ECEN321: Analogue Electronics
Assignment 1: Power Amplifiers - Submission

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Question 1

I. *An audio amplifier operates in the frequency range of..*
   a. 20Hz to 20kHz

II. *For maximum peak-to-peak output voltage, the Q point should be..*
   c. At the centre of the dc load line

III. *An amplifier has two load lines because..*
   d. All of the above

IV. *Push-pull is almost always used with..*
   b. Class B

V. *Class C amplifiers are almost always..*
   c. Tuned RF amplifiers

VI. *The input signal of a class C amplifier..*
   c. Produces brief pulses of collector current

VII. *If RC=100Ω and RL=180Ω, the ac load resistance equals..*
   a. 64Ω

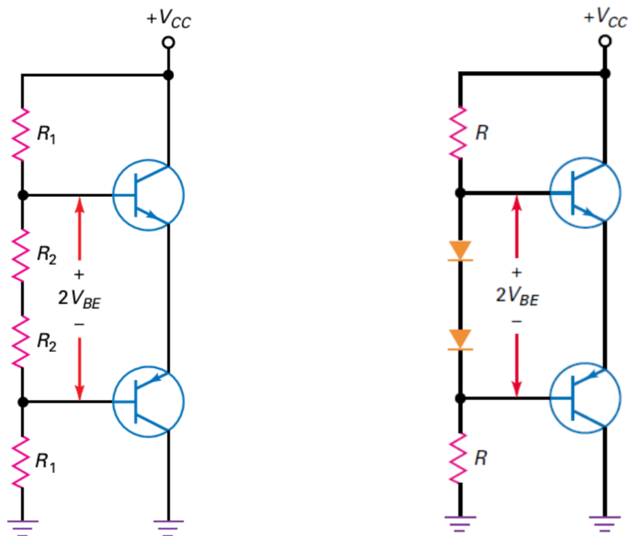
VIII. *In a class A amplifier, the collector current flows for..*
   d. The entire cycle

IX. *With class A, the output signal should be..*
   a. Unclipped

X. *A small quiescent current is necessary with a class AB push-pull amplifier to avoid..*
   a. Crossover distortion

Question 2

a) In the push push-pull configuration, the base-emitter junctions of the transistors have a potential of 0.7V. Thus when the input drops below this, at the **crossover** around the zero-point, the output is cut-off. This introduces a flatline distortion between positive and negative half cycles.



(a) Voltage-Divider Bias

(b) Diode Bias

Figure 1: Class B/AB Biasing Configurations

b) Figure 1a shows a voltage-divider biasing configuration with a summed potential difference of $2V_{BE}$ to unsure the transistors are always on, so the avoid the crossover distortion. The issue with this being high temperature sensitivity with the ultimate issue being thermal runaway.

Figure 1b shows a diode biasing configuration, this is a way to avoid thermal runaway and still providing the same potential difference. The curves of the compensating diodes must match the V_{BE} curves of the transistors so temperature changes result in an adjusted bias voltage.

Question 3

$V_{CC} = +20V$ $R_{1,2} = 1k$ $R_C = 50\Omega$ $R_E = 100\Omega$ $R_L = 50\Omega$

i)

$$\begin{aligned}
P_{i(dc)} &= V_{CC} \cdot I_{CQ} \\
V_B &= \frac{R_2}{R_1 + R_2} V_{CC} = \frac{1k}{1k + 1k} 20V = 10V \\
V_E &= V_B - 0.7 = 9.3V \\
I_E &= \frac{V_E}{R_E} = \frac{9.3}{100} = 93mA \approx I_{CQ} \\
\therefore P_{i(dc)} &= 20 \times 93mA = 1.86W
\end{aligned}$$

ii)

$$\begin{aligned}
P_{o(ac)} &= \frac{V_{CEQ} \cdot I_{CQ}}{2} \\
V_{CEQ} &= V_C - V_E = (V_{CC} - I_C \cdot R_C) - V_E \\
&= (20V - 93mA \times 50\Omega) - 9.3V = 6.05V \\
\therefore P_{o(ac)} &= \frac{6.05V \times 93mA}{2} = 0.28W
\end{aligned}$$

iii)

$$\begin{aligned}
\%\eta &= \frac{P_{o(ac)}}{P_{i(dc)}} \times 100 \\
&= \frac{0.28}{1.86} \times 100 = 15\%
\end{aligned}$$

Question 4

$V_{CC} = V_{CEQ} = 5V$ $I_{CQ} = 50mA$

i)

$$\begin{aligned}
P_{o(ac\,max)} &= \frac{I_{CQ} \cdot V_{CEQ}}{2} \\
&= \frac{50mA \times 5V}{2} = 0.125W
\end{aligned}$$

ii)

$$\begin{aligned}
P_{i(dc)} &= I_{CQ} \cdot V_{CEQ} \\
&= 50mA \times 5V = 0.25W
\end{aligned}$$

iii)

$$\begin{aligned}
\%\eta_{max} &= \frac{P_{o(ac\,max)}}{P_{i(dc)}} \times 100 \\
&= \frac{\frac{I_{CQ} \cdot V_{CEQ}}{2}}{I_{CQ} \cdot V_{CEQ}} \times 100 \\
&= \frac{0.125}{0.25} \times 100 = 50\%
\end{aligned}$$

Question 5

$V_{CC} = +30V$ $V_{BE} = 0.7V$ $R_1 = 300\Omega$ $R_L = 16\Omega$

$$\begin{aligned} V_{CC} &= 2R_1 \cdot I + 2V_{BE} \\ 30V &= 600\Omega \times I + 1.4V \\ I &= \frac{30V - 1.4V}{600\Omega} = 47.67mA \\ R_2 &= \frac{V_{BE}}{I} = \frac{0.7V}{47.67mA} = 14.67\Omega \end{aligned}$$

Question 6

$f = 3\text{MHz}$ $V_{CC} = 20V$ $V_{CE(sat)} = 0.3V$ $I_P = 500mA$

i)

$$\begin{aligned} V_P &= V_{CC} - V_{CE(sat)} \\ &= 20V - 0.3 = 19.7V \\ P_) &= \frac{V_P^2}{2R_L} = \frac{388.09}{200} = 1.94W \\ I_{dc} &= \frac{P_O}{V_P} = \frac{1.94}{19.7} = 98.5mA \\ P_{dc} &= V_{CC} \cdot I_{dc} = 20 \times 98.5 = 1.97W \\ \%\eta &= \frac{P_O}{P_{dc}} \times 100 = \frac{1.94}{1.97} \times 100 \\ &= 98.5\% \end{aligned}$$

ii)

$$\begin{aligned} T &= \frac{1}{f} = \frac{1}{3 \times 10^6} = 3.33 \times 10^{-7} \\ t &= \frac{P_O \cdot T}{I_P \cdot V_P} = \frac{1.94 \times 3.33 \times 10^{-7}}{500 \times 19.7} = 6.56 \times 10^{-8} \\ \phi &= \frac{P_O}{P_{dc}} \times 360 = \frac{6.56 \times 10^{-8}}{3.33 \times 10^{-7}} \times 360 \\ &= 70.92^\circ \end{aligned}$$