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## Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



# 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

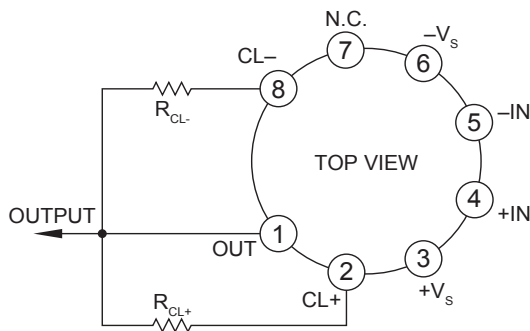
8-PIN TO-3  
PACKAGE STYLE CE

## DESCRIPTION

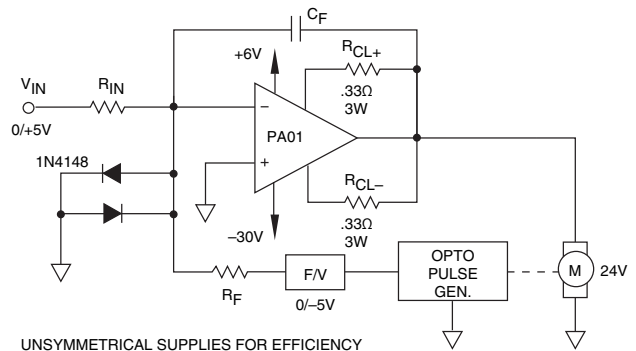
The PA01 and PA73 are high voltage, high output current operational amplifiers designed to drive resistive, inductive and capacitive loads. For optimum linearity, the PA01 has a class A/B output stage. The PA73 has a simple class C output stage (see Note 1) to reduce cost for motor control and other 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

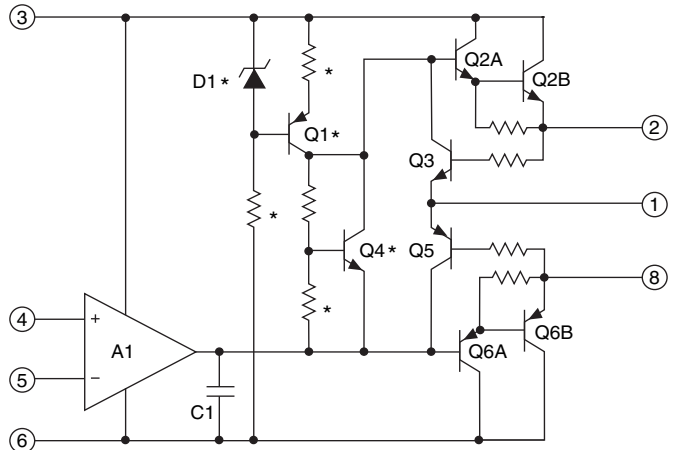


UNSYMMETRICAL SUPPLIES FOR EFFICIENCY

### 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**

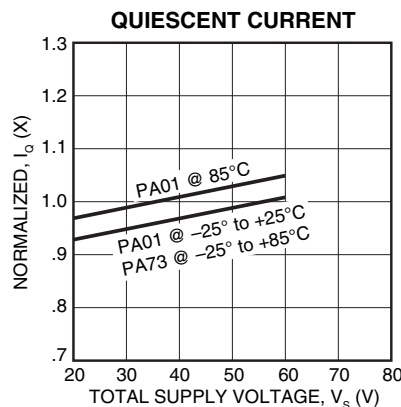
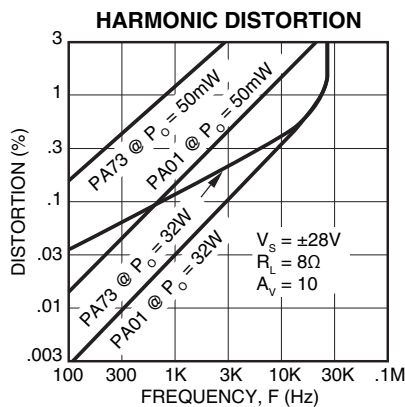
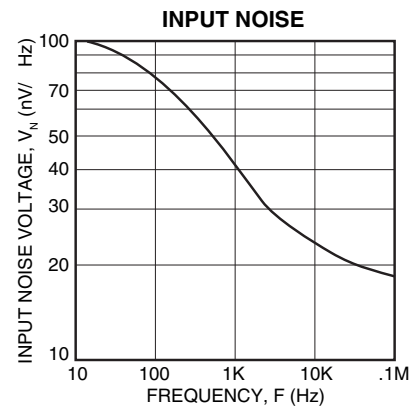
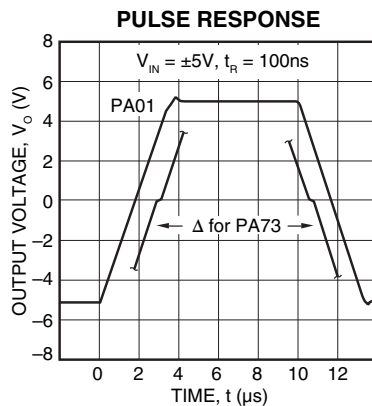
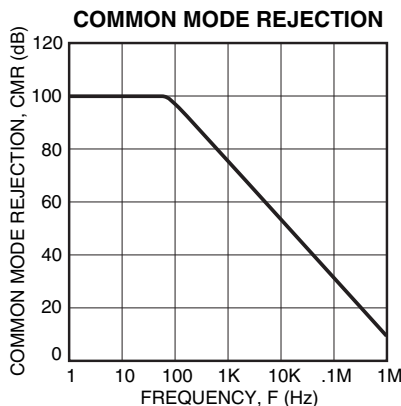
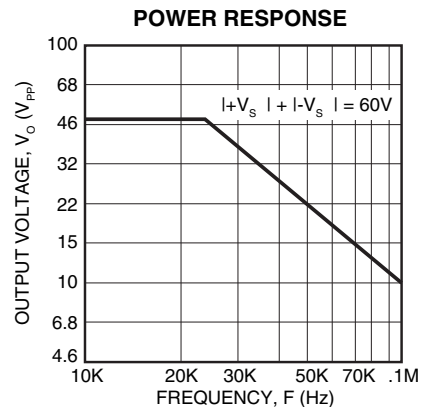
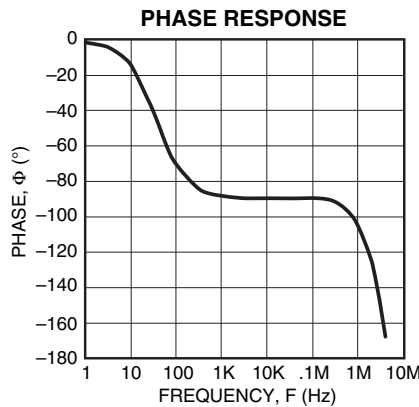
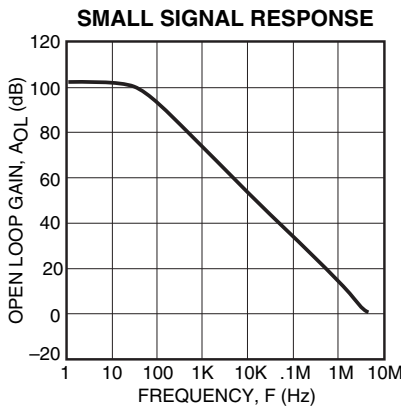
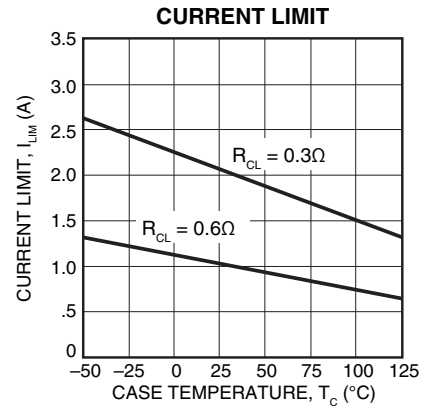
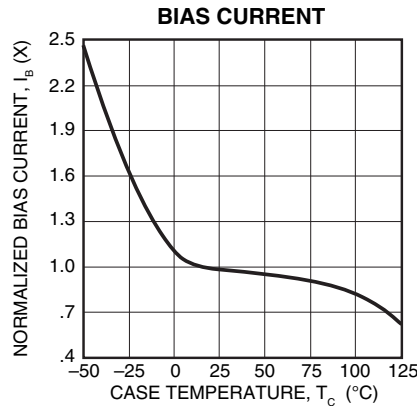
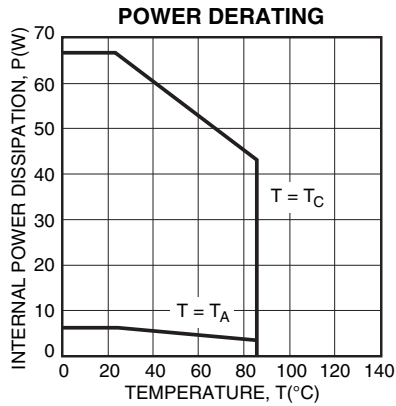
|  | PA01            | PA73            |
|--|-----------------|-----------------|
| SUPPLY VOLTAGE, +V <sub>S</sub> to -V <sub>S</sub> | 60V             | 68V             |
| OUTPUT CURRENT, within SOA                         | 5A              | 5A              |
| POWER DISSIPATION, internal                        | 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   |                     | ±0.05              |     | *                  |     |      | 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.



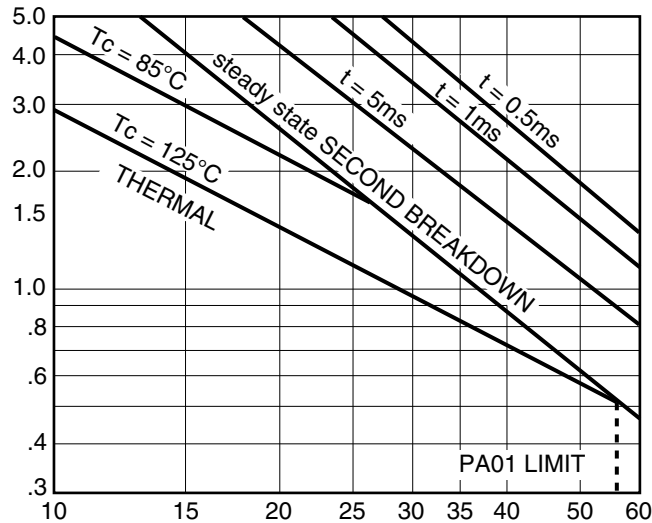
**GENERAL**

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 $\pm V_s$<br>C, L, OR EMF LOAD | SHORT TO<br>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)

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