PA08 • PA08A

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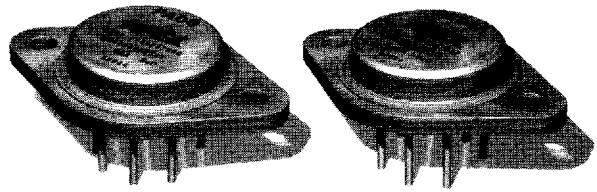
FEATURES

- WIDE SUPPLY RANGE — ±15V to ±150V
- PROGRAMMABLE OUTPUT CURRENT LIMIT
- HIGH OUTPUT CURRENT — Up to ±150mA
- LOW BIAS CURRENT — FET Input



APPLICATIONS

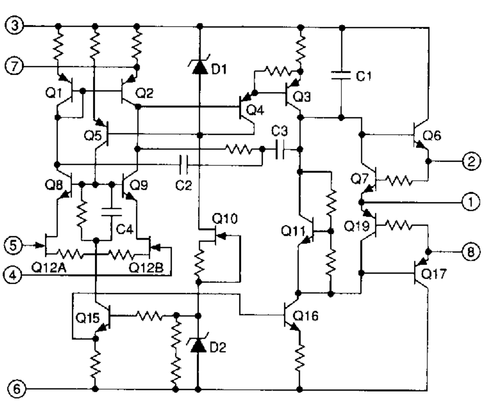
- HIGH VOLTAGE INSTRUMENTATION
- ELECTROSTATIC TRANSDUCERS & DEFLECTION
- PROGRAMMABLE POWER SUPPLIES UP TO 290V
- ANALOG SIMULATORS

DESCRIPTION

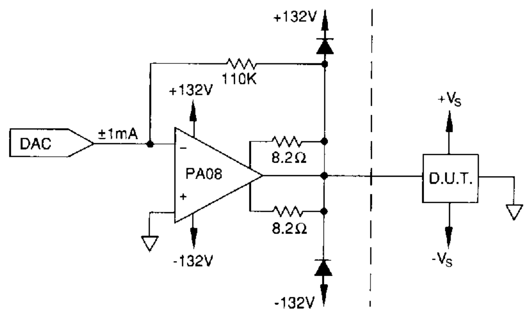
The PA08 is a high voltage operational amplifier designed for output voltage swings of up to ±145V with a dual (±) supply or 290V with a single supply. High accuracy is achieved with a cascode input circuit configuration. All internal biasing is referenced to a zener diode fed by a FET constant current source. As a result, the PA08 features an unprecedented supply range and excellent supply rejection. The output stage is biased-on for linear operation. Internal phase compensation assures stability at all gain settings. The safe operating area (SOA) can be observed with all types of loads by choosing the appropriate current limiting resistors. For operation into inductive loads, two external flyback pulse protection diodes are recommended. A heatsink may be necessary to maintain the proper case temperature under normal operating conditions.

This hybrid integrated circuit utilizes beryllia (BeO) substrate, thick film 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 isolation washers and/or improper mounting torque will void the product warranty. Please see "General Operating Considerations".

EQUIVALENT SCHEMATIC



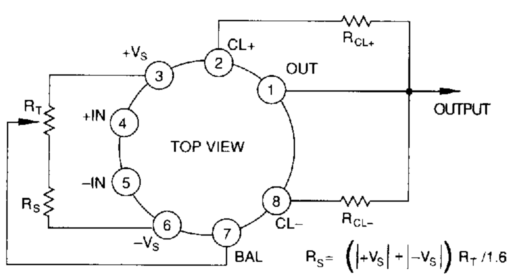
TYPICAL APPLICATION



ATE PIN DRIVER

The PA08 as a pin driver is capable of supplying high test voltages to a device under test (DUT). Due to the possibility of short circuits to any terminal of the DUT, current limit must be set to be safe when limiting with a supply to output voltage differential equal to the amplifier supply plus the largest magnitude voltage applied to any other pin of the DUT. In addition, flyback diodes are recommended when the output of the amplifier exits any equipment enclosure to prevent damage due to electrostatic discharges. Refer to Application Note 7 for details on accuracy considerations of this circuit.

EXTERNAL CONNECTIONS



$R_S = (|+V_S| + |-V_S|)\ R_T/1.6$

NOTE: Input offset voltage trim optional. R_T = 10KΩ MAX

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ABSOLUTE MAXIMUM RATINGS

SUPPLY VOLTAGE, $+V_S$ to $-V_S$	300V
OUTPUT CURRENT, within SOA	200mA
POWER DISSIPATION, internal at T_C = 25°C	17.5W
INPUT VOLTAGE, differential	±50V
INPUT VOLTAGE, common mode	$\pm V_S$
TEMPERATURE, pin solder - 10s max	300°C
TEMPERATURE, junction[1]	200°C
TEMPERATURE RANGE, storage	–65 to +150°C
OPERATING TEMPERATURE RANGE, case	–55 to +125°C

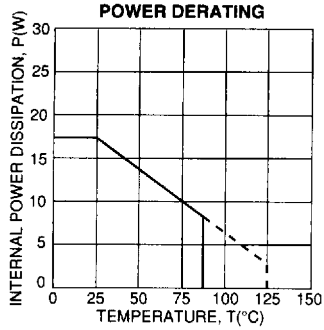
SPECIFICATIONS

PARAMETER	TEST CONDITIONS[2]	PA08 MIN	PA08 TYP	PA08 MAX	PA08A MIN	PA08A TYP	PA08A MAX	UNITS
INPUT								
OFFSET VOLTAGE, initial	T_C = 25°C		±.5	±2		±.25	±.5	mV
OFFSET VOLTAGE, vs. temperature	T_C = –25°C to +85°C		±15	±30		±5	±10	µV/°C
OFFSET VOLTAGE, vs. supply	T_C = 25°C		±.5			*	2	µV/V
OFFSET VOLTAGE, vs. time	T_C = 25°C		±75			*		µV/√kh
BIAS CURRENT, initial[3]	T_C = 25°C		5	50		3	10	pA
BIAS CURRENT, vs. supply	T_C = 25°C		.01			*		pA/V
OFFSET CURRENT, initial[3]	T_C = 25°C		±2.5	±50		±1.5	±10	pA
INPUT IMPEDANCE, DC	T_C = 25°C		10^5			*		MΩ
INPUT CAPACITANCE	T_C = 25°C		4			*		pF
COMMON MODE VOLTAGE RANGE[4]	T_C = –25°C to +85°C	$\pm V_S$–10			*			V
COMMON MODE REJECTION, DC	T_C = –25°C to +85°C, V_{CM} = ±90V		130			*		dB
GAIN								
OPEN LOOP GAIN at 10Hz	T_C = 25°C, $R_L = \infty$		118			*		dB
OPEN LOOP GAIN at 10Hz	T_C = 25°C, R_L = 1.2KΩ	96	111		*	*		dB
GAIN BANDWIDTH PRODUCT at 1MHz	T_C = 25°C, R_L = 1.2KΩ		5			*		MHz
POWER BANDWIDTH	T_C = 25°C, R_L = 1.2KΩ		90			*		kHz
PHASE MARGIN	T_C = –25 to +85°C		60			*		°
OUTPUT								
VOLTAGE SWING[4]	T_C = 25°C, I_O = 150mA	$\pm V_S$–15	$\pm V_S$–8		*	*		V
VOLTAGE SWING[4]	T_C = –25° C to +85°C, I_O = ±75mA	$\pm V_S$–10	$\pm V_S$–5		*	*		V
VOLTAGE SWING[4]	T_C = –25° C to +85°C, I_O = ±20mA	$\pm V_S$–5	$\pm V_S$–3		*	*		V
CURRENT, peak	T_C = 85°C	150			*			mA
SLEW RATE	T_C = 25°C		30		20	*		V/µs
CAPACITIVE LOAD, A_V = 1	T_C = –25 to +85°C			10			*	nF
CAPACITIVE LOAD, A_V > 4	T_C = –25 to +85°C			SOA			*	
SETTLING TIME to .1%	T_C = 25°C, R_L= 1.2KΩ, 2V step		1			*		µs
POWER SUPPLY								
VOLTAGE	T_C = –55 to +125°C	±15	±100	±150	*	*	*	V
CURRENT, quiescent	T_C = 25°C		6	8.5		*	*	mA
THERMAL								
RESISTANCE, AC junction to case[5]	T_C = –55 to +125°C, F > 60Hz		3.8			*		°C/W
RESISTANCE, DC junction to case	T_C = –55 to +125°C, F < 60Hz		6.0	6.5		*	*	°C/W
RESISTANCE, junction to air	T_C = –55 to +125°C		30			*		°C/W
TEMPERATURE RANGE, case	Meets full range specification	–25		85	*		*	°C

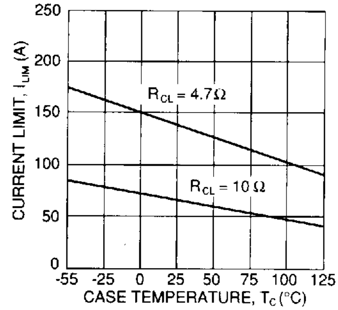
NOTES:
- * The specification of PA08A is identical to the specification for PA08 in applicable column to the left.
1. Long term operation at the maximum junction temperature will result in reduced product life. Derate power dissipation to achieve high MTTF.
2. The power supply voltage specified under typical (TYP) applies unless otherwise noted.
3. Doubles for every 10°C of temperature increase.
4. $+V_S$ and $-V_S$ denote the positive and negative supply rail respectively.
5. Rating applies only if 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.

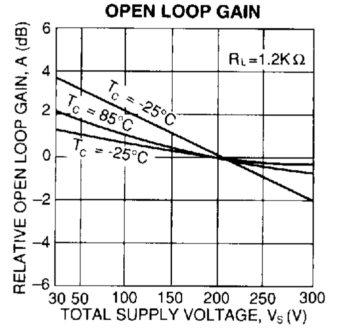
POWER DERATING



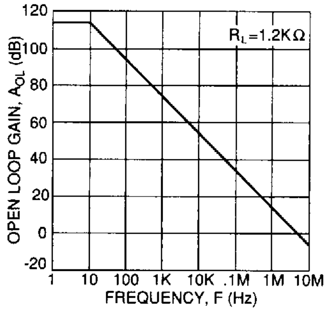
CURRENT LIMIT



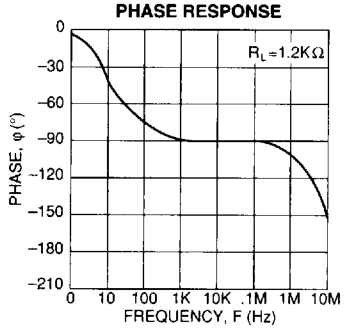
OPEN LOOP GAIN



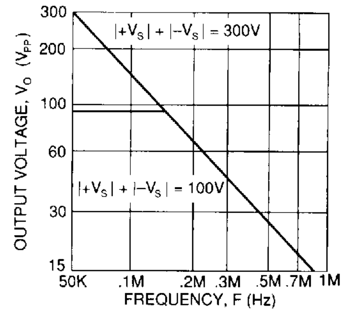
SMALL SIGNAL RESPONSE



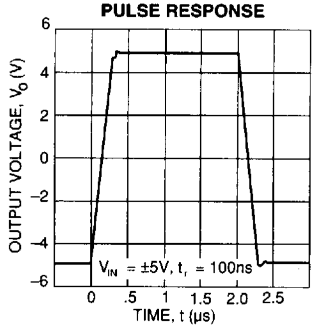
PHASE RESPONSE



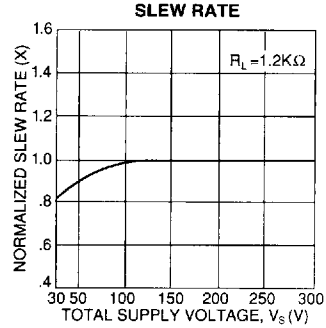
POWER RESPONSE



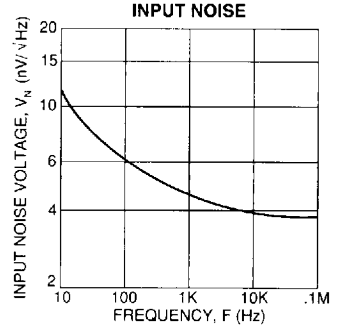
PULSE RESPONSE



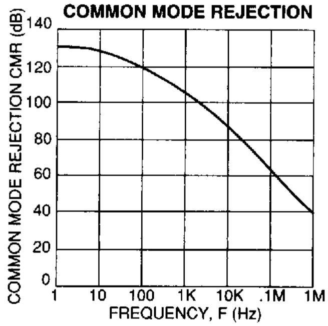
SLEW RATE



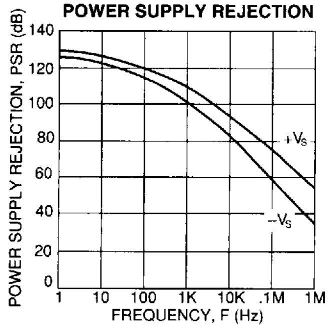
INPUT NOISE



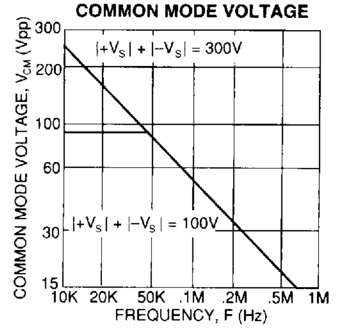
COMMON MODE REJECTION



POWER SUPPLY REJECTION



COMMON MODE VOLTAGE



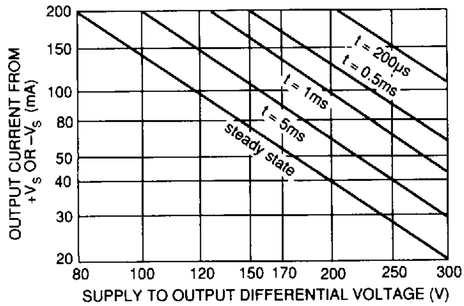
GENERAL

Please read the "General Operating Considerations", 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, see the "Package Outlines" and "Accessories" sections of the handbook.

SAFE OPERATING AREA (SOA)

The output stage of most power amplifiers has two 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.



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. However, the following guidelines may save extensive analytical efforts.

1. Under transient conditions, the following capacitive and inductive loads are safe with the current limits set to the maximum:

$\pm V_S$	C(MAX)	L(MAX)
150V	.4μF	280mH
125V	.9μF	380mH
100V	2μF	500mH
75V	10μF	1200mH
50V	100μF	13H

2. The amplifier can handle any EMF generating or reactive load and short circuits to the supply rails or simple shorts to common if the current limits are set as follows:

$\pm V_S$	SHORT TO $\pm V_{SC}$, C, L, OR EMF LOAD	SHORT TO COMMON
150V	20mA	67mA
125V	27mA	90mA
100V	42mA	130mA
75V	67mA	200mA
50V	130mA	200mA

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.

INDUCTIVE LOADS

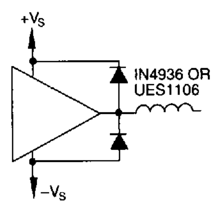
Two external diodes as shown in Figure 1, are required to protect these amplifiers from flyback (kickback) pulses exceeding the supply voltages of the amplifier when driving inductive loads. For component selection, these external diodes must be very quick, such as ultra fast recovery diodes with no more than 200 nanoseconds of reverse recovery time. The diode will turn on to divert the flyback energy into the supply rails thus protecting the output transistors from destruction due to reverse bias.

A note of caution about the supply. The energy of the flyback pulse must be absorbed by the power supply. As a result, a transient will be superimposed on the supply voltage, the magnitude of the transient being a function of its transient impedance and current sinking capability. If the supply voltage plus transient exceeds the maximum supply rating or if the AC impedance of the supply is unknown, it is best to clamp the output and the supply with a zener diode to absorb the transient.

INPUT PROTECTION

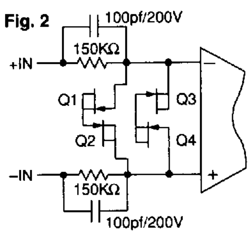
The input is protected against common mode voltages up to the supply rails and differential voltages up to ±50V. Increased protection against differential input voltages can be obtained by adding 2 resistors, 2 capacitors and 4 diode connected FETs as shown in Figure 2.

Fig. 1



PROTECTION, INDUCTIVE LOAD

Fig. 2



PROTECTION, OVERVOLTAGE

CURRENT LIMITING

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 3.24Ω. 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.

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TABLE 4 GROUP A INSPECTION

PA08M

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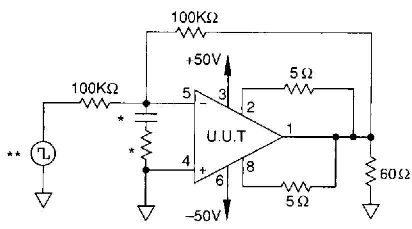
SG	PARAMETER	SYMBOL	TEMP.	POWER	TEST CONDITIONS	MIN	MAX	UNITS
1	Quiescent Current	I_Q	25°C	±100V	$V_{IN} = 0$, $A_V = 100$		8.5	mA
1	Input Offset Voltage	V_{OS}	25°C	±100V	$V_{IN} = 0$, $A_V = 100$		2	mV
1	Input Offset Voltage	V_{OS}	25°C	±15V	$V_{IN} = 0$, $A_V = 100$		3.7	mV
1	Input Offset Voltage	V_{OS}	25°C	±150V	$V_{IN} = 0$, $A_V = 100$		3	mV
1	Input Bias Current, +IN	$+I_B$	25°C	±100V	$V_{IN} = 0$		50	pA
1	Input Bias Current, –IN	$-I_B$	25°C	±100V	$V_{IN} = 0$		50	pA
1	Input Offset Current	I_{OS}	25°C	±100V	$V_{IN} = 0$		50	pA
3	Quiescent Current	I_Q	–55°C	±100V	$V_{IN} = 0$, $A_V = 100$		9.5	mA
3	Input Offset Voltage	V_{OS}	–55°C	±100V	$V_{IN} = 0$, $A_V = 100$		4.4	mV
3	Input Offset Voltage	V_{OS}	–55°C	±15V	$V_{IN} = 0$, $A_V = 100$		6.1	mV
3	Input Offset Voltage	V_{OS}	–55°C	±150V	$V_{IN} = 0$, $A_V = 100$		5.4	mV
3	Input Bias Current, +IN	$+I_B$	–55°C	±100V	$V_{IN} = 0$		50	pA
3	Input BiasCurrent, –IN	$-I_B$	–55°C	±100V	$V_{IN} = 0$		50	pA
3	Input Offset Current	I_{OS}	–55°C	±100V	$V_{IN} = 0$		50	pA
2	Quiescent Current	I_Q	125°C	±100V	$V_{IN} = 0$, $A_V = 100$		11	mA
2	Input Offset Voltage	V_{OS}	125°C	±100V	$V_{IN} = 0$, $A_V = 100$		5	mV
2	Input Offset Voltage	V_{OS}	125°C	±15V	$V_{IN} = 0$, $A_V = 100$		6.7	mV
2	Input Offset Voltage	V_{OS}	125°C	±150V	$V_{IN} = 0$, $A_V = 100$		6	mV
2	Input Bias Current, +IN	$+I_B$	125°C	±100V	$V_{IN} = 0$		10	nA
2	Input Bias Current, –IN	$-I_B$	125°C	±100V	$V_{IN} = 0$		10	nA
2	Input Offset Current	I_{OS}	125°C	±100V	$V_{IN} = 0$		10	nA
4	Output Voltage, I_O = 150mA	V_O	25°C	±31V	$R_L = 100\Omega$	15		V
4	Output Voltage, I_O = 29mA	V_O	25°C	±150V	$R_L = 5K$	145		V
4	Output Voltage, I_O = 80mA	V_O	25°C	± 90V	$R_L = 1K$	80		V
4	Current Limits	I_{CL}	25°C	±30V	$R_L = 100\Omega$	75	125	mA
4	Stability/Noise	E_N	25°C	±100V	$R_L = 5K$, $A_V = 1$, $C_L = 10nF$		1	mV
4	Slew Rate	SR	25°C	±100V	$R_L = 5K$	20	100	V/µs
4	Open Loop Gain	A_{OL}	25°C	±100V	$R_L = 5K$, F = 10Hz	96		dB
4	Common Mode Rejection	CMR	25°C	±32.5V	$R_L = 5K$, F = DC, $V_{CM} = \pm 22.5V$	90		dB
6	Output Voltage, I_O = 100mA	V_O	–55°C	±31V	$R_L = 100\Omega$	10		V
6	Output Voltage, I_O = 29mA	V_O	–55°C	±150V	$R_L = 5K$	145		V
6	Output Voltage, I_O = 70mA	V_O	–55°C	±90V	$R_L = 1K$	70		V
6	Stability/Noise	E_N	–55°C	±100V	$R_L = 5K$, $A_V = 1$, $C_L = 10nF$		1	mV
6	Slew Rate	SR	–55°C	±100V	$R_L = 5K$	20	100	V/µs
6	Open Loop Gain	A_{OL}	–55°C	±100V	$R_L = 5K$, F = 10Hz	96		dB
6	Common Mode Rejection	CMR	–55°C	±32.5V	$R_L = 5K$, F = DC, $V_{CM} = \pm 22.5V$	90		dB
5	Output Voltage, I_O = 150mA	V_O	125°C	±31V	$R_L = 100\Omega$	15		V
5	Output Voltage, I_O = 29mA	V_O	125°C	±150V	$R_L = 5K$	145		V
5	Output Voltage, I_O = 80mA	V_O	125°C	±90V	$R_L = 1K$	80		V
5	Stability/Noise	E_N	125°C	±100V	$R_L = 5K$, $A_V = 1$, $C_L = 10nF$		1	mV
5	Slew Rate	SR	125°C	±100V	$R_L = 5K$	20	100	V/µs
5	Open Loop Gain	A_{OL}	125°C	±100V	$R_L = 5K$, F = 10Hz	96		dB
5	Common Mode Rejection	CMR	125°C	±32.5V	$R_L = 5K$, F = DC, $V_{CM} = \pm 22.5V$	90		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.

PA08V

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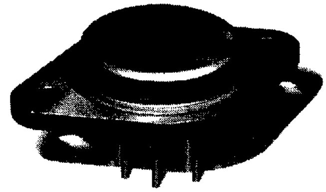
FEATURES

- **EXTENDED SUPPLY RANGE**
  UP TO ±175V or
  350V TOTAL
- **PROVIDES PA08 PERFORMANCE**
  UP TO ±150mA
  PROGRAMMABLE CURRENT LIMIT
  LOW DRIFT FET INPUT



APPLICATIONS

- **PROGRAMMABLE POWER SUPPLIES UP TO 340V**
- **ELECTROSTATIC TRANSDUCERS & DEFLECTION**
- **PIEZO ELECTRIC TRANSDUCERS**
- **HIGH VOLTAGE INSTRUMENTATION**

Please consult the PA08 data sheet for basic information on this amplifier, plus the application notes in this APEX DATA BOOK, for recommendations on stability, current limiting, heatsinks, bypassing, and suggestions for circuit functions.

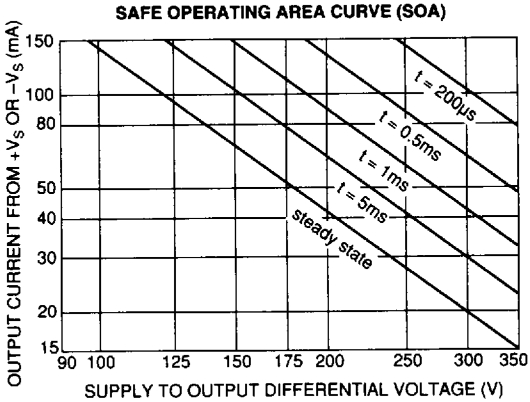
DESCRIPTION

The PA08V is an extended supply range operational amplifier capable of output voltage swings of ±170V with dual supplies or 340V total supply voltage on single or non-symmetric supplies.

High accuracy is achieved with a cascode input circuit configuration. All internal biasing is referenced to a zener diode fed by a FET constant current source. As a result, the PA08 features an unprecedented supply range and excellent supply rejection. The output stage is biased class A-B for linear operation. Internal phase compensation assures stability at all gain settings. The safe operating area (SOA) can be observed with all types of loads by choosing the appropriate current limiting resistors. For operation into inductive loads, two external flyback pulse protection diodes are recommended. A heatsink may be necessary to maintain the proper case temperature under normal operating conditions.

This hybrid integrated circuit utilizes a beryllia (BeO) substrate, thick film 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 TO-3 package is hermetically sealed and electrically isolated. The use of compressible thermal isolation washers and/or improper mounting torque will void the product warranty. Please see "General Operating Considerations".

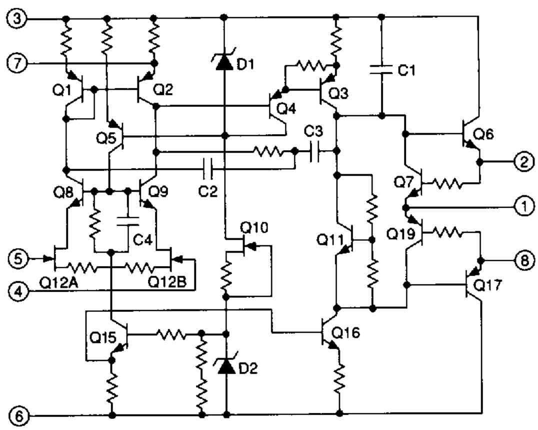
SAFE OPERATING AREA CURVE (SOA)



SPECIFICATIONS

Specifications of the standard PA08 apply with the benefit of supply ratings being extended to ±175V. Design changes enabling the total supply rating of 350V have no effect on the shape of the typical performance graphs.

EQUIVALENT SCHEMATIC



GENERAL CONSIDERATIONS

SAFE OPERATING AREA

The extended safe operating area is as follows:

When operating on ±175V, maximum safe values of capacitive and inductive loading are .2μF and 200mH. Maximum safe current limit for a short to common is 50mA, and for a short to supply rails, the maximum is 15mA.