High Voltage Power Operational Amplifier

RoHS COMPLIANT

FEATURES

- RoHS COMPLIANT
- MONOLITHIC MOS TECHNOLOGY
- LOW COST
- HIGH VOLTAGE OPERATION—350V
- LOW QUIESCENT CURRENT TYP.—2.2mA
- NO SECOND BREAKDOWN
- HIGH OUTPUT CURRENT—120 mA PEAK

APPLICATIONS

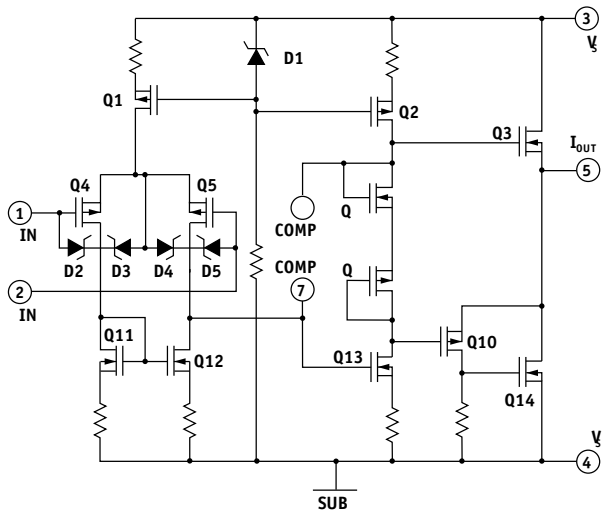
- TELEPHONE RING GENERATOR
- PIEZO ELECTRIC POSITIONING
- ELECTROSTATIC TRANSDUCER & DEFLECTION
- DEFORMABLE MIRROR FOCUSING
- PACKAGING OPTIONS
  - 7 TO-220 with staggered Lead Form (PA240CX)
  - 7 DDPAK Surface Mount Package (PA240CC)

DESCRIPTION

The PA240 is a high voltage monolithic MOSFET operational amplifier achieving performance features previously found only in hybrid designs while increasing reliability. Inputs are protected from excessive common mode and differential mode voltages. The safe operating area (SOA) has no second breakdown limitations. External compensation provides the user flexibility in choosing optimum gain and bandwidth for the application.

The PA240 is packaged in two standard package designs. The surface mount version of the PA240, the PA240CC, is an industry standard non-hermetic plastic 7-pin DDPAK. The through hole version of the PA240, the PA240CX, is an industry standard non-hermetic plastic 7-pin TO-220 package. The PA240CX is a staggered lead formed option that offers industry standard 100 mil spacing. This allows for easier PC board layout. (Please refer to package drawings for outline dimensions.)

EQUIVALENT SCHEMATIC



DDPAK
PKG. STYLE CC

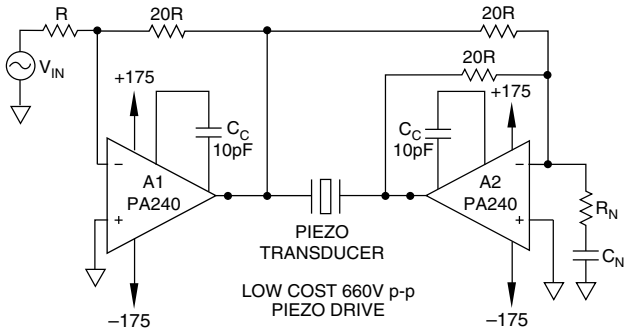
TO-220
STAGGERED LEADS
PKG. STYLE CX

High voltage considerations should be taken when designing board layouts for the PA240. The PA240 may require a derate in supply voltage depending on the spacing used for board layout. The 15-mil and 14-mil minimum spacing of the 7 TO-220 and 7 DDPAK respectively is adequate to standoff the 350V rating of the PA240. However, a supply voltage derate to 250V is required if the spacing of circuit board artwork is less than 11 mils. In cases where the PA240 is used to its maximum voltage rating, the PA240CX is recommended given that the staggered lead form allows for 100-mil standard spacing.

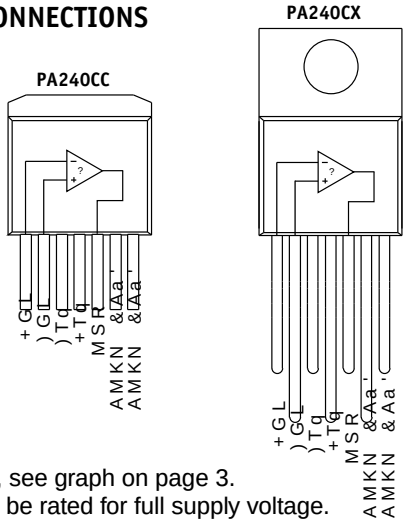
The metal tabs of both the PA240CC and PA240CX packages are directly tied to -Vs.

TYPICAL APPLICATON

Reference Application Notes 3, 20 and 25



EXTERNAL CONNECTIONS



For CC values, see graph on page 3.
Note: CC must be rated for full supply voltage.

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ABSOLUTE MAXIMUM RATINGS

SUPPLY VOLTAGE, $+V_S$ to $-V_S$	350V
OUTPUT CURRENT, continuous within SOA	60 mA
OUTPUT CURRENT, peak[3]	120 mA
POWER DISSIPATION, continuous @ T_C = 25°C	14W
INPUT VOLTAGE, differential	±16 V
INPUT VOLTAGE, common mode	$\pm V_S$
TEMPERATURE, pin solder – 10 sec	220°C
TEMPERATURE, junction[2]	150°C
TEMPERATURE, storage	–65 to +150°C
TEMPERATURE RANGE, powered (case)	–40 to +125°C

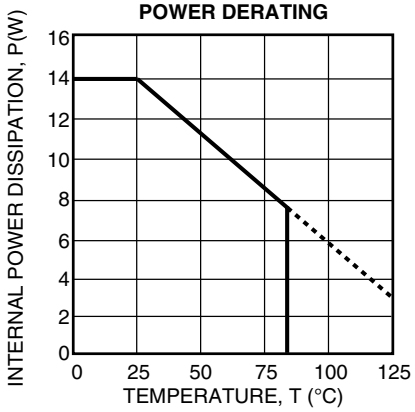
SPECIFICATIONS

PARAMETER	TEST CONDITIONS[1]	PA240 MIN	PA240 TYP	PA240 MAX	UNITS
INPUT					
OFFSET VOLTAGE, initial			25	40	mV
OFFSET VOLTAGE, vs. temperature[3]	25°C to 85°C		100	250	µV/°C
OFFSET VOLTAGE, vs. temperature[3]	-25°C to 25°C		270	500	µV/°C
OFFSET VOLTAGE, vs supply			3		µV/V
OFFSET VOLTAGE, vs time			70	130	µV/kh
BIAS CURRENT, initial			50	200	pA
BIAS CURRENT, vs supply			2		pA/V
OFFSET CURRENT, initial			50	200	pA
INPUT IMPEDANCE, DC			10^{11}		Ω
INPUT CAPACITANCE			6		pF
COMMON MODE, voltage range		$+V_S$–14			V
COMMON MODE, voltage range		$-V_S$+12			V
COMMON MODE REJECTION, DC	V_{CM} = ±90V DC	84	94		dB
NOISE, broad band	10kHz BW, R_S = 1K		50		µV RMS
NOISE, low frequency	1-10 Hz		125		µV p-p
GAIN					
OPEN LOOP at 15Hz	R_L = 5K	90	96		dB
BANDWIDTH, gain bandwidth product			3		MHz
POWER BANDWIDTH	280V p-p		30		kHz
OUTPUT					
VOLTAGE SWING	I_O = 40mA	$\pm V_S$–12	$\pm V_S$–10		V
CURRENT, peak[3]		120			mA
CURRENT, continuous		60			mA
SETTLING TIME to .1%	10V step, A_V = –10		2		µs
SLEW RATE	C_C = 3.3pF		30		V/µs
RESISTANCE[4], 1mA	R_{CL} = 0		150		Ω
RESISTANCE[4], 40 mA	R_{CL} = 0		5		Ω
POWER SUPPLY					
VOLTAGE		±50	±150	±175	V
CURRENT, quiescent			2.2	2.5	mA
THERMAL					
RESISTANCE, AC junction to case	F > 60Hz		5.9	6.85	°C/W
RESISTANCE, DC junction to case	F < 60Hz		7.7	8.9	°C/W
RESISTANCE, junction to air (CX)	Full temperature range		60		°C/W
RESISTANCE, junction to air (CC)[5]	Full temperature range		27		°C/W
TEMPERATURE RANGE, case	Meets full range specifications	–25	25	+85	°C

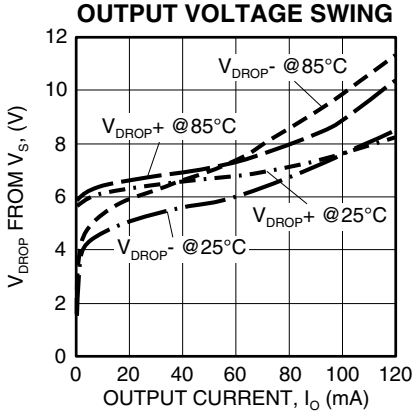
NOTES:
1. Unless otherwise noted T_C = 25°C, C_C = 6.8pF. DC input specifications are ± value given. Power supply voltage is typical rating.
2. Long term operation at the maximum junction temperature will result in reduced product life. Derate internal power dissipation to achieve high MTTF. For guidance, refer to heatsink data sheet.
3. Guaranteed but not tested.
4. Since the PA240 has no current limit, load impedance must be large enough to limit output current to 120mA.
5. Heat tab attached to 3/32" FR-4 board with 2oz. copper. Topside copper area (heat tab directly attached) = 1000 sq. mm, backside copper area = 2500 sq. mm, board area = 2500 sq. mm.

CAUTION The PA240 is constructed from MOSFET transistors. ESD handling procedures must be observed.

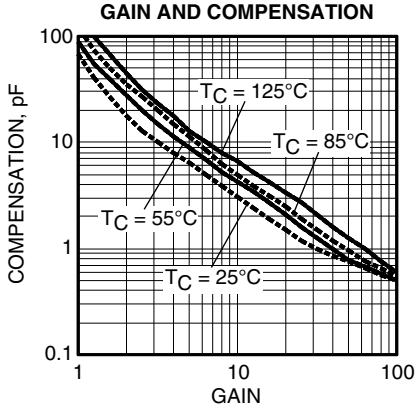
POWER DERATING



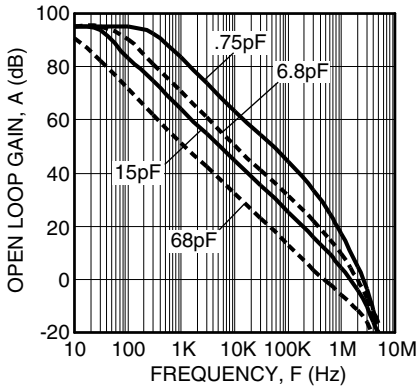
OUTPUT VOLTAGE SWING



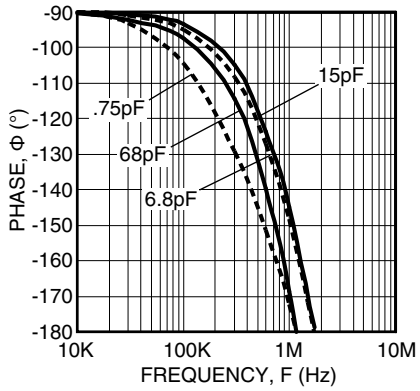
GAIN AND COMPENSATION



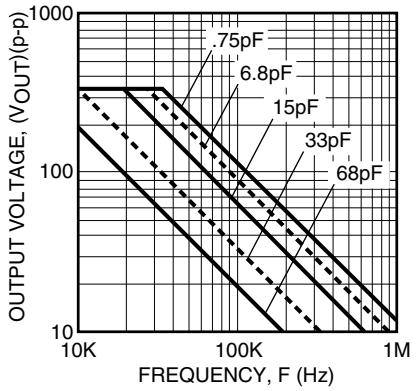
SMALL SIGNAL RESPONSE



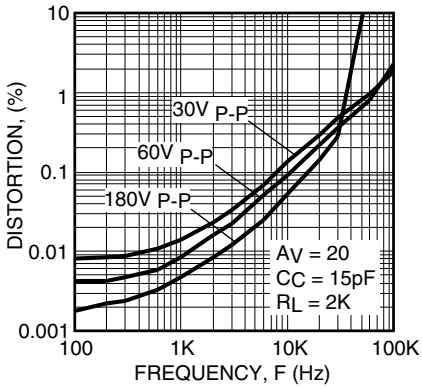
PHASE RESPONSE



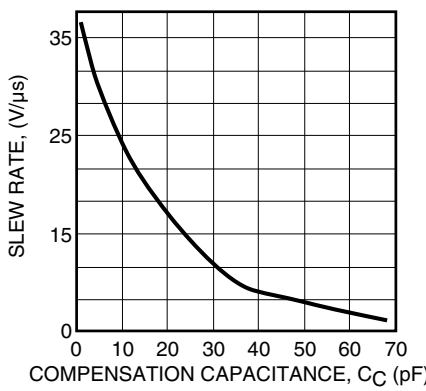
POWER RESPONSE



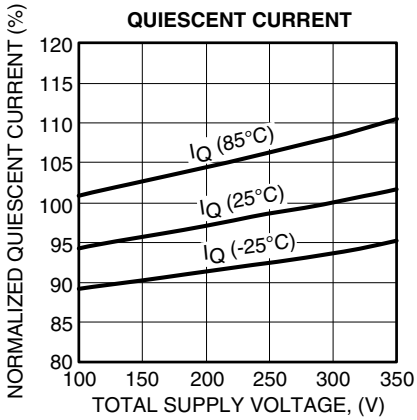
HARMONIC DISTORTION



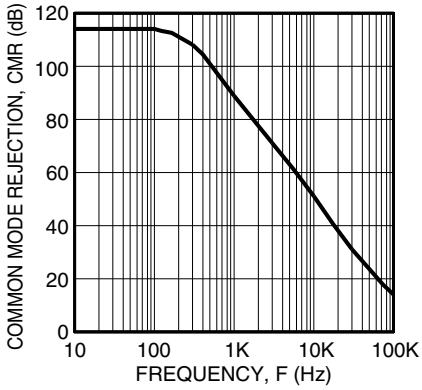
SLEW RATE



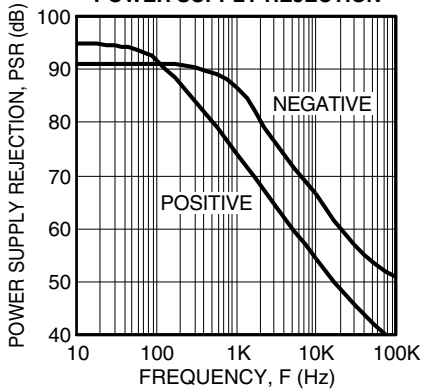
QUIESCENT CURRENT



COMMON MODE REJECTION



POWER SUPPLY REJECTION



GENERAL

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

PHASE COMPENSATION

Open loop gain and phase shift both increase with increasing temperature. The PHASE COMPENSATION typical graph shows closed loop gain and phase compensation capacitor value relationships for four case temperatures. The curves are based on achieving a phase margin of 50°. Calculate the highest case temperature for the application (maximum ambient temperature and highest internal power dissipation) before choosing the compensation. Keep in mind that when working with small values of compensation, parasitics may play a large role in performance of the □nished circuit. The compensation capacitor must be rated for at least the total voltage applied to the ampli□er and should be a temperature stable type such as NPO or COG.

OTHER STABILITY CONCERNS

There are two important concepts about closed loop gain when choosing compensation. They stem from the fact that while "gain" is the most commonly used term, β (the feedback factor) is really what counts when designing for stability.

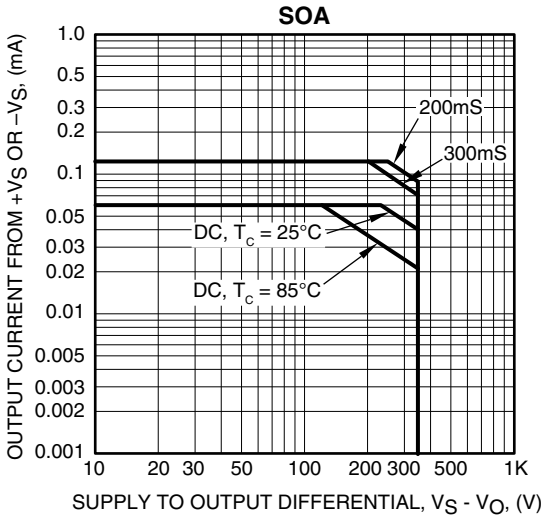
1. Gain must be calculated as a non-inverting circuit (equal input and feedback resistors can provide a signal gain of -1, but for calculating offset errors, noise, and stability, this is a gain of 2).
2. Including a feedback capacitor changes the feedback factor or gain of the circuit. Consider Rin=4.7k, Rf=47k for a gain of 11. Compensation of 4.7 to 6.8pF would be reasonable. Adding 33pF parallel to the 47k rolls off the circuit at 103kHz, and at 2MHz has reduced gain from 11 to roughly 15 and the circuit is likely to oscillate.

As a general rule the DC summing junction impedance (parallel combination of the feedback resistor and all input resistors) should be limited to 5k ohms or less. The ampli□er input capacitance of about 6pF, plus capacitance of connecting traces or wires and (if used) a socket will cause undesirable circuit performance and even oscillation if these resistances are too high. In circuits requiring high resistances, measure or estimate the total sum point capacitance, multiply by Rin/Rf, and parallel Rf with this value. Capacitors included for this purpose are usually in the single digit pF range. This technique results in equal feedback factor calculations for AC and DC cases. It does not produce a roll off, but merely keeps β constant over a wide frequency range. Paragraph 6 of Application Note 19 details suitable stability tests for the □nished circuit.

SAFE OPERATING AREA

The MOSFET output stage of the PA240 is not limited by second breakdown considerations as in bipolar output stages. However there are still three distinct limitations:

1. Voltage withstand capability of the transistors.
2. Current handling capability of the die metalization.
3. Temperature of the output MOSFETS.



These limitations can be seen in the SOA (see Safe Operating Area graphs). Note that each pulse capability line shows a constant power level (unlike second breakdown limitations where power varies with voltage stress). These lines are shown for a case temperature of 25°C. Pulse stress levels for other case temperatures can be calculated in the same manner as DC power levels at different temperatures. The output stage is protected against transient □yback by the parasitic diodes of the output stage MOSFET structure. However, for protection against sustained high energy □yback external fast-recovery diodes must be used.

HEATSINKING

The PA240CC 7-pin DDPAK surface mountable package has a large exposed integrated copper heatslug to which the monolithic ampli□er is directly attached. The PA240CC requires surface mount techniques of heatsinking. A solder connection to a copper foil area as de□ned in Note 5 of Page 2 is recommended for circuit board layouts. This may be adequate heatsinking but the large number of variables suggests temperature measurements to be made on the top of the package. Do not allow the temperature to exceed 85°C.

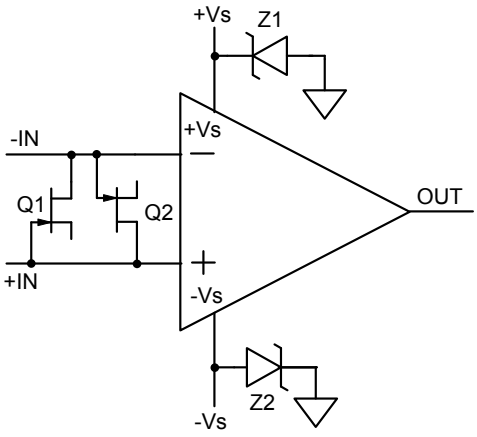


FIGURE 1

OVERVOLTAGE PROTECTION

Although the PA240 can withstand differential input voltages up to 16V, in some applications additional external protection may be needed. Differential inputs exceeding 16V will be clipped by the protection circuitry. However, if more than a few milliamps of current is available from the overload source, the protection circuitry could be destroyed. For differential sources above 16V, adding series resistance limiting input current to 1mA will prevent damage. Alternatively, 1N4148 signal diodes connected anti-parallel across the input pins is usually sufficient. In more demanding applications where bias current is important, diode connected JFETs such as 2N4416 will be required. See Q1 and Q2 in Figure 1. In either case the differential input voltage will be clamped to 0.7V. This is sufficient overdrive to produce the maximum power bandwidth.

In the case of inverting circuits where the +IN pin is grounded, the diodes mentioned above will also afford protection from excessive common mode voltage. In the case of non-inverting circuits, clamp diodes from each input to each supply will provide protection. Note that these diodes will have substantial reverse bias voltage under normal operation and diode leakage will produce errors.

Some applications will also need over-voltage protection devices connected to the power supply rails. Unidirectional zener diode transient suppressors are recommended. 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. See Z1 and Z2 in Figure 1.

APPLICATION REFERENCES:

For additional technical information please refer to the following Application Notes:

AN01: General Operating Considerations
AN03: Bridge Circuit Drives
AN25: Driving Capacitive Loads
AN38: Loop Stability with Reactive Loads

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