

With the V<sub>B</sub> feature the small signal stages of the amplifier are operated at higher supply voltages than the amplifier’s high current output stage. +V<sub>B</sub> (pin 11) and -V<sub>B</sub> (pin 12) are connected to the small signal circuitry of the amplifier. +V<sub>S</sub> (pin 9,10) and -V<sub>S</sub> (pin 3,4) are connected to the high current output stage. An additional 10V on the V<sub>B</sub> pins is sufficient to allow the small signal stages to drive the output transistors into

saturation and improve the output voltage swing for extra efficient operation when required. When close swings to the supply rails is not required the  $+V_B$  and  $+V_S$  pins must be strapped together as well as the  $-V_B$  and  $-V_S$  pins. The boost voltage pins must not be at a voltage lower than the  $V_S$  pins.

### COMPENSATION

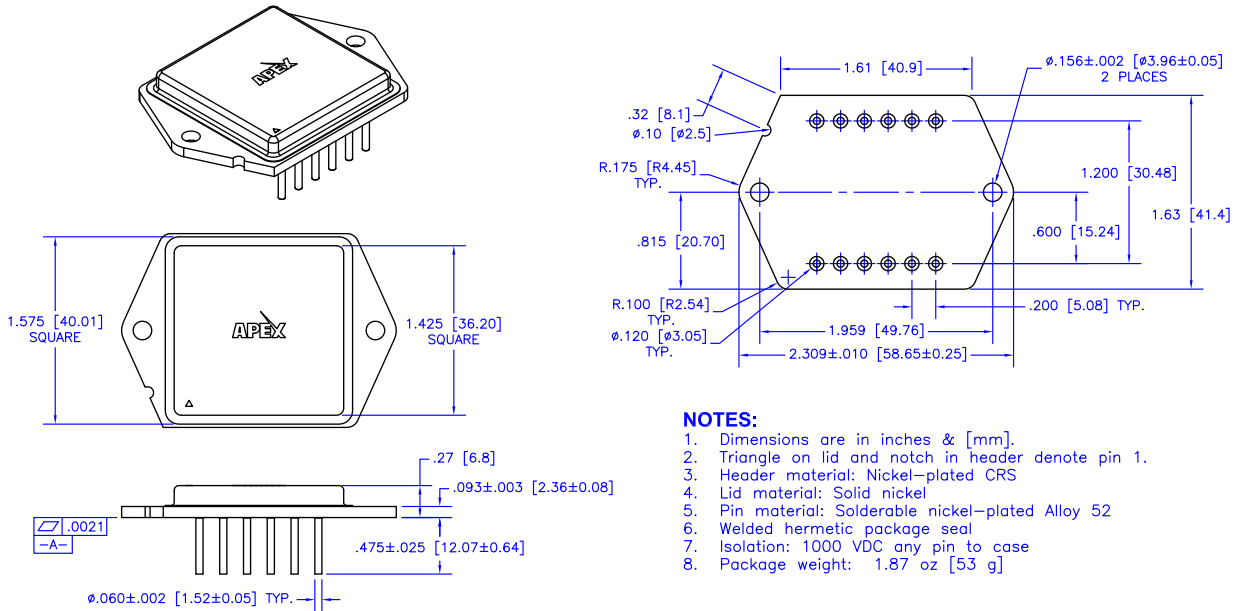
Compensation is internally fixed for a gain of 3 or more and is not adjustable by the user. The PA52 therefore is not unity gain stable.

### POWER SUPPLY BYPASSING

Proper and sufficient power supply bypassing is crucial to proper operation of the PA52. Bypass the  $+V_B$  and  $-V_B$  supply pins with a minimum  $0.1\mu\text{F}$  ceramic capacitors directly at the supply pins. On the  $+V_S$  and  $-V_S$  pins use a combination of ceramic and electrolytic capacitors. Use  $1\mu\text{F}$  ceramic capacitors and an electrolytic capacitor at least  $10\mu\text{F}$  for each amp of output current required.

**PACKAGE DESIGN**

**PACKAGE STYLE CR**



**NOTES:**

1. Dimensions are in inches & [mm].
2. Triangle on lid and notch in header denote pin 1.
3. Header material: Nickel-plated CRS
4. Lid material: Solid nickel
5. Pin material: Solderable nickel-plated Alloy 52
6. Welded hermetic package seal
7. Isolation: 1000 VDC any pin to case
8. Package weight: 1.87 oz [53 g]

**NEED TECHNICAL HELP? CONTACT APEX SUPPORT!**

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