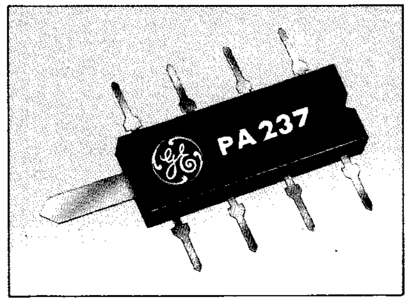
ELECTRONIC INNOVATIONS IN ACTION
SEMICONDUCTORS

Integrated Circuit
2 Watt Audio Amplifier

PA237

Including Application Notes

The General Electric PA237 is a monolithic audio amplifier designed to deliver 2 watts of continuous power to a 16-ohm load. It can, however, be operated from a wide variety of supply voltages and load impedances, thereby providing user versatility. Housed in an 8-lead plastic dual-in-line package, the PA237 has an attached tab for heat transfer to a printed circuit board. In addition to many audio applications, the PA237 may also be utilized for several voltage regulator and servo amplifier uses.

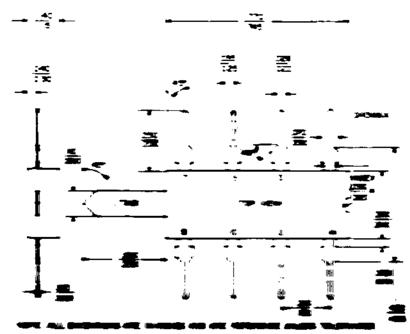


Features:

1. 2 watts output
2. 9 to 27 volts power supply range
3. Dual-in-line package
4. 8 m V sensitivity
5. −55°C to +125°C operating temperature

Applications:

1. Phonographs
2. Tape players/recorders
3. Dictating equipment
4. TV and FM receivers
5. Movie projectors
6. Voltage regulators



Package Outline

maximum ratings: (25°C)

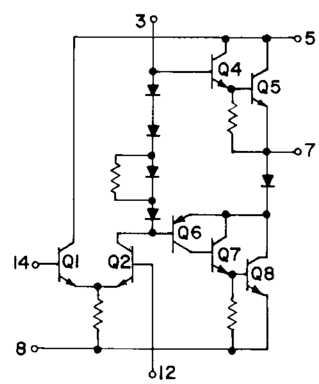
Supply Voltage	27	Volts
Output Current	1.0	Amp
Package Dissipation (Tab at 50°C)	2.25	Watts
(Derate 30 mW/°C above 50°C)		
(Ambient at 25°C)	0.8	Watt
(Derate 8 mW/°C above 25°C)		
Temperature		
Storage	-65 to 150°C	
Operating	-55 to 125°C	

Note: Tab is connected to substrate and should be externally connected to the circuit ground at pin 8. See pages 8, 9, 10, 11, and 12.

electrical characteristics: (25°C) (24V supply in Test Circuit)

	Min.	Typ.	Max.	
Audio Power Output (continuous) (<5% total harmonic distortion)	2.0			Watts
Input Voltage for P_o = 2 watts*				
(R_6 = 0)		8		mV
(R_6 = 6.8k)		120	140	mV
Efficiency (P_o = 2 watts)		52		%
Distortion at 1 kHz*				
(2 watts P_o)		1.0	5	%
(0.05 watts P_o)		0.5	2	%
Output Quiescent Voltage* (pin 7)		12.5		V
Quiescent Current	3		15	mA
Frequency Response* (± 3 dB at P_o = 1w)		30 to 100k		Hz
Noise Output Level Relative to 2 watts output (Input open, BW = 30 Hz to 100kHz)		−75		dB
Input Impedance*		40k		ohms
Output Impedance*		0.85		ohms

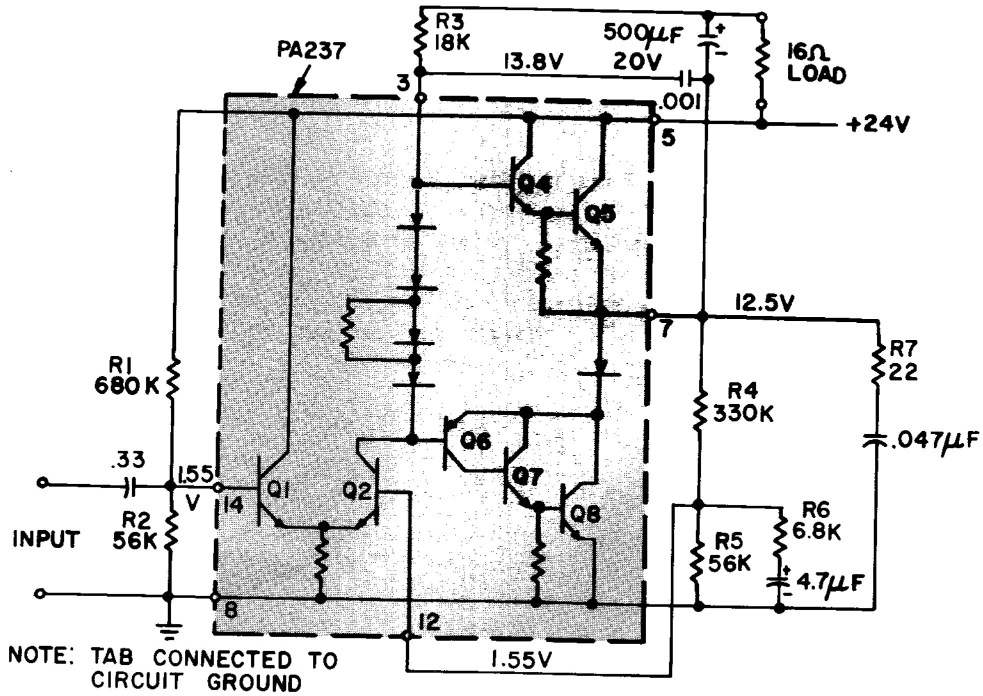
*Performance is determined by external components used in the test circuit.



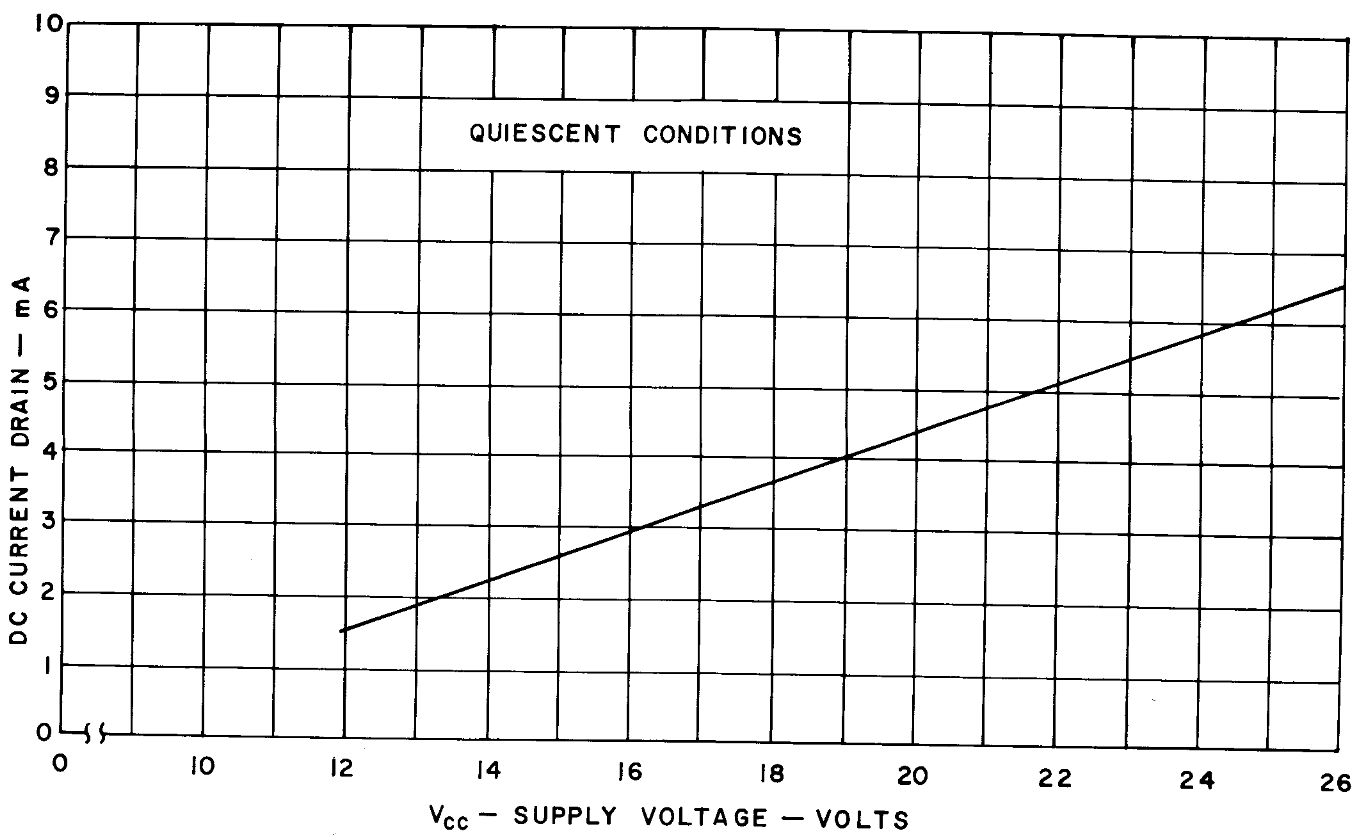
Circuit Diagram

GENERAL ELECTRIC

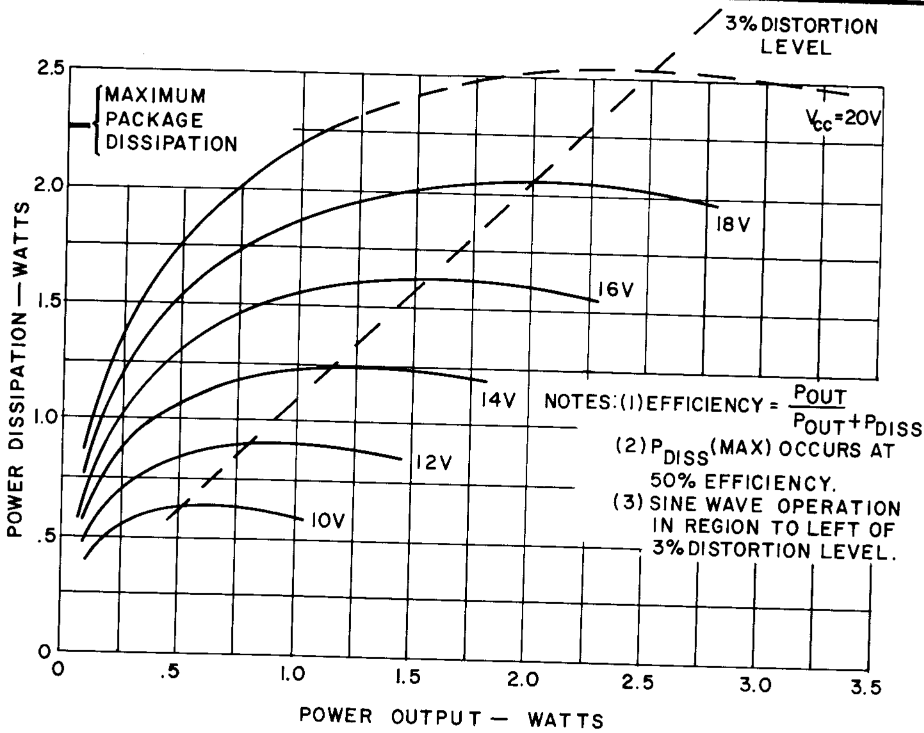
Test Circuit



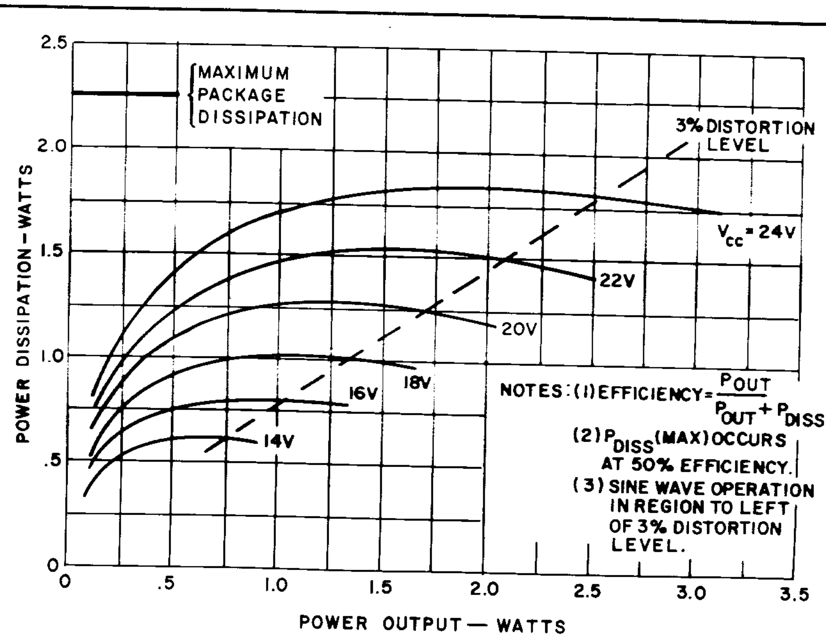
DC Current Drain vs. Supply Voltage



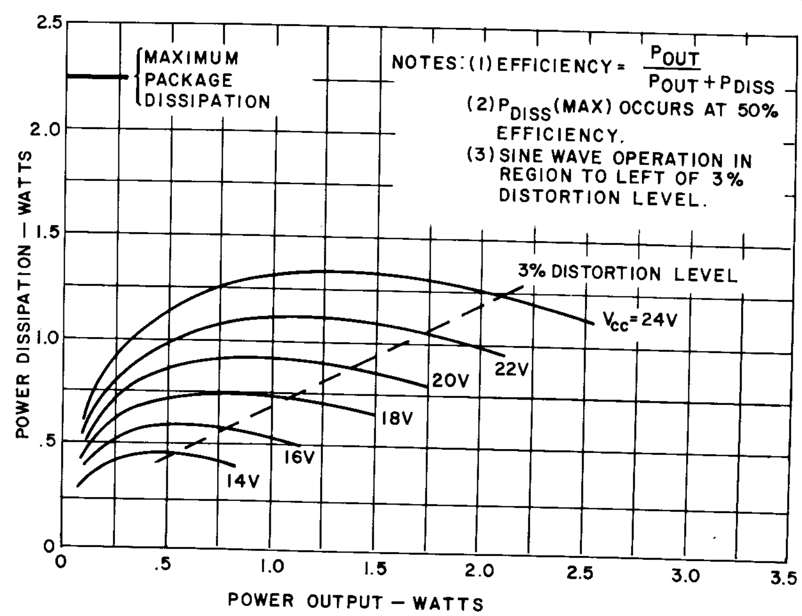
Internal Dissipation vs.
Power Output
Delivered to an 8-ohm Load



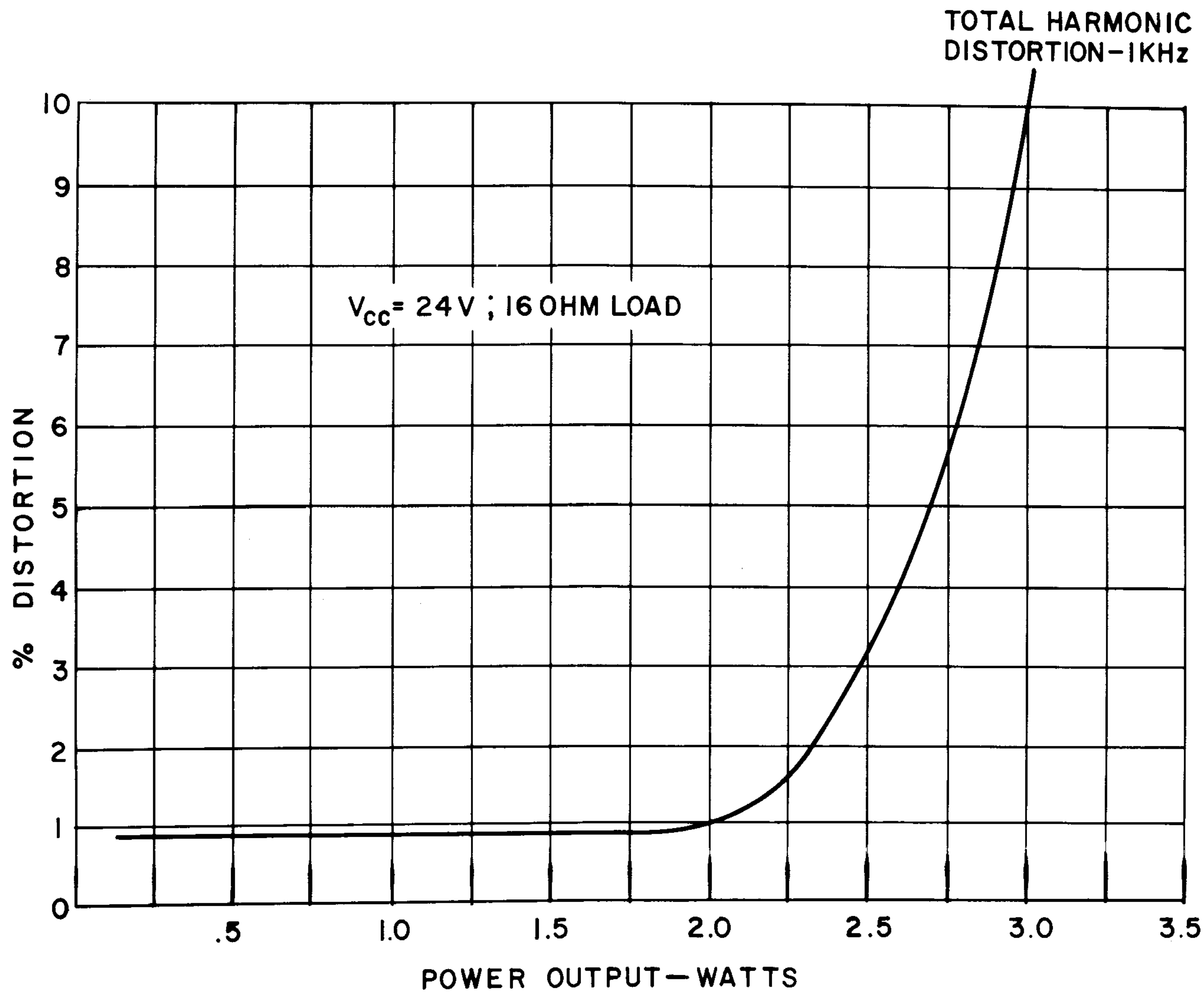
Internal Dissipation vs.
Power Output
Delivered to a 16-ohm Load



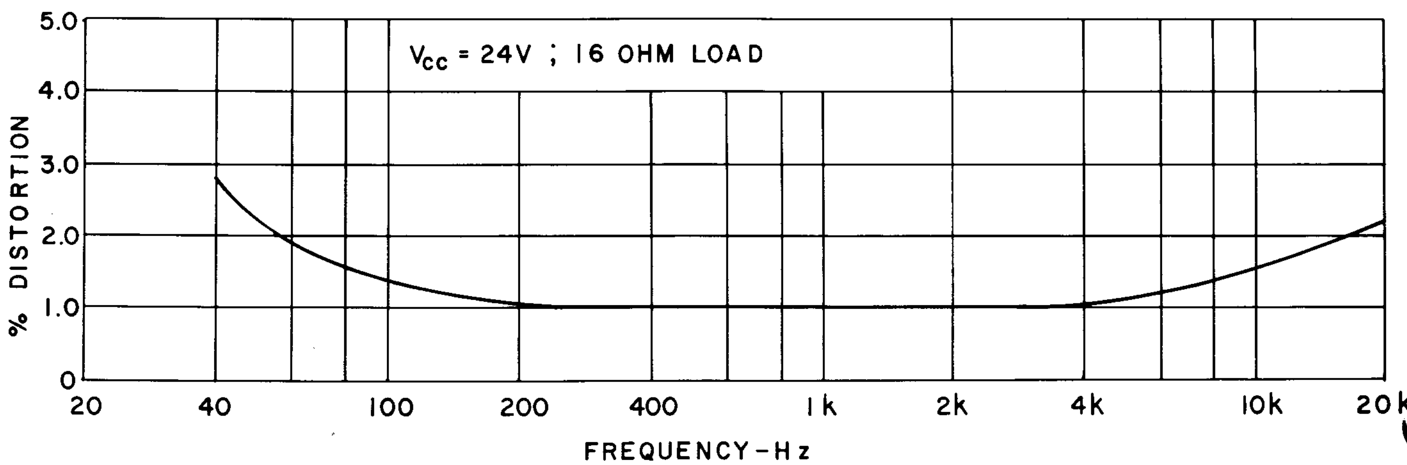
Internal Dissipation vs.
Power Output
Delivered to a 22-ohm Load

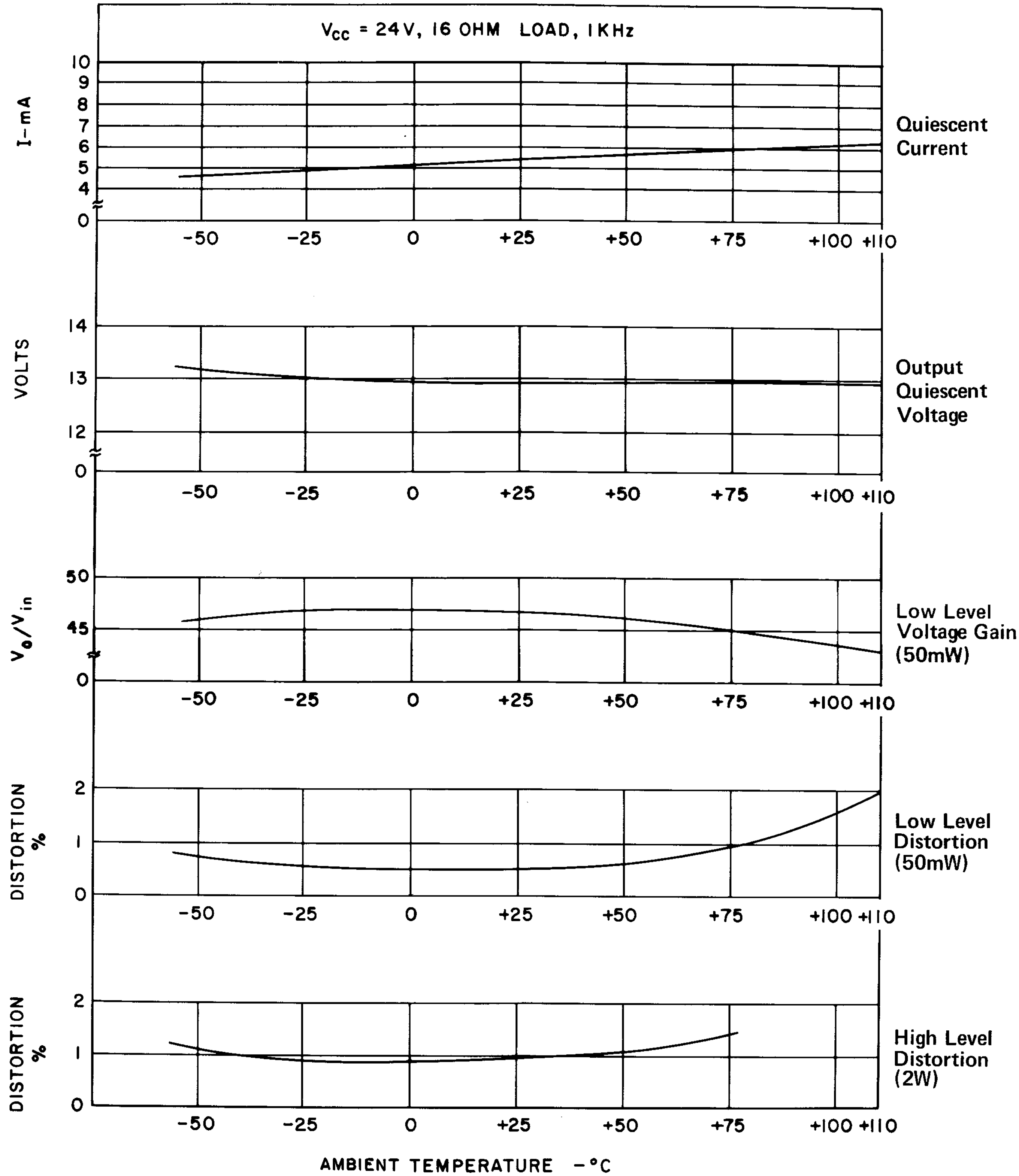


Total Harmonic Distortion vs. Power Output



Total Harmonic Distortion at 2 Watts Power Output vs. Frequency





V_{CC} = 24V, 16 OHM LOAD, 1KHz
I–mA
10
9
8
7
6
5
4
0
Quiescent Current
-50
-25
0
+25
+50
+75
+100 +110
VOLTS
14
13
12
0
Output Quiescent Voltage
V_o/V_{in}
50
45
0
Low Level Voltage Gain (50mW)
DISTORTION %
2
1
0
Low Level Distortion (50mW)
High Level Distortion (2W)
AMBIENT TEMPERATURE –°C

MONOLITHIC INTEGRATED CIRCUIT POWER AMPLIFIER

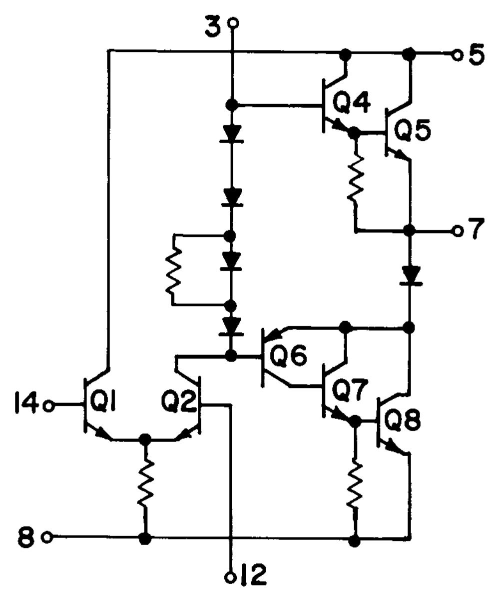
by
J. E. Byerly
Application Engineering
Syracuse, New York

The General Electric PA237 is a silicon monolithic audio amplifier designed for versatile performance to meet a wide variety of applications. Some of these applications include phonograph, tape player, AM-FM-TV audio, intercom, servo-amplifiers, and industrial uses.

The broad application of this amplifier is made possible through its ability to operate over a wide range of supply voltage and bias conditions. Different forms of feedback may be applied to the amplifier to allow adjustment of stability, input and output impedance, and amplifier sensitivity. Both AC and DC feedback is employed to provide excellent stability with frequency and temperature.

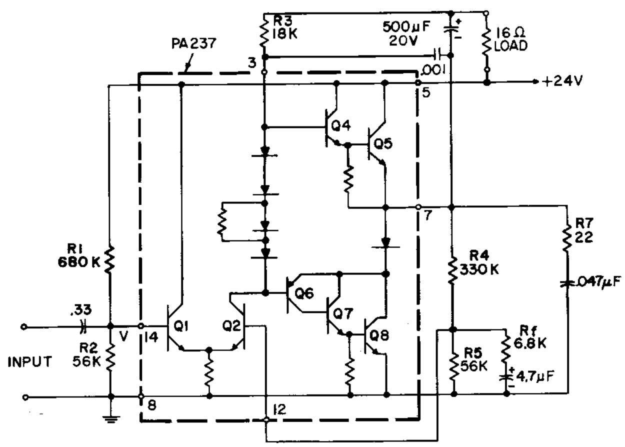
Figure 1 shows the schematic diagram of the silicon monolithic chip.

Figure 1 - Monolithic Chip



The output is a quasi-complementary push-pull circuit consisting of transistors Q_4, Q_5, Q_6, Q_7 and Q_8. The darlington configuration enables the driving circuit to operate at low current levels and therefore provides good sensitivity and noise characteristics. The driving circuit consists of transistors Q_1 and Q_2 in differential amplifier configuration. This provides good bias stability against variations of h_{FE} and temperature.* The biasing network is external to the chip to provide overall user economy and allow maximum versatility of application. The PA237 can be biased into Class A, Class A-B or Class B operation. Many biasing arrangements may be employed, including current source biasing, various degrees of voltage source biasing, common mode biasing, etc. The standby idle current is established by the current in the diode chain regulator. Increasing the diode current moves the amplifier toward Class A operation. The center point voltage (pin 7) is established by the voltage drop across the load (R_3) in series with the diode string (pin 3) (see Figure 2). Thus, by properly choosing this resistor value and diode current, one can obtain the center point voltage and output idle current of one's choice.

The operating voltage is 9 to 27 volts for the standard PA237. Higher voltage devices are available upon special order. The output has over 1 ampere peak capability which enables the amplifier to drive low impedance loads.



R_f	0	1KΩ	5KΩ	10KΩ
Sens. at 2W	8.0mV	22mV	86mV	150mV
THD at 2W	5.2%	2.9%	1.7%	1.5%
Z(in)	20KΩ	35KΩ	40KΩ	40KΩ
Freq. Resp. -3dB	80-24 kHz	35-50 kHz	18-100 kHz	17-110 kHz

Figure 2 - PA237 Test Circuit

Figure 2 shows the amplifier test circuit with voltage source biasing, high and low frequency roll-off, bootstrapping, negative DC feedback, and negative AC feedback loop closure. The amplifier is biased into Class A-B operation. The sensitivity is 120mV for 2W output or a voltage gain $>$ 45. The input impedance is 40KΩ and the output impedance 0.85Ω. Noise output is 75dB below 2W. The ratio of R_4 to R_f determines the amount of AC feedback closure. Setting the 6.8KΩ feedback resistor (R_f) to other values enables the sensitivity, input impedance and distortion to vary as seen on the chart accompanying Figure 2. Making this feedback resistor the volume control may be advantageous in that as the output level is decreased by increasing the negative A.C. feedback, the distortion decreases. This is particularly desirable for lowering crossover distortion at low levels in that it is at low levels where crossover becomes a significant portion of the total distortion.

*For more detailed explanation of circuit configuration refer to Publication Number 90.73.

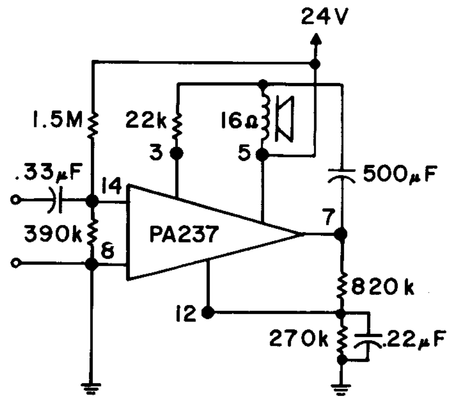


Figure 3 - 24V Open Loop Configuration

Figure 3 shows the PA237 in a 24V-16Ω open loop application. It has a sensitivity of 5mV for 2W output or a voltage gain of $>$ 1100. The input impedance is $>$ 15KΩ. This sensitivity enables the amplifier to be driven directly from a diode detector or magnetic phono cartridge.

The same configuration can be used at other combinations of voltage and load impedance simply by changing the values of the biasing resistors. Figure 4 shows such a change for 12V and 8Ω operation.

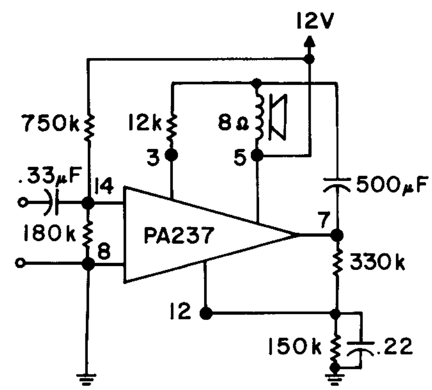
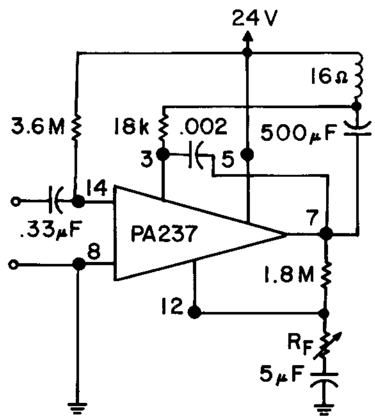


Figure 4 - 12V Open Loop Configuration

Seven millivolts drives the amplifier to 3/4W output for a voltage gain of 350 at 3.5% T.H.D. Maximum power out is 1W at 10% T.H.D. The input impedance is 15KΩ.

The number of external components can be reduced where the application does not require all the protective elements that were included in Figure 2. The configuration of Figure 5 employs current source biasing, adjustable loop closure, and low frequency roll-off for a total external component count of four resistors and two capacitors. (The current gain (h_{FE}) of the differential amplifier



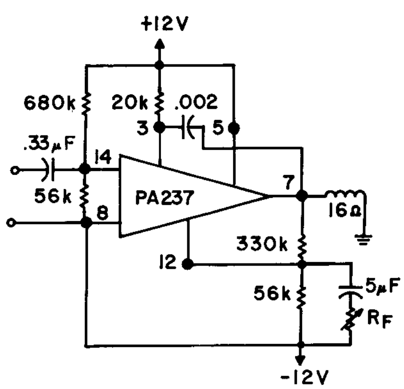
R_f	0	1KΩ	5KΩ	10KΩ
Sens. at 2W	5mV	11mV	26mV	40mV
THD at 2W	5.0%	4.5%	3.5%	1.8%
Z(in)	24KΩ	50KΩ	80KΩ	100KΩ
Freq. Resp. -3dB	60-19 kHz	40-29 kHz	20-41 kHz	10-50 kHz

Figure 5 - Current Source Bias Configuration

transistors (Q_1 and Q_2) must be known to enable one to choose the current source resistor values.)

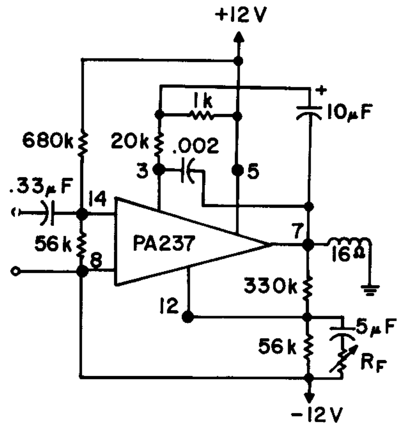
Figure 5 shows the configuration for 24V and 16Ω Class A-B operation. The accompanying chart shows the amplifier performance for different degrees of loop closure.

The large output coupling capacitor can be eliminated by using two supplies when available. Figure 6a shows such a configuration employing voltage source biasing. The same circuit but with the addition of load bootstrapping is shown in Figure 6b.



R_f	0	1KΩ	5KΩ	10KΩ
Sens. at 2W	40mV	80mV	150mV	220mV
THD at 2W	4.5%	3.2%	2.5%	2.2%
Z(in)	15KΩ	20KΩ	30KΩ	35KΩ
Freq. Resp. -3dB	10-75 kHz	12-90 kHz	9-100 kHz	8-130 kHz

Figure 6a - Dual Supply Configuration

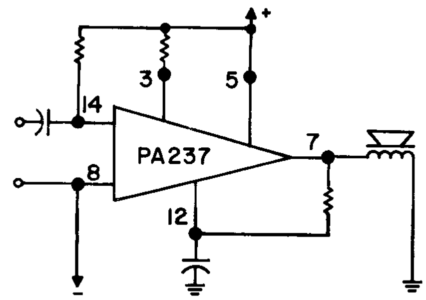


R_f	0	1KΩ	5KΩ	10KΩ
Sens. at 2W	10mV	23mV	85mV	140mV
THD at 2W	7.5%	4.5%	2.0%	1.5%
Z(in)	24KΩ	20KΩ	35KΩ	40KΩ
Freq. Resp. -3dB	50-20 kHz	25-40 kHz	12-80 kHz	10-95 kHz

Figure 6b - Dual Supply Configuration with Load Bootstrapping

The circuit in Figure 7 employs a minimum number of external components when some of the performance of the other circuits can be sacrificed.

Figure 7 - Minimum External Component Configuration



For operation from high source impedance transducers such as ceramic and crystal phono cartridges the amplifier input impedance may be increased by the methods shown in the following circuit configurations.

Figure 8 - Bootstrapped Input Configuration

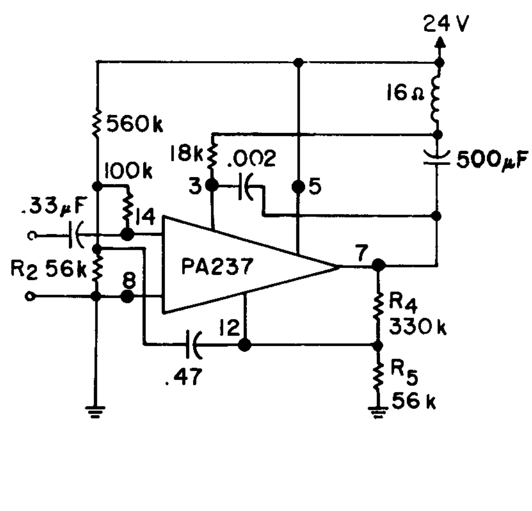
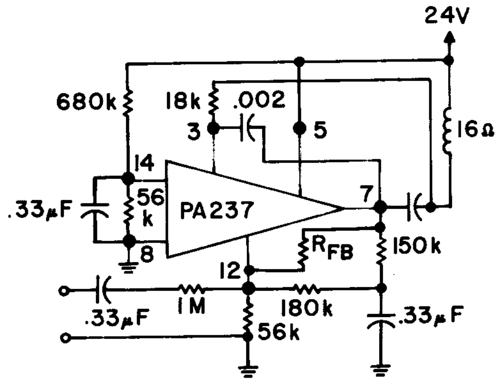


Figure 8 shows the PA237 with additional input bootstrapping to increase input impedance. The ratio of the parallel combination of resistors R_2 and R_5 to R_4 determines the amount of AC feedback closure. One can adjust the loop gain by choosing the biasing resistors so that the parallel combination of R_2 and R_5 result in the desired loop closure. Another method is to place an AC shunt consisting of a capacitor and the desired resistor value across R_5.



R_{FB}	∞	10MΩ	5MΩ
Sens. at 2W	650mV	1.1V	1.9V
THD at 2W	3.0%	1.8%	1.25%
Z(in)	1MΩ	1MΩ	1MΩ
Freq. Resp. -3dB	150-10 kHz	80-21 kHz	50-34 kHz

Figure 9 - Voltage Ratio Feedback Configuration

For operation with crystal phono cartridges or other high impedance sources, the circuit of Figure 9 may be considered using voltage ratio feedback. The accompanying chart shows the circuit performance for different degrees of feedback closure.

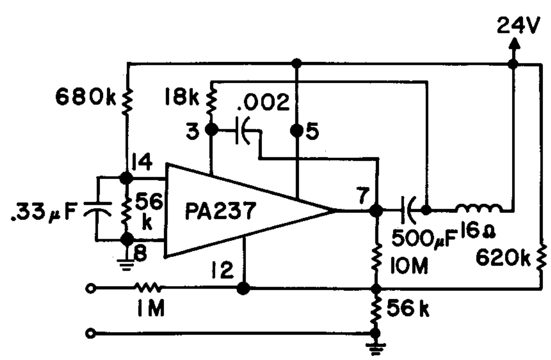


Figure 10

The circuit of Figure 10 may be used in place of that of Figure 9 saving a resistor and capacitor where the degree of negative DC feedback of the circuit in Figure 9 is not required.

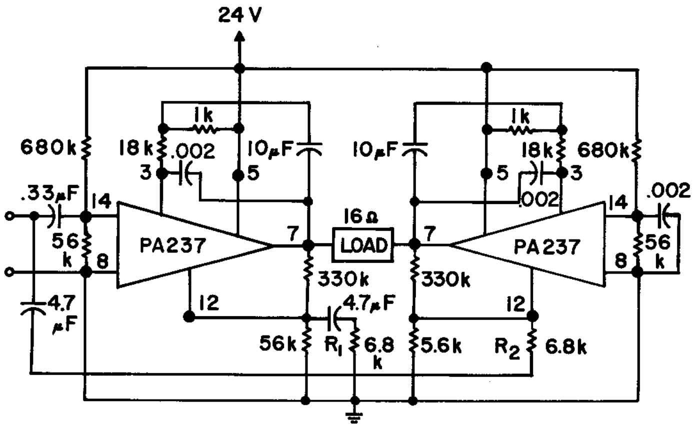


Figure 11 -

Bootstrapped Bridge Configuration

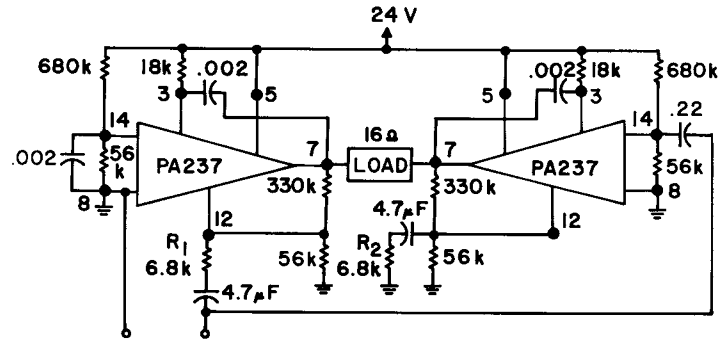
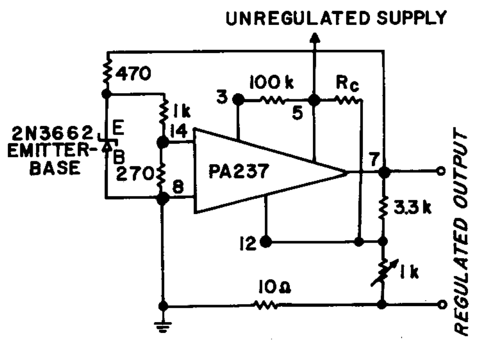


Figure 12 -

Bridge Configuration without Bootstrapping

For higher power applications, the PA237 may be used in a bridge configuration thereby doubling the available power output. Figures 11 and 12 show two bridge circuits, one with load bootstrapping and one without. Resistors R1 and R2 are adjusted for the desired amplifier sensitivity and input impedance. Of course, the various biasing configurations previously discussed for the single amplifier are applicable to the bridge circuits also.

The PA237 may also be used as a voltage regulator as is shown in Figure 13. The current capability is limited by the difference between input voltage and regulated voltage so that the VI product does not exceed the power rating of the 237. Short circuit protection is provided by the resistor in the ground return path. An alternate method of current limiting which provides a sharper cutoff is to use a transistor to shunt the reference diode at the desired current. The accompanying chart shows the performance of the circuit of Figure 13 for various regulator output voltages versus unregulated input voltage.



Unregulated Input Voltage	15	20	25	30*	35*	40*	
							Compensating Resistor
Regulated Output Voltage	9.9	10.0	10.0	10.0	10.0	10.0	R_C = 100KΩ
	11.7	12.0	12.0	12.0	12.0	12.0	R_C = 70KΩ
		14.8	15.0	15.0	15.0	15.0	R_C = 50KΩ
		16.5	17.0	17.0	17.0	17.0	R_C = 40KΩ
			19.9	20.1	20.1	20.1	R_C = 30KΩ
			22.4	22.6	22.5	22.5	R_C = 20KΩ

Figure 13 - Voltage Regulator

*Utilizes selected high voltage PA237's

Codes: 50 thru 56; 40, 41, 42, 44, 45, 47

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SEMICONDUCTOR PRODUCTS DEPARTMENT
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GENERAL ELECTRIC

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