ASSIGNMENT 04 – Amplifier Design

Prologue

The EN2110 assignment series from Assignment 01 to Assignment 04 is designed to provide a power amplifier design experience to the ENTC students. In this series of assignments, you will be starting with a reference amplifier circuit. The first assignment itself guides you to derive the design equations for DC analysis. The second and third assignments will guide you to derive equations for small-signal analysis and power analysis of the amplifier, respectively. The final assignment will guide you in the calculation of the resistor values to satisfy the design specifications. The coupling capacitor calculations are not included in this assignment series. A separate session will be conducted to discuss your answers and guide you in simulating such circuits to investigate the operating point, DC sweep, AC sweep, and time-domain behavior.

To do this, you need everything you learned about transistor circuits from Electronics I to Electronics III.

May the force be with you!

INSTRUCTIONS

- This assignment contains 11 questions which accounts for 40 marks.
- Clearly state any assumptions you made.
- Scan your answer scripts using a tool such as cam-scanner to compile it as a PDF. Submission file name should be in the following format.

  <assignment_number>_<index_number>

  For example, if your index number is 070022G and you are submitting the answers for assignment 1, the file name should be,

  A01_070022G

- If you are having any problems, send an email to "thilinaa@uom.lk" with the subject "EN2110-B18-<assignment number>".

A two-transistor cascaded amplifier is shown in Fig. 1. The DC current-gain of the transistors Q_1 and Q_2 are β_1 and $beta_2$, respectively. In this circuit, we assume that the capacitors are large enough to block the DC voltages and allow all AC signals to flow through them. Furthermore, all junction-capacitances of the transistors are negligible within the frequency band of interest. Approximate the thermal voltage V_T to 20 mV.

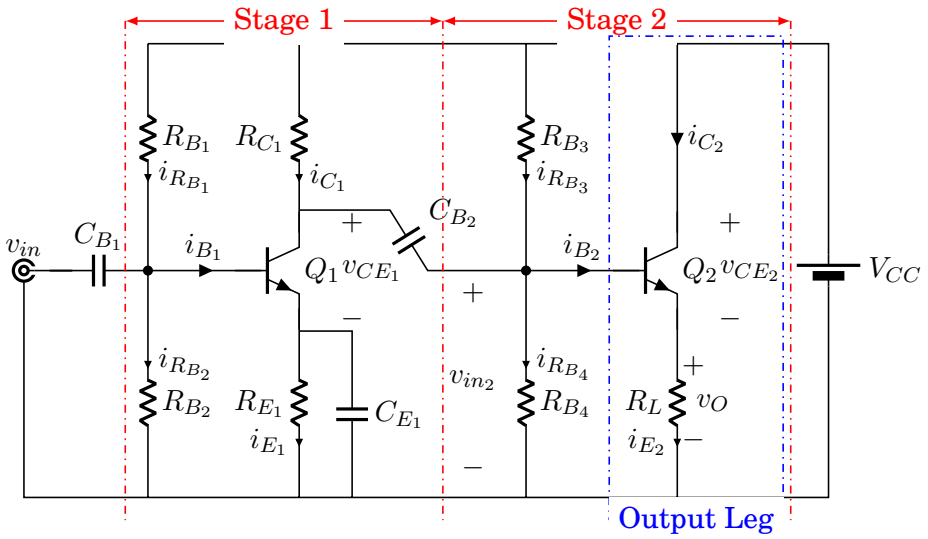

Figure 1: A two stage transistor amplifier.

In this assignment you will be design the amplifier by calculating appropriate values for the resistors to satisfy a given set of specifications as follows.

Supply voltage V_CC	24 V DC
Load R_L	16 Ω
Overall voltage gain $A_v = \frac{v_o}{v_{in}}$	120
Stage 1 output	maximum voltage swing
Stage 2 output	Class A operation
Transistor 1 current gain β_1	100
Transistor 1 BE voltage V_{BE_1}	0.6 V
Transistor 2 current gain β_2	400
Transistor 2 BE voltage V_{BE_2}	0.5 V

1. What is the quiscent emitter current I_{E_2} of the output leg? [2 marks]
2. Calculate collector-emitter current ratio (α_2), collector current I_{C_2}, transconductance g_{m_2}, and intrinsic emitter resistance r_{e_2} of the transistor Q_2. [7 marks]
3. What is the voltage gain of stage 2 ($A_{v_2} = \frac{v_L}{v_{in_2}}$)? [1 mark]
4. Calculate the base current of Q2 (I_{B_2}). [2 mark]
5. The resistor R_{B_4} is selected such that $I_{RB_4} = \frac{1}{9} I_{B_2}$. Calculate R_{B_4} and R_{B_3}? [5 marks]
6. Calculate the input resistance of stage 2. [2 marks]
7. In-order to minimize the power consumption in stage 1, lets select I_{C_1} to be $\frac{1}{500}^{th}$ of I_{C_2}. Calculate collector current I_{C_1}, transconductance g_{m_1} of the transistor Q_1. [3 marks]

8. What is the required gain of stage 1 ($A_{v_1} = \frac{v_{in_2}}{v_{in}}$) to achieve the specified overall voltage gain (A_v)? Hence, calculate R_{C_1} and R_{E_1}. [8 marks]

9. A design decision has made to make $I_{RB_4} = \frac{1}{9} I_{B_2}$. Find appropriate values for R_{B_1} and R_{B_2}. [5 marks]

10. What is the small signal input voltage v_{in} which results in $4\,\mathrm{W}$ AC power at the output R_L?. [2 marks]

11. A small signal having a peak voltage of $85\,\mathrm{mV}$ is applied at the input terminals of the amplifier. Calculate the AC power output at the load R_L and the efficiency of the output leg of the amplifier. [3 marks]