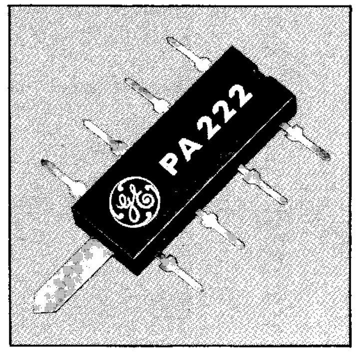
ELECTRONIC INNOVATIONS IN ACTION

SEMICONDUCTORS

Integrated Circuit
Audio Amplifier

PA222

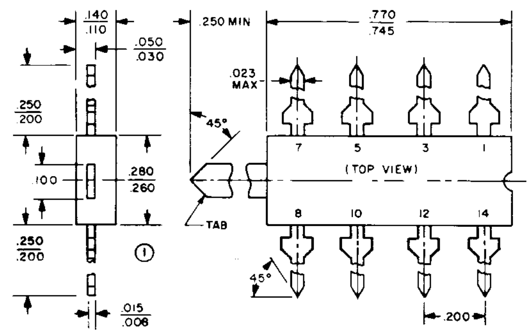
The General Electric PA222 is a 1-watt audio amplifier housed in an 8-lead dual-in-line package. A tab is available for attachment to a heat sink which can be simply a copper area on a printed circuit board (See note 1). The PA222 is intended for use in consumer and industrial products where reliability and cost are of primary importance. Typical applications for the PA222 are phonographs, tape recorders, sound amplifiers for TV and FM sets, AM radio output, and intercoms.



maximum ratings: (25°C)

Maximum Supply Voltage		
Pin 8 to 12	25	Volts
Pin 7 to 12	35	Volts
Maximum Output Voltage		
Pin 10 to 12	25	Volts
Maximum Output Current		
Pin 10	400	mA
Storage Temperature	−65 to +150	°C
Maximum Package Dissipation*		
Free Air at 25°C	800	mW
Tab at 50°C	1250	mW

*See derating curve, Figure 2.



Package Outline

electrical performance: At 22 volts supply and 25°C in test circuit (See Note 2)

	Min.	Typ.	Max.	
Audio Power Out at 25°C Tab Temperature and < 10% THD	1.0			Watt
Frequency Response, ±3 dB (P_O = 1 W)		55-15,000		Hz
Distortion, Low Level (P_O = 50 mW, 1kHz)		1	3	%
Input Voltage, Pin 3 (P_O = 1 W)		52	65	mV (rms)
Power Gain (Load = 22 ohms)		72		dB
Input Impedance	40	55		kOhms
Output Impedance		1		Ohm
Current Drain (No Signal, Note 3)	6		25	mA
Efficiency (P_O = 1 W)		46		%
Noise Output Relative to 1 watt		−65	−55	dB

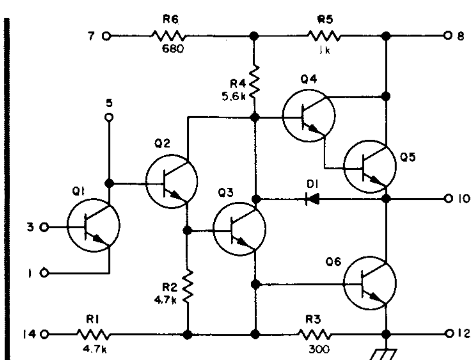


Figure 1. Integrated Circuit Diagram

Notes:

1. The PA222 should have the tab soldered to a ½″ to 1″ square copper area on the printed circuit board for 1 watt applications.
2. Performance is determined by external components used for feedback and stabilization in the test circuit.
3. The value of the external resistor needed to obtain this current level is specified. See external resistor cross-reference chart in Figure 5.

Circuit Operation (See Figure 1)

The input signal and feedback is fed into a common-emitter amplifier, Q1. Q2 is an emitter follower, supplying drive to Q3, a split-load phase inverter. Q4 and Q5 are emitter followers which drive the load during the positive half of the output signal. Q6 is a common-emitter stage which drives the load during the negative half of the output signal. Transistors Q5 and Q6 thus form a conventional series-connected, single-ended, push-pull output stage. Diode D1 is a latching diode to ensure full drive during the negative half of the output signal.

GENERAL ELECTRIC

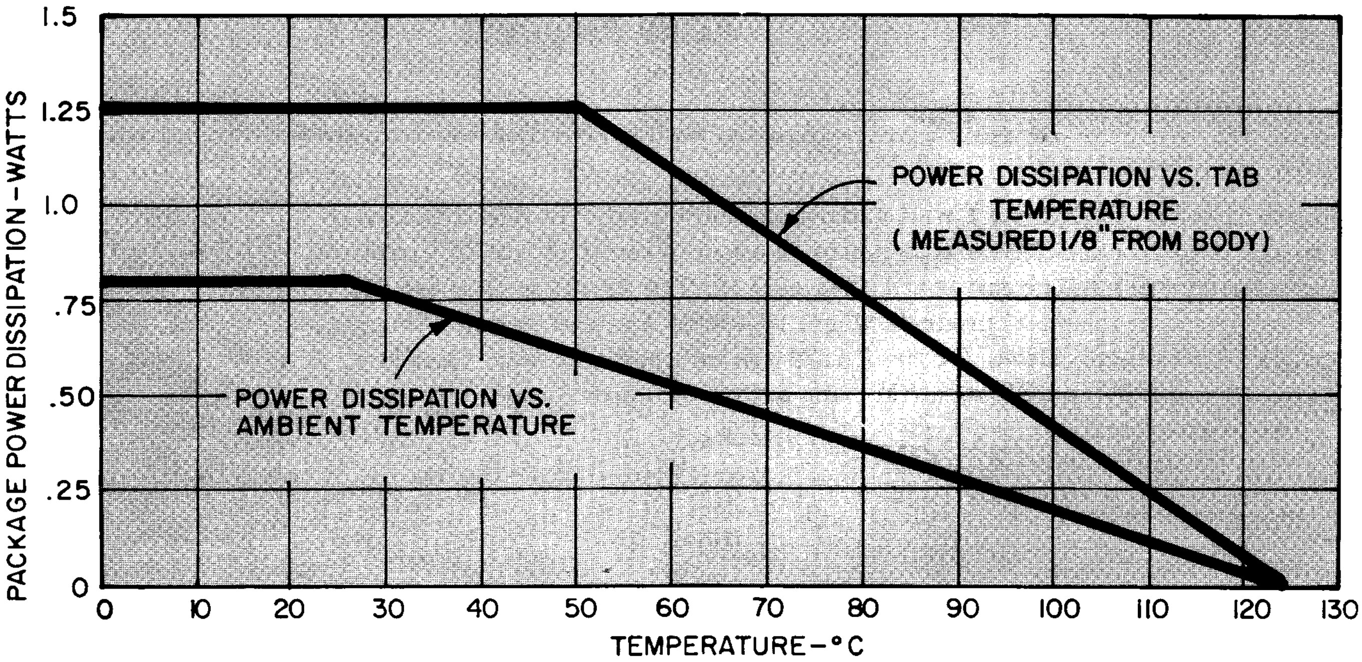


Figure 2. Maximum Power Derating Curve (Continuous Power)

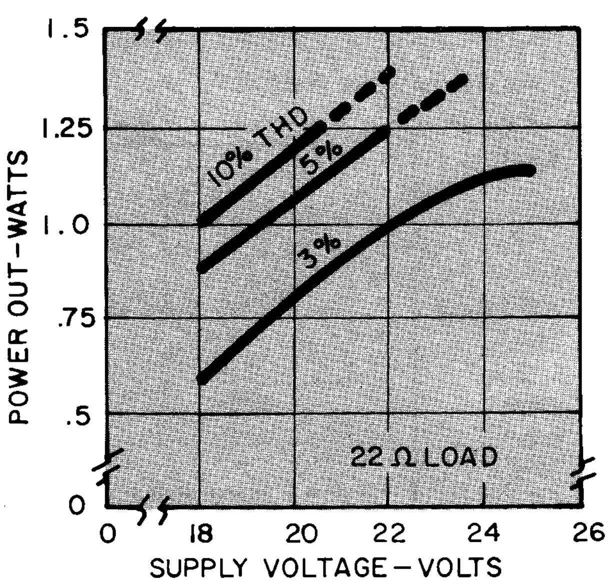


Figure 3. Typical Power Output vs. Supply Voltage

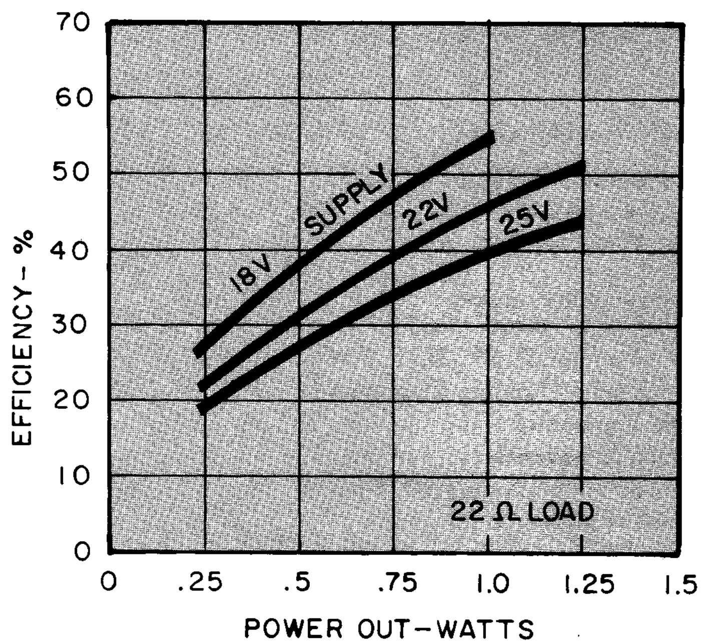
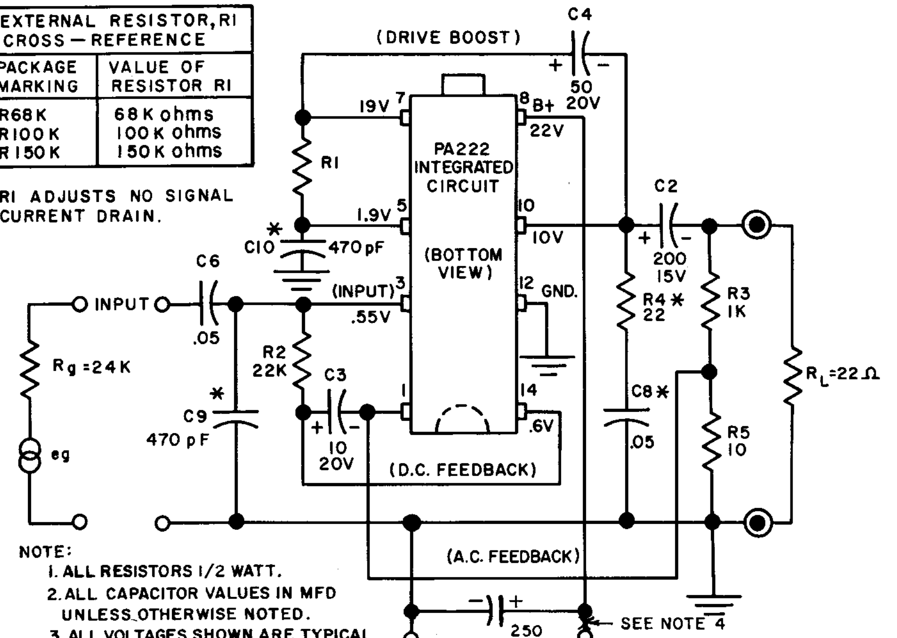


Figure 4. Typical Efficiency vs. Power Out



EXTERNAL RESISTOR, RI CROSS — REFERENCE	
PACKAGE MARKING	VALUE OF RESISTOR RI
R68K	68K ohms
R100K	100K ohms
R150K	150K ohms

RI ADJUSTS NO SIGNAL CURRENT DRAIN.

NOTE:
1. ALL RESISTORS 1/2 WATT.
2. ALL CAPACITOR VALUES IN MFD UNLESS OTHERWISE NOTED.
3. ALL VOLTAGES SHOWN ARE TYPICAL WITH NO SIGNAL APPLIED TO CIRCUIT.
4. #53 PILOT LAMP MAY BE INSERTED HERE DURING LIMITED POWER TESTING TO LIMIT CURRENT TO A SAFE VALUE.

* RF SUPPRESSORS. BECAUSE OF THE EXCELLENT HIGH FREQUENCY RESPONSE OF MONOLITHIC TRANSISTORS, CAUTION SHOULD BE TAKEN WITH LEAD DRESS AND GROUNDING PATHS.

Figure 5. Test Circuit

DESIGN NOTES

To standardize the performance of the PA222, it has been tested with the passive components and power supply illustrated in the Audio circuit of Figure 5.

R1 is selected to set the zero-signal (idle) current and the dc voltage at pin 10. The proper value of R1 is clearly marked on each unit. (See external resistor cross reference table in Figure 5.) If R1 is chosen too high, the zero-signal current will be low and excessive crossover distortion at low signal levels will result. Conversely, if R1 is too low, high zero-signal currents and excessive heating will result. (High currents may also be caused by a leaky capacitor, C3.)

The PA222 has both extremely high open loop voltage and current gain. Because of this, certain precautions must be observed in using this or any other high gain amplifier.

GROUND LOOPS — The power supply output filter capacitor should be as close to pin 12 as possible and all other ground returns run *separately* to this point. Common ground impedances can cause hum due to power supply filter charging currents and distortion due to Class B output currents.

HIGH FREQUENCY STABILITY — To prevent high frequency oscillations, care should be used in the component layout. This is required because integrated circuit transistors are capable of amplifying higher frequencies than their discrete counterparts. Thus, the components used for high frequency stabilization (C9, C10, R4, and C8) should be located close to amplifier pins 3, 5, and 10 respectively. The input and output impedances are stabilized by C9 and the R4-C8 combination, while C10 provides stabilization within the feedback loop.

High frequency response of the circuit is controlled by the time constant formed by C9 and the source impedance. It is desirable to keep this source impedance below 24k ohms because the type of feedback used is more effective with a voltage source. C3 is necessary to prevent ac feedback via the dc feedback loop and to increase the input impedance.

Bootstrap capacitor C4 is used between pins 10 and 7 to insure full drive during the positive half of the output signal.

Overall gain of the circuit is determined by the value of R3. For example, with R5 fixed R3 may be adjusted from the indicated value to increase or decrease the gain.

A limited power test can be performed by employing a lamp in series with the power supply as shown in the test circuit of Figure 5 and the audio amplifier circuit of Figure 6. By using a lamp in this manner, several trouble shooting advantages are realized.

1. The maximum current in the amplifier — 115 mA — will be well below the safe limit for any component in the circuit.
2. Cold resistance of the lamp is low — approximately 32 ohms — and in a normal amplifier only slightly effects the dc (zero-signal) voltage and current measurements.
3. Current in excess of 28 mA causes the lamp to light providing a visual indication of currents above normal.
4. In addition to monitoring the dc operation of the amplifier, small signal checks can also be made. With an input signal, the sensitivity or voltage gain of the amplifier can be verified.

One of the outstanding features of this integrated circuit is its ability to compensate for changing thermal conditions and thereby eliminate thermal runaway. This feature was achieved by establishing a dc negative feedback path between the base of the lower output stage and the base of the input stage. Thus, the base-emitter diode voltage (and hence the zero-signal current) of the output stage is controlled by the base-emitter voltage of the input stage. Because the current density in the input stage is lower than that of the output stage, the input base-emitter voltage has a larger temperature coefficient that slightly over-compensates for bias shifts due to temperature. Hence, the zero-signal current is reduced as the junction temperature rises.

This compensation technique illustrates one of the unique advantages of the monolithic technology. Satisfactory circuit performance results because of the close matching and low thermal time constant between devices located on the same silicon chip.

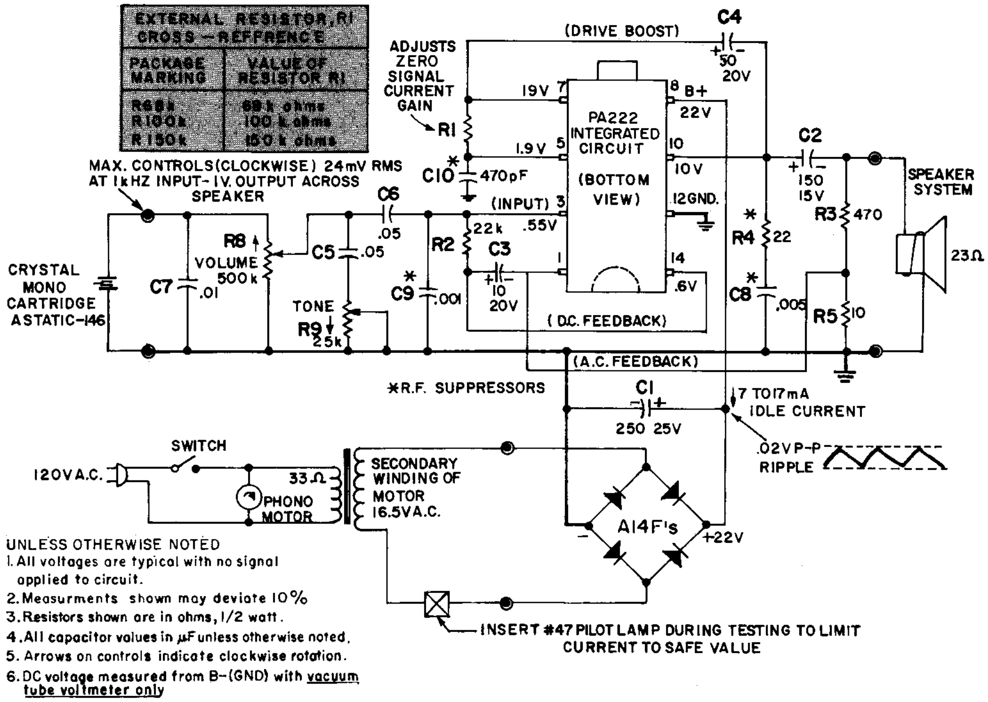


Figure 6. Circuit Diagram of I.C. Phonograph

TYPICAL APPLICATIONS

Specific applications of the PA222 may utilize different combinations of external components. These components determining the actual performance of the circuit. A practical example of a complete audio amplifier circuit is shown in Figure 6[1]. This particular circuit is used in a portable phonograph that has an output of 1 to 1½ watts (with less than 5% distortion).

Because the PA222 has good sensitivity and prefers low source impedance, the crystal cartridge has been shunted with a 0.01μF capacitor. To reduce both its voltage and impedance, the volume control is connected to give a loudness-control type action, boosting the bass at low levels and reducing it at maximum volume.

As previously indicated, the external components determine the actual performance of the PA222. Figure 7 illustrates a combination of R's and C's that extend the operation of the PA222 above the audio range. Response of this circuit is from 50 Hz to 100k Hz; however, even this limit could be extended to 900k Hz by removing C9. At these higher frequencies, some sacrifice in wave shape will result because of circuit phase shifts and lower loop gain.

The circuit in Figure 7 requires fewer components than the previously described audio application. Reductions include bootstrap capacitor C4 which is eliminated because the drive boost is removed and stabilization elements R4, C8 and C10 which are not required with the resistive load. In addition, bypass capacitor, C3, is now brought to ground rather than pin 2. As a result of these modifications, the input resistance is lowered and is approximately equal to the value of R2. Removal of the drive boost results in lower output power and a typical distortion level of 3% as opposed to 2% for the audio circuit. Other than the exceptions discussed, performance of this extended frequency circuit is similar to the audio circuit.

The circuits described are intended to serve only as a guide in using the PA222. Modifications can be made to meet specific circuit requirements, however, the design precautions noted should be utilized for each application.

Reference:

[1]Petrie, A. F. "First Integrated-Circuit Phonograph," *Electronics World*, December 1966.

EXTERNAL RESISTOR, R1 CROSS — REFERENCE	
PACKAGE MARKING	VALUE OF RESISTOR R1
R68K	68K ohms
R100K	100K ohms
R150K	150K ohms

R1 ADJUSTS NO SIGNAL CURRENT DRAIN

NOTE:

1. ALL RESISTORS 1/2 WATT.
2. ALL CAPACITOR VALUES IN MFD UNLESS OTHERWISED NOTED.
3. ALL VOLTAGES SHOWN ARE TYPICAL WITH NO SIGNAL APPLIED TO CIRCUIT.

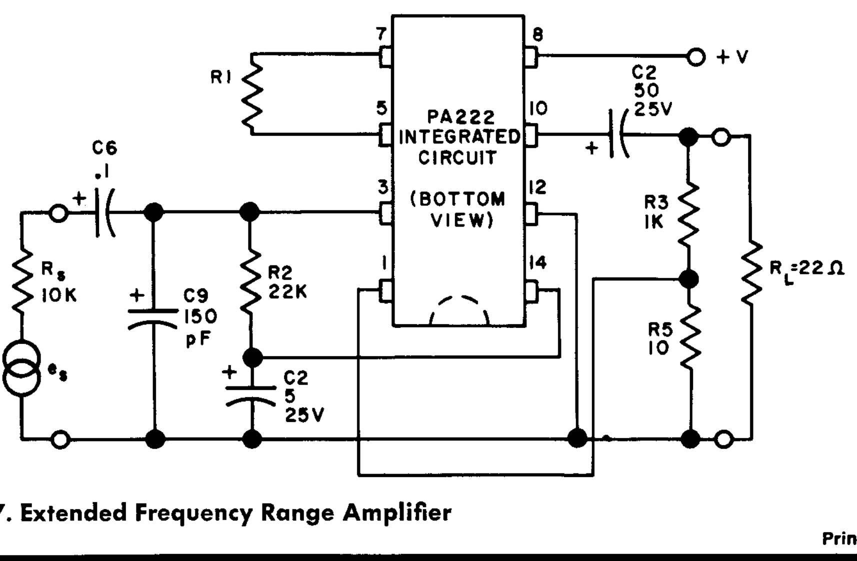


Figure 7. Extended Frequency Range Amplifier

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