5. CLASS-B AMPLIFIERS

5.1 OBJECTIVES
- To explore the characteristics of class B power amplifier.

5.2 INTRODUCTION AND THEORY

Class A amplifiers have almost linear response but are inefficient (maximum efficiency=25%). Class B amplifiers can operate at efficiencies up to %78.5 and are often used in high power amplifiers.

Class B power amplifier consists of two complementary pair of power transistors (PNP and NPN) with emitters connected as shown in figure 1. The operating point of each one of the complementary pair initially located in the cutoff region. This implies that the operating points for the transistor $Q_1$ and the transistor $Q_2$ be equal when the input signal $v_i = 0$. Ideally, the maximum instantaneous swing voltage (each transistor) for the operating point is equal to the power supply $V_{cc}$ when $V_{cc} = -V_{EE}$.

![Figure 1](image1.png)

The circuit operates in a push-pull fashion. One transistor will take care of the positive half (assume a sinusoidal input signal) of the signal, the second transistor will charge the negative half of the signal. As a result of having the dc operating point in the cutoff region a small amount of the applied input voltage will be consumed in bringing the operating point into the active region of the device. This amount is about 0.5 V for $Q_1$ and −0.5 V for $Q_2$ and can be seen as a dead band in the transfer characteristic $(v_o,v_i)$ of the class B stage. The presence of the dead band in the transfer
characteristic produces the crossover distortion in the output signal. A biasing network is added in Figure 2 to reduce the crossover distortion. The diodes automatically bias the transistors at soft cutoff (Class AB) and this helps to reduce or eliminate crossover distortion.

Useful formulas:

\[ P_{AC} = \frac{V_{Out}^2}{2R_L}, \quad P_{DC} = 2V_{CC}I_{C_{DC}} \text{ (when } V_{CC} = -V_{EE}), \]

\[ \eta = \frac{P_{AC}}{P_{DC}} \]

5.3 EQUIPMENTS

- KL-21001 Linear Circuit Lab
- Digital Multimeter (DMM)
- Function Generator
- Dual Trace Oscilloscope
- 2 x 1N4148
- NPN Transistor, 2N3904
- PNP Transistor, 2N3906
- Resistors: \( R_L = 100\Omega, \quad R_1 = R_2 = 10k\Omega \)

5.4 LAB PROCEDURE:

1) Build the power amplifier shown in Figure 1.
2) With the input grounded, turn on the power and adjust \( V_{CC} = -V_{EE} = 9V \). Verify with the scope or digital voltmeter that no current flowing through the transistors or \( R_L \).
3) Connect the CH1 to input and CH2 to output voltage respectively.
4) Apply a sin. signal of 1 kHz frequency with minimum amplitude available from function generator. Confirm that the signal is not present yet, due to both transistors being still turned off.
5) Gradually increase the amplitude of the input signal until you first see the output signal peaks. Record this input threshold value and sketch the waveform.

\[ \left( V_{IN \, p-p} \right)_{min} = \]
6) Continue increasing the amplitude of input signal until one (or both) of the transistors begins to saturate.

7) Measure $v_s$ and $v_o$, and calculate the measured voltage gain of the Class AB Amplifier.
   Gain: …………………………………

8) Insert an ammeter to properly measure collector current $I_C$. Increase the input signal until the amplifier has maximum output signal. Record $I_C$.
   $I_C =$ ……………………………

9) Measure the peak value of output voltage. $(\hat{V}_{OUT})_{max} =$ ……………………………

10) Calculate the efficiency of the amplifier. $\eta =$ ……………………………

11) **Turn off** the power and **add the biasing network** as shown in Figure 2. Turn on the power again, and repeat step 6. Observe the reduction of the distortion.
QUESTIONS

1) Suggest a way (with a diagram) how you might be able to improve the biasing to eliminate the crossover distortion.

2) How you might reduce distortion by using a negative feedback?

3) Compare the output signals that you have drawn in Figures 3 and 4.

4) What is the practical application of this circuit?

5) Calculate $I_{CQ1}$ in Figure 2 for $v_s = 0$. Assume that these diodes must match the current-voltage characteristics of the base-emitter diodes of the transistors.