

Darlington Power Transistors in Audio Amplifiers

EB 103

Price 20p

SUMMARY

A description is given of three amplifiers with the following output powers:

- a) 75W from 2 x 32V rails into 4 Ω
- b) 50W from 2 x 26V rails into 4 Ω
- and c) 25W from 2 x 20V rails into 4 Ω

These audio circuits are designed primarily for mains powered home equipment.

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DARLINGTON POWER TRANSISTORS IN AUDIO AMPLIFIERS

INTRODUCTION

The use of Darlington transistors in audio amplifiers gives the advantage of a lower component cost and thus mounting cost, both by reducing the number of actual devices required and, through their high gains, the number of conventional driver stages. Also by using complementary Darlington output stages the problem of providing inversion stages is removed.

CIRCUIT DESCRIPTION

A circuit diagram of the 25 and 50W amplifier is given in Figure 1 and of the 75W amplifier in Figure 2. These amplifiers use direct coupling at the output and consequently a differential stage is used at the input to ensure low offset voltages. Otherwise, excessive offset could lead to de-centring of the loudspeaker cone or, in the extreme case, its destruction. Negative feedback is also provided to the

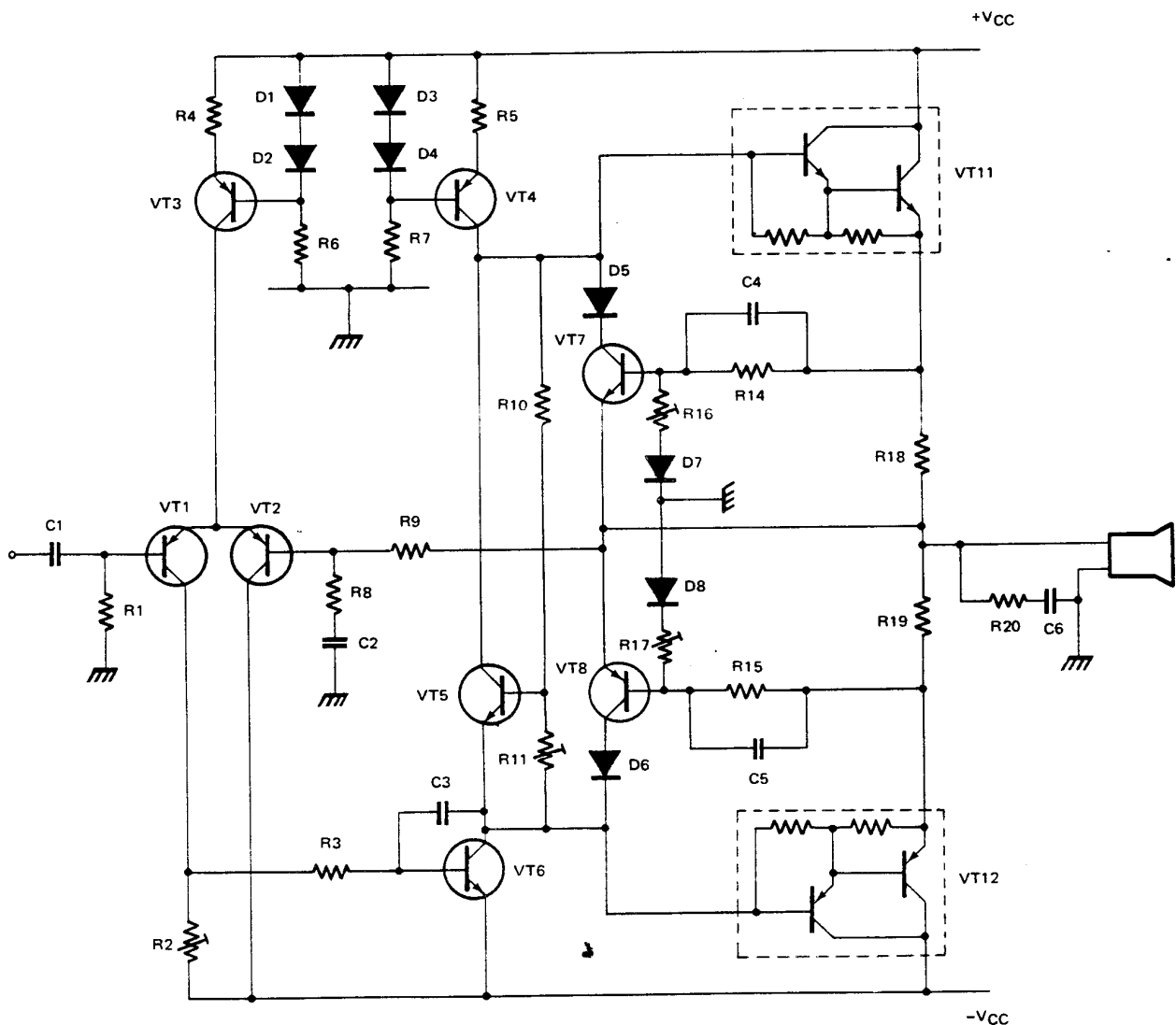


FIGURE 1. Circuit Diagram of 25 and 50W Amplifiers

Components List

	25W	50W	75W
R1	120k Ω	120k Ω	120k Ω
R2	2k5	2k5	2k5
R3	1k	1k	1k
R4	560	560	560
R5	56	47	180
R6	3k3	3k3	3k3
R7	3k3	3k3	3k3
R8	1k2	1k2	1k2
R9	110k	110k	110k
R10	1k8	1k8	3k3
R11	1k	1k	1k
R12, R13	—	—	470
R14, R15	270	270	270
R16, R17	5k	5k	5k
R18, R19	0.27	0.27	0.27
R20	2 Ω 7	2 Ω 7	2 Ω 7
C1	680nF	680nF	680nF
C2	47 μ F	47 μ F	47 μ F
C3	27pF	27pF	27pF
C4, C5	10nF	10nF	10nF
C6	100nF	100nF	100nF
D1-D6	1N914	1N914	1N914
VT1-VT4	BC212	BC212	BC212
VT5	BC429	BC429	BC429
VT6-VT7	BC182	BC182	BC182
VT8	BC212	BC212	BC212
VT9	—	—	BC182
VT10	—	—	BC212
VT11	TIP120	TIP130	TIP141
VT12	TIP125	TIP135	TIP146

CALCULATIONS

For the 25W into 4 Ω AmplifierSpecification $P_{out} = 25W$ $R_L = 4\Omega$ Input Impedance $R_{in} \geq 100k\Omega$ Voltage gain $\approx 40dB$ V_{in} for full output 110mV

$$\text{Supply voltage } V_S = (P_{out} \times 8 \times [R_L + R_{in}])^{1/2} + 2 \times V_{CE(sat)}$$

$$P_{out} = 1.2 \times P_{out} = 30W$$

 R_E is chosen to be 0.27 Ω where $R_E = R_{18} = R_{19}$

$$R_L = 4\Omega$$

$$V_{CE(sat)} = 2V$$

$$\therefore V_S = (60 \times 8 [4 + 0.27])^{1/2} \times 2 \times 2$$

$$= 36V$$

2 x 20V supplies would be quite adequate.

The peak collector current of the output transistors VT11 and VT12

$$\hat{I}_C = (V_S - 2 \times V_{CE(sat)}) / 2 \times R_L + R_{in}$$

$$\text{where } R_L = 0.8 \times R_L = 3.2\Omega$$

$$\hat{I}_C = (40 - 2 \times 2) / 2 \times (3.2 + 0.27) = 5.2A$$

In order to meet these requirements ($V_{CEO} = 60V$ and $I_C = 5A$) the correct Darlington transistors for the output devices are the TIP120 and TIP125.

$$I_B = I_C / h_{FE} \quad \text{where } h_{FE} = 1600$$

$$I_B = 5 / 1600 = 3.12mA$$

With a resistor value of 56 Ω for R5, the constant current value

$$I_Q = 0.7 / 56 = 12.5mA$$

and an output driving ratio

$$V = I_B / I_Q = 3.12 / 12.5 = 0.25$$

Graphs of total harmonic distortion (t.h.d.) versus output power and versus frequency for this amplifier are given in Figures 3 and 4, and the frequency response is shown in Figure 5.

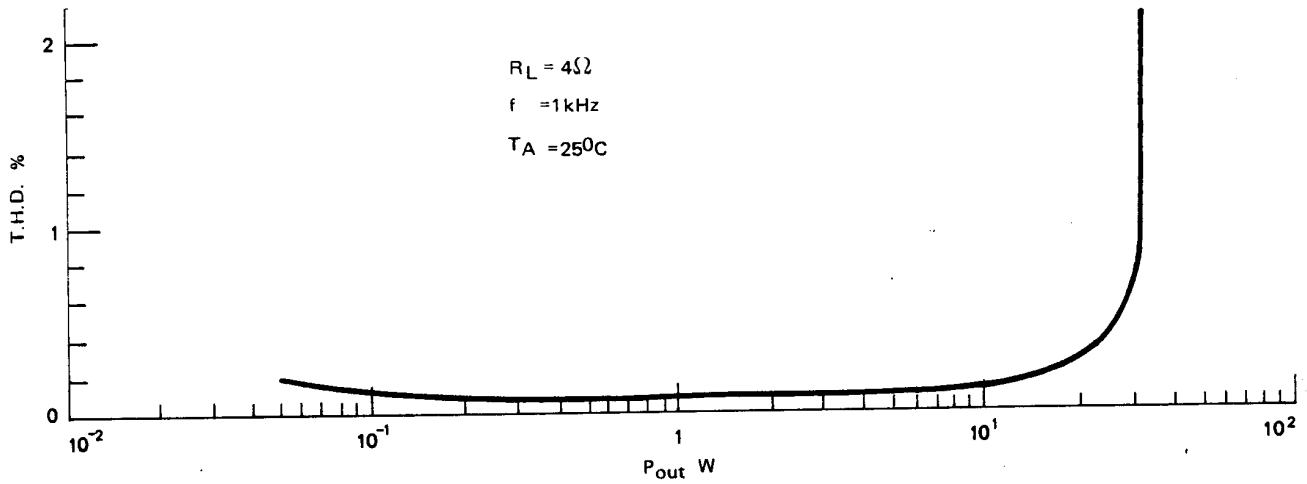


FIGURE 3. T.H.D. vs Output Power of 25W Amplifier

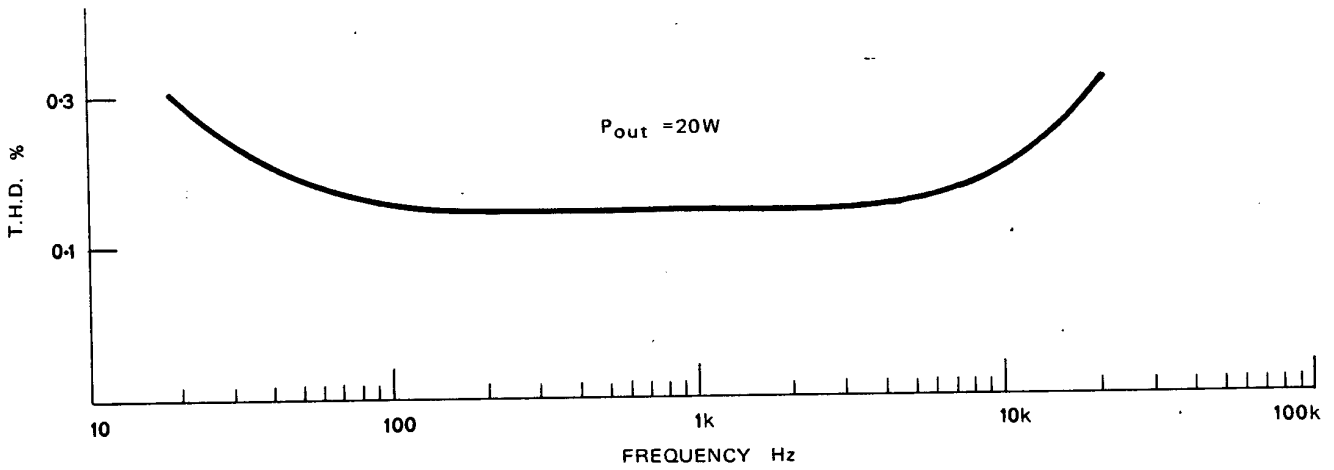


FIGURE 4. T.H.D vs Frequency of 25W Amplifier

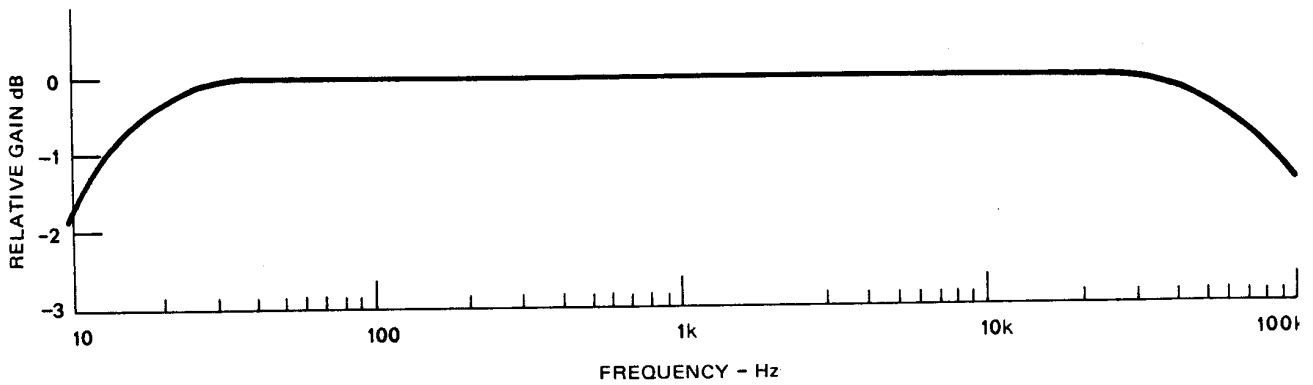


FIGURE 5. Frequency Response of 25W Amplifier

50W into 4Ω Amplifier

Rest of Specification

Input Impedance $R_{in} = 100k\Omega$

V_{in} for full output = 157mV

Suitable supply voltages are $\pm 26V$ and Darlington

Transistors to supply the required 6.8A are the TIP130 and TIP135.

Graphs of t.h.d. versus output power and frequency, and frequency response for this amplifier are given in Figures 6, 7 and 8 respectively.

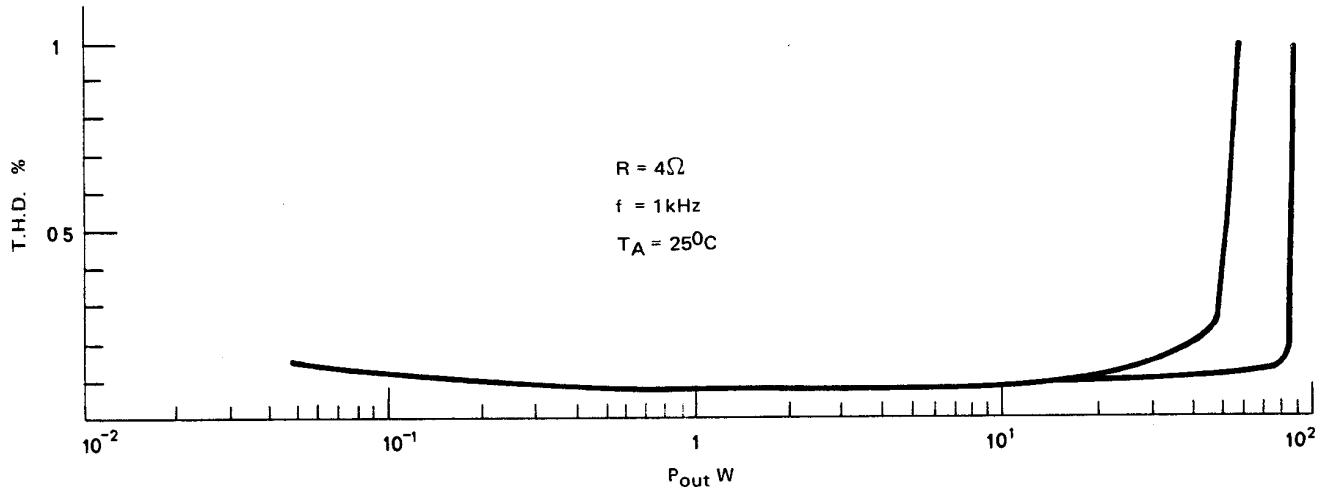


FIGURE 6. T.H.D. vs Output Power of 50W and 75W Amplifiers

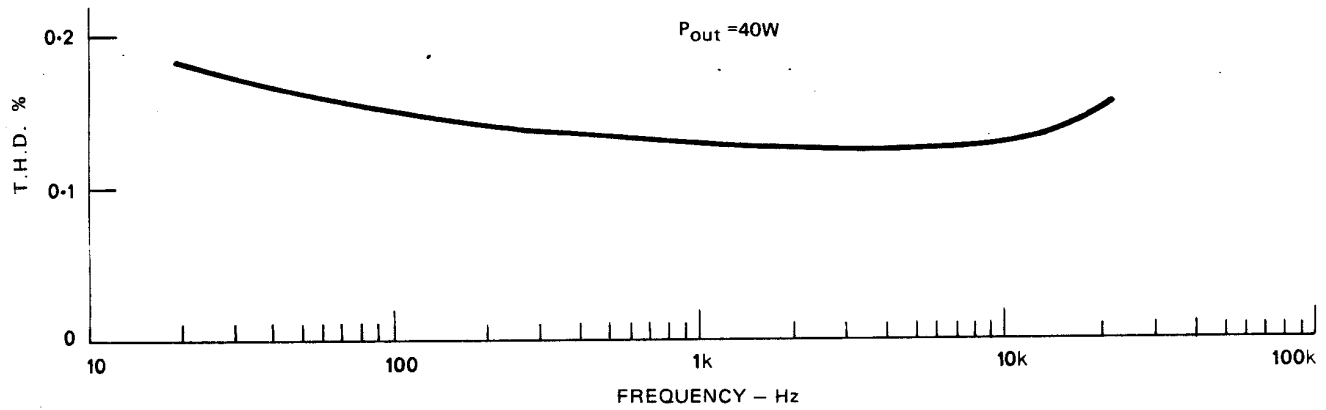


FIGURE 7. T.H.D. vs Frequency of 50W Amplifier

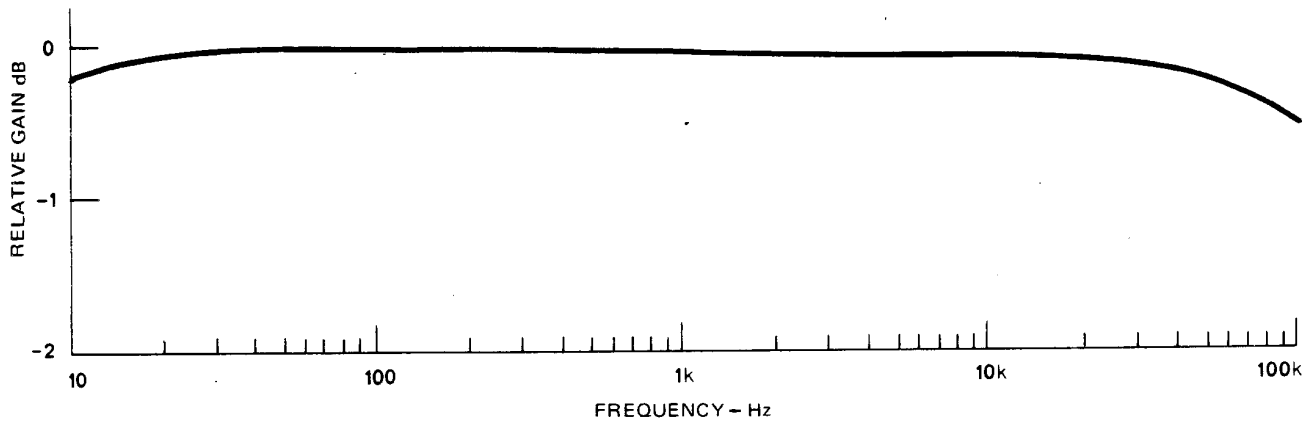


FIGURE 8. Frequency Response of 50W Amplifier

75W into 4Ω Amplifier

Rest of Specification

Input Impedance $R_{in} = 100k\Omega$

V_{in} for full output = 192mV

Suitable supply voltages are $\pm 31V$ and Darlington transistors to supply the required 8.2A are the TIP141 and TIP146.

The use of a constant current source giving approximately 20mA is not possible due to the high power requirements for transistors VT4 and VT5. Therefore in order to have relatively small currents and minimum power dissipation in the class A driver and the constant current supply device, small signal driver transistors are employed.

Graphs of t.h.d. versus output power and frequency, and frequency response are given in Figures 6, 9 and 10 respectively.

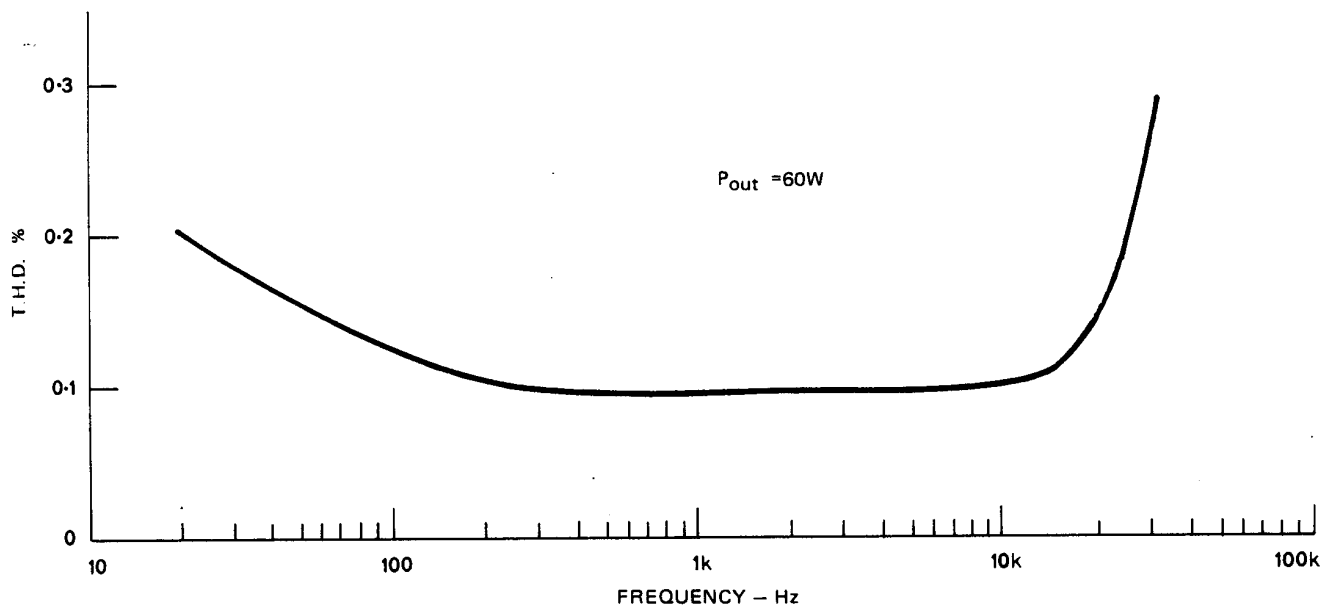


FIGURE 9. T.H.D. vs Frequency of 75W Amplifier

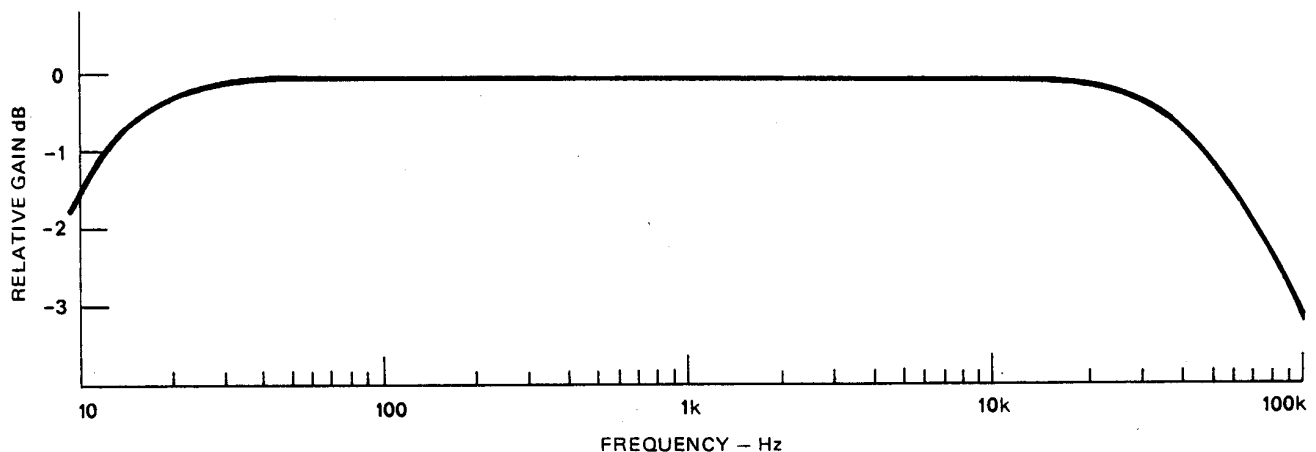


FIGURE 10. Frequency Response of 75W Amplifier