EXPERIMENT 6
Power Amplifiers

A. Background

Class A Stage

The amplifier given in Fig. 6.1 is of type called Class A amplifier.

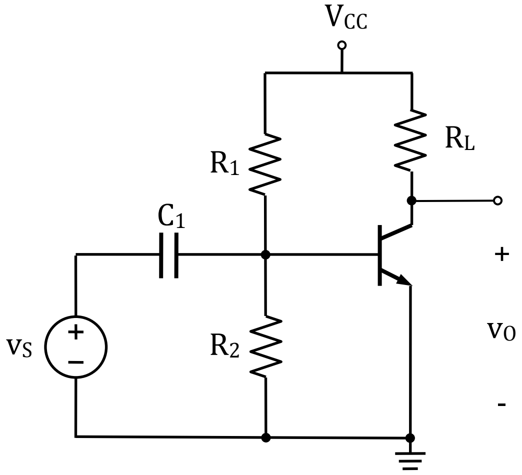


Fig. 6. 1. Class A Amplifier

If the input is a sinusoidal, then the output is also sinusoidal over the DC biasing voltage (Fig. 8.2).

$$v_o(t) = V_{CQ} + V_{CP} \sin \omega_0 t \text{ volts}$$

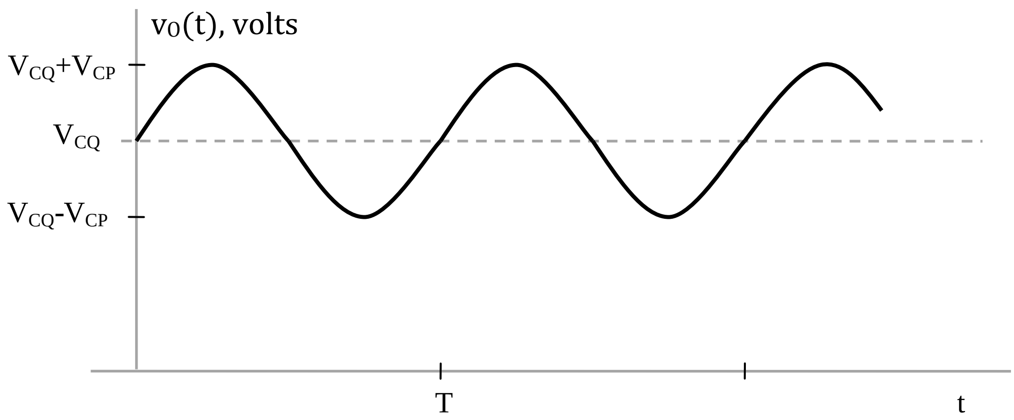


Fig. 6.2

The useful AC power is then

$$P_L = V_{CP}^2/2R_L$$

For the power delivered to the circuit, the power spent over the base circuitry is neglected and the average power delivered from the power supply is obtained as:

$$P_S = V_{CC} I_{CQ}$$

The power efficiency is defined as

$$\eta = P_L/P_S$$

or

$$\eta = V_{CP}^2/2V_{CC} I_{CQ} R_L$$

The maximum efficiency is reached if

$$V_{CQ} = V_{CC}/2 \text{ and } V_{CP} = V_{CC}/2 \text{ and } I_{CQ} = V_{CC}/2 R_L$$

Under these conditions, the efficiency becomes:

$$\eta = 0.25 = 25\%$$

i.e.., the 25 percent of the power delivered to the circuit is obtained as useful load power.

Class B Stage

The efficiency of a power amplifier may be increased using the following (Fig. 6.3) Class B amplifier called push-pull amplifier.

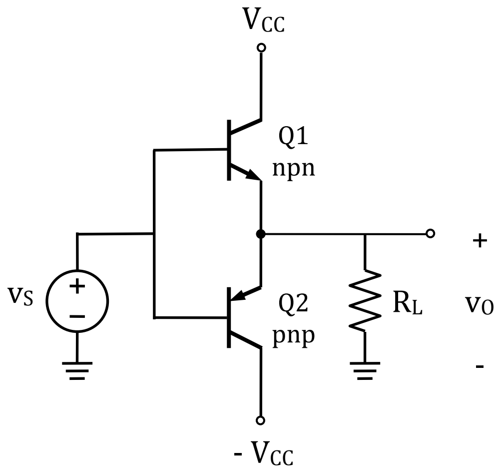


Fig. 6.3

During the positive cycles, Q1 conducts, during the negative cycles Q2 conducts; but the voltage over the load is a continuous sinusoidal (Fig. 6.4). The signal over the load then does not contain any DC component.

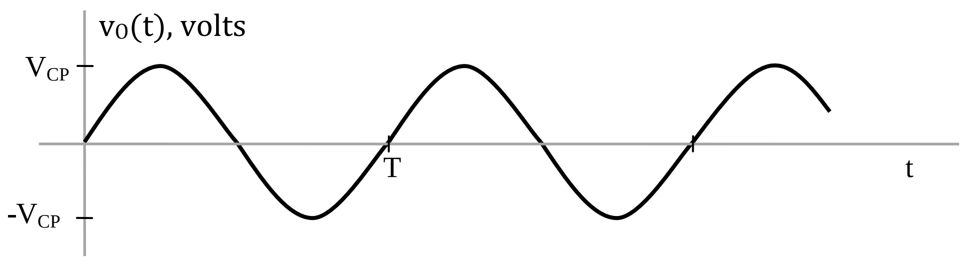


Fig. 6.4

For the Class B amplifier then

$$P_L = V_{CP}^2/2R_L$$

and the power from the above power supply proportional to V_{CC} and the average current through the collector of Q1.

$$P_{S1} = V_{CC}\, I_{C1(DC)}$$

The collector current of Q_1 is a half-wave rectified sine wave (Fig. 6.5).

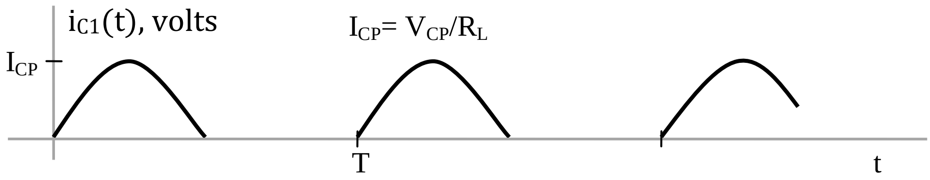


Fig. 6.5

The average (DC) value of the collector current is then

$$I_{C1(DC)} = I_{CP}/\pi \quad \text{or} \quad I_{C1(DC)} = V_{CP}/R_L\, \pi$$

and

$$P_{S1} = V_{CC}\, V_{CP}/\pi\, R_L$$

The total power from the two sources is therefore

$$P_S = 2\, P_{S1} = \frac{2\, V_{CC} V_{CP}}{\pi\, R_L}$$

Hence the efficiency is

$$\eta = \frac{P_L}{P_S} = \frac{V_{CP}^2/2R_L}{2\, V_{CC} V_{CP}/\pi\, R_L} = \frac{V_{CP}/4}{V_{CC}/\pi} = \frac{\pi\, V_{CP}}{4\, V_{CC}}$$

As it can be seen from the above result, the efficiency is linearly proportional to V_{CP}. The maximum efficiency is reached when $V_{CP} = V_{CC}$, then

$$\eta = \frac{\pi}{4} = 78.5\ \%$$

Class AB Amplifier

Because of the turn-on voltages of base-emitter junctions of the transistors, the output voltage is distorted and not a pure sine wave (Fig. 6.6). This distortion is called ***cross-over distortion***.

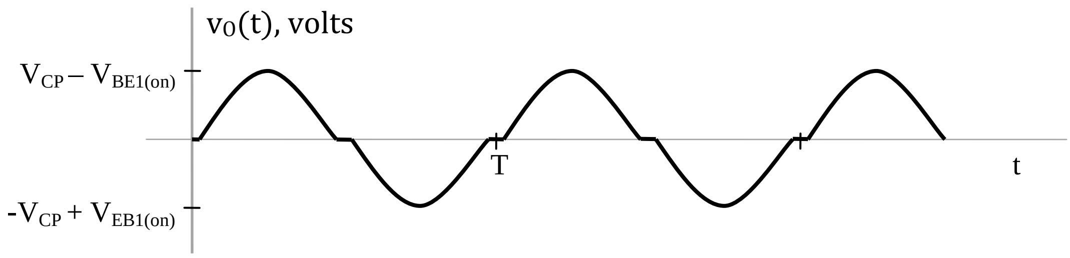


Fig. 6.6

The cross-over distortion may be avoided by using an additional circuitry at the input side (Fig. 6.7).

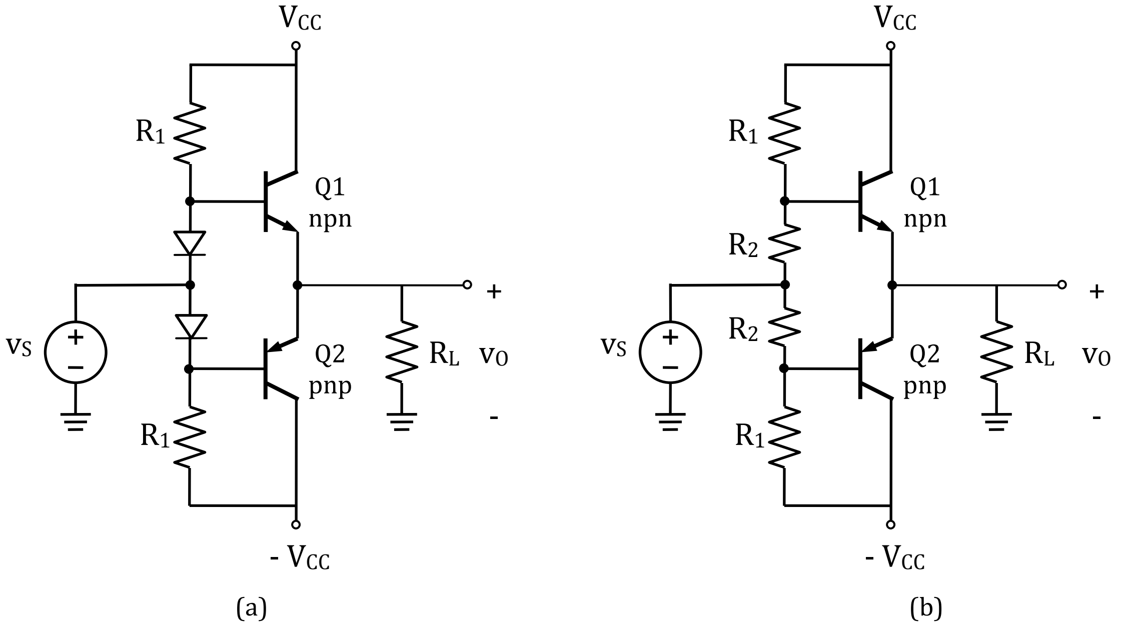


Fig. 6.7

The turn-on voltages of the diodes (Fig. 8.7a) or the DC voltage drop over R_2's ($R_2 << R_L$) are set very close to the base emitter drops of the transistors to cancel out the cross-over distortion at the output.

B. Preliminary Work

a) Consider the Class A stage given in Fig. 6.8. Assume β = 120 and $V_{BE(on)}$ = 0.6 V for the transistor. Determine the values of R_1 and R_2 to set V_{CQ} = 6 V and V_{BB} = 3.5 V.

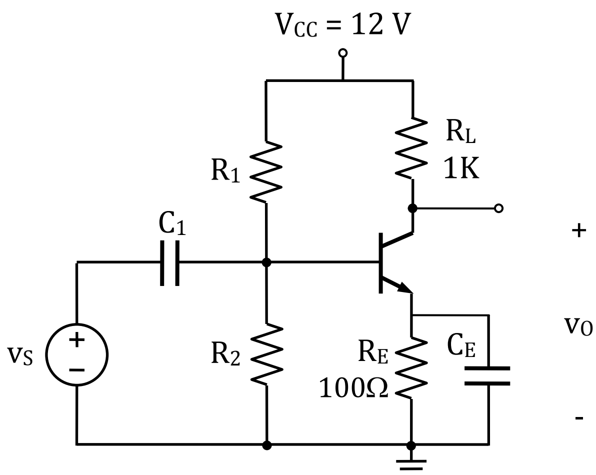


Fig. 6.8

C. Experimental Work

1. Set up the circuit given in Fig. 6.9 with the resistors you have determined in Preliminary Work. (C_E = 100 μF, C_1 = 10 μF. Be careful with the polarities of the capacitors)

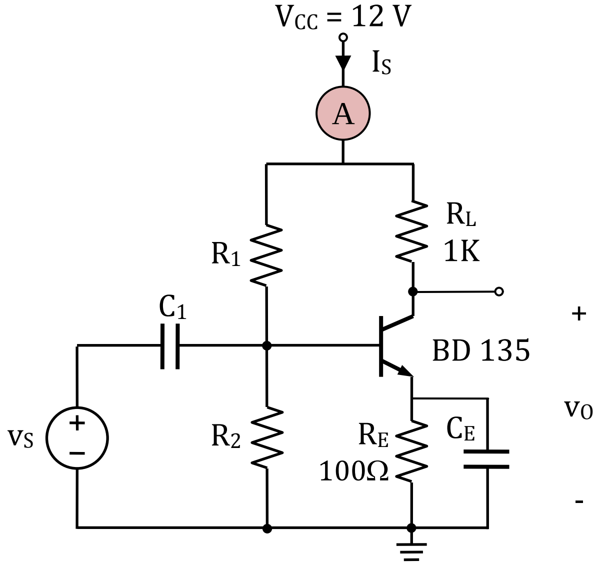


Fig. 6.9

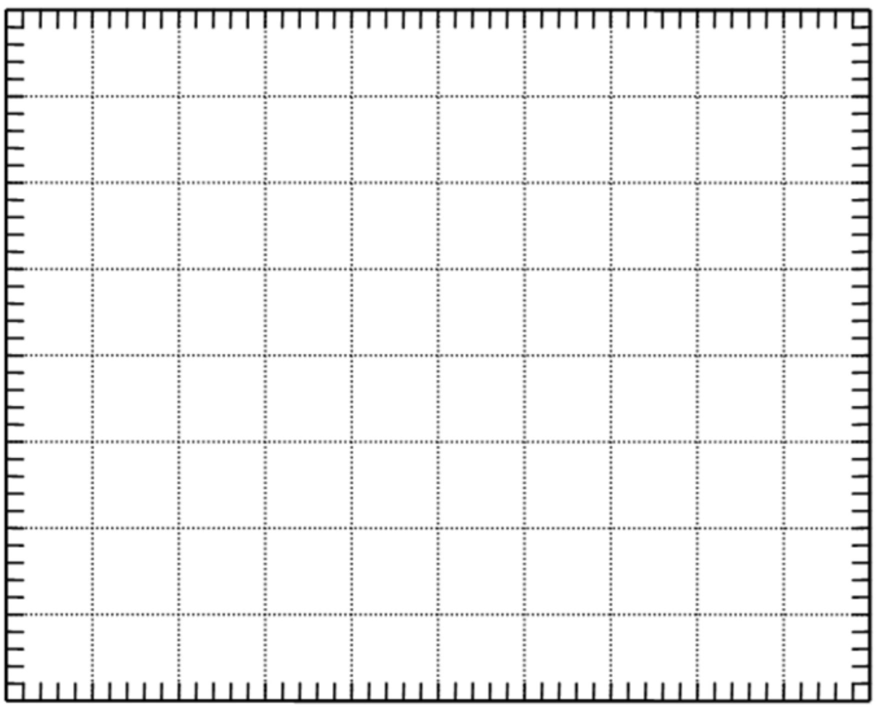
(a) Measure V_{CQ}. If $V_{CQ} \neq 6V$, make necessary modifications to set V_{CQ} = 6 V.

(b) Apply a sinusoidal signal to the input at f = 1 kHz.

(c) Measure I_S and calculate P_S.

I_S = ……. mA => $P_S = V_{CC} I_S$ = …………… mW

(d) Now adjust V_{CP} = 3 V. Plot v_O below. What is the maximum V_{CP} that you can get?



$V_{CP(max)}$ = ………….. Volts

(e) Calculate the efficiencies for the following V_{CP} values.

V_{CP}	P_L	P_S	η
3 V			
$V_{CP(max)}$(……..V)			

2. Now set up the push-pull amplifier given in Fig. 6.10. (V_{CC} = 12 V)

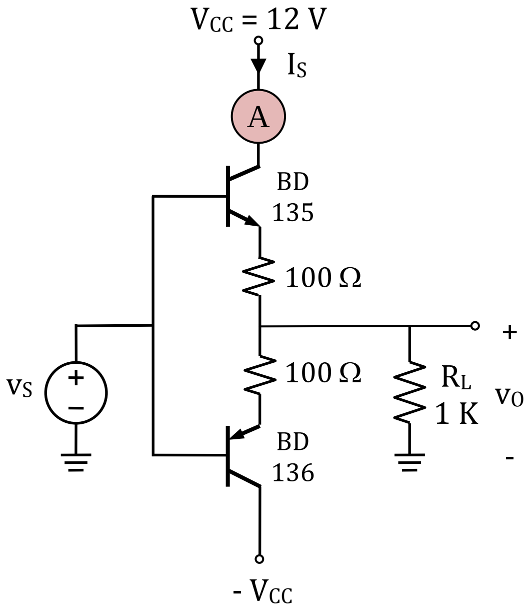
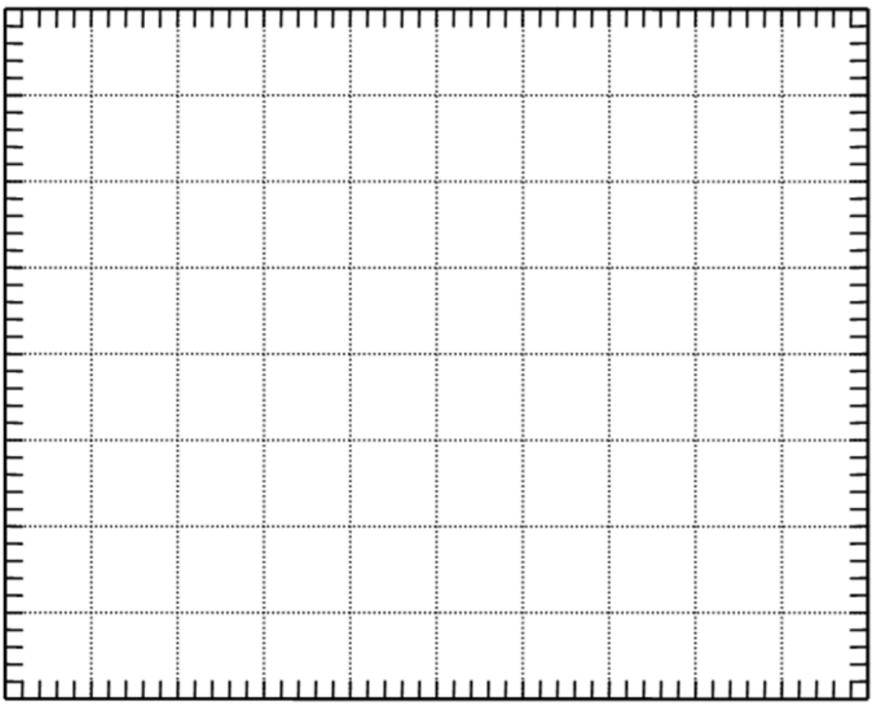


Fig. 6.10

(a) Apply a sinusoidal signal at 1 kHz to the input. Plot $v_O(t)$ for V_{CP} = 6 V.



$V_{CP(max)}$ = ………… Volts

(b) Calculate the efficiencies for the following V_{CP} values.

V_{CP}	P_L	P_S	η
6 V			
$V_{CP(max)}$(……..V)			

(c) Set up the following Class AB Amplifier. Apply a sinusoidal signal at 1 kHz to the input. Plot $v_O(t)$ for V_{CP} = 6 V.

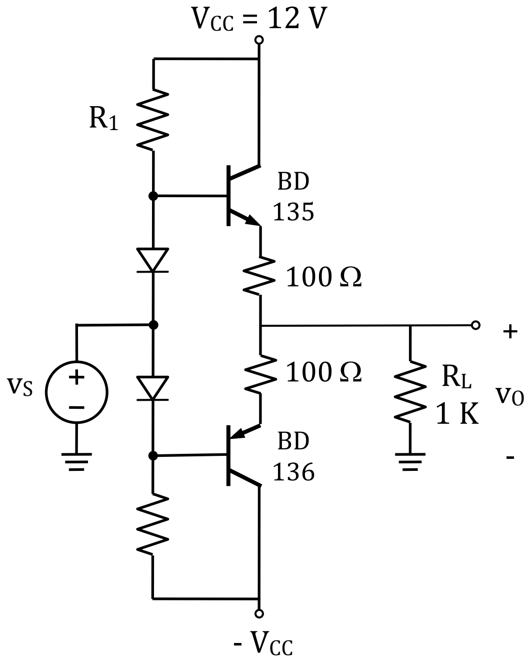


Fig. 6.11