PA10 • PA10A

FEATURES

- GAIN BANDWIDTH PRODUCT — 4MHz
- TEMPERATURE RANGE — –55 to +125°C (PA10A)
- EXCELLENT LINEARITY — Class A/B Output
- WIDE SUPPLY RANGE — ±10V to ±50V
- HIGH OUTPUT CURRENT — ±5A Peak

APPLICATIONS

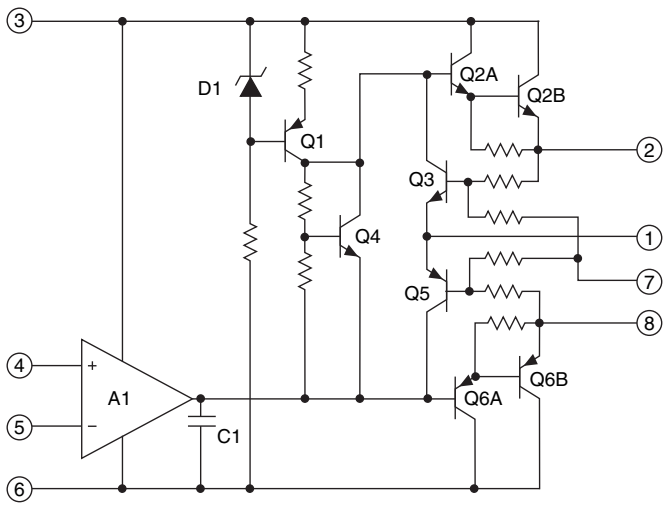
- MOTOR, VALVE AND ACTUATOR CONTROL
- MAGNETIC DEFLECTION CIRCUITS UP TO 4A
- POWER TRANSDUCERS UP TO 100kHz
- TEMPERATURE CONTROL UP TO 180W
- PROGRAMMABLE POWER SUPPLIES UP TO 90V
- AUDIO AMPLIFIERS UP TO 60W RMS

DESCRIPTION

The PA10 and PA10A are high voltage, high output current operational amplifiers designed to drive resistive, inductive and capacitive loads. For optimum linearity, the output stage is biased for class A/B operation. The safe operating area (SOA) 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, 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 isolation washers voids the warranty.

EQUIVALENT SCHEMATIC



8-PIN TO-3
PACKAGE STYLE CE

TYPICAL APPLICATION

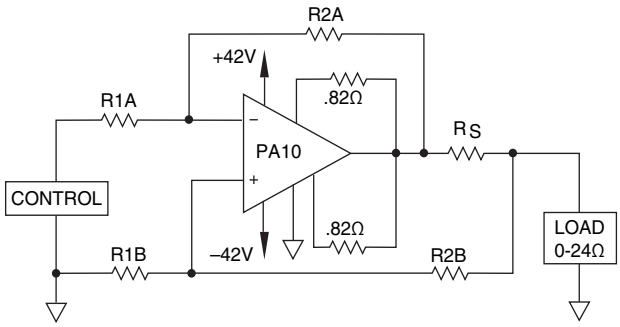
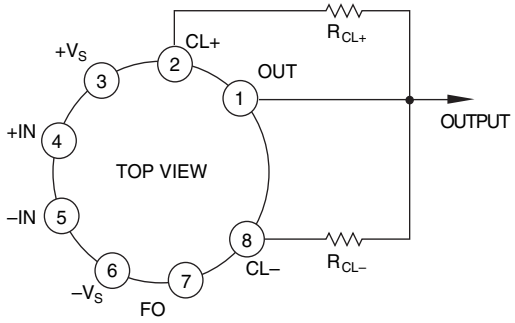


FIGURE 1. VOLTAGE-TO-CURRENT CONVERSION

DC and low distortion AC current waveforms are delivered to a grounded load by using matched resistors (A and B sections) and taking advantage of the high common mode rejection of the PA10.

Foldover current limit is used to modify current limits based on output voltage. When load resistance drops to 0, the current is limited based on output voltage. When load resistance drops to 0, the current limit is 0.79A resulting in an internal dissipation of 33.3 W. When output voltage increases to 36V, the current limit is 1.69A. Refer to Application Note 9 on foldover limiting for details.

EXTERNAL CONNECTIONS



ABSOLUTE MAXIMUM RATINGS

SUPPLY VOLTAGE, $+V_S$ to $-V_S$	100V
OUTPUT CURRENT, within SOA	5A
POWER DISSIPATION, internal	67W
INPUT VOLTAGE, differential	$\pm V_S$ –3V
INPUT VOLTAGE, common mode	$\pm V_S$
TEMPERATURE, pin solder - 10s	300°C
TEMPERATURE, junction[1]	200°C
TEMPERATURE RANGE, storage	–65 to +150°C
OPERATING TEMPERATURE RANGE, case	–55 to +125°C

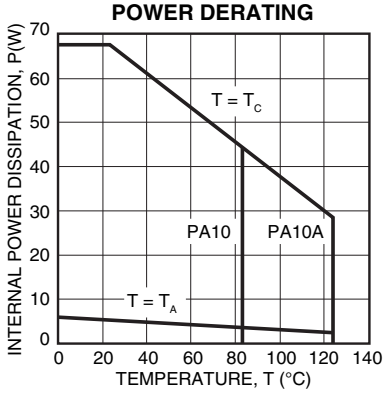
SPECIFICATIONS

PARAMETER	TEST CONDITIONS[2, 5]	PA10 MIN	PA10 TYP	PA10 MAX	PA10A MIN	PA10A TYP	PA10A MAX	UNITS
INPUT								
OFFSET VOLTAGE, initial	T_C = 25°C		±2	±6		±1	±4	mV
OFFSET VOLTAGE, vs. temperature	Full temperature range		±10	±65		*	±40	µV/°C
OFFSET VOLTAGE, vs. supply	T_C = 25°C		±30	±200		*	*	µV/V
OFFSET VOLTAGE, vs. power	T_C = 25°C		±20			*		µVW
BIAS CURRENT, initial	T_C = 25°C		12	30		10	20	nA
BIAS CURRENT, vs. temperature	Full temperature range		±50	±500		*	*	pA/°C
BIAS CURRENT, vs. supply	T_C = 25°C		.±10			*		pA/V
OFFSET CURRENT, initial	T_C = 25°C		±12	±30		±5	±10	nA
OFFSET CURRENT, vs. temperature	Full temperature range		±50			*		pA/°C
INPUT IMPEDANCE, DC	T_C = 25°C		200			*		MΩ
INPUT CAPACITANCE	T_C = 25°C		3			*		pF
COMMON MODE VOLTAGE RANGE[3]	Full temperature range	$\pm V_S$–5	$\pm V_S$–3		*	*		V
COMMON MODE REJECTION, DC[3]	Full temp. range, $V_{CM} = \pm V_S$ –6V	74	100		*	*		dB
GAIN								
OPEN LOOP GAIN at 10Hz	T_C = 25°C, 1KΩ load		110			*		dB
OPEN LOOP GAIN at 10Hz	Full temp. range, 15Ω load	96	108		*	*		dB
GAIN BANDWIDTH PRODUCT @ 1MHz	T_C = 25°C, 15Ω load		4			*		MHz
POWER BANDWIDTH	T_C = 25°C, 15Ω load	10	15		*	*		kHz
PHASE MARGIN	Full temp. range, 15Ω load		35			*		°
OUTPUT								
VOLTAGE SWING[3]	T_C = 25°C, I_O = 5A	$\pm V_S$–8	$\pm V_S$–5		$\pm V_S$–6	*		V
VOLTAGE SWING[3]	Full temp. range, I_O = 2A	$\pm V_S$–6			*			V
VOLTAGE SWING[3]	Full temp. range, I_O = 80mA	$\pm V_S$–5			*			V
CURRENT, peak	T_C = 25°C	5			*			A
SETTLING TIME to .1%	T_C = 25°C, 2V step		2			*		µs
SLEW RATE	T_C = 25°C	2	3		*	*		V/µs
CAPACITIVE LOAD	Full temperature range, A_V = 1			.68			*	nF
CAPACITIVE LOAD	Full temperature range, A_V = 2.5			10			*	nF
CAPACITIVE LOAD	Full temperature range, A_V > 10			SOA			*	nF
POWER SUPPLY								
VOLTAGE	Full temperature range	±10	±40	±45	*	*	±50	V
CURRENT, quiescent	T_C = 25°C	8	15	30	*	*	*	mA
THERMAL								
RESISTANCE, AC, junction to case[4]	T_C = –55 to +125°C, F > 60Hz		1.9	2.1		*	*	°C/W
RESISTANCE, DC, junction to case	T_C = –55 to +125°C		2.4	2.6		*	*	°C/W
RESISTANCE, junction to air	T_C = –55 to +125°C		30			*		°C/W
TEMPERATURE RANGE, case	Meets full range specifications	–25		+85	–55		+125	°C

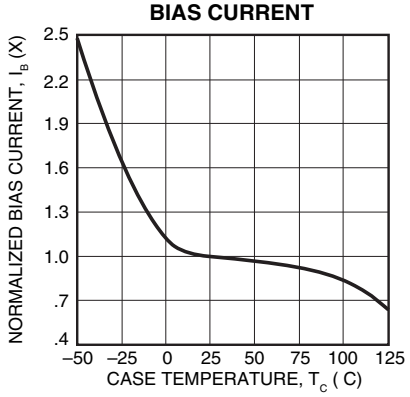
NOTES: * The specification of PA10A is identical to the specification for PA10 in applicable column to the left.
1. Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTTF.
2. The power supply voltage for all tests is ±40, 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 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.

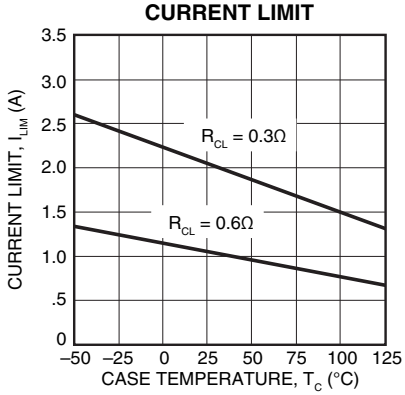
POWER DERATING



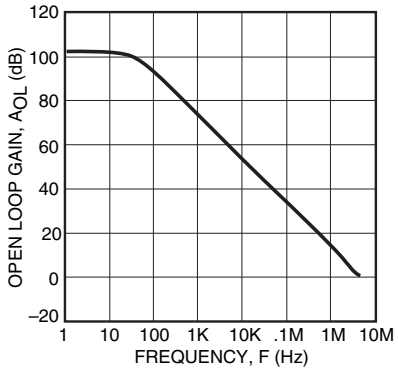
BIAS CURRENT



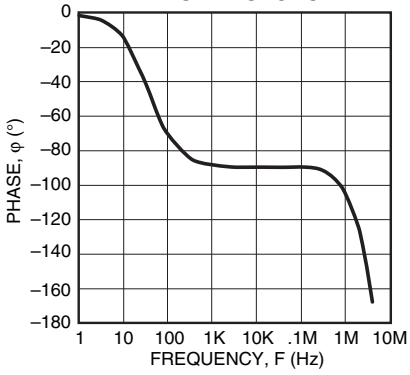
CURRENT LIMIT



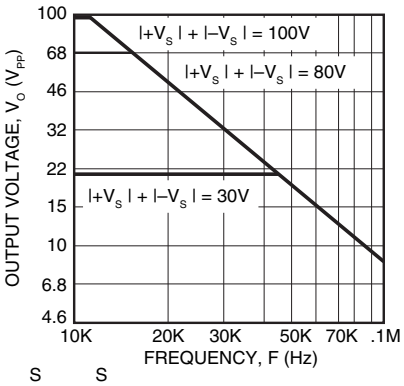
SMALL SIGNAL RESPONSE



PHASE RESPONSE

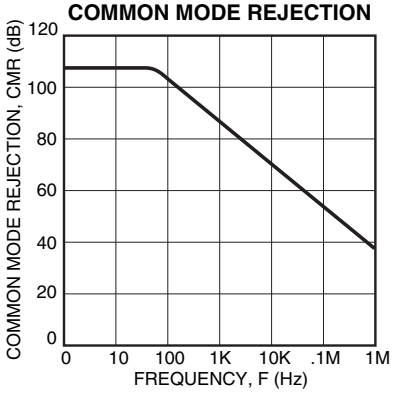


POWER RESPONSE

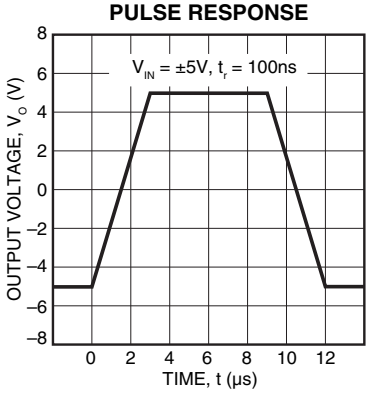


S S

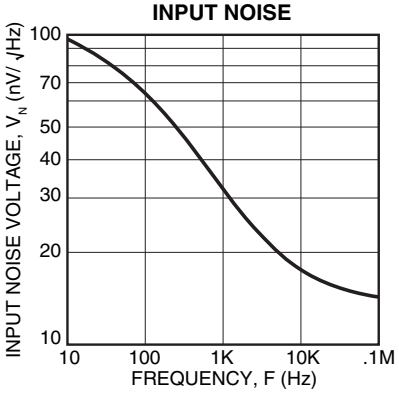
COMMON MODE REJECTION



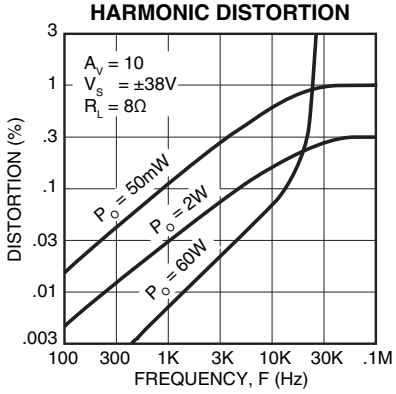
PULSE RESPONSE



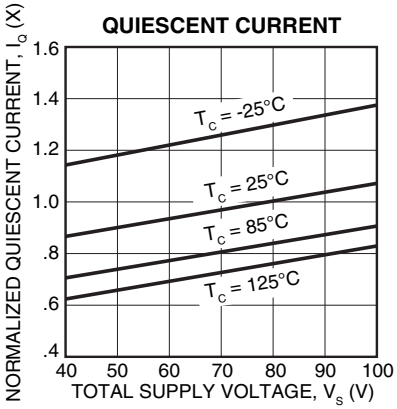
INPUT NOISE



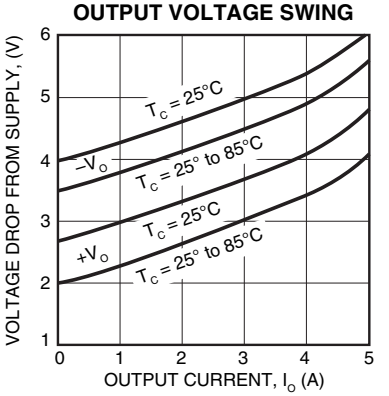
HARMONIC DISTORTION



QUIESCENT CURRENT



OUTPUT VOLTAGE SWING



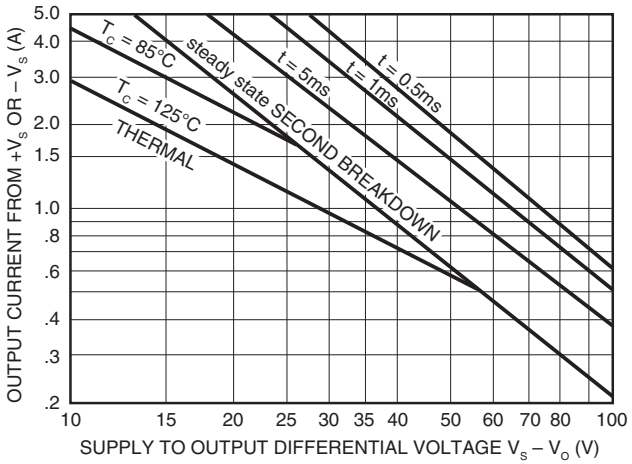
GENERAL

Please read Application Note 1 "General Operating Considerations" which covers stability, supplies, heat sinking, mounting, current limit, SOA interpretation, and specification interpretation. Visit www.apexmicrotech.com for design tools that help automate tasks such as calculations for stability, internal power dissipation, current limit; heat sink selection; Apex's complete Application Notes library; Technical Seminar Workbook; and Evaluation Kits.

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 DC outputs, especially those resulting from fault conditions, check worst case stress levels against the new SOA graph.

   For sine wave outputs, use Power Design[1] 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%.

   [1] Note 1. Power Design is a self-extracting Excel spreadsheet available free from www.apexmicrotech.com

   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. 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°C:

$\pm V_S$	SHORT TO $\pm V_S$ C, L, OR EMF LOAD	SHORT TO COMMON
50V	.21A	.61A
40V	.3A	.87A
35V	.36A	1.0A
30V	.46A	1.4A
25V	.61A	1.7A
20V	.87A	2.2A
15V	1.4A	2.9A

CURRENT LIMITING

Refer to Application Note 9, "Current Limiting", for details of both fixed and foldover current limit operation. Visit the Apex web site at www.apexmicrotech.com for a copy of the Power Design spreadsheet (Excel) which plots current limits vs. steady state SOA. Beware that current limit should be thought of as a +/–20% function initially and varies about 2:1 over the range of –55°C to 125°C.

For fixed current limit, leave pin 7 open and use equations 1 and 2.

$$R_{CL} = 0.65/L_{CL} \quad (1)$$

$$I_{CL} = 0.65/R_{CL} \quad (2)$$

Where:

I_{CL} is the current limit in amperes.

R_{CL} is the current limit resistor in ohms.

For certain applications, foldover current limit adds a slope to the current limit which allows more power to be delivered to the load without violating the SOA. For maximum foldover slope, ground pin 7 and use equations 3 and 4.

$$I_{CL} = \frac{0.65 + (Vo * 0.014)}{R_{CL}} \quad (3)$$

$$R_{CL} = \frac{0.65 + (Vo * 0.014)}{I_{CL}} \quad (4)$$

Where:

Vo is the output voltage in volts.

Most designers start with either equation 1 to set R_{CL} for the desired current at 0v out, or with equation 4 to set R_{CL} at the maximum output voltage. Equation 3 should then be used to plot the resulting foldover limits on the SOA graph. If equation 3 results in a negative current limit, foldover slope must be reduced. This can happen when the output voltage is the opposite polarity of the supply conducting the current.

In applications where a reduced foldover slope is desired, this can be achieved by adding a resistor (R_{FO}) between pin 7 and ground. Use equations 4 and 5 with this new resistor in the circuit.

$$I_{CL} = \frac{0.65 + \frac{Vo * 0.14}{10.14 + R_{FO}}}{R_{CL}} \quad (5)$$

$$R_{CL} = \frac{0.65 + \frac{Vo * 0.14}{10.14 + R_{FO}}}{I_{CL}} \quad (6)$$

Where:

R_{FO} is in K ohms.

This data sheet has been carefully checked and is believed to be reliable, however, no responsibility is assumed for possible inaccuracies or omissions. All specifications are subject to change without notice.

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