PA90

High Voltage Power Operational Amplifiers

RoHS COMPLIANT

FEATURES

- High Voltage — 400V (±200V)
- Low Quiescent Current — 10mA
- High Output Current — 200mA
- Programmable Current Limit
- High Slew Rate — 300V/µs

APPLICATIONS

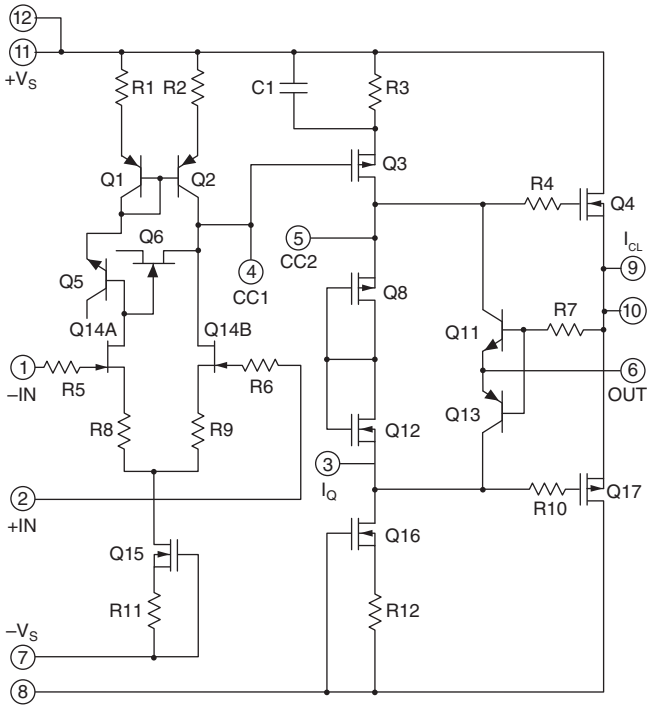
- Piezoelectric Positioning
- High Voltage Instrumentation
- Electrostatic Transducers
- Programmable Power Supplies up to 390V

DESCRIPTION

The PA90 is a high voltage, low quiescent current MOSFET operational amplifier designed as a low cost solution for driving continuous output currents up to 200mA and pulse currents up to 350mA. The safe operating area (SOA) has no second breakdown limitations and can be observed for all type loads by choosing an appropriate current limiting resistor. The MOSFET output stage is biased AB for linear operation. External compensation provides flexibility in choosing bandwidth and slew rate for the application. Apex Microtechnology's Power SIP package uses a minimum of board space allowing for high density circuit boards. The 12-pin Power SIP is electrically isolated.

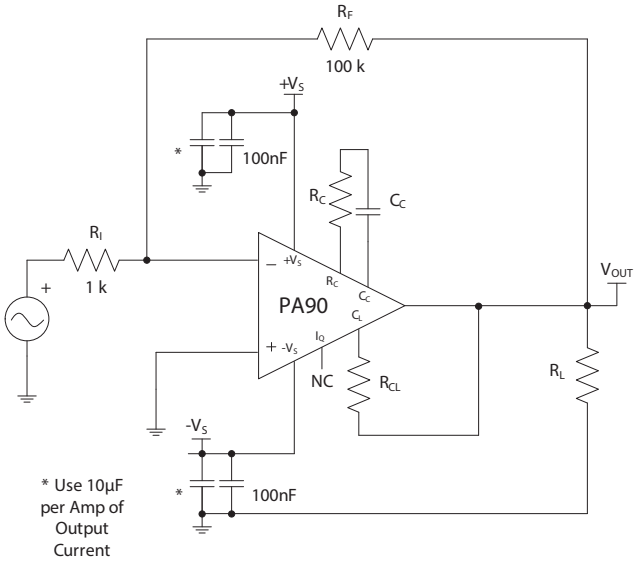
EQUIVALENT SCHEMATIC

Figure 1: Equivalent Schematic



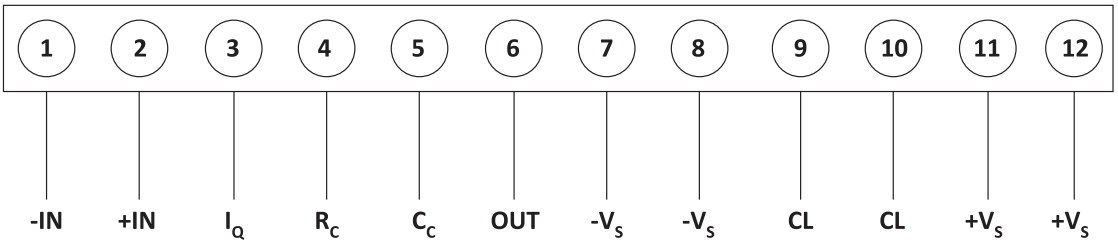
TYPICAL CONNECTIONS

Figure 2: Typical Connection



PINOUT AND DESCRIPTION TABLE

Figure 3: External Connections



Pin Number	Name	Description
1	-IN	The inverting input.
2	+IN	The non-inverting input.
3	IQ	Quiescent current reduction pin. Connect to pin 5 to disable the AB bias. See applicable section.
4	RC	Compensation resistor connection. Select value based on Phase Compensation. See applicable section.
5	C_C	Compensation capacitor connection. Select value based on Phase Compensation. See applicable section.
6	OUT	The output. Connect this pin to load and to the feedback resistors.
7, 8	$-V_S$	The negative supply rail. Pins 7 and 8 are not internally connected and must be shorted.
9, 10	CL	Connect to the current limit resistor. Output current flows into/out of these pins through R_{CL}. The output pins and the load are connected to the other side of R_{CL}. Pins 9 and 10 are internally connected.
11, 12	$+V_S$	The positive supply rail. Pins 11 and 12 are internally connected.

SPECIFICATIONS

All Min/Max characteristics and specifications are guaranteed over the Specified Operating Conditions. Typical performance characteristics and specifications are derived from measurements taken at typical supply voltages and T_C = 25°C.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Min	Max	Units
Supply Voltage, $+V_s$ to $-V_s$	$+V_S$ to $-V_S$		400	V
Output Current, source, sink, peak, within SOA	I_{OUT}		350	mA
Power Dissipation, continuous @ T_c = 25°C	P_D		30	W
Input Voltage, differential	$V_{IN\ (Diff)}$	-20	+20	V
Input Voltage, common mode	V_{CM}	$-V_S$	$+V_S$	V
Temperature, pin solder, 10s max.			260	°C
Temperature, junction [1]	T_J		150	°C
Temperature Range, storage		-55	125	°C
Operating Temperature Range, case	T_C	-40	85	°C

1. Long term operation at the maximum junction temperature will result in reduced product life. Derate power dissipation to achieve high MTTF.

CAUTION The PA90 is constructed from MOSFET transistors. ESD handling procedures must be observed. The substrate contains beryllia (BeO). Do not crush, machine, or subject to temperatures in excess of 850°C to avoid generating toxic fumes.

INPUT

Parameter	Test Conditions	Min	Typ	Max	Units
Offset Voltage, initial			0.5	2	mV
Offset Voltage vs. Temperature	Full temp range		15	50	µV/°C
Offset Voltage vs. Supply			10	25	µV/V
Offset Voltage vs. Time			75		µV/kh
Bias Current, initial			200	2000	pA
Bias Current vs. Supply			4		pA/V
Offset Current, initial			50	500	pA
Input Impedance, DC			10^{11}		Ω
Input Capacitance			4		pF
Common Mode Voltage Range [1]		$\pm V_S \mp 15$			V
Common Mode Rejection, DC	V_{CM} = ±90V	80	98		dB
Noise	100 kHz bandwidth, R_S = 1 kΩ, C_C = OPEN		1		µV RMS

1. $+V_S$ and $-V_S$ denote the positive and negative power supply rail respectively.

GAIN

Parameter	Test Conditions	Min	Typ	Max	Units
Open Loop @ 15 Hz	R_L = 2 kΩ, C_C = Open	94	111		dB
Gain Bandwidth Product @ 1 MHz	R_L = 2 kΩ, C_C = Open		100		MHz
Power Bandwidth	R_L = 2 kΩ, C_C = Open		470		kHz
Phase Margin	Full temp range		60		°

OUTPUT

Parameter	Test Conditions	Min	Typ	Max	Units
Voltage Swing[1]	I_{OUT} = 200mA	$\pm V_S \mp 12$	$\pm V_S \mp 10$		V
Current, continuous		200			mA
Slew Rate, A_V = 100	C_C = Open	240	300		V/µs
Capacitive Load, A_V = +1	Full temp range	470			pF
Settling Time to 0.1%	C_C = Open, 2V step		1		µs
Resistance, no load			50		Ω

1. $+V_S$ and $-V_S$ denote the positive and negative power supply rail respectively.

POWER SUPPLY

Parameter	Test Conditions	Min	Typ	Max	Units
Voltage [1]		±40	±150	±200	V
Current, quiescent			10	14	mA

1. Derate max supply rating 0.625 V/°C below 25°C case. No derating needed above 25°C case.

THERMAL

Parameter	Test Conditions	Min	Typ	Max	Units
Resistance, AC, junction to case [1]	Full temp range, F > 60 Hz			2.5	°C/W
Resistance, DC, junction to case	Full temp range, F < 60 Hz			4.2	°C/W
Resistance, junction to air	Full temp range		30		°C/W
Temperature Range, case	Meets full range specifications	-25		+85	°C

1. Rating applies if the output current alternates between both output transistors at a rate faster than 60 Hz.

TYPICAL PERFORMANCE GRAPHS

Figure 4: Power Derating

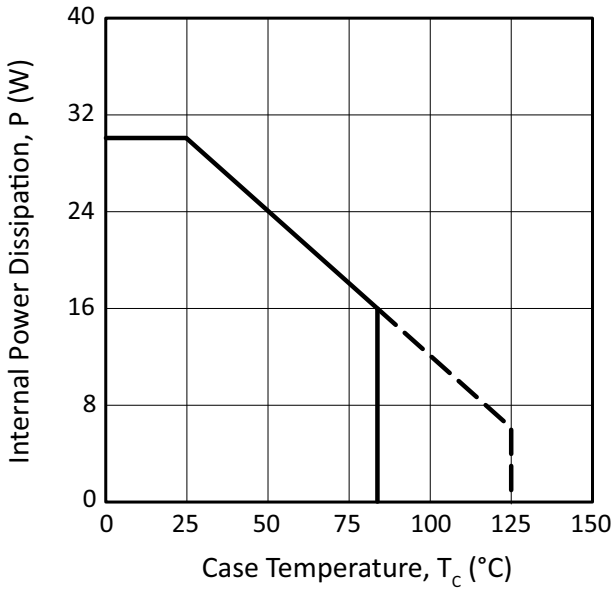


Figure 5: Normalized Quiescent Current

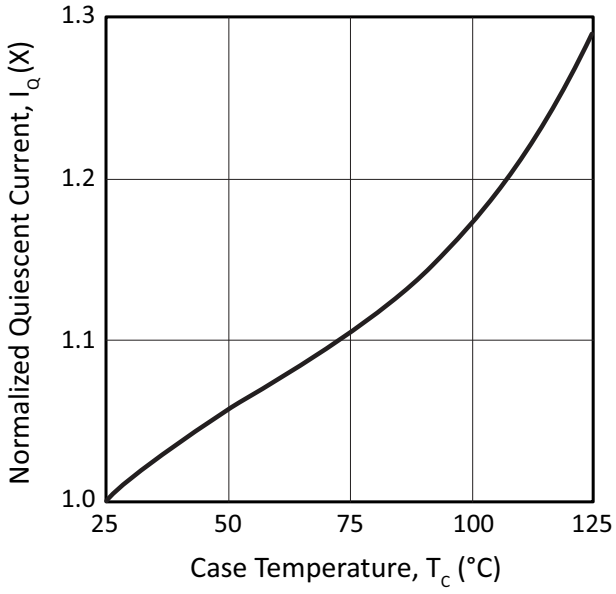


Figure 6: Small Signal Response

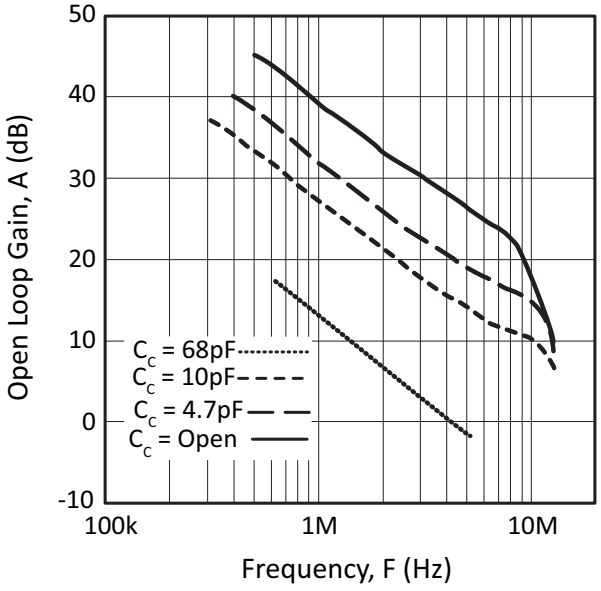


Figure 7: Phase Response

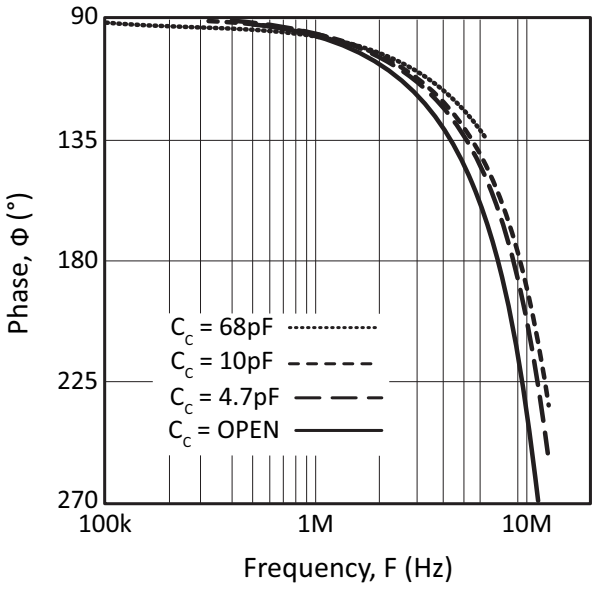


Figure 8: Output Voltage Swing

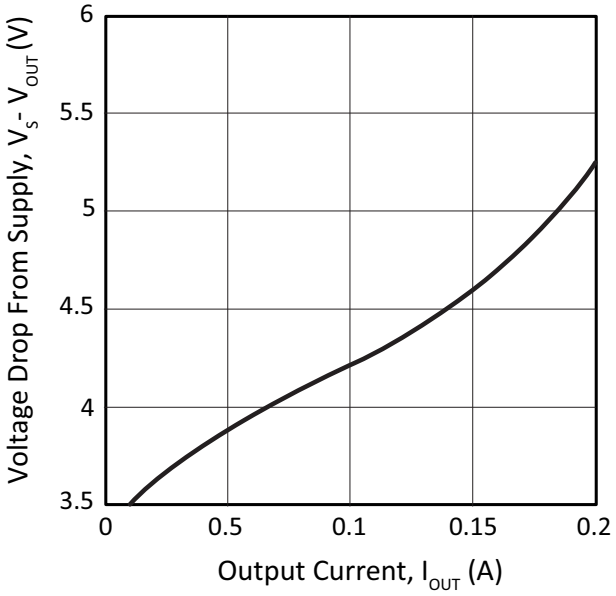


Figure 9: Power Response

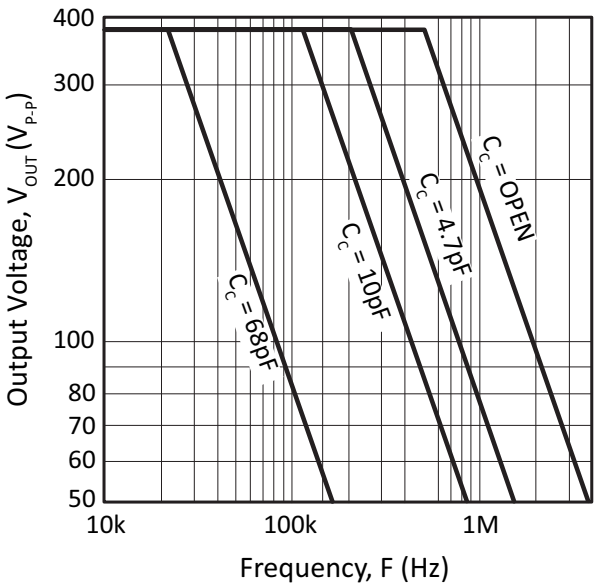


Figure 10: Slew Rate

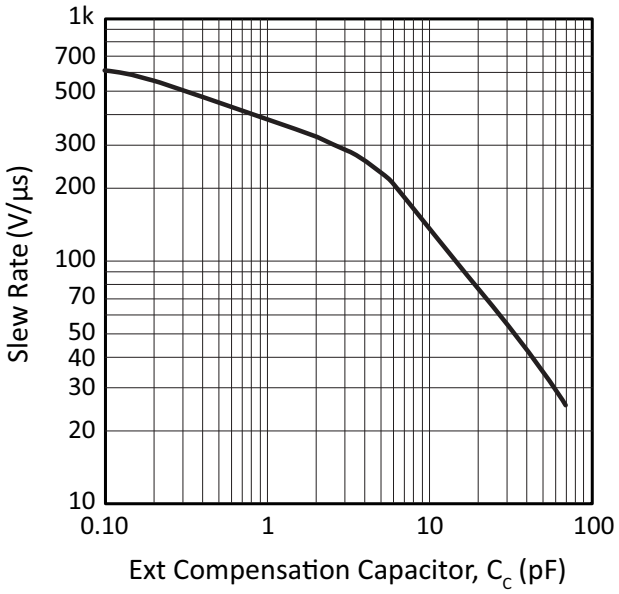


Figure 11: Harmonic Distortion

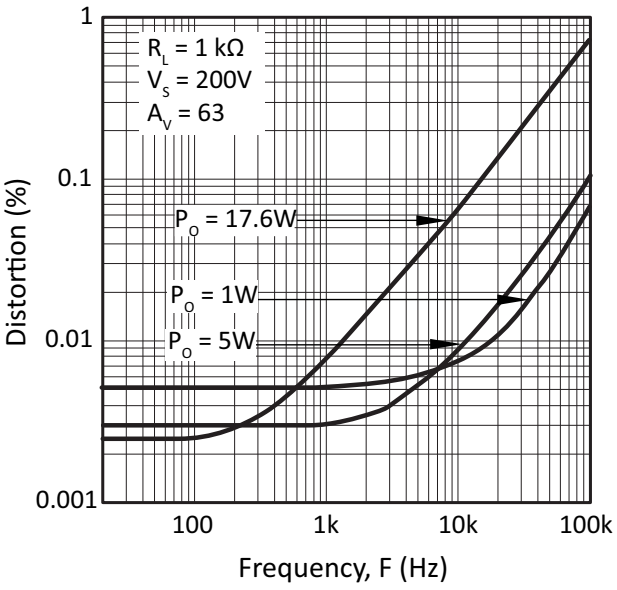


Figure 12: Input Noise Voltage

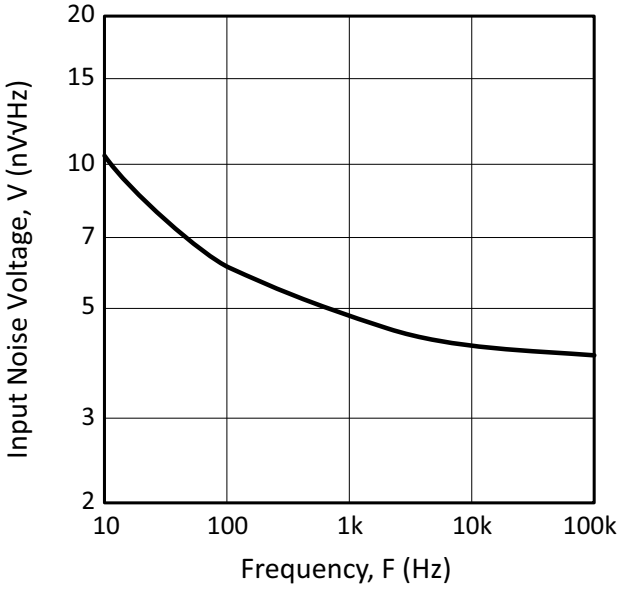


Figure 13: Current Limit

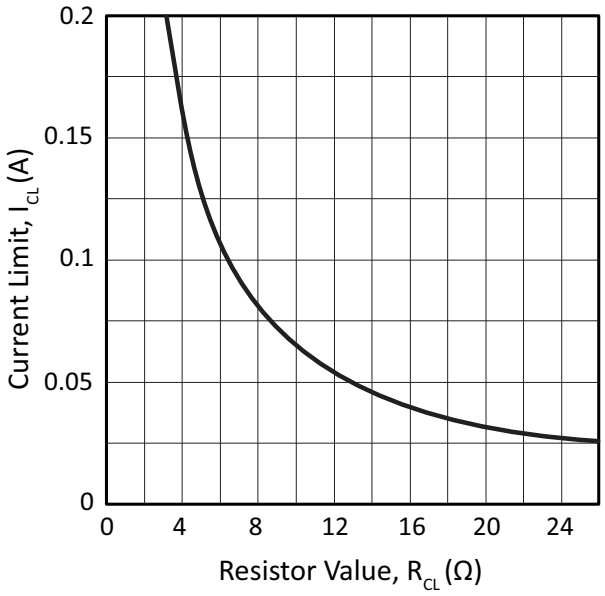
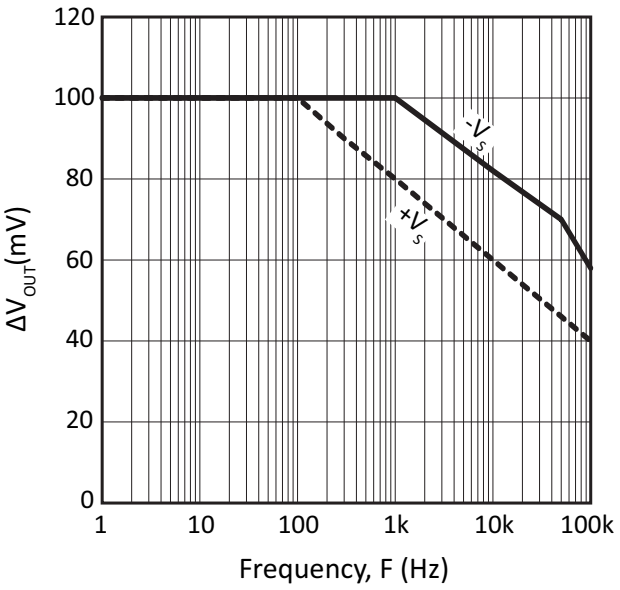


Figure 14: Power Supply Rejection



SAFE OPERATING AREA (SOA)

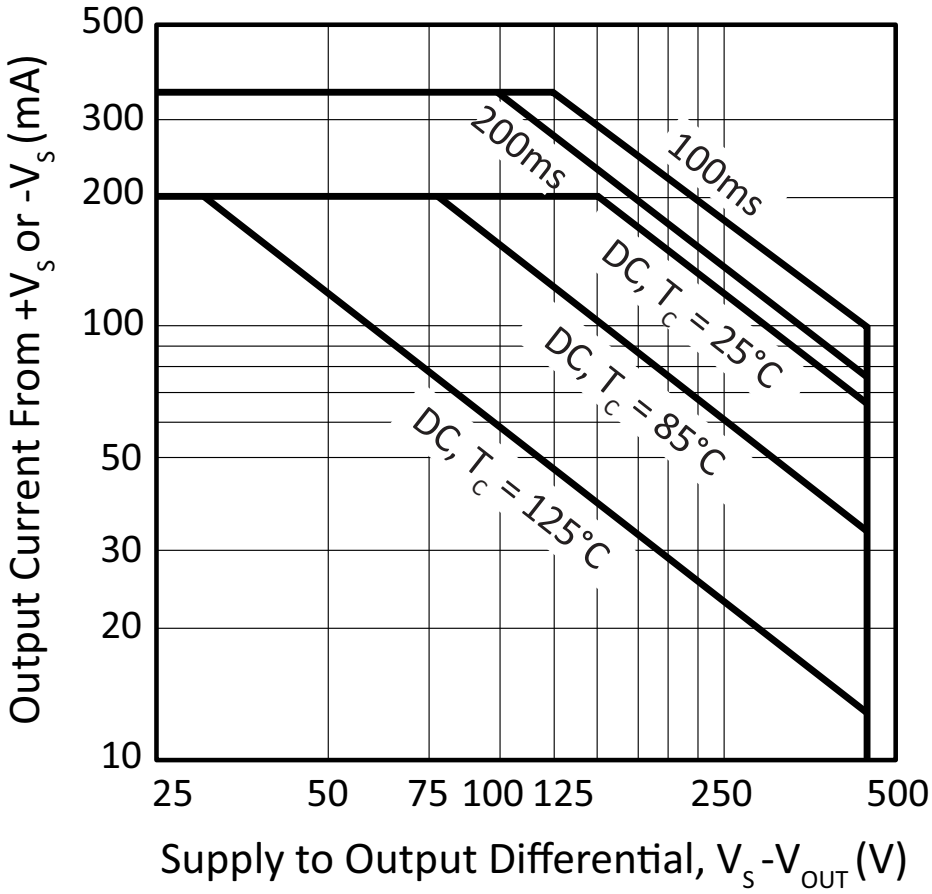
The safe operating area curves define the maximum additional internal power dissipation the amplifier can tolerate when it produces the necessary output to drive an external load.

The MOSFET output stage of this power operational amplifier has two distinct limitations:

1. The current handling capability of the MOSFET geometry and the wire bonds.
2. The junction temperature of the output MOSFETs.

Note: The output stage is protected against transient flyback. However, for protection against sustained, high energy flyback, external fast-recovery diodes should be used.

Figure 15: SOA



GENERAL

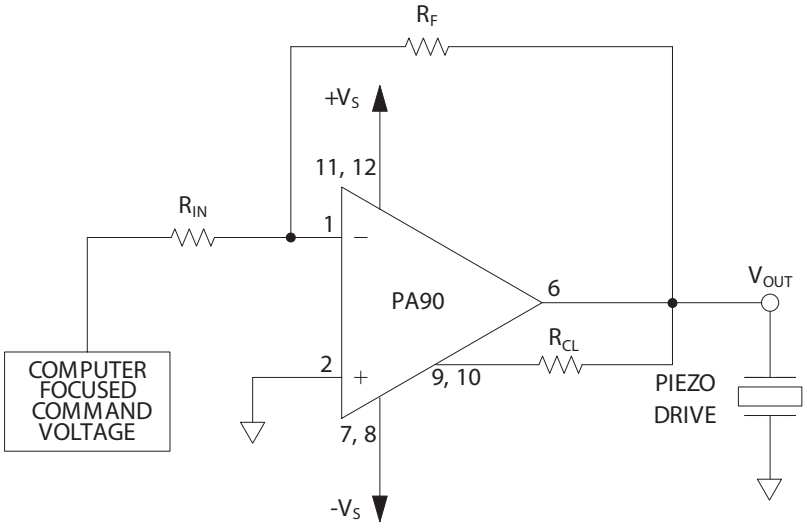
Please read Application Note 1 “General Operating Considerations” which covers stability, supplies, heat sinking, mounting, current limit, SOA interpretation, and specification interpretation. Visit www.apexanalog.com for Apex Microtechnology’s complete Application Notes library, Technical Seminar Workbook, and Evaluation Kits.

TYPICAL APPLICATION

Low Power, Piezoelectric Positioning

Piezo positioning may be applied to the focusing of segmented mirror systems. The composite mirror may be composed of hundreds of elements, each requiring focusing under computer control. In such complex systems the PA90 reduces the costs of power supplies and cooling with its advantages of low cost and low quiescent power consumption while increasing circuit density with the SIP.

Figure 16: Typical Application



PHASE COMPENSATION

Gain	C_C*	R_C
≥1	68pF	100 Ω
≥5	10pF	100 Ω
≥10	4.7pF	0 Ω
≥30	NONE	0 Ω

*C_C To be rated for the full supply voltage $+V_S$ to $–V_S$. Use NPO ceramic (COG) type.

CURRENT LIMIT

For proper operation, the current limit resistor (R_{CL}) must be connected as shown in the typical connection diagram. For optimum reliability the resistor value should be set as high as possible. The value is calculated as follows; with the maximum practical value of 32 ohms.

$$R_{CL}(\Omega) = \frac{0.65V}{I_{CL}(A)}$$

INPUT PROTECTION

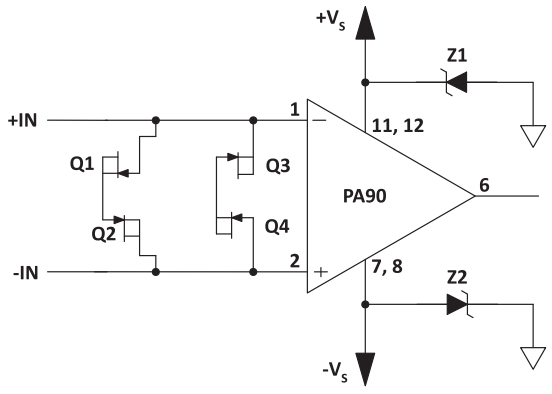
Although the PA90 can withstand differential voltages up to ±20V, additional external protection is recommended. Low leakage, low capacitance JFETs connected as diodes are recommended (e.g. 2N4416, Q1-Q4 in Figure 16). The differential input voltage will be clamped to ±1.4V. This is sufficient overdrive to produce maximum power bandwidth.

POWER SUPPLY PROTECTION

Unidirectional zener diode transient suppressors are recommended as protection on the supply pins. See Figure 16. The zeners clamp transients to voltages within the power supply rating and also clamp power supply reversals to ground. Whether the zeners are used or not, the system power supply should be evaluated for transient performance including power-on overshoot and power-off polarity reversals as well as line regulation.

Conditions which can cause open circuits or polarity reversals on either power supply rail should be avoided or protected against. Reversals or opens on the negative supply rail is known to induce input stage failure. Unidirectional transzorbs prevent this, and it is desirable that they be both electrically and physically as close to the amplifier as possible.

Figure 17: Overvoltage Protection



STABILITY

The PA90 is externally compensated and performance can be tailored to the application. Use the graphs of small signal response and power response as a guide. The compensation capacitor C_C must be rated at 500V working voltage. An NPO capacitor is recommended. The compensation network C_CR_C must be mounted closely to the amplifier pins 4 and 5 to avoid spurious oscillation.

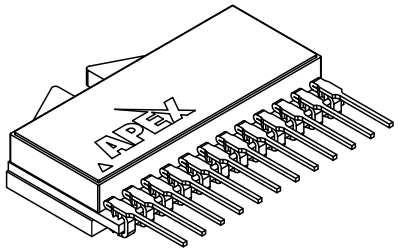
QUIESCENT CURRENT REDUCTION

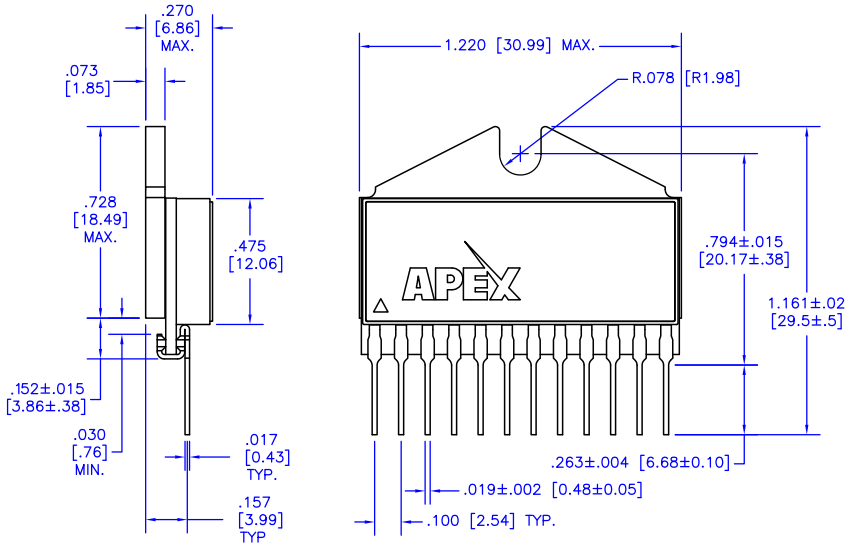
When pin 3 (I_Q) is shorted to pin 5 (CC2) the AB biasing of the output stage is disabled. This raises distortion since the output stage is then class C biased, but reduces the quiescent current by 1mA for a power dissipation savings of 0.4W. Pin 3 may be left open if not used.

PACKAGE DESIGN

Part Number	Apex Package Style	Description
PA90	DP	12-Pin SIP
PA90EE	EE	12-Pin SIP w/ formed leads

PACKAGE STYLE DP





NOTES:
1. Dimensions are inches & [mm].
2. Triangle on lid denotes pin 1.
3. Pins: Alloy 510 phosphor bronze plated with matte tin (150 – 300µ") over nickel (50 µ" max.) underplate.
4. Package: Vectra liquid crystal polymer, black
5. Epoxy–sealed & ultrasonically welded non–hermetic package.
6. Package weight: .367 oz. [11.41 g]