

# Power Operational Amplifier

## FEATURES

- LOW COST, ECONOMY MODEL — PA01
- 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 20kHz
- TEMPERATURE CONTROL UP TO 180W
- PROGRAMMABLE POWER SUPPLIES UP TO 48V
- AUDIO AMPLIFIERS UP TO 50W RMS

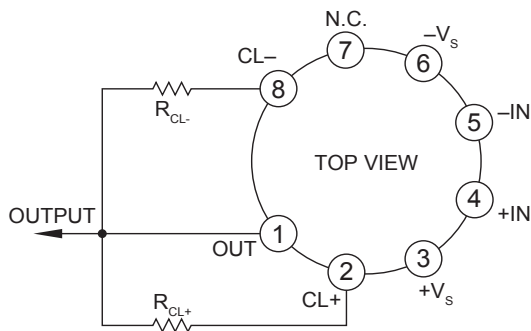
8-PIN TO-3  
PACKAGE STYLE CE

## DESCRIPTION

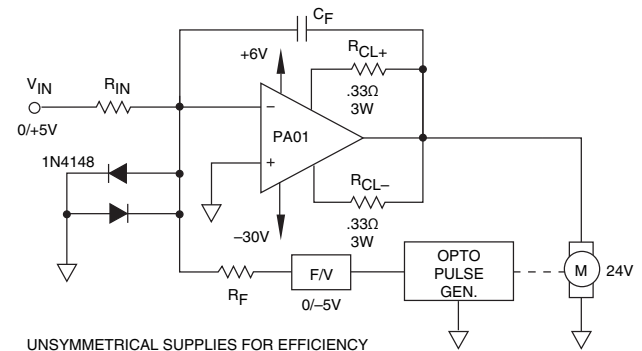
The PA01 and PA73 are high voltage, high output current operational amplifiers designed to drive resistive, inductive and capacitive loads. For optimum linearity, the PA01 has a class A/B output stage. The PA73 has a simple class C output stage (see Note 1) to reduce cost for motor control and other applications where crossover distortion is not critical and to provide interchangeability with type 3573 amplifiers. 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 "General Operating Considerations".

## EXTERNAL CONNECTIONS



## TYPICAL APPLICATION

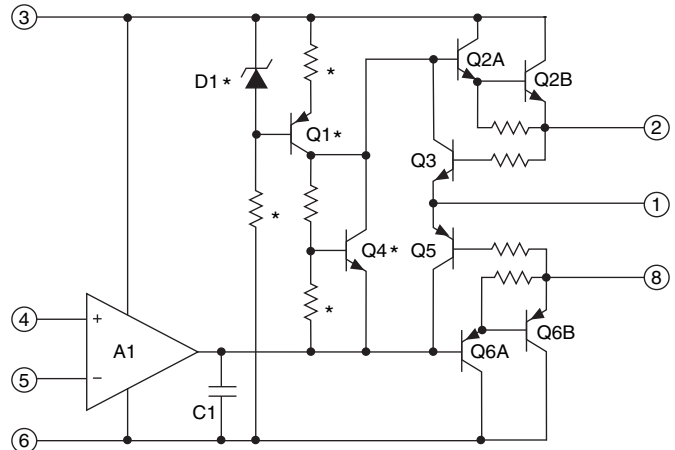


UNSYMMETRICAL SUPPLIES FOR EFFICIENCY

### Unidirectional Optical Speed Control

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 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.

## EQUIVALENT SCHEMATIC



NOTE 1: \* Indicates not used in PA73. Open base of Q2A connected to output of A1.

**ABSOLUTE MAXIMUM RATINGS**

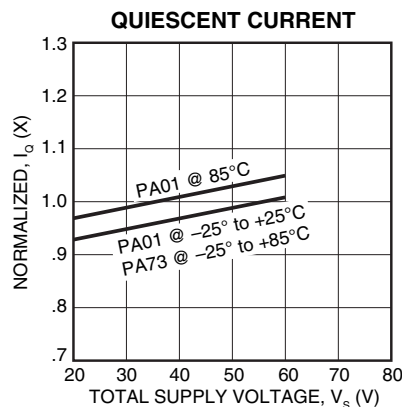
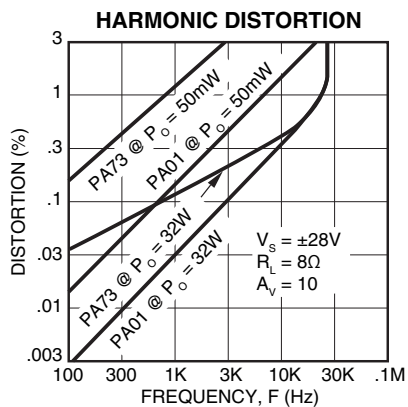
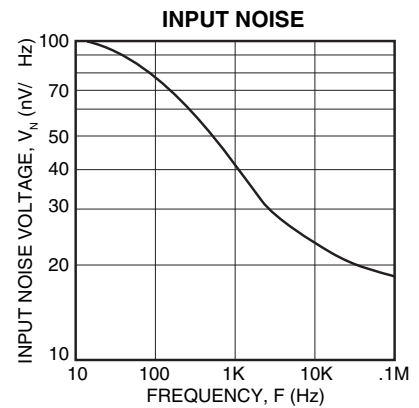
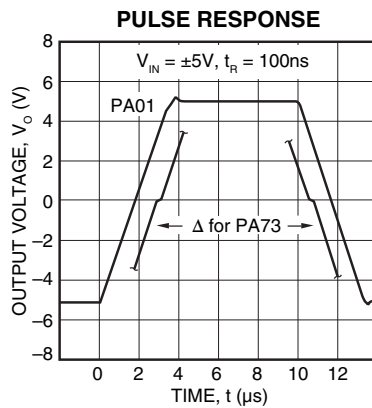
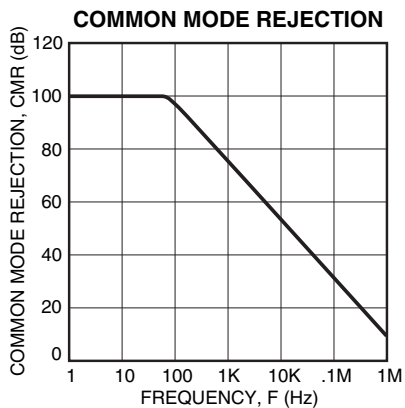
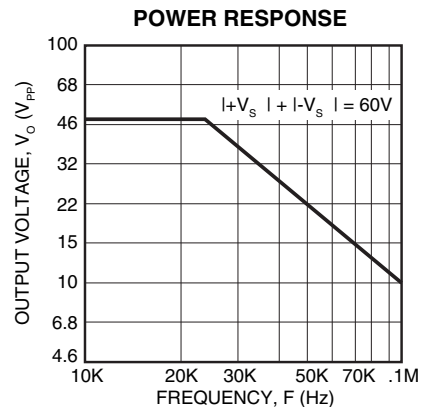
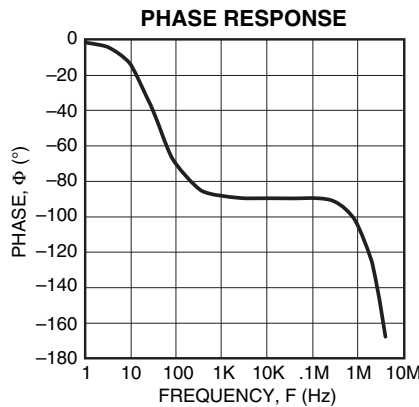
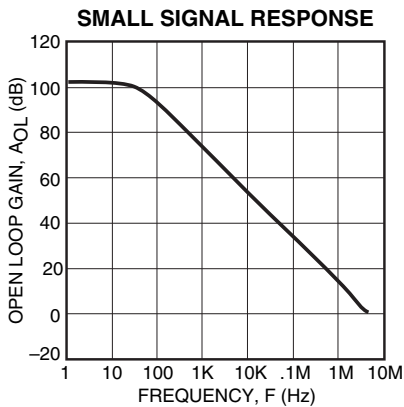
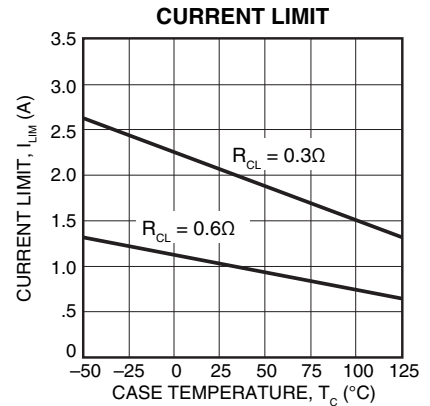
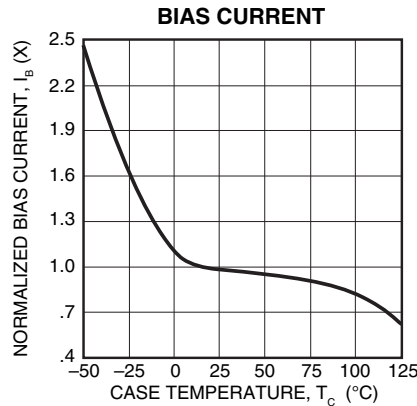
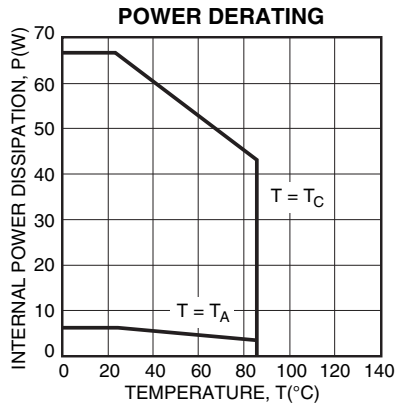
	PA01	PA73
SUPPLY VOLTAGE, +V <sub>S</sub> to -V <sub>S</sub>	60V	68V
OUTPUT CURRENT, within SOA	5A	5A
POWER DISSIPATION, internal	67W	67W
INPUT VOLTAGE, differential	±37V	±37V
INPUT VOLTAGE, common-mode	±V <sub>S</sub>	±V <sub>S</sub>
TEMPERATURE, junction <sup>1</sup>	200°C	200°C
TEMPERATURE, pin solder -10s	350°C	350°C
TEMPERATURE RANGE, storage	-65 to +150°C	-65 to +150°C
OPERATING TEMPERATURE RANGE, case	-25 to +85°C	-25 to +85°C

**SPECIFICATIONS**

PARAMETER	TEST CONDITIONS <sup>2</sup>	PA01			PA73			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>INPUT</b>								
OFFSET VOLTAGE, initial	T <sub>C</sub> = 25°C		±5	±12	*		±10	mV
OFFSET VOLTAGE, vs. temperature	Full temperature range		±10	±65	*		*	µV/°C
OFFSET VOLTAGE, vs. supply	T <sub>C</sub> = 25°C		±35		*		±200	µV/V
OFFSET VOLTAGE, vs. power	T <sub>C</sub> = 25°C		±20		*			µV/W
BIAS CURRENT, initial	T <sub>C</sub> = 25°C		±15	±50	*		±40	nA
BIAS CURRENT, vs. temperature	Full temperature range		±0.05	±.4	*		*	nA/°C
BIAS CURRENT, vs. supply	T <sub>C</sub> = 25°C		±.02		*			nA/V
OFFSET CURRENT, initial	T <sub>C</sub> = 25°C		±12	±30	*		*	nA
OFFSET CURRENT, vs. temperature	Full temperature range		±.05		*			nA/°C
INPUT IMPEDANCE, common-mode	T <sub>C</sub> = 25°C		200		*			MΩ
INPUT IMPEDANCE, differential	T <sub>C</sub> = 25°C		10		*			MΩ
INPUT CAPACITANCE	T <sub>C</sub> = 25°C		3		*			pF
COMMON MODE VOLTAGE RANGE <sup>3</sup>	Full temperature range	±V <sub>S</sub> -6	±V <sub>S</sub> -3		*	*		V
COMMON MODE REJECTION, DC <sup>3</sup>	T <sub>C</sub> = 25°C, V <sub>CM</sub> = V <sub>S</sub> -6V	70	110		*	*		dB
<b>GAIN</b>								
OPEN LOOP GAIN at 10Hz	Full temp. range, full load	91	113		*	*		dB
GAIN BANDWIDTH PRODUCT @ 1MHz	T <sub>C</sub> = 25°C, full load		1		*	*		MHz
POWER BANDWIDTH	T <sub>C</sub> = 25°C, I <sub>O</sub> = 4A, V <sub>O</sub> = 40V <sub>PP</sub>	15	23		*	*		kHz
PHASE MARGIN	Full temperature range		45		*	*		°
<b>OUTPUT</b>								
VOLTAGE SWING <sup>3</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>3</sup>	Full temp. range, I <sub>O</sub> = 2A	±V <sub>S</sub> -6	±V <sub>S</sub> -5		*	*		V
VOLTAGE SWING <sup>3</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 .1%	T <sub>C</sub> = 25°C, 2V step		2		*	*		µs
SLEW RATE	T <sub>C</sub> = 25°C, R <sub>L</sub> = 2.5Ω	1.0	2.6		*	*		V/µs
CAPACITIVE LOAD, unity gain	Full temperature range			1			*	nF
CAPACITIVE LOAD, gain > 4	Full temperature range			SOA			*	
<b>POWER SUPPLY</b>								
VOLTAGE	Full temperature range	±10	±28	±28	*	*	±30	V
CURRENT, quiescent	T <sub>C</sub> = 25°C		20	50		2.6	5	mA
<b>THERMAL</b>								
RESISTANCE, AC, junction to case <sup>4</sup>	F > 60Hz		1.9	2.1		*	*	°C/W
RESISTANCE, DC, junction to case	F < 60Hz		2.4	2.6		*	*	°C/W
RESISTANCE, junction to air			30			*	*	°C/W
TEMPERATURE RANGE, case	Meets full range specifications	-25	25	+85	*	*	*	°C

- NOTES: \* The specification of PA73 is identical to the specification for PA01 in applicable column to the left.
1. Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTTF.
  2. The power supply voltage specified under the TYP rating applies unless otherwise noted as a test condition.
  3. +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>.
  4. Rating applies if the output current alternates between both output transistors at a rate faster than 60Hz.

**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.



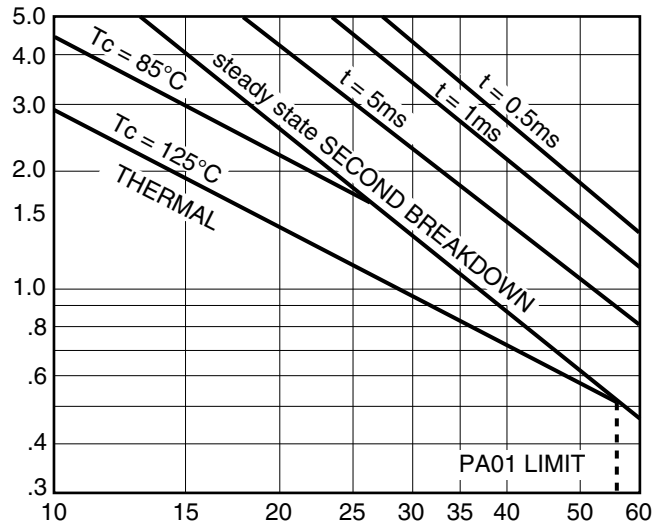
**GENERAL**

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 design tools that help automate tasks such as calculations for stability, internal power dissipation, current limit and heat sink selection. The "Application Notes" and "Technical Seminar" sections contain a wealth of information on specific types of applications. Package outlines, heat sinks, mounting hardware and other accessories are located in the "Packages and Accessories" section. Evaluation Kits are available for most Apex Precision Power product models, consult the "Evaluation Kit" section for details. For the most current version of all Apex Microtechnology product data sheets, visit [www.apexanalog.com](http://www.apexanalog.com).

**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.



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.

1. For sine wave outputs, use Power Design<sup>1</sup> to plot a load line. Make sure the load line does not cross the 0.5ms limit and that excursions beyond any other second breakdown line do not exceed the time label, and have a duty cycle of no more than 10%.

For other waveform outputs, manual load line plotting is recommended. Applications Note 22, SOA AND LOAD LINES, will be helpful. A Spice type analysis can be very useful in that a hardware setup often calls for instruments or amplifiers with wide common mode rejection ranges.

2. 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	.58A	1.1A
30V	.46A	1.4A
25V	.61A	1.7A
20V	.86A	2.1A
15V	1.3A	2.9A

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

**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.

<sup>1</sup> Note 1. Power Design is a self-extracting Excel spreadsheet available free from [www.apexanalog.com](http://www.apexanalog.com)

---

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

For all Apex Microtechnology product questions and inquiries, call toll free 800-546-2739 in North America.

For inquiries via email, please contact [apex.support@apexanalog.com](mailto:apex.support@apexanalog.com).

International customers can also request support by contacting their local Apex Microtechnology Sales Representative.

To find the one nearest to you, go to [www.apexanalog.com](http://www.apexanalog.com)

---

### IMPORTANT NOTICE

Apex Microtechnology, Inc. has made every effort to insure the accuracy of the content contained in this document. However, the information is subject to change without notice and is provided "AS IS" without warranty of any kind (expressed or implied). Apex Microtechnology reserves the right to make changes without further notice to any specifications or products mentioned herein to improve reliability. This document is the property of Apex Microtechnology and by furnishing this information, Apex Microtechnology grants no license, expressed or implied under any patents, mask work rights, copyrights, trademarks, trade secrets or other intellectual property rights. Apex Microtechnology owns the copyrights associated with the information contained herein and gives consent for copies to be made of the information only for use within your organization with respect to Apex Microtechnology integrated circuits or other products of Apex Microtechnology. This consent does not extend to other copying such as copying for general distribution, advertising or promotional purposes, or for creating any work for resale.

APEX MICROTECHNOLOGY PRODUCTS ARE NOT DESIGNED, AUTHORIZED OR WARRANTED TO BE SUITABLE FOR USE IN PRODUCTS USED FOR LIFE SUPPORT, AUTOMOTIVE SAFETY, SECURITY DEVICES, OR OTHER CRITICAL APPLICATIONS. PRODUCTS IN SUCH APPLICATIONS ARE UNDERSTOOD TO BE FULLY AT THE CUSTOMER OR THE CUSTOMER'S RISK.

Apex Microtechnology, Apex and Apex Precision Power are trademarks of Apex Microtechnology, Inc. All other corporate names noted herein may be trademarks of their respective holders.