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Design a Low Cost 1000 Watt Power Amplifier for Rural Nigeria

Arobieke O. Oluwole
Electrical Engineering Department, Rufus Giwa Polytechnic, Owo.
Email:- oluarobieke@yahoo.com

***Abstract*—The need to get cheap and workable equipment to the rural areas cannot be overemphasised. The rural area of Nigeria represents more than half of the population. As enlightments grows, so also is the demand for "the good things of life". The opportunity to use a rugged and durable, high quality amplifier is the brainwork behind this paper.**

Keywords—OP-Amp, resistor, capacitor, power, Nigeria

INTRODUCTION

1.0DESIGN OF 1000 WATT POWER AMPLIFIER

It is known from the intention that this paper is foe 1000 watts. So the output power is 1000 watts. This will be supplied from a rectified power supply of 12V with a projected load of 8Ω

The various stages to be equally designed are the power supply, amplifying and the output units.

POWER SUPPLY UNIT

This stage is very important because it involves the conversion of the alternating current (A.C.) to direct current (D.C.) form required by the various stages within the system. It consists of a transformer, rectifier and a filter. It has a step down transformer with 45 volts output voltage.

TRANSFORMER CIRCUIT

For the transformer (fig 1) let us assume that the primary winding consist of 500 turns with an input voltage of 220V. The output voltage is 45V. The desired turns at the secondary winding will be determined by the transformed ratio.

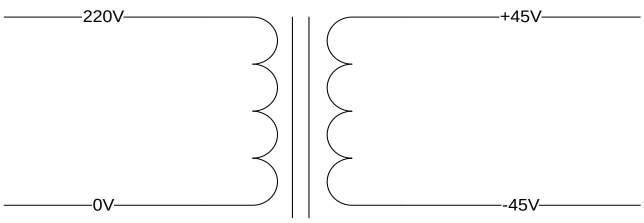

Fig. 1: Transformer

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

Where

V_S = Secondary Voltage

V_P = Primary Voltage

N_S = Secondary Turns

N_P = Primary Turns

$$\frac{45}{220} = \frac{N_S}{500} \Rightarrow \frac{500 \times 45}{220} = N_S = 102 \text{ Turns}$$

So the secondary winding consists of 102turns.

RECTIFYING CIRCUIT

The rectifying diode voltage (peak) = 50V

Power (P) = 1000w

Voltage (V) = 50V

P = VI

Where I is the current

$$\therefore I_{(\max)} = \frac{P}{V_{(\max)}} = \frac{400}{50} = 8A$$

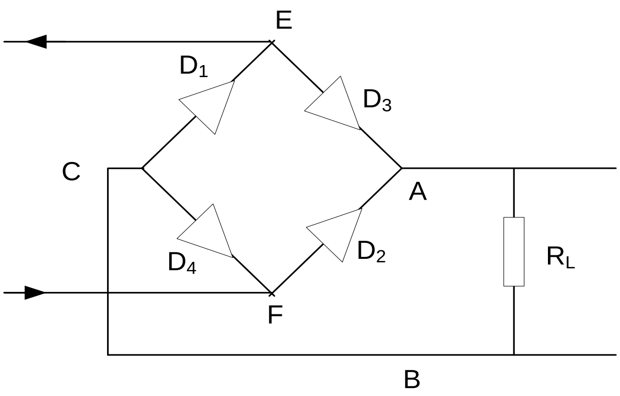

Fig. 2: Rectifying Circuit

The diode rating that can accommodate the required current without heating is IN5400

FILTERING CIRCUIT

The smoothing or filtering circuit, the output of two capacitors will pass through the resistors that are connected in parallel. To calculate the value of the capacitors used in the filtering circuit.

$V_{r.m.s.}$ = 45V

$V_{Peak} = V_{max} = \sqrt{2} \times V_{rms} = \sqrt{2} \times 45 = 63.63V$

$V_{d.c} = 0.636 \times 63.63 = 40.5V$

$V_{ripple} = 63.63 - 40.5 = 23.13V$

V_{ripple} = 63.63 – 40.5 = 23.13V

V_{ripple} (peak to peak) =2 x23.13 = 46.26V

The required ripple voltage should be 5% peak to peak

$$= \frac{5}{100} \times 46.26 = 2.31V$$

Capacitance

$$= \frac{T \times V_{max}}{\text{Projected Load} \times \text{Required Ripple Voltage}}$$

Where T = period = 1/f where F is the frequency = 50HZ

$$\therefore T = \frac{1}{50} = 0.02Sec$$

Projected load = 8Ω

Assuring that $R_1 = R_2$ = 1kΩ

Capacitance = $\frac{0.02 \times 63.63}{2.31 \times 8} = \frac{1.2726}{18.48}$

$$= 6886 \times 10^{-6} F = 6886 \mu F$$

And $C_1 = C_2$ =6886μF

The reactive value is 6800μF which is capable of performing the function of the calculated value.

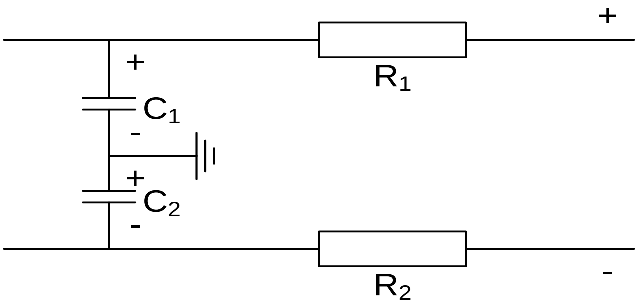

Fig. 3: Filtering Circuit

The secondary voltage is 45V for one side of the winding. Therefore, the capacitor rating voltage will be 45 x 2 = 90V. So, a capacitor 6800μF 80V rating will be preferred for efficient filtering and operation. The resistors R_1 and R_2 of Fig. 3 are assumed to be 1kΩ

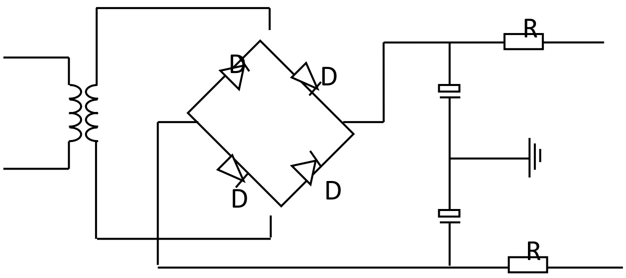

Fig. 4: Complete Power Supply Stage

AMPLIFIER STAGE

It makes use of an OP- Amp (JRC 4558). It is used due to its high gain and minimum distortion in the audio frequency range. For efficiency in the system, the gain should be between 10dB and 20dB

Assume voltage gain =20dB

For effectiveness the values of resistor lies between 10kΩ and 200kΩ.

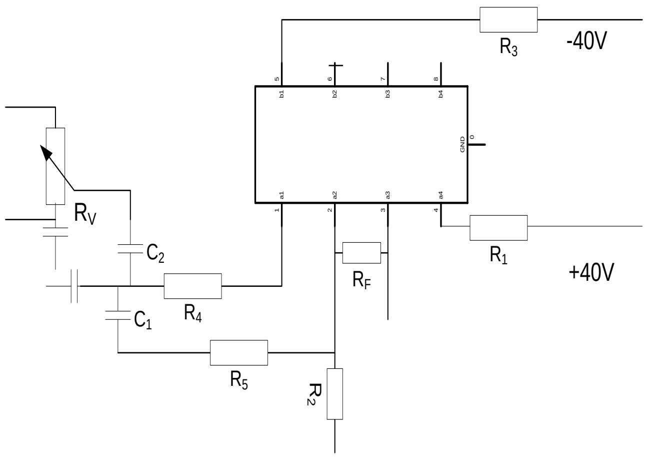

Fig. 5: Amplifier Circuit

Assuming that R_4 from fig. 5 above = 56kΩ

And $C = \frac{1}{2\pi f X_C}$ where f= 50H_Z

$$C = \frac{1}{2 \times 3.142 \times 56 \times 10^3 \times 50} = \frac{10^{-5}}{56} = 0.1\mu F$$

To calculate the value of the feedback resistor (R_f), we have

$$Gain = \frac{R_F}{R_{in}}$$

$$20 = \frac{R_F}{56} \Rightarrow R_F = 20 \times 56 \times 10^3 = 1120k\Omega$$

The preferred and readily available value is 1200kΩ. Also, for the variable resistor at the input terminal a 100kΩ resistor is used for efficiency.

OUTPUT STAGE

This stage of the power amplifier makes use of power transistors (MOSFETS). There are eight (8) MOSFETs in all, that is, 4 per channel. There are two P - channel MOSFET (IREP250N) and two N – channel MOSFET (IREP9240).

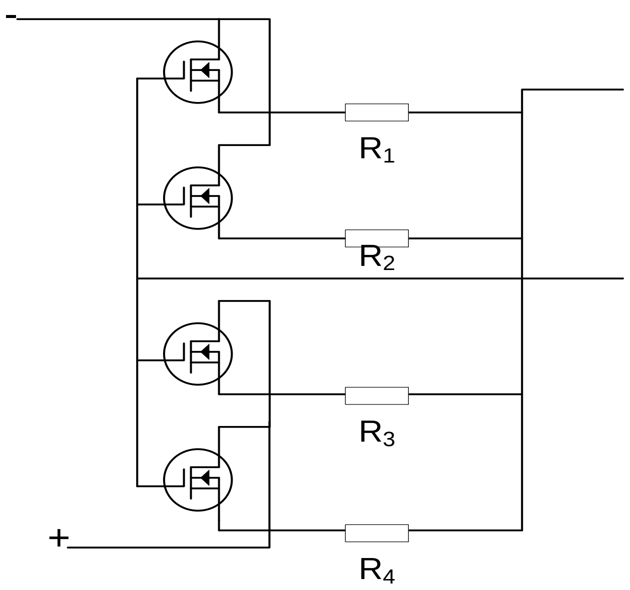

Fig. 6: Power Amplifying Stage

The minimum voltage that must be applied to the output stage for it to give the required output is given by.

$$V_{DD} = V_D + I_D R_L$$

Where

V_D = Drain Voltage

I_D = Drain Current

R_L = Load Resistor

Drain Voltage = 40V and

power per channel = 200W

from P = IV

$$I = \frac{P}{V} = \frac{200}{40} = 5A$$

Load Resistor = 8Ω

From $V_{DD} = V_D + I_D R_L$

$$V_{DD} = 40 + (8 \times 5)$$

$$V_{DD} = 40 + 40 = 80V$$

V_{PP} is the peak to peak voltage swing at the output of the power amplifier

$$\therefore P_{r.m.s} = \frac{V_{PP}^2}{2^2 R_L}$$

$$V_{PP}^2 = \frac{P_{r.m.s} \times 2^2 R_L}{\sqrt{P_{r.m.s} \times 2R_L}} = \sqrt{400 \times 2^2 \times 8} = \sqrt[2]{8 \times 400} = \sqrt[2]{3200} = 113.14V$$

And I_{PP} = peak to peak current delivered to the loudspeaker

$$I_{PP} = \frac{V_{PP}}{2R_L} = \frac{113.14}{2 \times 8} = \frac{113.14}{16} = 7.07A$$

Power delivered by each channel is given by

$P_2 = P_1$ =VI

Where V = 40V and I = 5 Amps

$P_1 = P_2$ = 40 x 5 = 200W

∴ Total Power delivered by the two channels is given by

$P_T = P_1 + P_2$ = 200 + 200 = 400W.

Table 1

BILL OF ENGINEERING MEASUREMENT AND EVALUATION (BEME)

FOR POWER AMPLIFIER

S/N	Component	Quality	Rate (N)	Amount (N)
1.	Transformer	1	1000	1000
2.	Diode IN 5400	4	50	200
3.	Power switch	1	70	70
4.	Capacitor 8600µF 80V	2	300	600
5.	Capacitor 0.1µF 50V	4	300	1200
6.	Vero Board	1	100	100
7.	Soldering lead	30 FT	15	150
8.	AC power cord	1	70	70
9.	Indicator	2	40	80
10.	JRC 4558	2	40	80
11.	MOSFET	8	100	800
12.	Fuse	8	100	800
13.	Variable Resistor	1	50	50
14.	Fixed Resistor	22	20	440
15.	Heat sink	2	100	200
16.	Fan	1	600	600
17.	Air let grill	2	150	300
18.	AC Socket	1	120	120
19.	Knobs	2	70	140
20.	Housing	1	2500	2500
21.	Edge Rubber	4	50	200
22.	Rug covering		300	300
23.	Screw	34	10	340
24.	Connecting wire	15 ft	10	50
25.	Speaker Terminal Socket	4	50	200
26.	Miscellaneous		1000	1000
	Total			11,590

CONCLUSION

Looking closely at the attendant cost (Table 1); it can be seen to be about one third of the price of the equivalent 1000 watts amplifier in the open market.

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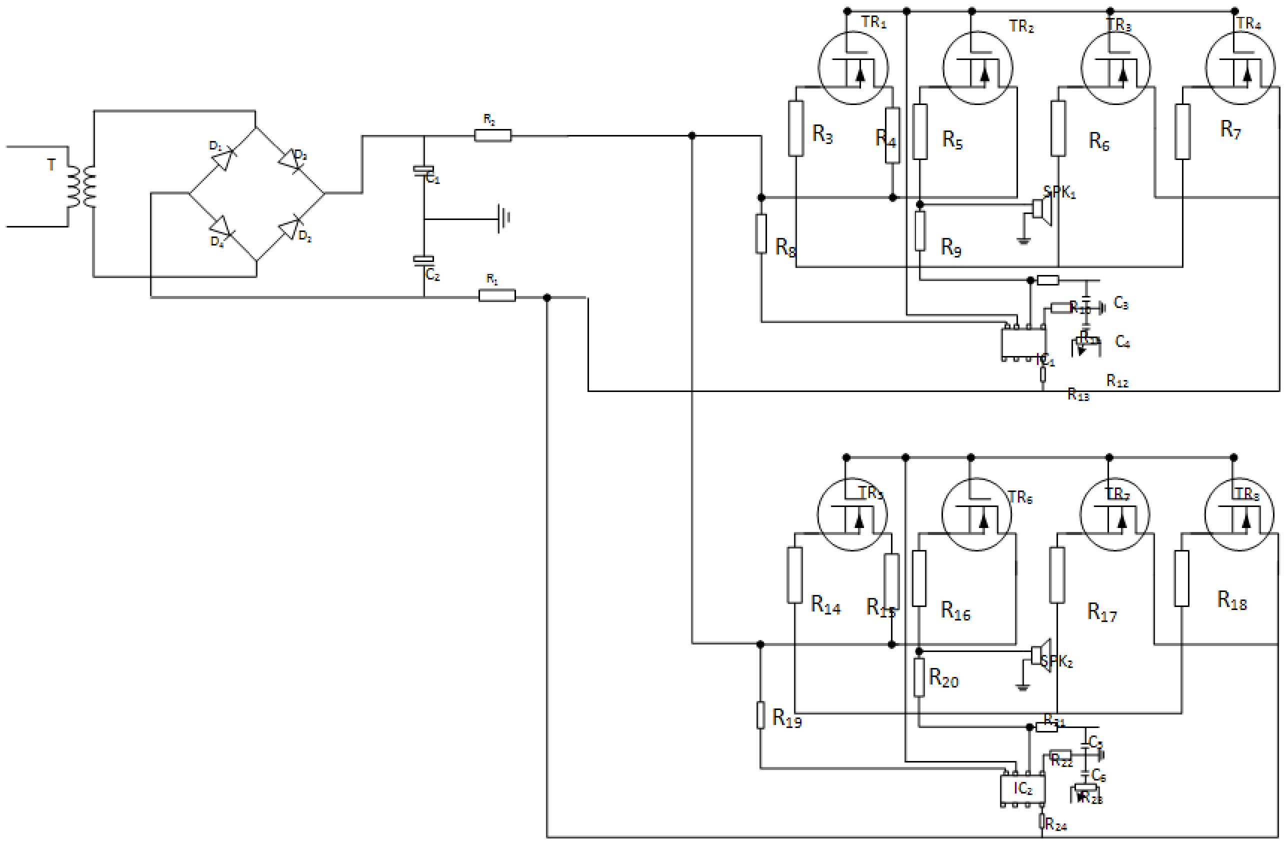

Fig. 7: Complete Circuit Diagram of 400W Power Amplifier