



PA83 • PA83A

POWER OPERATIONAL AMPLIFIERS

FEATURES

- LOW BIAS CURRENT, LOW NOISE - FET Input
- PROTECTED OUTPUT - Thermal Shutoff
- FULLY PROTECTED INPUT - Up to $\pm 150V$
- WIDE SUPPLY RANGE - $\pm 15V$ to $\pm 150V$
- SECOND SOURCEABLE - BB3583AM/JM

APPLICATIONS

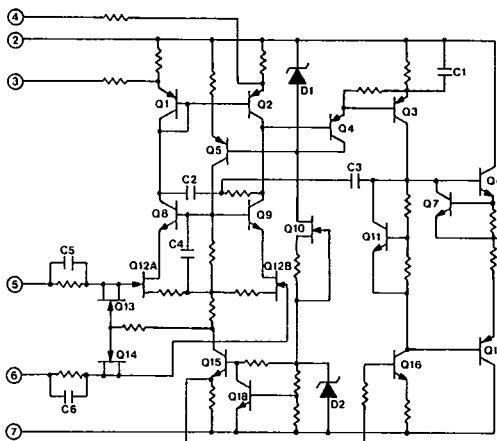
- HIGH VOLTAGE INSTRUMENTATION
- ELECTROSTATIC TRANSDUCERS & DEFLECTION
- PROGRAMMABLE POWER SUPPLIES UP TO 290V
- ANALOG SIMULATORS

DESCRIPTION

The PA83 is a high voltage operational amplifier designed for output voltage swings up to $\pm 145V$ with a dual ($\pm$) supply or 290V with a single supply. Its input stage is protected against transient and steady state overvoltages up to and including the supply rails. 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 PA83 features an unprecedented supply range and excellent supply rejection. The output stage is biased in the class A/B mode for linear operation. Internal phase compensation assures stability at all gain settings without need for external components. Fixed current limits protect these amplifiers against shorts to common at supply voltages up to 120V. For operation into inductive loads, two external flyback pulse protection diodes are recommended. A built-in thermal shutoff circuit prevents destructive overheating. However, a heatsink may be necessary to maintain the proper case temperature under normal operating conditions.

This hybrid circuit utilizes beryllia (BeO) substrates, thick (cermet) film resistors, ceramic capacitors and silicon 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 washers may void the warranty.

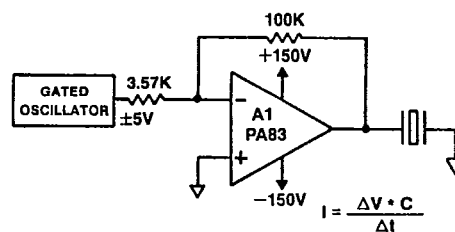
EQUIVALENT SCHEMATIC



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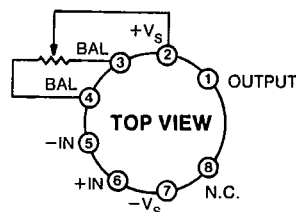
TYPICAL APPLICATION



SIMPLE PIEZO ELECTRIC TRANSDUCER DRIVE

While piezo electric transducers present a complex impedance, they are often primarily capacitive at useful frequencies. Due to this capacitance, the speed limitation for a given transducer/amplifier combination may well stem from limited current drive rather than power bandwidth restrictions. With its drive capability of 75mA, the PA83 can drive transducers having up to 2nF of capacitance at 40kHz at maximum output voltage. In the event the transducer may be subject to shock or vibration, flyback diodes, voltage clamps or other protection networks must be added to protect the amplifier from high voltages which may be generated.

EXTERNAL CONNECTIONS



- NOTES: 1. Pin 8 not internally connected.
2. Input offset trimpot optional. Recommended value 100K Ω .

PA83 ABSOLUTE MAXIMUM RATINGS

T-79-23

SUPPLY VOLTAGE, $+V_s$ to $-V_s$	300V
OUTPUT CURRENT, within SOA	Internally Limited
POWER DISSIPATION, internal at $T_c = 25^\circ\text{C}$ ¹	17.5W
INPUT VOLTAGE, differential	$\pm 300\text{V}$
INPUT VOLTAGE, common-mode	$\pm 300\text{V}$
TEMPERATURE, pin solder-10s max (solder)	300°C
TEMPERATURE, junction	150°C
TEMPERATURE RANGE, storage	-65 to +150°C
OPERATING TEMPERATURE RANGE, case	-55 to +125°C

SPECIFICATIONS

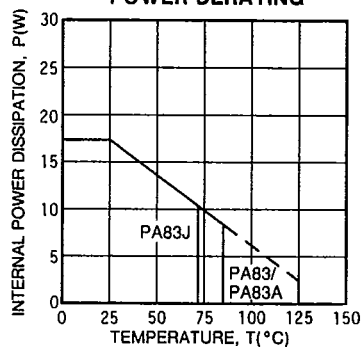
		PA83/PA83J			PA83A			
PARAMETER	TEST CONDITIONS ²	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
INPUT								
OFFSET VOLTAGE, initial	T _c = 25°C		±1.5	±3		±.5	±1	mV
OFFSET VOLTAGE, vs. temperature	Full temperature range		±10	±25		±5	±10	μV/°C
OFFSET VOLTAGE, vs. supply	T _c = 25°C		±.5			±.2		μV/V
OFFSET VOLTAGE, vs. time	T _c = 25°C		±75			*		μV/√kHz
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
OFFSET CURRENT, vs. supply	T _c = 25°C		±.01			*		pA/V
INPUT IMPEDANCE, dc	T _c = 25°C		10 ¹¹			*		Ω
INPUT CAPACITANCE	Full temperature range		6			*		pF
COMMON-MODE VOLTAGE RANGE ⁴	Full temperature range	±V _s -10			*			V
COMMON-MODE REJECTION, dc	Full temperature range		130			*		db
GAIN								
OPEN LOOP GAIN at 10Hz	T _c = 25°C, R _L = 2KΩ	96	116		*	*		db
UNITY GAIN CROSSOVER FREQ.	T _c = 25°C, R _L = 2KΩ		5		3	*		MHz
POWER BANDWIDTH	T _c = 25°C, R _L = 10KΩ		60		40	*		kHz
PHASE MARGIN	Full temperature range		60			*		°
OUTPUT								
VOLTAGE SWING ⁴ , full load	Full temp. range, I _o = 75mA	±V _s -10	±V _s -5		*	*		V
VOLTAGE SWING ⁴	Full temp. range, I _o = 15mA	±V _s -5	±V _s -3		*	*		V
CURRENT, peak	T _c = 25°C	75			*	*		mA
CURRENT, short circuit	T _c = 25°C		100			*		mA
SLEW RATE ⁵	T _c = 25°C, R _L = 2KΩ	20	30	10	*	*	*	V/μs
CAPACITIVE LOAD, unity gain	Full temperature range			SOA			*	nF
CAPACITIVE LOAD, gain>4	Full temperature range					*	*	μF
SETTLING TIME to 0.1%	T _c = 25°C, R _L = 2KΩ, 10V step		12			*		μs
POWER SUPPLY								
VOLTAGE	T _c = -55 to +125°C	±15	±150	±150	*	*	*	V
CURRENT, quiescent	T _c = 25°C		6	8.5		*	*	mA
THERMAL								
RESISTANCE, ac ⁶ junction to case	F>60Hz		3.8			*		°C/W
RESISTANCE, dc junction to case	F<60Hz		6	6.5		*	*	°C/W
RESISTANCE, case to air			30			*		°C/W
TEMP. RANGE, case (PA83/PA83A)	Meets full range specification	-25		+85	*		*	°C
TEMP. RANGE, case (PA83J)	Meets full range specification	0		70				°C

- NOTES:**
- * The specification of PA83A is identical to the specification for PA83 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 for all tests is the TYP rating unless otherwise specified as a test condition.
 - 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 if the output current alternates between both output transistors at a rate faster than 60Hz.
 - 6. Signal slew rates at pins 5 and 6 must be limited to less than 1V/ns to avoid damage. When faster waveforms are unavoidable, resistors in series with those pins, limiting current to 150mA will protect the amplifier from damage.
- 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.

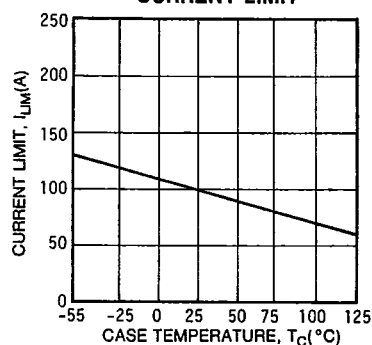
PA83 TYPICAL PERFORMANCE GRAPHS

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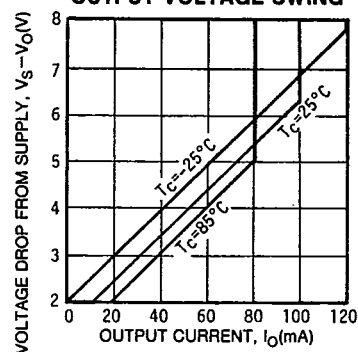
POWER DERATING



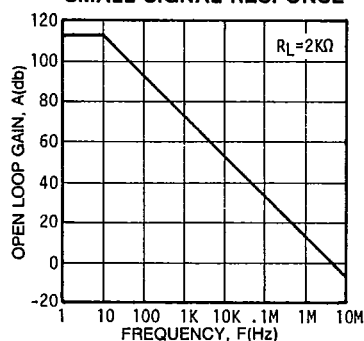
CURRENT LIMIT



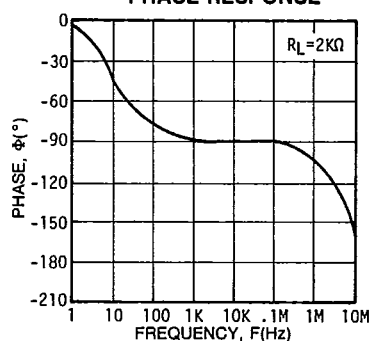
OUTPUT VOLTAGE SWING



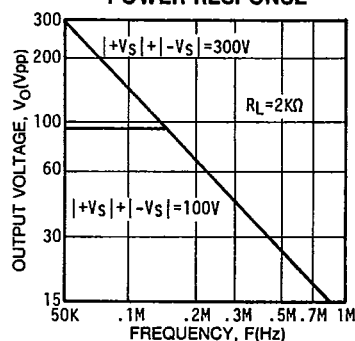
SMALL SIGNAL RESPONSE



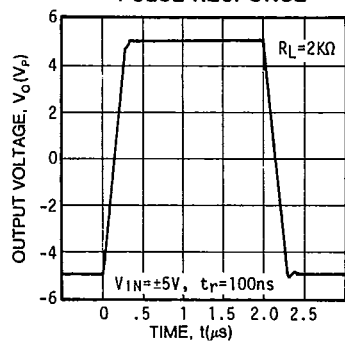
PHASE RESPONSE



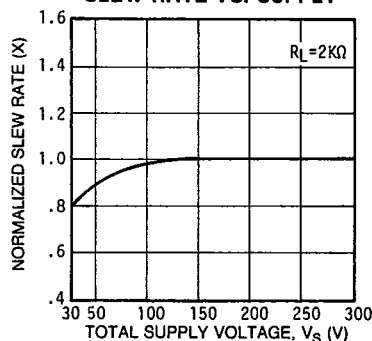
POWER RESPONSE



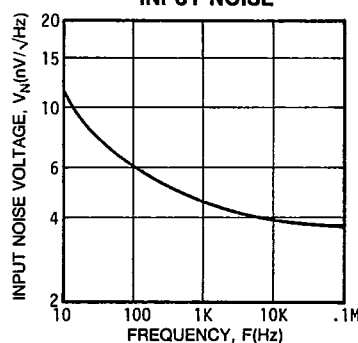
PULSE RESPONSE



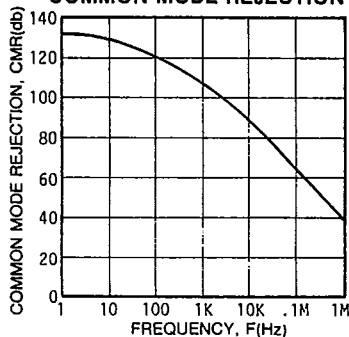
SLEW RATE VS. SUPPLY



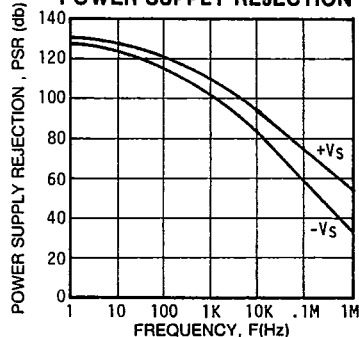
INPUT NOISE



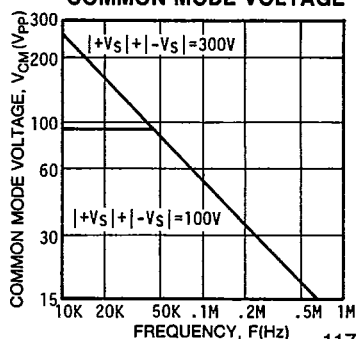
COMMON MODE REJECTION



POWER SUPPLY REJECTION



COMMON MODE VOLTAGE



PA83 OPERATING CONSIDERATIONS

T-79-23

GENERAL

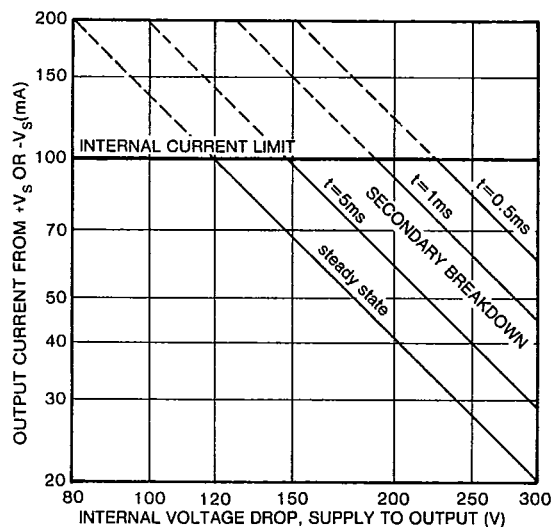
Please read the "General Operating Considerations" section, which covers stability, supplies, heatsinking, mounting, current limit, SOA interpretation, and specification interpretation. Additional information can be found in the applications notes. For information on the package outline, heatsinks, and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

SAFE OPERATING AREA (SOA)

The bipolar output stage of this high voltage amplifier has two distinct limitations:

1. The internal current limit, which limits maximum available output current.
2. The secondary breakdown effect, which occurs whenever the simultaneous collector current and collector-emitter voltage exceed specified limits.

SAFE OPERATING AREA CURVES



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. The following capacitive and inductive loads are safe:

$\pm V_s$	C(MAX)	L(MAX)
150V	.7 μ F	1.5H
125V	2.0 μ F	2.5H
100V	5.0 μ F	6.0H
75V	60 μ F	30H
50V	ALL	ALL
2. Short circuits to ground are safe with dual supplies up to $\pm 120V$ or single supplies up to 120V.
3. Short circuits to the supply rails are safe with total supply voltages up to 120V. (ie $\pm 60V$).
4. The output stage is protected against transient flyback. However, for protection against sustained, high energy flyback, external fast-recovery diodes should be used.

THERMAL SHUTDOWN PROTECTION

The thermal protection circuit shuts off the amplifier when the substrate temperature exceeds approximately 150°C. This allows heatsink selection to be based on normal operating conditions while protecting the amplifier against excessive junction temperature during temporary fault conditions.

Thermal protection is a fairly slow-acting circuit and therefore does not protect the amplifier against transient SOA violations (areas outside of the $T_c = 25^\circ C$ boundary). It is designed to protect against short-term fault conditions that result in high power dissipation within the amplifier. If the conditions that cause thermal shutdown are not removed, the amplifier will oscillate in and out of shutdown. This will result in high peak power stresses, destroy signal integrity, and reduce the reliability of the device.

INDUCTIVE LOADS

Two external diodes as shown in figure 1, are required to protect these amplifiers against 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.

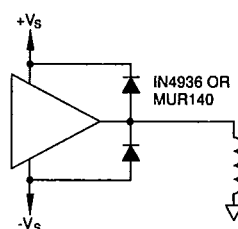


FIGURE 1. PROTECTION, INDUCTIVE LOAD.



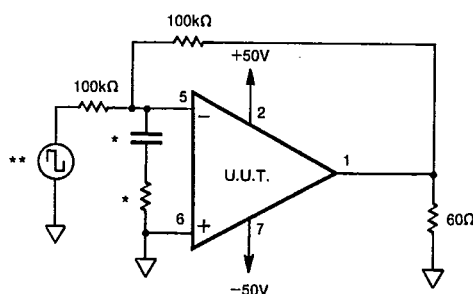
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PA83M

TABLE 4 — GROUP A INSPECTION

SG	PARAMETER	SYMBOL	TEMP	PWR	TEST CONDITIONS	MIN	MAX	UNITS
1	Quiescent Current	I_Q	25°C	±150V	$V_{IN} = 0, G = 100$		8.5	mA
1	Input Offset Voltage	V_{OS}	25°C	±150V	$V_{IN} = 0, G = 100$		3	mV
1	Input Offset Voltage	V_{OS}	25°C	±15V	$V_{IN} = 0, G = 100$		5.7	mV
1	Input Bias Current, +IN	$+I_B$	25°C	±150V	$V_{IN} = 0, G = 100$		50	pA
1	Input Bias Current, -IN	$-I_B$	25°C	±150V	$V_{IN} = 0, G = 100$		50	pA
1	Input Offset Current	I_{OS}	25°C	±150V	$V_{IN} = 0, G = 100$		50	pA
3	Quiescent Current	I_Q	-55°C	±150V	$V_{IN} = 0, G = 100$		10	mA
3	Input Offset Voltage	V_{OS}	-55°C	±150V	$V_{IN} = 0, G = 100$		5	mV
3	Input Offset Voltage	V_{OS}	-55°C	±15V	$V_{IN} = 0, G = 100$		7.7	mV
3	Input Bias Current, +IN	$+I_B$	-55°C	±150V	$V_{IN} = 0, G = 100$		50	pA
3	Input Bias Current, -IN	$-I_B$	-55°C	±150V	$V_{IN} = 0, G = 100$		50	pA
3	Input Offset Current	I_{OS}	-55°C	±150V	$V_{IN} = 0, G = 100$		50	pA
2	Quiescent Current	I_Q	125°C	±150V	$V_{IN} = 0, G = 100$		10	mA
2	Input Offset Voltage	V_{OS}	125°C	±150V	$V_{IN} = 0, G = 100$		5.5	mV
2	Input Offset Voltage	V_{OS}	125°C	±15V	$V_{IN} = 0, G = 100$		8.2	mV
2	Input Bias Current, +IN	$+I_B$	125°C	±150V	$V_{IN} = 0, G = 100$		10	nA
2	Input Bias Current, -IN	$-I_B$	125°C	±150V	$V_{IN} = 0, G = 100$		10	nA
2	Input Offset Current	I_{OS}	125°C	±150V	$V_{IN} = 0, G = 100$		10	nA
4	Output Voltage, $I_O = 75mA$	V_O	25°C	±85V	$R_L = 1K$	75		V
4	Output Voltage, $I_O = 29mA$	V_O	25°C	±150V	$R_L = 5K$	145		V
4	Current Limits	I_{CL}	25°C	±30V	$R_L = 100\Omega$	75	125	mA
4	Stability/Noise	E_N	25°C	±150V	$R_L = 5K, G = 1, C_L = 10nF$		1	mV
4	Slew Rate	SR	25°C	±150V	$R_L = 5K$	20	60	V/ μs
4	Open Loop Gain	A_{OL}	25°C	±150V	$R_L = 5K, f = 10Hz$	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, $I_O = 40mA$	V_O	-55°C	±45V	$R_L = 1K$	40		V
6	Output Voltage, $I_O = 29mA$	V_O	-55°C	±150V	$R_L = 5K$	145		V
6	Stability/Noise	E_N	-55°C	±150V	$R_L = 5K, G = 1, C_L = 10nF$		1	mV
6	Slew Rate	SR	-55°C	±150V	$R_L = 5K$	20	60	V/ μs
6	Open Loop Gain	A_{OL}	-55°C	±150V	$R_L = 5K, f = 10Hz$	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, $I_O = 40mA$	V_O	125°C	±45V	$R_L = 1K$	40		V
5	Output Voltage, $I_O = 29mA$	V_O	125°C	±150V	$R_L = 5K$	145		V
5	Stability/Noise	E_N	125°C	±150V	$R_L = 5K, G = 1, C_L = 10nF$		1	mV
5	Slew Rate	SR	125°C	±150V	$R_L = 5K$	20	60	V/ μs
5	Open Loop Gain	A_{OL}	125°C	±150V	$R_L = 5K, f = 10Hz$	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.

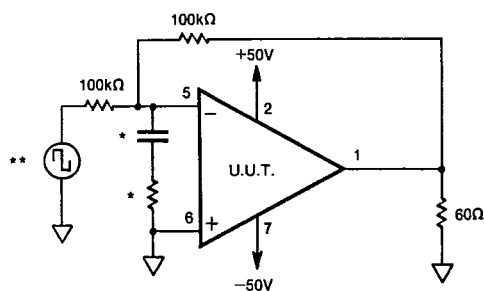
**Input signals are calculated to result in internal power dissipation of approximately 2.1W at case temperature = 125°C.



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PA83Q
 100% TEST TABLE

SG	PARAMETER	SYMBOL	TEMP	PWR	TEST CONDITIONS	MIN	MAX	UNITS
1	Quiescent Current	I_o	25°C	±150V	$V_{IN} = 0, G = 100$		8.5	mA
1	Input Offset Voltage	V_{os}	25°C	±150V	$V_{IN} = 0, G = 100$		3	mV
1	Input Offset Voltage	V_{os}	25°C	±15V	$V_{IN} = 0, G = 100$		5.7	mV
1	Input Bias Current, +IN	$+I_b$	25°C	±150V	$V_{IN} = 0, G = 100$		50	pA
1	Input Bias Current, -IN	$-I_b$	25°C	±150V	$V_{IN} = 0, G = 100$		50	pA
1	Input Offset Current	I_{os}	25°C	±150V	$V_{IN} = 0, G = 100$		50	pA
3	Quiescent Current	I_o	-25°C	±150V	$V_{IN} = 0, G = 100$		10	mA
3	Input Offset Voltage	V_{os}	-25°C	±150V	$V_{IN} = 0, G = 100$		4.2	mV
3	Input Offset Voltage	V_{os}	-25°C	±15V	$V_{IN} = 0, G = 100$		6.9	mV
3	Input Bias Current, +IN	$+I_b$	-25°C	±150V	$V_{IN} = 0, G = 100$		50	pA
3	Input Bias Current, -IN	$-I_b$	-25°C	±150V	$V_{IN} = 0, G = 100$		50	pA
3	Input Offset Current	I_{os}	-25°C	±150V	$V_{IN} = 0, G = 100$		50	pA
2	Quiescent Current	I_o	85°C	±150V	$V_{IN} = 0, G = 100$		10	mA
2	Input Offset Voltage	V_{os}	85°C	±150V	$V_{IN} = 0, G = 100$		4.5	mV
2	Input Offset Voltage	V_{os}	85°C	±15V	$V_{IN} = 0, G = 100$		7.2	mV
2	Input Bias Current, +IN	$+I_b$	85°C	±150V	$V_{IN} = 0, G = 100$		3.2	nA
2	Input Bias Current, -IN	$-I_b$	85°C	±150V	$V_{IN} = 0, G = 100$		3.2	nA
2	Input Offset Current	I_{os}	85°C	±150V	$V_{IN} = 0, G = 100$		3.2	nA
4	Output Voltage, $I_o = 75mA$	V_o	25°C	±85V	$R_L = 1K$	75		V
4	Output Voltage, $I_o = 75mA$	V_o	25°C	±85V	$R_L = 5K$	145		V
4	Current Limits	I_{CL}	25°C	±30V	$R_L = 100\Omega$	75		mA
4	Stability/Noise	E_N	25°C	±150V	$R_L = 5K, G = 1, C_L = 10nF$		1	mV
4	Slew Rate	SR	25°C	±150V	$R_L = 5K$	20	60	V/ μs
4	Open Loop Gain	A_{OL}	25°C	±150V	$R_L = 5K, f = 10Hz$	96		db
4	Common-mode Rejection	CMR	25°C	±32V	$R_L = 5K, f = DC, V_{CM} = \pm 22.5V$	90		db
6	Output Voltage, $I_o = 55mA$	V_o	-25°C	±65V	$R_L = 1K$	3		V
6	Output Voltage, $I_o = 29mA$	V_o	-25°C	±150V	$R_L = 5K$	145		V
6	Stability/Noise	E_N	-25°C	±150V	$R_L = 5K, G = 1, C_L = 10nF$		1	mV
6	Slew Rate	SR	-25°C	±150V	$R_L = 5K$	20	60	V/ μs
6	Open Loop Gain	A_{OL}	-25°C	±150V	$R_L = 5K, f = 10Hz$	96		db
6	Common-mode Rejection	CMR	-25°C	±32V	$R_L = 5K, f = DC, V_{CM} = \pm 22.5V$	90		db
5	Output Voltage, $I_o = 55mA$	V_o	85°C	±65V	$R_L = 1K$	55		V
5	Output Voltage, $I_o = 29mA$	V_o	85°C	±150V	$R_L = 5K$	145		V
5	Stability/Noise	E_N	85°C	±150V	$R_L = 5K, G = 1, C_L = 10nF$		1	mV
5	Slew Rate	SR	85°C	±150V	$R_L = 5K$	20	60	V/ μs
5	Open Loop Gain	A_{OL}	85°C	±150V	$R_L = 5K, f = 10Hz$	96		db
5	Common-mode Rejection	CMR	85°C	±32V	$R_L = 5K, f = DC, V_{CM} = \pm 22.5V$	90		db

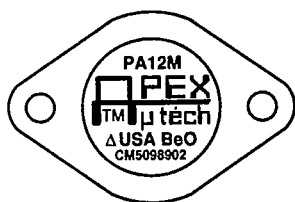
BURN IN CIRCUIT:

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

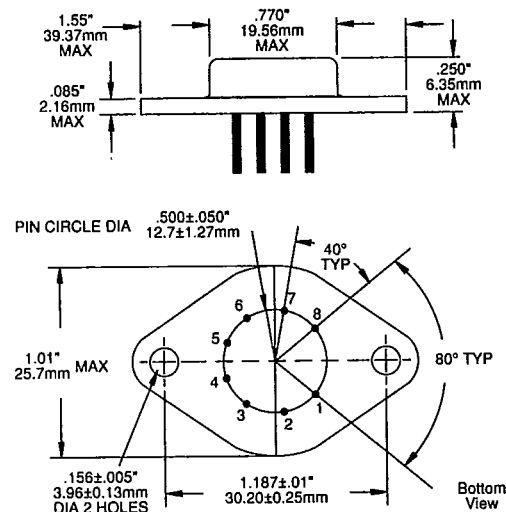
**Input signals are calculated to result in internal power dissipation of approximately 2.1W at case temperature = 125°C.

PACKAGE OUTLINE DIMENSIONS

STANDARD 8 PIN TO-3



NOTE: ESD triangle (Δ) on top of package denotes pin 1 location.



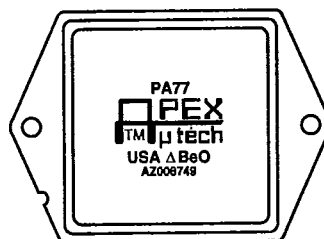
PIN DIAMETER: .967/1.07mm or .038/.042"
 PIN LENGTH: 11.4/12.7mm or .450/.500"
 PIN MATERIAL, STD: Nickel plated alloy 52, solderable
 PIN MATERIAL, MIL: Gold plated alloy 52, solderable
 PACKAGE: Hermetic, nickel plated steel
 WEIGHT: 15 grams or .53 ounces
 ISOLATION: 500VDC any pin to case
 SOCKETS: APEX PN: MS03
 CAGE JACKS: APEX PN: MS02 (Set of 8)
 HEATSINKS: APEX PN: HS01 thru HS05

CAUTION

Recommended mounting torque
 is 4 – 7 in•lbs (.45 – .79 N•m)

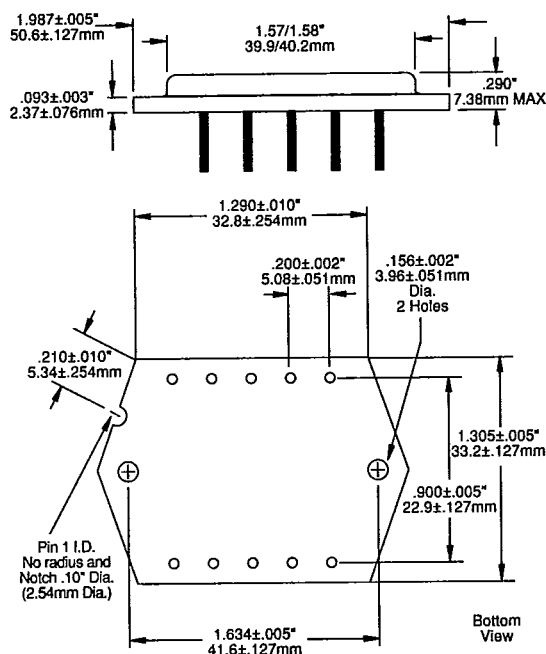
POWER PD10

T-90-20



NOTE: Notch on package base denotes pin 1 location.

PD10/60S



PIN DIAMETER: 1.47/1.58mm or .058/.062"
 PIN LENGTH: 11.4/12.7mm or .450/.500"
 PIN MATERIAL, STD: Nickel plated steel
 PACKAGE: Hermetic, nickel plated steel
 WEIGHT: 36 grams or 1.27 ounces
 ISOLATION: 500VDC any pin to case
 CAGE JACKS: MS04 (Set of 12)

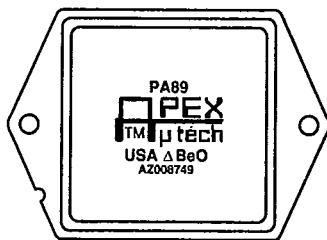
CAUTION

Recommended mounting torque
 is 8 – 10 in•lbs (.90 – 1.13 N•m)

PACKAGE OUTLINE DIMENSIONS

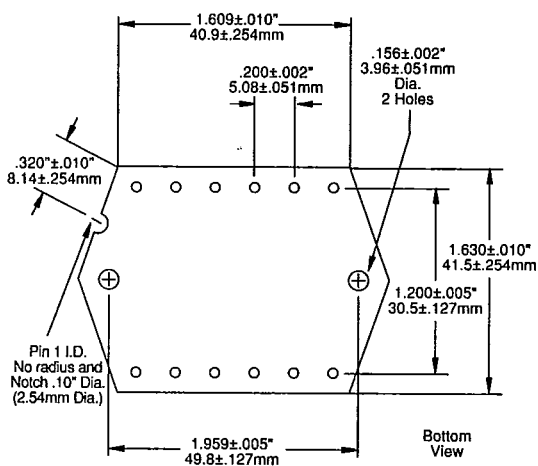
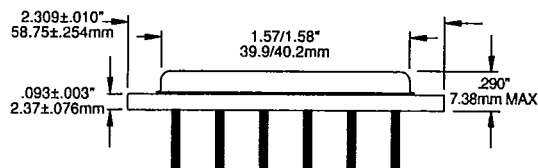
T-90-20

HIGH VOLTAGE PD12



NOTE: Notch on package base denotes pin 1 location.

PD12/25S

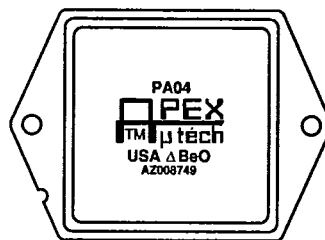


PIN DIAMETER: .585/.687mm or .023/.027"
 PIN LENGTH: 11.4/12.7mm or .450/.500"
 PIN MATERIAL, STD: Nickel plated steel
 PACKAGE: Hermetic, nickel plated steel
 WEIGHT: 53 grams or 1.87 ounces
 ISOLATION: 1200VDC any pin to case

CAUTION

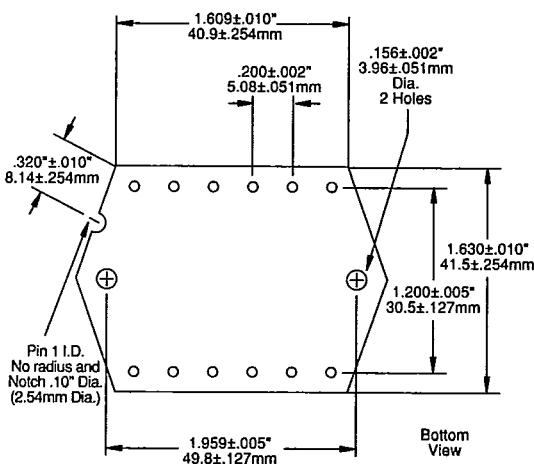
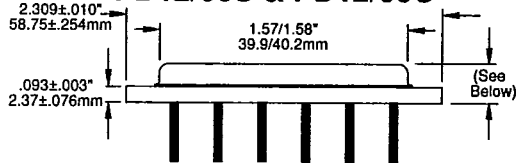
Recommended mounting torque
 is 8 – 10 in•lbs (.90 – 1.13 N•m)

HIGH POWER PD12



NOTE: Notch on package base denotes pin 1 location.

PD12/60S & PD12/60C



PIN DIAMETER: 1.47/1.58mm or .058/.062"
 PIN LENGTH: 11.4/12.7mm or .450/.500"
 PIN MATERIAL, STD: Nickel plated steel
 ISOLATION: PD12/60S: 500VDC any pin to case
 PD12/60C: 300VDC any pin to case
 HEIGHT: PD12/60S: 7.38mm or .290" MAX
 PD12/60C: 8.90mm or .350" MAX
 PACKAGE: PD12/60S: Hermetic, nickel plated steel
 PD12/60C: Base: Nickel plated copper
 PD12/60C: Cap: Hermetic, nickel plated steel
 WEIGHT: PD12/60S: 53 grams or 1.87 ounces
 PD12/60C: 58 grams or 2.05 ounces
 CAGE JACKS: Apex PN: MS04 (Set of 12)
 HEAT SINKS: Apex PN: HS06
 MATING SOCKET: Apex PN: MS05

CAUTION

Recommended mounting torque is
 8–10 in•lbs (.90–1.13 N•m)