

# PA51 • PA51A

APEX MICROTECHNOLOGY CORPORATION • APPLICATIONS HOTLINE 800 546 APEX (800 546 2739)

## FEATURES

- WIDE SUPPLY RANGE —  $\pm 10$  to  $\pm 40$ V
- HIGH OUTPUT CURRENT —  $\pm 10$ A Peak
- SECOND SOURCEABLE — OPA501, 8785
- CLASS "C" OUTPUT — Low Cost
- LOW QUIESCENT CURRENT — 2.6mA

## APPLICATIONS

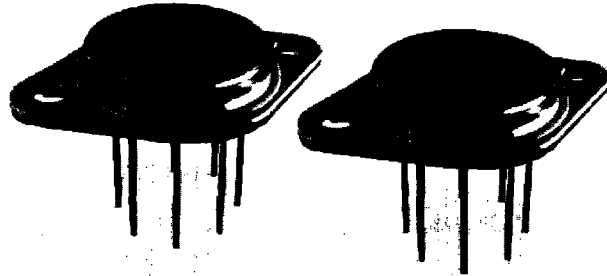
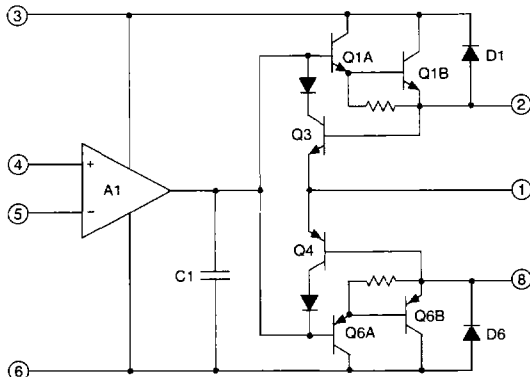
- DC SERVO AMPLIFIER
- MOTOR/SYNCHRO DRIVER
- VALVE AND ACTUATOR CONTROL
- DC OR AC POWER REGULATOR

## DESCRIPTION

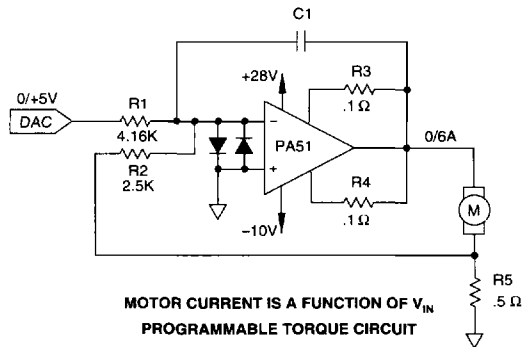
The PA51 and PA51A are high voltage, high output current operational amplifiers designed to drive resistive, inductive and capacitive loads. Their complementary common emitter output stage is protected against transient inductive kickback and optimized for low frequency applications where crossover distortion is not critical. These amplifiers are not recommended for audio, transducer or deflection coil drive circuits. The safe operating area (SOA) is fully specified and can be observed for all operating conditions by selection of user programmable current limiting resistors. Both amplifiers are internally compensated for all gain settings. For continuous operation under load, mounting on a heatsink of proper rating is recommended. Do not use isolation washers!

This hybrid integrated circuit utilizes thick film conductors, 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 electrically isolated and hermetically sealed. The use of compressible thermal washers and/or improper mounting torque will void the product warranty. Please see "General Operating Considerations".

## EQUIVALENT SCHEMATIC

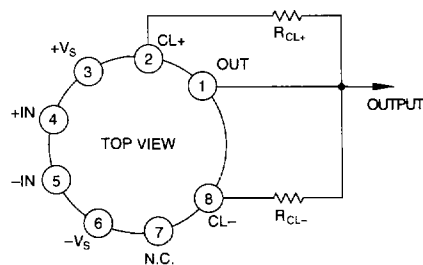


## TYPICAL APPLICATION



The linear relationship of torque output to current input of the modern torque motor makes this simple control circuit ideal for many material processing and testing applications. The sense resistor develops a feedback voltage proportional to motor current and the small signal properties of the Power Op Amp insure accuracy. With this closed loop operation, temperature induced impedance variations of the motor winding are automatically compensated.

## EXTERNAL CONNECTIONS



# PA51 • PA51A

## ABSOLUTE MAXIMUM RATINGS SPECIFICATIONS

### ABSOLUTE MAXIMUM RATINGS

|                                    |                |
|------------------------------------|----------------|
| SUPPLY VOLTAGE, $+V_S$ to $-V_S$   | 80V            |
| OUTPUT CURRENT, within SOA         | 10A            |
| POWER DISSIPATION, internal        | 97W            |
| INPUT VOLTAGE, differential        | $\pm V_S - 3V$ |
| INPUT VOLTAGE, common mode         | $\pm V_S$      |
| TEMPERATURE, junction <sup>1</sup> | 200°C          |
| TEMPERATURE, pin solder -10s       | 300°C          |
| TEMPERATURE RANGE, storage         | -65 to +150°C  |
| OPERATING TEMPERATURE RANGE, case  | -55 to +125°C  |

### SPECIFICATIONS

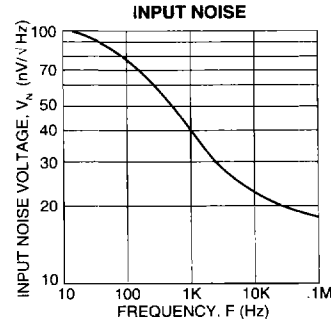
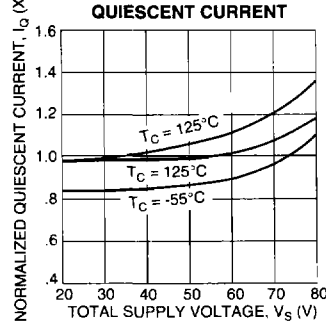
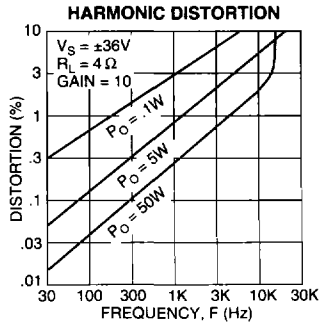
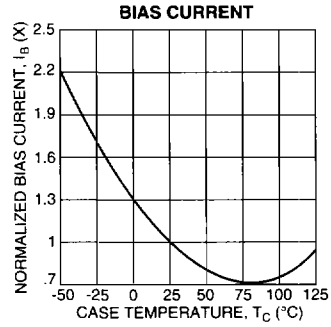
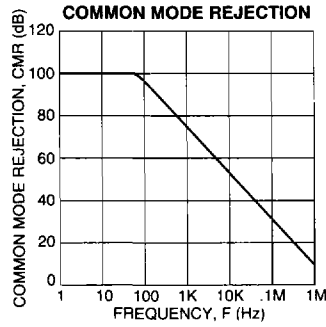
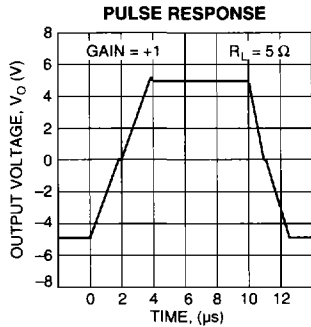
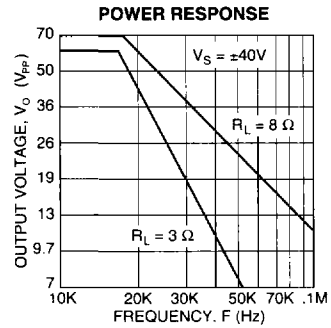
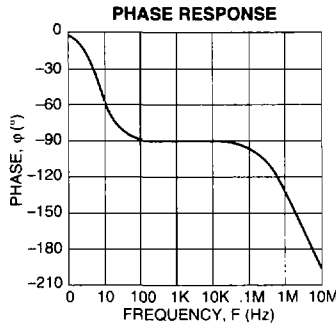
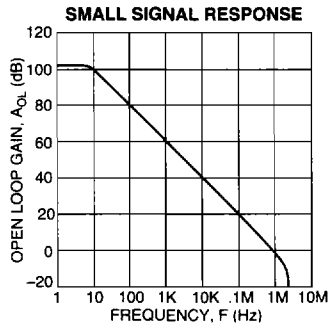
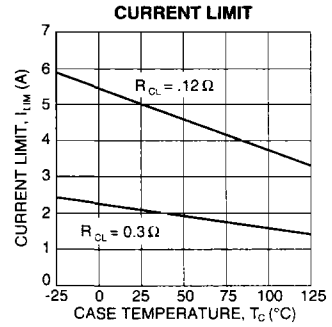
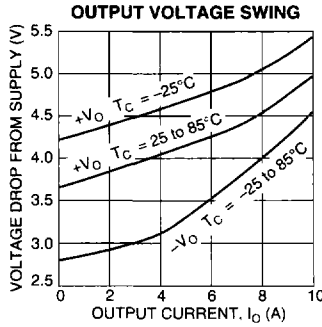
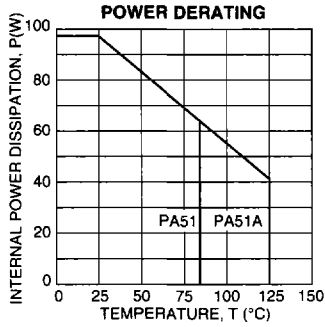
| PARAMETER                                     | TEST CONDITIONS <sup>2,5</sup>                                 | PA51          |               |          | PA51A |          |          | UNITS                        |
|---|--|---------------|---------------|----------|-------|----------|----------|------------------------------|
|   |  | MIN           | TYP           | MAX      | MIN   | TYP      | MAX      |                              |
| <b>INPUT</b>                                  |  |               |               |          |       |          |          |                              |
| OFFSET VOLTAGE, initial                       | $T_C \approx 25^\circ\text{C}$                                 |               | $\pm 5$       | $\pm 10$ |       | $\pm 2$  | $\pm 5$  | mV                           |
| OFFSET VOLTAGE, vs. temperature               | Full temperature range   |               | $\pm 10$      | $\pm 65$ |       | *        | $\pm 40$ | $\mu\text{V}/^\circ\text{C}$ |
| OFFSET VOLTAGE, vs. supply                    | $T_C \approx 25^\circ\text{C}$                                 |               | $\pm 35$      |          |       | *        |          | $\mu\text{V}/\text{V}$       |
| OFFSET VOLTAGE, vs. power                     | $T_C \approx 25^\circ\text{C}$                                 |               | $\pm 20$      |          |       | *        |          | $\mu\text{V}/\text{W}$       |
| BIAS CURRENT, initial                         | $T_C \approx 25^\circ\text{C}$                                 |               | $\pm 15$      | $\pm 40$ |       | *        | $\pm 20$ | nA                           |
| BIAS CURRENT, vs. temperature                 | Full temperature range   |               | $\pm 0.5$     |          |       | *        |          | $\text{nA}/^\circ\text{C}$   |
| BIAS CURRENT, vs. supply                      | $T_C \approx 25^\circ\text{C}$                                 |               | $\pm 0.2$     |          |       | *        |          | $\text{nA}/\text{V}$         |
| OFFSET CURRENT, initial                       | $T_C \approx 25^\circ\text{C}$                                 |               | $\pm 5$       | $\pm 12$ |       | $\pm 2$  | $\pm 3$  | nA                           |
| OFFSET CURRENT, vs. temperature               | Full temperature range   |               | $\pm 0.1$     |          |       | *        |          | $\text{nA}/^\circ\text{C}$   |
| INPUT IMPEDANCE, common mode                  | $T_C \approx 25^\circ\text{C}$                                 |               | 250           |          |       | *        |          | M $\Omega$                   |
| INPUT IMPEDANCE, differential                 | $T_C \approx 25^\circ\text{C}$                                 |               | 10            |          |       | *        |          | M $\Omega$                   |
| INPUT CAPACITANCE                             | $T_C \approx 25^\circ\text{C}$                                 |               | 3             |          |       | *        |          | pF                           |
| COMMON MODE VOLTAGE RANGE <sup>3</sup>        | Full temperature range   | $\pm V_S - 6$ | $\pm V_S - 3$ |          | *     | *        |          | V                            |
| COMMON MODE REJECTION, DC <sup>3</sup>        | $T_C \approx 25^\circ\text{C}$ , $V_{CM} = \pm V_S - 6V$       | 70            | 110           |          | 80    | *        |          | dB                           |
| <b>GAIN</b>                                   |  |               |               |          |       |          |          |                              |
| OPEN LOOP GAIN at 10Hz                        | Full temp. range, full load                                    | 94            | 115           |          | *     | *        |          | dB                           |
| GAIN BANDWIDTH PRODUCT @ 1MHz                 | $T_C \approx 25^\circ\text{C}$ , full load                     |               | 1             |          | *     | *        |          | MHz                          |
| POWER BANDWIDTH                               | $T_C \approx 25^\circ\text{C}$ , $I_O = 8A$ , $V_O = 40V_{PP}$ | 10            | 16            |          | *     | *        |          | kHz                          |
| PHASE MARGIN                                  | Full temperature range   |               | 45            |          |       | *        |          | °                            |
| <b>OUTPUT</b>                                 |  |               |               |          |       |          |          |                              |
| VOLTAGE SWING <sup>3</sup>                    | $T_C \approx 25^\circ\text{C}$ , $I_O = 10A$                   | $\pm V_S - 8$ | $\pm V_S - 5$ |          | *     | *        |          | V                            |
| VOLTAGE SWING <sup>3</sup>                    | Full temp. range, $I_O = 4A$                                   | $\pm V_S - 6$ | $\pm V_S - 4$ |          | *     | *        |          | V                            |
| VOLTAGE SWING <sup>3</sup>                    | Full temp. range, $I_O = 68\text{mA}$                          | $\pm V_S - 6$ |               |          | *     | *        |          | V                            |
| CURRENT                                       | $T_C \approx 25^\circ\text{C}$                                 | $\pm 10$      |               |          | *     | *        |          | A                            |
| SETTLING TIME to .1%                          | $T_C \approx 25^\circ\text{C}$ , 2V step                       |               | 2             |          | *     | *        |          | $\mu\text{s}$                |
| SLEW RATE                                     | $T_C \approx 25^\circ\text{C}$ , $R_L = 6\Omega$               | 1.0           | 2.6           |          | *     | *        |          | V/ $\mu\text{s}$             |
| CAPACITIVE LOAD, unity gain                   | Full temperature range   |               |               | 1.5      |       | *        |          | nF                           |
| CAPACITIVE LOAD, gain > 4                     | Full temperature range   |               |               | SOA      |       | *        |          | nF                           |
| <b>POWER SUPPLY</b>                           |  |               |               |          |       |          |          |                              |
| VOLTAGE                                       | Full temperature range   | $\pm 10$      | $\pm 28$      | $\pm 36$ | *     | $\pm 34$ | $\pm 40$ | V                            |
| CURRENT, quiescent                            | $T_C \approx 25^\circ\text{C}$                                 |               | 2.6           | 10       |       | *        |          | mA                           |
| <b>THERMAL</b>                                |  |               |               |          |       |          |          |                              |
| RESISTANCE, AC, junction to case <sup>4</sup> | $F > 60\text{Hz}$  |               | 1.0           | 1.2      |       | *        | *        | $^\circ\text{C}/\text{W}$    |
| RESISTANCE, DC, junction to case              | $F < 60\text{Hz}$  |               | 1.5           | 1.8      |       | *        | *        | $^\circ\text{C}/\text{W}$    |
| RESISTANCE, junction to air                   |  |               | 30            |          |       | *        | *        | $^\circ\text{C}/\text{W}$    |
| TEMPERATURE RANGE, case                       | Meets full range specifications                                | -25           |               | +85      | -55   |          | +125     | $^\circ\text{C}$             |

NOTES: \* The specification of PA51A is identical to the specification for PA51 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.  $+V_S$  and  $-V_S$  denote the positive and negative supply rail respectively. Total  $V_S$  is measured from  $+V_S$  to  $-V_S$ .
4. Rating applies if the output current alternates between both output transistors at a rate faster than 60Hz.
5. Full temperature range specifications are guaranteed but not 100% tested.

### 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.



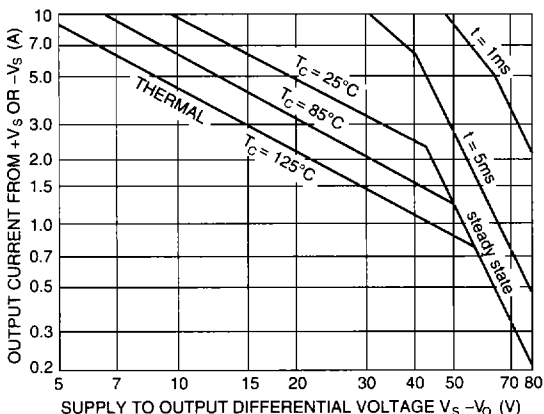
### GENERAL

Please read the "General Operating Considerations" section, which covers stability, supplies, heatsinking, mounting, current limit, SOA interpretation, and specification interpretation. Additional information can be found in the application notes. For information on the package outline, heatsinks, and mounting hardware, consult the "Accessory and Package Mechanical Data" section of the handbook.

### 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 all limits for this Power Op Amp. 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. The following guidelines may save extensive analytical efforts.

1. Under transient conditions, capacitive and dynamic\* inductive loads up to the following maximums are safe:

| $\pm V_S$ | CAPACITIVE LOAD     |                   | INDUCTIVE LOAD |                 |
|-----------|---------------------|-------------------|----------------|-----------------|
|           | $I_{LIM} = 5A$      | $I_{LIM} = 10A$   | $I_{LIM} = 5A$ | $I_{LIM} = 10A$ |
| 40V       | 400 $\mu\text{F}$   | 200 $\mu\text{F}$ | 11mH           | 4.3mH           |
| 35V       | 800 $\mu\text{F}$   | 400 $\mu\text{F}$ | 20mH           | 5.0mH           |
| 30V       | 1,600 $\mu\text{F}$ | 800 $\mu\text{F}$ | 35mH           | 6.2mH           |
| 25V       | 5.0mF               | 2.5mF             | 50mH           | 15mH            |
| 20V       | 10mF                | 5.0mF             | 400mH          | 20mH            |
| 15V       | 20mF                | 10mF              | **             | 100mH           |

- \* If the inductive load is driven near steady state conditions, allowing the output voltage to drop more than 8V below the supply rail with  $I_{LIM} = 10A$  or 15V below the supply rail with  $I_{LIM} = 5A$  while the amplifier is current limiting, the inductor should be capacitively coupled or the current limit must be lowered to meet SOA criteria.

- \*\* Second breakdown effect imposes no limitation but thermal limitations must still be observed.

2. The amplifier can handle any EMF generating or reactive load and short circuits to the supply rail or shorts to common 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 |
|-----------|---|--------------------|
| 45V       | 0.1A                                    | 1.3A               |
| 40V       | 0.2A                                    | 1.5A               |
| 35V       | 0.3A                                    | 1.6A               |
| 30V       | 0.5A                                    | 2.0A               |
| 25V       | 1.2A                                    | 2.4A               |
| 20V       | 1.5A                                    | 3.0A               |
| 15V       | 2.0A                                    | 4.0A               |

These simplified limits may be exceeded with further analysis using the operating conditions for a specific application.

3. The output stage is protected against 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 .06 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.

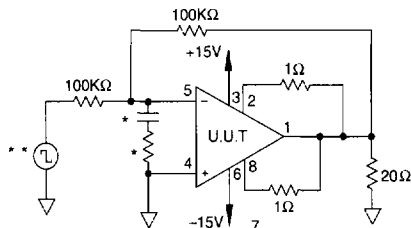
# PA51M

APEX MICROTECHNOLOGY CORPORATION • APPLICATIONS HOTLINE 800 546 APEX (800-546-2739)

| SG | PARAMETER                    | SYMBOL   | TEMP. | POWER | TEST CONDITIONS                            | MIN | MAX   | UNITS      |
|----|------------------------------|----------|-------|-------|--|-----|-------|------------|
| 1  | Quiescent current            | $I_Q$    | 25°C  | ±34V  | $V_{IN} = 0, A_v = 100, R_{CL} = .1\Omega$ |     | 10    | mA         |
| 1  | Input offset voltage         | $V_{OS}$ | 25°C  | ±34V  | $V_{IN} = 0, A_v = 100$                    |     | ±10   | mV         |
| 1  | Input offset voltage         | $V_{OS}$ | 25°C  | ±10V  | $V_{IN} = 0, A_v = 100$                    |     | ±16   | mV         |
| 1  | Input offset voltage         | $V_{OS}$ | 25°C  | ±40V  | $V_{IN} = 0, A_v = 100$                    |     | ±11.2 | mV         |
| 1  | Input bias current, +IN      | $+I_B$   | 25°C  | ±34V  | $V_{IN} = 0$                               |     | ±40   | nA         |
| 1  | Input bias current, -IN      | $-I_B$   | 25°C  | ±34V  | $V_{IN} = 0$                               |     | ±40   | nA         |
| 1  | Input offset current         | $I_{OS}$ | 25°C  | ±34V  | $V_{IN} = 0$                               |     | ±10   | nA         |
| 3  | Quiescent current            | $I_Q$    | -55°C | ±34V  | $V_{IN} = 0, A_v = 100, R_{CL} = .1\Omega$ |     | 10    | mA         |
| 3  | Input offset voltage         | $V_{OS}$ | -55°C | ±34V  | $V_{IN} = 0, A_v = 100$                    |     | ±15.2 | mV         |
| 3  | Input offset voltage         | $V_{OS}$ | -55°C | ±10V  | $V_{IN} = 0, A_v = 100$                    |     | ±21.2 | mV         |
| 3  | Input offset voltage         | $V_{OS}$ | -55°C | ±40V  | $V_{IN} = 0, A_v = 100$                    |     | ±16.4 | mV         |
| 3  | Input bias current, +IN      | $+I_B$   | -55°C | ±34V  | $V_{IN} = 0$                               |     | ±72   | nA         |
| 3  | Input bias current, -IN      | $-I_B$   | -55°C | ±34V  | $V_{IN} = 0$                               |     | ±72   | nA         |
| 3  | Input offset current         | $I_{OS}$ | -55°C | ±34V  | $V_{IN} = 0$                               |     | ±26   | nA         |
| 2  | Quiescent current            | $I_Q$    | 125°C | ±34V  | $V_{IN} = 0, A_v = 100, R_{CL} = .1\Omega$ |     | 13    | mA         |
| 2  | Input offset voltage         | $V_{OS}$ | 125°C | ±34V  | $V_{IN} = 0, A_v = 100$                    |     | ±16.5 | mV         |
| 2  | Input offset voltage         | $V_{OS}$ | 125°C | ±10V  | $V_{IN} = 0, A_v = 100$                    |     | ±22.5 | mV         |
| 2  | Input offset voltage         | $V_{OS}$ | 125°C | ±40V  | $V_{IN} = 0, A_v = 100$                    |     | ±17.7 | mV         |
| 2  | Input bias current, +IN      | $+I_B$   | 125°C | ±34V  | $V_{IN} = 0$                               |     | ±80   | nA         |
| 2  | Input bias current, -IN      | $-I_B$   | 125°C | ±34V  | $V_{IN} = 0$                               |     | ±80   | nA         |
| 2  | Input offset current         | $I_{OS}$ | 125°C | ±34V  | $V_{IN} = 0$                               |     | ±30   | nA         |
| 4  | Output voltage, $I_O = 10A$  | $V_O$    | 25°C  | ±18V  | $R_L = 1\Omega$                            | 10  |       | V          |
| 4  | Output voltage, $I_O = 68mA$ | $V_O$    | 25°C  | ±40V  | $R_L = 500\Omega$                          | 34  |       | V          |
| 4  | Output voltage, $I_O = 4A$   | $V_O$    | 25°C  | ±30V  | $R_L = 6\Omega$                            | 24  |       | V          |
| 4  | Current limits               | $I_{CL}$ | 25°C  | ±16V  | $R_{CL} = 1\Omega, R_{CL} = .1\Omega$      | 5   | 7.9   | A          |
| 4  | Stability/noise              | $E_N$    | 25°C  | ±34V  | $R_L = 500\Omega, A_v = +1, C_L = 1.5nF$   |     | 1     | mV         |
| 4  | Slew rate                    | SR       | 25°C  | ±34V  | $R_L = 500\Omega$                          | 1.0 | 10    | V/ $\mu$ s |
| 4  | Open loop gain               | $A_{OL}$ | 25°C  | ±34V  | $R_L = 500\Omega, F = 10Hz$                | 94  |       | dB         |
| 4  | Common-mode rejection        | CMR      | 25°C  | ±15V  | $R_L = 500\Omega, F = DC, V_{CM} = \pm 9V$ | 70  |       | dB         |
| 6  | Output voltage, $I_O = 10A$  | $V_O$    | -55°C | ±18V  | $R_L = 1\Omega$                            | 10  |       | V          |
| 6  | Output voltage, $I_O = 68mA$ | $V_O$    | -55°C | ±40V  | $R_L = 500\Omega$                          | 34  |       | V          |
| 6  | Output voltage, $I_O = 4A$   | $V_O$    | -55°C | ±30V  | $R_L = 6\Omega$                            | 24  |       | V          |
| 6  | Stability/noise              | $E_N$    | -55°C | ±34V  | $R_L = 500\Omega, A_v = +1, C_L = 1.5nF$   |     | 1     | mV         |
| 6  | Slew rate                    | SR       | -55°C | ±34V  | $R_L = 500\Omega$                          | 1.0 | 10    | V/ $\mu$ s |
| 6  | Open loop gain               | $A_{OL}$ | -55°C | ±34V  | $R_L = 500\Omega, F = 10Hz$                | 94  |       | dB         |
| 6  | Common-mode rejection        | CMR      | -55°C | ±15V  | $R_L = 500\Omega, F = DC, V_{CM} = \pm 9V$ | 70  |       | dB         |
| 5  | Output voltage, $I_O = 8A$   | $V_O$    | 125°C | ±16V  | $R_L = 1\Omega$                            | 8   |       | V          |
| 5  | Output voltage, $I_O = 68mA$ | $V_O$    | 125°C | ±40V  | $R_L = 500\Omega$                          | 34  |       | V          |
| 5  | Output voltage, $I_O = 4A$   | $V_O$    | 125°C | ±30V  | $R_L = 6\Omega$                            | 24  |       | V          |
| 5  | Stability/noise              | $E_N$    | 125°C | ±34V  | $R_L = 500\Omega, A_v = +1, C_L = 1.5nF$   |     | 1     | mV         |
| 5  | Slew rate                    | SR       | 125°C | ±34V  | $R_L = 500\Omega$                          | 1.0 | 10    | V/ $\mu$ s |
| 5  | Open loop gain               | $A_{OL}$ | 125°C | ±34V  | $R_L = 500\Omega, F = 10Hz$                | 94  |       | dB         |
| 5  | Common-mode rejection        | CMR      | 125°C | ±15V  | $R_L = 500\Omega, F = DC, V_{CM} = \pm 9V$ | 70  |       | dB         |



## BURN IN CIRCUIT



\* These components are used to stabilize device due to poor high frequency characteristics of burn in board.

\*\* Input signals are calculated to result in internal power dissipation of approximately 2.1W at case temperature = 125°C.