

**Power Operational Amplifier**



**FEATURES**

- High Output Current — Up to  $\pm 5A$  Peak
- Excellent Linearity — PA01
- High Supply Voltage — Up to  $\pm 30V$
- Isolated Case — 300V



**APPLICATIONS**

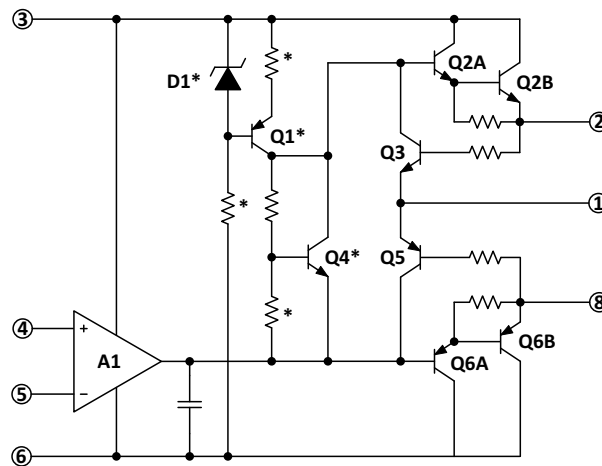
- Motor, Valve And Actuator Control
- Magnetic Deflection Circuits up to 4A
- Power Transducers up to 20 kHz
- Temperature Control up to 180W
- Programmable Power Supplies up to 48V
- Audio Amplifiers up to 50W RMS

**DESCRIPTION**

The PA01 and PA73 are high voltage, high output current operational amplifiers designed to drive resistive, inductive and capacitive loads. For optimum linearity, the PA01 has a class A/B output stage. The PA73 has a simple class C output stage to reduce cost for motor control and other applications where crossover distortion is not critical. The safe operating area (SOA) can be observed for all operating conditions by selection of user programmable current limit resistors. These amplifiers are internally compensated for all gain settings. For continuous operation under load, a heatsink of proper rating is recommended.

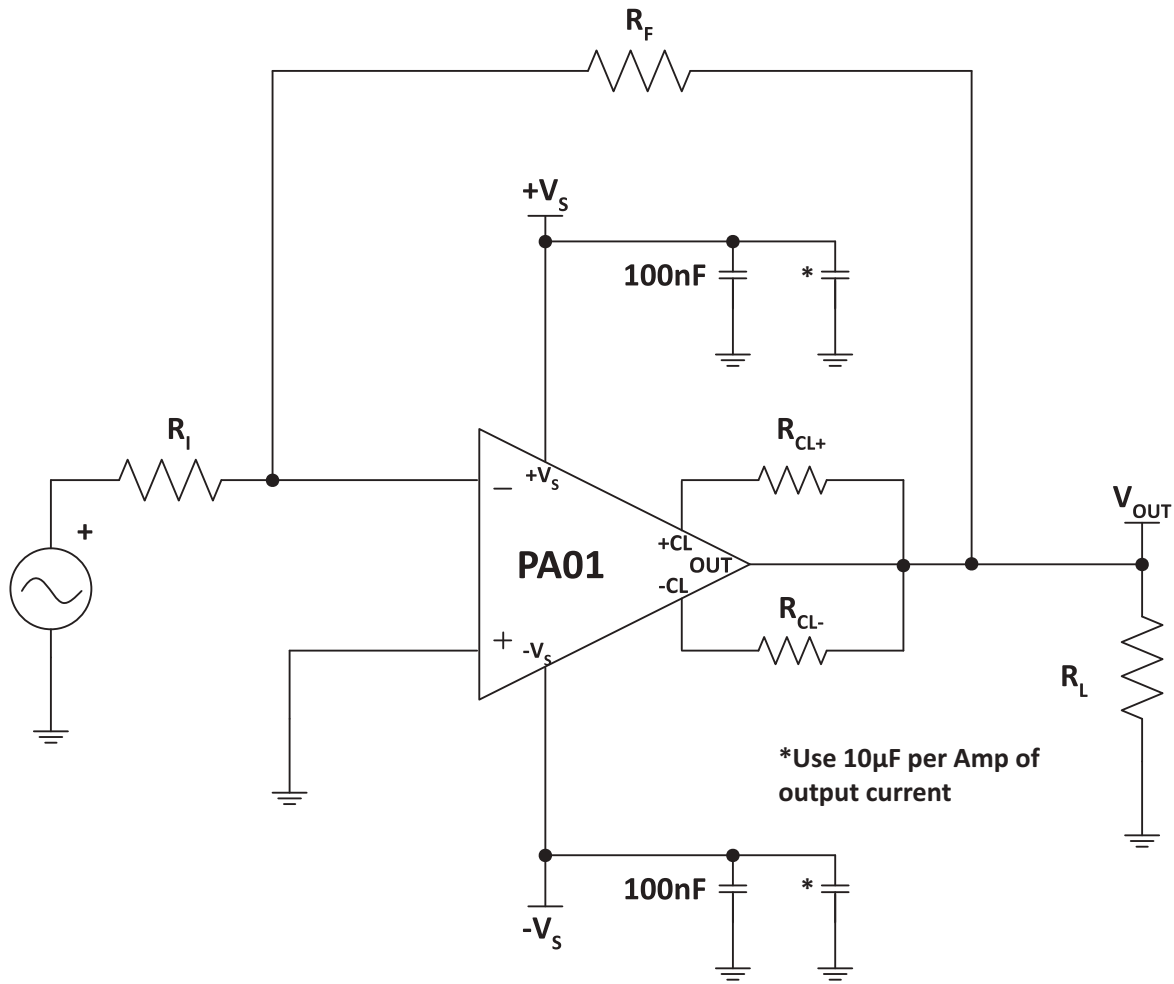
This hybrid integrated circuit utilizes thick film (cermet) resistors, ceramic capacitors and semiconductor chips to maximize reliability, minimize size and give top performance. Ultrasonically bonded aluminum wires provide reliable interconnections at all operating temperatures. The 8-pin TO-3 package is hermetically sealed and electrically isolated. 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**



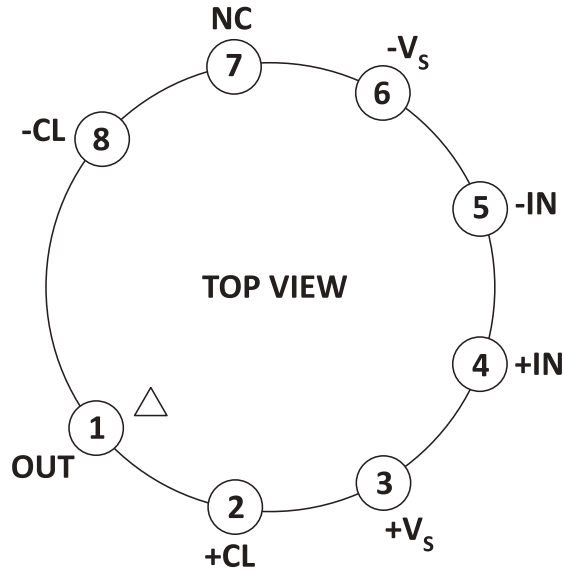
TYPICAL CONNECTION

Figure 2: Typical Connection



**PINOUT AND DESCRIPTION TABLE**

Figure 3: External Connections



Triangle indicates Pin 1

Pin Number	Name	Description
1	OUT	The output. Connect this pin to load and to the feedback resistors.
2	+CL	Connect to the sourcing current limit resistor. Output current flows out of this pin through $R_{CL+}$ . The output pin and the load are connected to the other side of $R_{CL+}$ .
3	+ $V_s$	The positive supply rail.
4	+IN	The non-inverting input.
5	-IN	The inverting input.
6	- $V_s$	The negative supply rail.
7	NC	No connection.
8	-CL	Connect to the sinking current limit resistor. Output current flows into this pin through $R_{CL-}$ . The output pin and the load are connected to the other side of $R_{CL-}$ .

## SPECIFICATIONS

The power supply voltage specified under the TYP rating applies unless otherwise noted as a test condition.

### ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	PA01		PA73		Units
		Min	Max	Min	Max	
Supply Voltage, Total	$+V_S$ to $-V_S$		60		68	V
Output Current, Source, within SOA	$I_O$		5		*	A
Power Dissipation, Internal	$P_D$		67		*	W
Input Voltage, Differential	$V_{IN}$ (Diff)		$\pm 37$		*	V
Input Voltage, Common Mode	$V_{cm}$		$\pm V_S$		*	V
Temperature, Pin Solder, 10s max.			350		*	°C
Temperature, Junction <sup>1</sup>	$T_J$		200		*	°C
Temperature Range, Storage		-65	+150	*	*	°C
Operating Temperature Range, Case	$T_C$	-25	+85	*	*	°C

1. Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTTF.

#### CAUTION

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°C to avoid generating toxic fumes.

**INPUT**

Parameter	Test Conditions	PA01			PA73			Units
		Min	Typ	Max	Min	Typ	Max	
Offset Voltage, Initial	$T_C = 25^\circ\text{C}$		$\pm 5$	$\pm 12$		*	$\pm 10$	mV
Offset Voltage vs. Temperature	Full temp range		$\pm 10$	$\pm 65$		*	*	$\mu\text{V}/^\circ\text{C}$
Offset Voltage vs. Supply	$T_C = 25^\circ\text{C}$		$\pm 35$			*	$\pm 200$	$\mu\text{V}/\text{V}$
Offset Voltage vs. Power	$T_C = 25^\circ\text{C}$		$\pm 20$			*		$\mu\text{V}/\text{W}$
Bias Current, Initial	$T_C = 25^\circ\text{C}$		$\pm 15$	$\pm 50$		*	$\pm 40$	nA
Bias Current vs. Temperature	Full temp range		$\pm 0.05$	$\pm 0.4$		*	*	$\text{nA}/^\circ\text{C}$
Bias Current vs. Supply	$T_C = 25^\circ\text{C}$		$\pm 0.02$			*		$\text{nA}/\text{V}$
Offset Current, Initial	$T_C = 25^\circ\text{C}$		$\pm 12$	$\pm 30$		*	*	nA
Offset Current vs. Temperature	Full temp range		$\pm 0.05$			*		$\text{nA}/^\circ\text{C}$
Input Impedance, Common-mode	$T_C = 25^\circ\text{C}$		200			*		M $\Omega$
Input Impedance, Differential	$T_C = 25^\circ\text{C}$		10			*		M $\Omega$
Input Capacitance	$T_C = 25^\circ\text{C}$		3			*		pF
Common Mode Voltage Range <sup>1</sup>	Full temp range	$\pm V_S - 6$	$\pm V_S - 3$		*	*		V
Common Mode Rejection, DC <sup>1</sup>	$T_C = 25^\circ\text{C}, V_{\text{CM}} = V_S - 6_V$	70	110		*	*		dB

1.  $+V_S$  and  $-V_S$  denote the positive and negative supply rail respectively. Total  $V_S$  is measured from  $+V_S$  to  $-V_S$ .

**GAIN**

Parameter	Test Conditions	PA01			PA73			Units
		Min	Typ	Max	Min	Typ	Max	
Open Loop Gain at 10 Hz	Full temp range, full load	91	113		*	*		dB
Gain Bandwidth Product @ 1 MHz	$T_C = 25^\circ\text{C}$ , full load		1			*		MHz
Power Bandwidth	$T_C = 25^\circ\text{C}, I_O = 4\text{A}, V_O = 40V_{\text{PP}}$	15	23		*	*		kHz
Phase Margin	Full temp range		45			*		°

**OUTPUT**

Parameter	Test Conditions	PA01			PA73			Units
		Min	Typ	Max	Min	Typ	Max	
Voltage Swing <sup>1</sup>	T <sub>C</sub> =25°C, I <sub>O</sub> = 5A	±V <sub>S</sub> -10	±V <sub>S</sub> -5		±V <sub>S</sub> -8	*		V
Voltage Swing <sup>1</sup>	Full temp range, I <sub>O</sub> = 2A	±V <sub>S</sub> -6	±V <sub>S</sub> -5		*	*		V
Voltage Swing <sup>1</sup>	Full temp range, I <sub>O</sub> = 46mA	±V <sub>S</sub> -5			*			V
Current, Peak	T <sub>C</sub> = 25°C	±5			*			A
Settling Time to 0.1%	T <sub>C</sub> =25°C, 2V step		2			*		µs
Slew Rate	T <sub>C</sub> =25°C, R <sub>L</sub> = 2.5 Ω	1.0	2.6		*	*		V/µs
Capacitive Load, Unity Gain	Full temp range			1			*	nF
Capacitive Load, Gain > 4	Full temp range			SOA			*	

1. +V<sub>S</sub> and -V<sub>S</sub> denote the positive and negative supply rail respectively. Total V<sub>S</sub> is measured from +V<sub>S</sub> to -V<sub>S</sub>.

**POWER SUPPLY**

Parameter	Test Conditions	PA01			PA73			Units
		Min	Typ	Max	Min	Typ	Max	
Voltage	Full temp range	±10		±28	*	*	±30	V
Current, Quiescent	T <sub>C</sub> = 25°C		20	50		2.6	5	mA

**THERMAL**

Parameter	Test Conditions	PA01			PA73			Units
		Min	Typ	Max	Min	Typ	Max	
Resistance, AC, junction to Case <sup>1</sup>	F > 60 Hz		1.9	2.1		*	*	°C/W
Resistance, DC, junction to Case	F < 60 Hz		2.4	2.6		*	*	°C/W
Resistance, Junction to Air			30			*		°C/W
Temperature Range, Case	Meets full range specs	-25	25	+85	*	*	*	°C

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

**Note:** \*The specification of PA73 is identical to the specification for PA01 in applicable column to the left.

TYPICAL PERFORMANCE GRAPHS

Figure 4: Power Derating

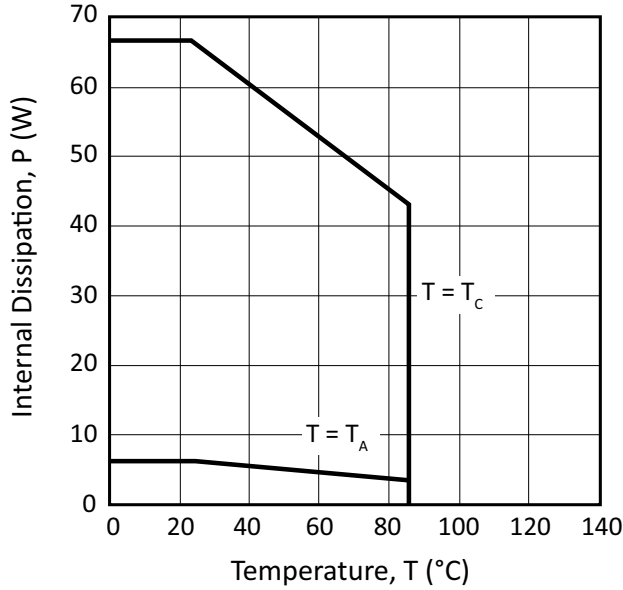


Figure 5: Bias Current

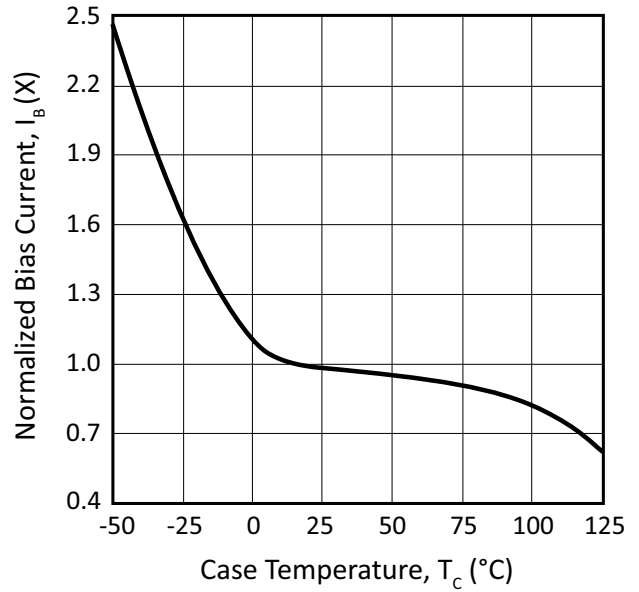


Figure 6: Small Signal Response

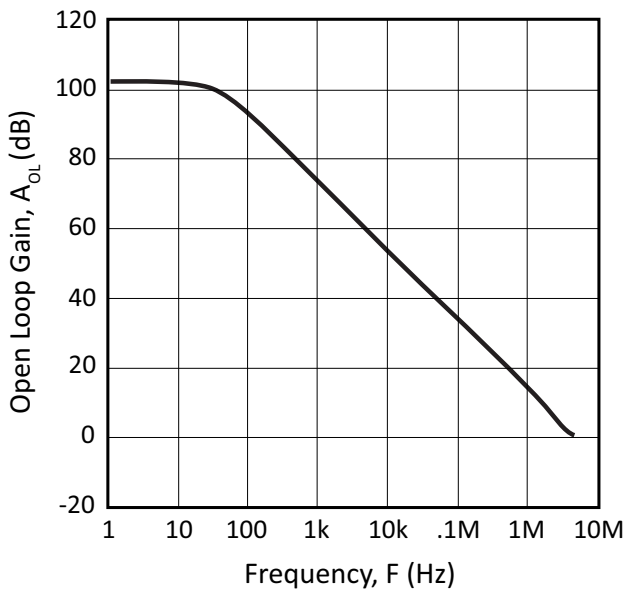


Figure 7: Phase Response

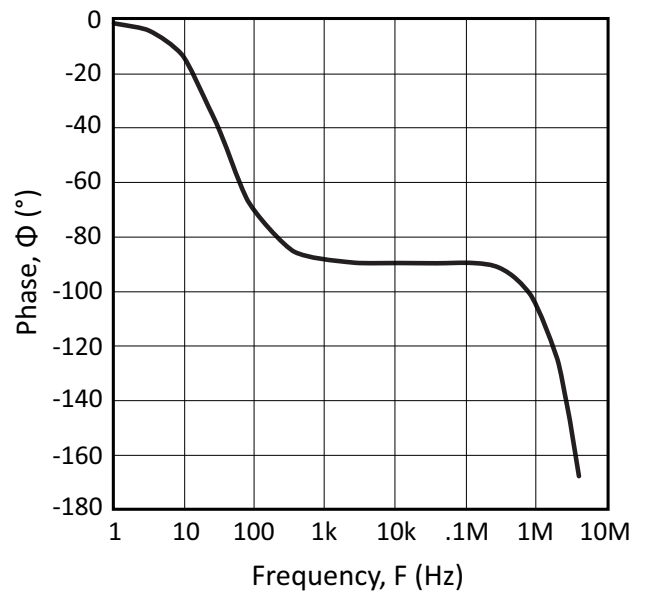


Figure 8: Current Limit

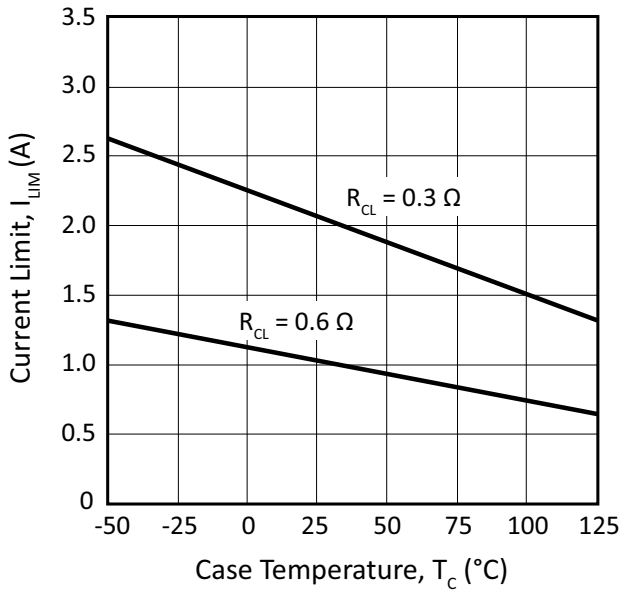


Figure 9: Power Response

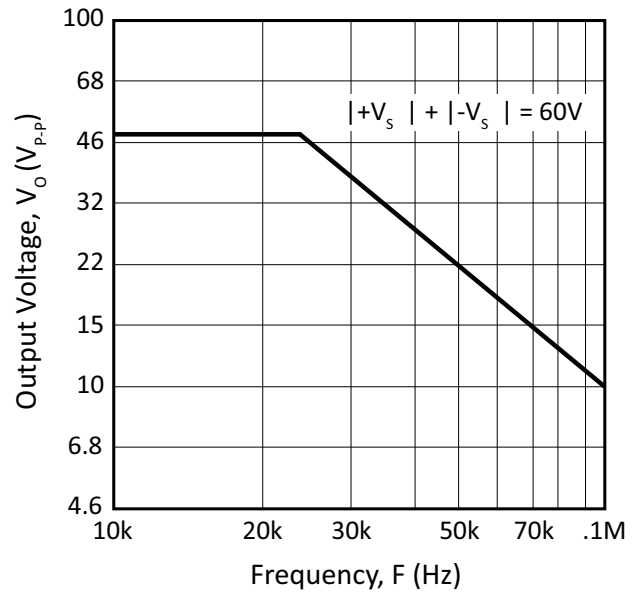


Figure 10: Common Mode Rejection

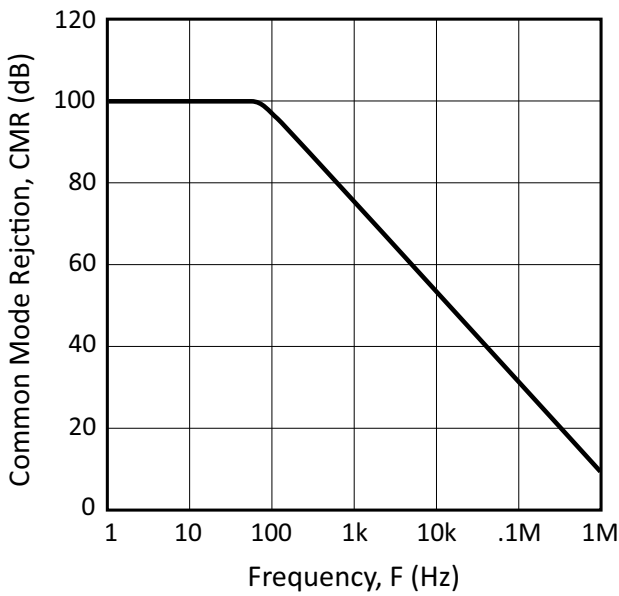


Figure 11: Pulse Response

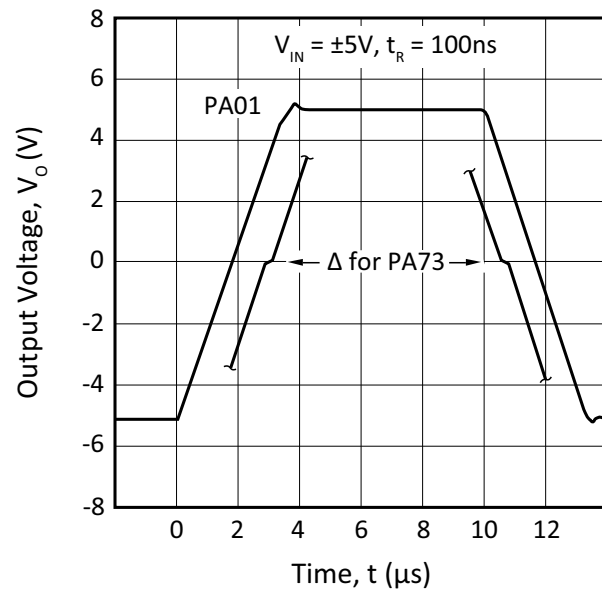




Figure 12: Input Noise

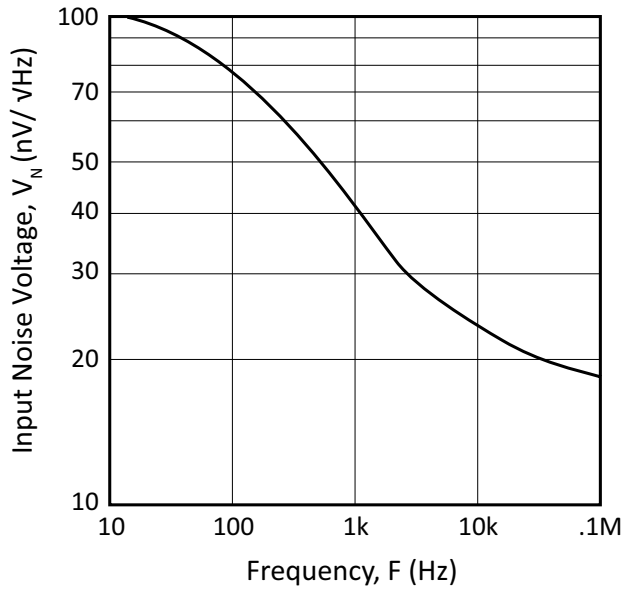


Figure 13: Harmonic Distortion

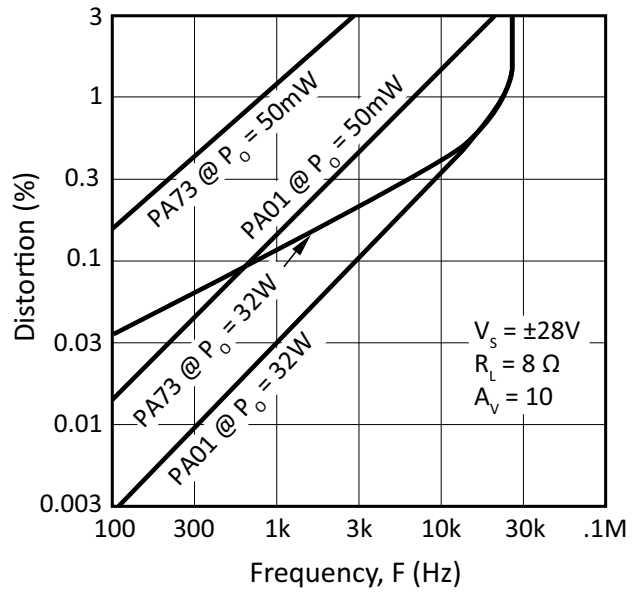
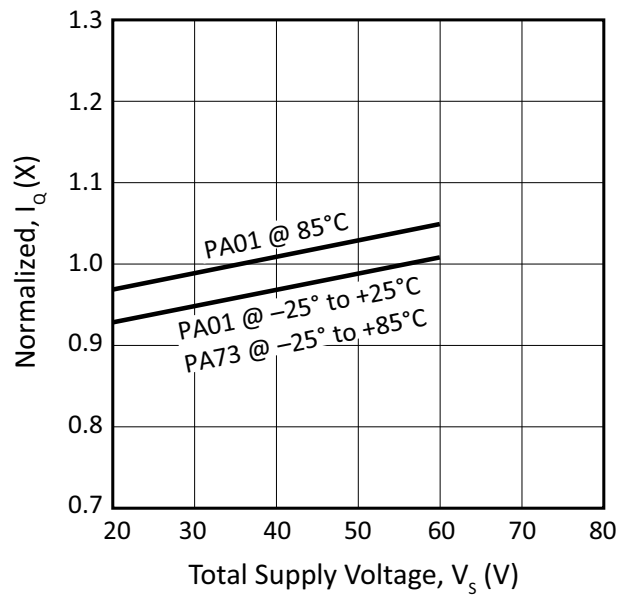


Figure 14: Quiescent Current

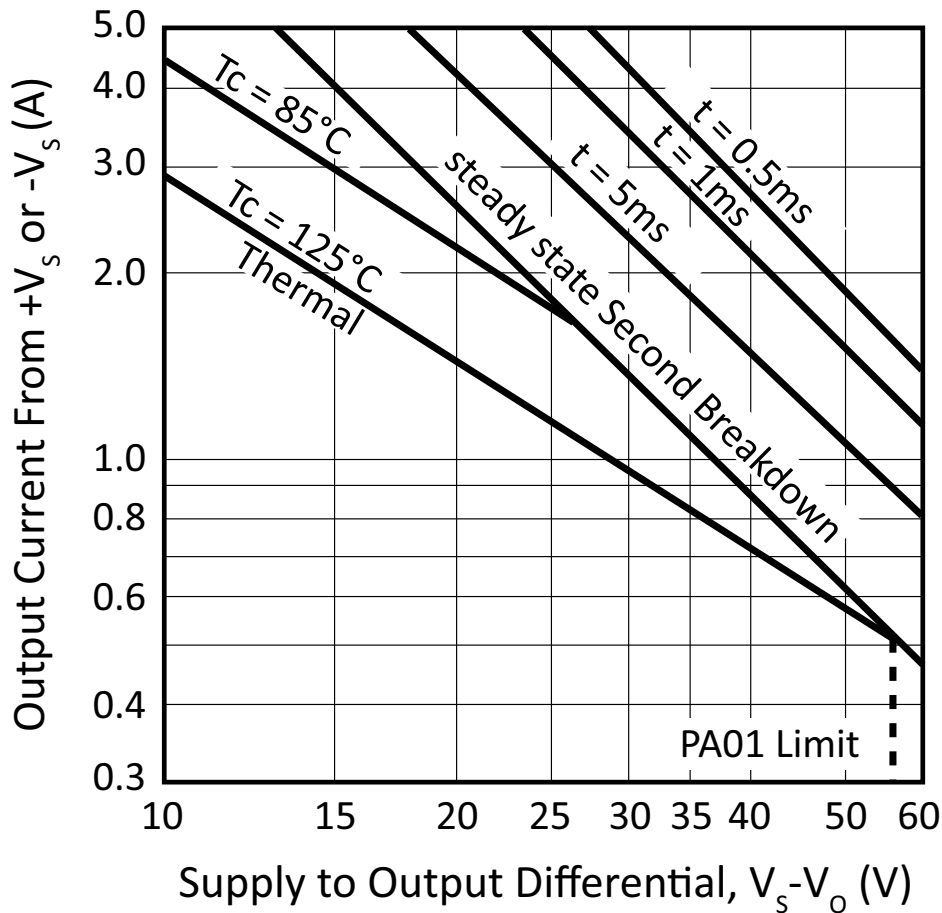


**SAFE OPERATING AREA (SOA)**

The output stage of most power amplifiers has three distinct limitations:

1. The current handling capability of the transistor geometry and the wire bonds.
2. The second breakdown effect which occurs whenever the simultaneous collector current and collector-emitter voltage exceeds specified limits.
3. The junction temperature of the output transistors.

Figure 15: SOA



The SOA curves combine the effect of these limits. For a given application, the direction and magnitude of the output current should be calculated or measured and checked against the SOA curves. This is simple for resistive loads but more complex for reactive and EMF generating loads. Please see Application Note 22.

1. EMF generating or reactive load and short circuits to the supply rail or shorts to common are safe if the current limits are set as follows at  $T_C = 85^\circ\text{C}$ .

$\pm V_S$	Short to $\pm V_S$ C, L, or EMF Load	Short to Common
34V	0.58A	1.1A
30V	0.46A	1.4A
25V	0.61A	1.7A
20V	0.86A	2.1A
15V	1.3A	2.9A

2. The output stage is protected against occasional transient flyback. However, for protection against sustained, high energy flyback, external fast-recovery diodes should be used.

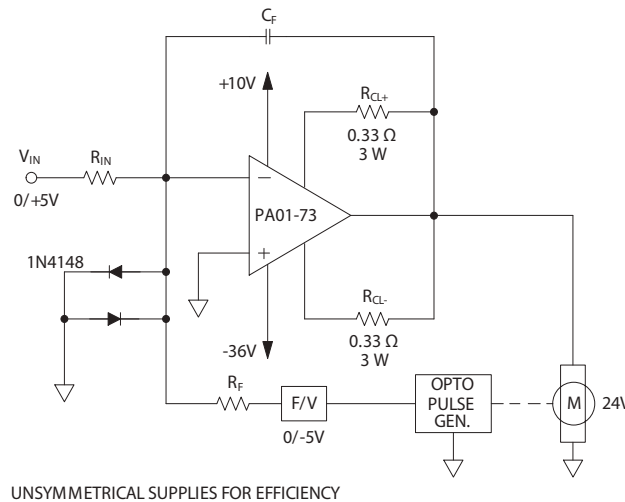
**GENERAL**

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.

**TYPICAL APPLICATION**

The pulse output of a non-contact optical sensor drives a voltage-to-frequency converter which generates feedback for the op amp. With the loop closed in this manner, the op amp corrects for any variations in the speed due to changing load. Because of operation in only one direction, an unsymmetrical supply is used to maximize efficiency of both the power op amp and power supply. High speed diodes at the input protect the op amp from commutator noise which may be generated by the motor.

**Figure 16: Typical Application (Unidirectional Optical Speed Control)**



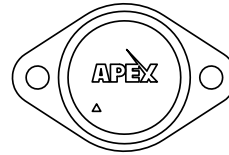
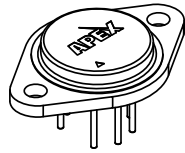
**CURRENT LIMIT**

Proper operation requires the use of two current limit resistors, connected as shown, in the external connection diagram. The minimum value for  $R_{CL}$  is 0.12 ohm; however, for optimum reliability it should be set as high as possible. Refer to the “General Operating Considerations” section of the handbook for current limit adjust details.

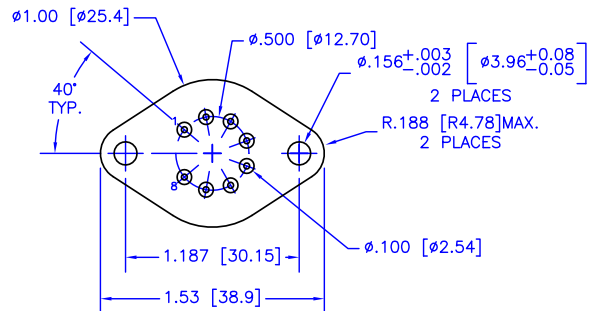
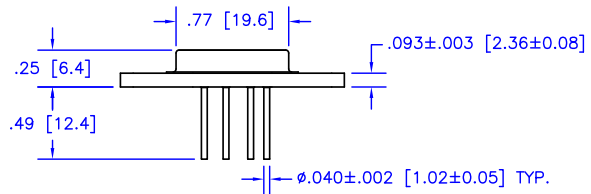
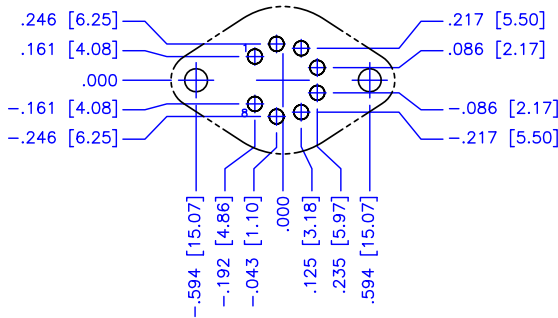
$$I_{LIM}(A) = \frac{0.6V}{R_{CL}(\Omega)}$$

**PACKAGE OPTIONS**

**PACKAGE STYLE CE**



**Ordinate dimensions for CAD layout**



**NOTES:**

1. Dimensions are inches & [mm].
2. Triangle printed on lid denotes pin 1.
3. Header flatness within pin circle is .0005" TIR, max.
4. Header flatness between mounting holes is .0015" TIR, max.
5. Standard pin material: Solderable nickel-plated Alloy 52.
6. Header material: Nickel-plated cold-rolled steel.
7. Welded hermetic package seal.
8. Isolation: 500 VDC any pin to case.
9. Package weight: .53 oz [15 g]

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

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