

# PA40

## FEATURES

- MONOLITHIC MOS TECHNOLOGY
- LOW COST
- HIGH VOLTAGE OPERATION—250V
- LOW QUIESCENT CURRENT—2mA
- NO SECOND BREAKDOWN
- HIGH OUTPUT CURRENT—120 mA PEAK

## APPLICATIONS

- TELEPHONE RING GENERATOR
- PIEZO ELECTRIC POSITIONING
- ELECTROSTATIC TRANSDUCER & DEFLECTION
- DEFORMABLE MIRROR FOCUSING

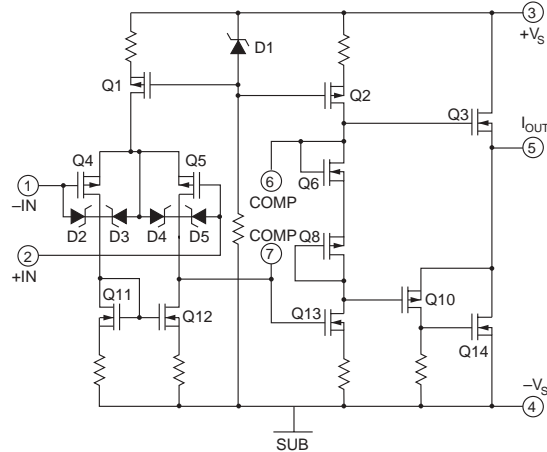


## DESCRIPTION

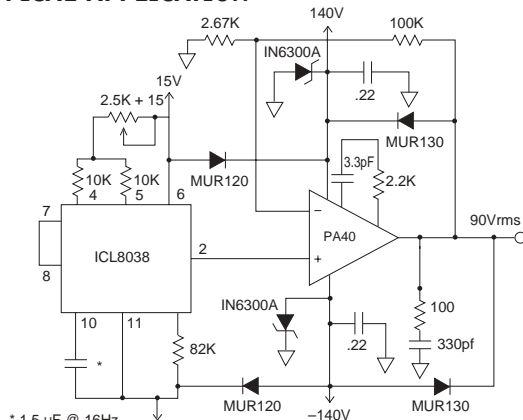
The PA40 is a high voltage monolithic MOSFET operational amplifier achieving performance features previously found only in hybrid designs while increasing reliability. Inputs are protected from excessive common mode and differential mode voltages. The safe operating area (SOA) has no second breakdown limitations. External compensation provides the user flexibility in choosing optimum gain and bandwidth for the application.

The PA40 is packaged in Apex's 7 LEAD TO220 package. The metal back of the package is tied to  $-V_s$ . The 15 mil minimum spacing of the TO220 package is adequate to stand-off the 250V rating of the PA40. The user must insure that a minimum of 11 mils spacing is maintained between pins for the circuit board artwork. If spacing is less than 11 mils, the voltage must be derated.

## EQUIVALENT SCHEMATIC



## TYPICAL APPLICATION



Telephone Ring Generator

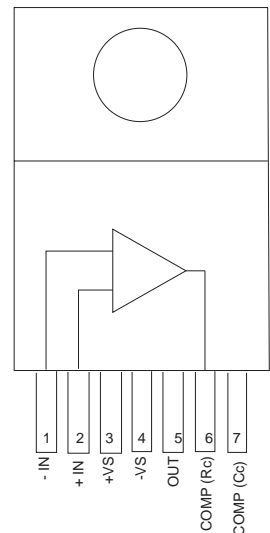
The PA40 is set for a gain of 38.5 boosting the 2.33V signal to 90V. The recommended compensation for gains above 30 is used. If capacitive loading is at least 330pF at all times, the recommended snubber network may be omitted.

## EXTERNAL CONNECTIONS

### PHASE COMPENSATION

Gain	$C_c$	$R_c$
1	18pF	2.2K
10	10pF	2.2K
30	3.3pF	2.2K

NOTE: At gains above 30,  $R_c$  and  $C_c$  may be omitted.



# PA40

## ABSOLUTE MAXIMUM RATINGS SPECIFICATIONS

### ABSOLUTE MAXIMUM RATINGS

SUPPLY VOLTAGE, $+V_s$ to $-V_s$	250V
OUTPUT CURRENT, continuous within SOA	60 mA
OUTPUT CURRENT, peak	120 mA
POWER DISSIPATION, continuous @ $T_c = 25^\circ\text{C}$	14W
INPUT VOLTAGE, differential	$\pm 16\text{ V}$
INPUT VOLTAGE, common mode	$\pm V_s$
TEMPERATURE, pin solder – 10 sec	$220^\circ\text{C}$
TEMPERATURE, junction <sup>2</sup>	$150^\circ\text{C}$
TEMPERATURE, storage	$-65$ to $+150^\circ\text{C}$
TEMPERATURE RANGE, powered (case)	$-40$ to $+125^\circ\text{C}$

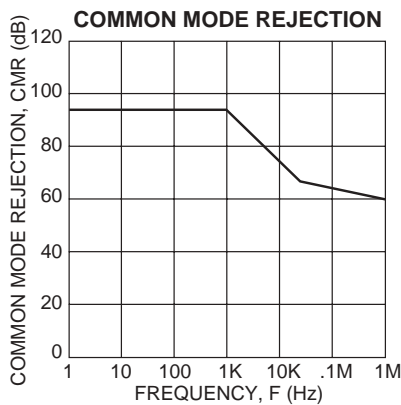
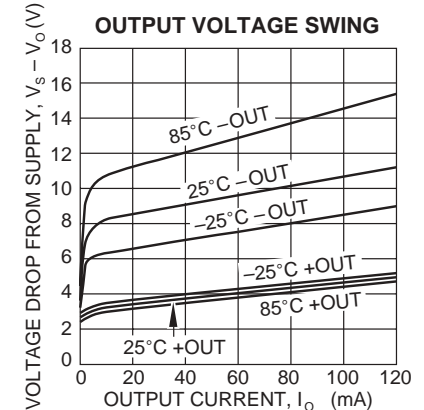
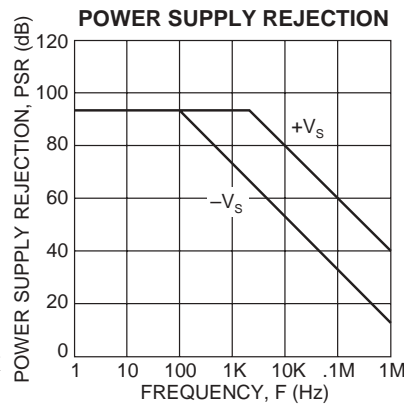
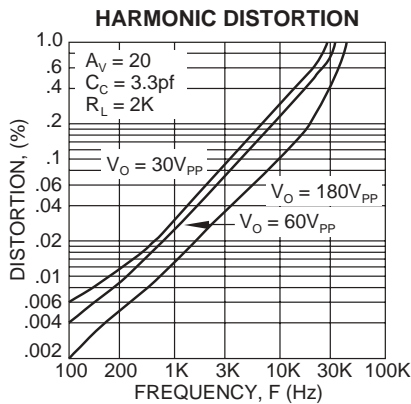
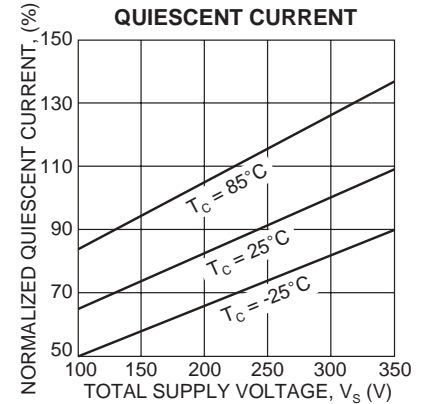
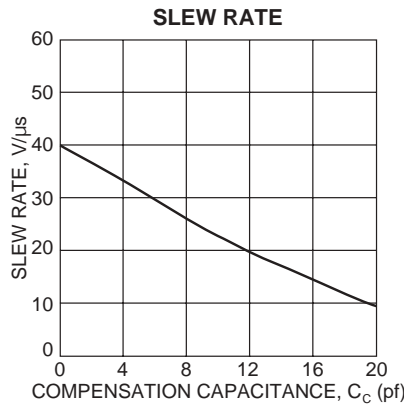
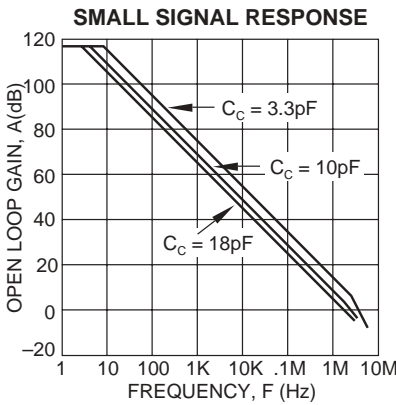
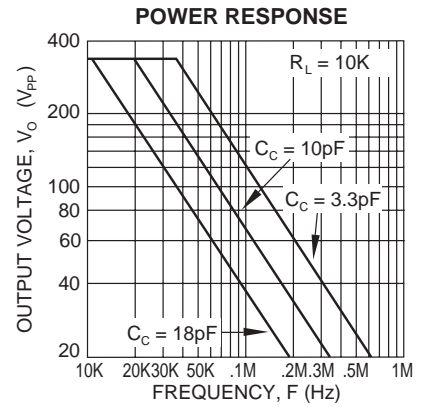
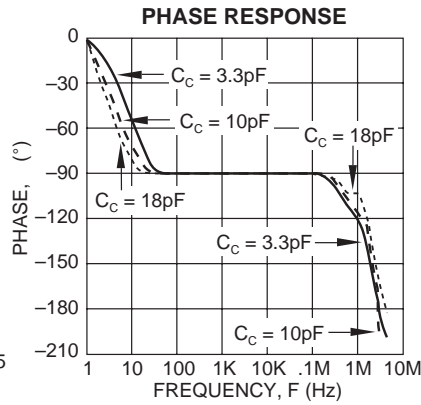
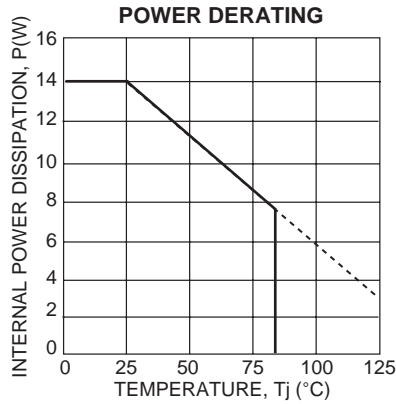
### SPECIFICATIONS

PARAMETER	TEST CONDITIONS <sup>1</sup>	PA40			UNITS
		MIN	TYP	MAX	
<b>INPUT</b>					
OFFSET VOLTAGE, initial			15	30	mV
OFFSET VOLTAGE, vs. temperature <sup>4</sup>	Full temperature range		70	130	$\mu\text{V}/^\circ\text{C}$
OFFSET VOLTAGE, vs supply			20	32	$\mu\text{V}/\text{V}$
OFFSET VOLTAGE, vs time			75		$\mu\text{V}/\text{kh}$
BIAS CURRENT, initial			50	200	pA
BIAS CURRENT, vs supply			2	20	pA/V
OFFSET CURRENT, initial			50	200	pA
INPUT IMPEDANCE, DC			$101^1$		
INPUT CAPACITANCE			5		pF
COMMON MODE, voltage range		$\pm V_s - 12$			V
COMMON MODE REJECTION, DC	VCM = $\pm 90\text{V DC}$	84	94		dB
NOISE, broad band	10kHz BW, RS = 1K		50		$\mu\text{V RMS}$
NOISE, low frequency	1-10 Hz		110		$\mu\text{V p-p}$
<b>GAIN</b>					
OPEN LOOP at 15Hz	RL = 5K	94	106		dB
BANDWIDTH, open loop			1.6		MHz
POWER BANDWIDTH	CC = 10pf, 280V p-p		26		kHz
PHASE MARGIN	Full temperature range		60		°
<b>OUTPUT</b>					
VOLTAGE SWING	IO = 40mA	$\pm V_s - 12$	$\pm V_s - 10$		V
CURRENT, peak <sup>5</sup>				120	mA
CURRENT, continuous		60			mA
SETTLING TIME to .1%	CC = 10pF, 10V step, AV = $\frac{1}{10}$		12		$\mu\text{s}$
SLEW RATE	CC = OPEN		40		V/ $\mu\text{s}$
CAPACITIVE LOAD	AV = +1	10			nF
RESISTANCE <sup>6</sup> , n° load	RCL = 0		150		
RESISTANCE <sup>6</sup> , 20 mA load	RCL = 0		25		
<b>POWER SUPPLY</b>					
VOLTAGE <sup>3</sup>	See Note 3	$\pm 50$		$\pm 125$	V
CURRENT, quiescent			1.6	2.0	mA
<b>THERMAL</b>					
RESISTANCE, AC junction to case <sup>6</sup>	F > 60Hz		5.9	6.85	$^\circ\text{C}/\text{W}$
RESISTANCE, DC junction to case <sup>6</sup>	F < 60Hz		7.7	8.9	$^\circ\text{C}/\text{W}$
RESISTANCE, junction to air	Full temperature range				$^\circ\text{C}/\text{W}$
TEMPERATURE RANGE, case	Meets full range specifications	-25	25	+85	$^\circ\text{C}$

- NOTES: 1. Unless otherwise noted  $T_c = 25^\circ\text{C}$ ,  $C_c = 18\text{pF}$ ,  $R_c = 2.2\text{K}$ . DC input specifications are  $\pm$  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.
3. Derate maximum supply voltage .5 V/ $^\circ\text{C}$  below case temperature of  $25^\circ\text{C}$ . No derating is needed above  $TC = 25^\circ\text{C}$ .
4. Sample tested by wafer to 95%.
5. Guaranteed but not tested.

### CAUTION

The PA40 is constructed from MOSFET transistors. ESD handling procedures must be observed.



### 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](http://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.

### INPUT PROTECTION

The PA40 inputs are protected against common mode voltages up the supply rails and differential voltages up to  $\pm 16$  volts as well as static discharge. Differential voltages exceeding 16 volts 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. The protection circuitry includes 300 ohm current limiting resistors at each input, but this may be insufficient for severe overloads. It may be necessary to add external resistors to the application circuit where severe overload conditions are expected. Limiting input current to 1mA will prevent damage.

### STABILITY

The PA40 has sufficient phase margin when compensated for unity gain to be stable with capacitive loads of at least 10 nF. However, the low pass circuit created by the sumpoint (-in) capacitance and the feedback network may add phase shift and cause instabilities. As a general rule, the sumpoint load resistance (input and feedback resistors in parallel) should be 1K ohm or less at low gain settings (up to 10). Alternatively, use a bypass capacitor across the feedback resistor. The time constant of the feedback resistor and bypass capacitor combination should match the time constant of the sumpoint resistance and sumpoint capacitance.

The PA40 is externally compensated and performance can be tailored to the application. Use the graphs of small signal gain and phase response as well as the graphs for slew rate and power response as a guide. The compensation capacitor  $C_c$  must be rated at 250V working voltage. The compensation capacitor and associated resistor  $R_c$  must be mounted closely to the amplifier pins to avoid spurious oscillation. An NPO capacitor is recommended for compensation.

### SAFE OPERATING AREA (SOA)

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

1. The current handling capability of the die metallization.
2. The 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.

