EEEE3117 – Analogue Electronics

Coursework: Amplifier Design

In this coursework, you will be looking at designing **mid-band** amplifier in Figure 1 based on BJTs and FET.

The mid-band design specifications for the amplifier are as follows:

Supply voltage V_{CC} = 15 V.

Signal source resistance R_S = 8 kΩ.

Load resistance R_L= 300 Ω.

The following parameters are given for the transistors (you will need to use these in your calculations):

The transistor parameters of Q_1 and Q_2 are V_{BE} = 0.7 V, β = 150 and V_A = 65 V.

M_3 has K_n = 5 mA/V^2 and V_{TN} = -2 V. Assume that λ = 0.01 V^{-1} and all the capacitors have a value of 22 μF.

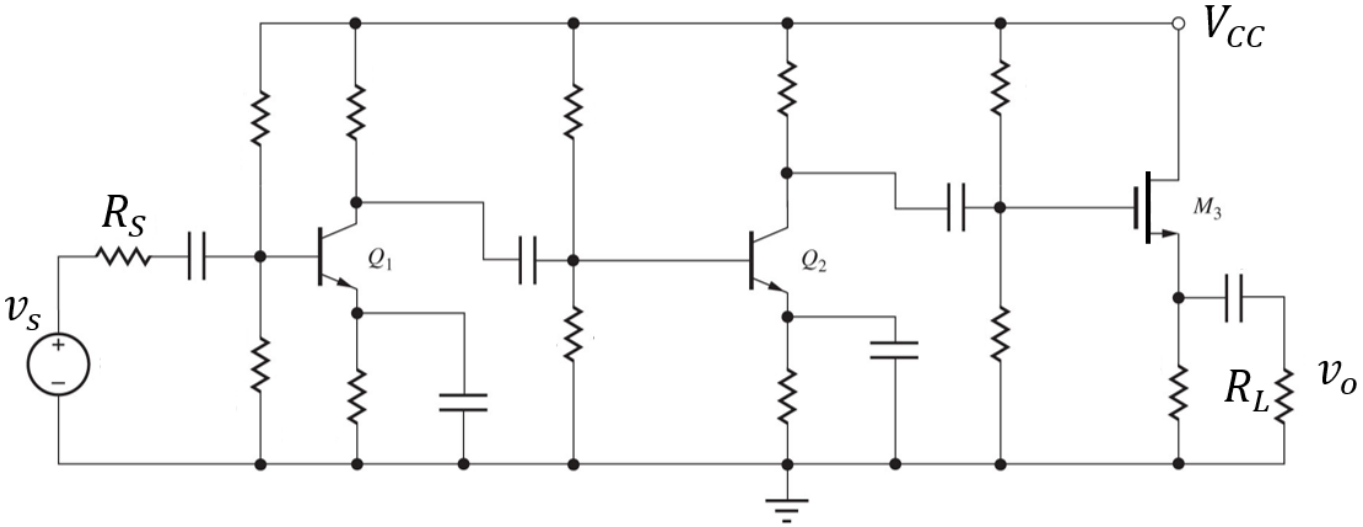

Figure 1

You must first start by labelling each component in Figure 1 and include it in the first page of your report. Marks will be deducted if this requirement is not met.

(a) Determine the configurations of Q1, Q2 and M3.

[3 marks]

(b) Draw the resulting mid-band small-signal equivalent circuit.

[5 marks]

(c) Using **top-down approach**, design (determine the values of all the resistors by **using ALL the numbers available in your student ID**) the circuit such that mid-band small-signal voltage gain $A_V = \frac{v_o}{v_s}$ falls between 50 to 400. Show your working. (Note: **repetition of numbers in student ID is allowed, BUT Q1 and Q2 should not have the exact same resistor values.**)

Then, calculate the input and output resistances of your design circuit.

E. g. Student ID: 20158532

Table 1: Use of Student ID Numbers in Resistor Values

Number(s) from Student ID	Resistor	Actual Resistor Value (Ω)
20	R_{C1}	20 k
158	R_2	158
5	R_4	50 k
32	R_{E2}	320

A table similar to Table 1, but extended with all other resistor values must be included in first page of your report.

[23 marks]

(d) With the designed values found in Part (c), prove that each stage is working in the desired operation region.

[6 marks]

(e) Simulate your designed circuit of Part (c) using LTspice. Include screenshot of the simulated DC base, emitter and collector (and gate, source and drain for FET) voltages and currents in your report. Then, compare in table format the simulated values with your calculated values.

[6 marks]

(f) Simulate (ac analysis by carrying out ac sweep) the designed circuit of Part (c) using LTspice. Measure the ac voltage gain and phase difference, input and output resistances. Compare the simulated results with your calculated value. In your report show the output from the ac sweep analysis of the above simulated results - comment on how well the design requirement is met and reasons of the difference.

[7 marks]

(g) Without changing the transistors and your designed voltage and resistor values (as well as no adding or removing resistors), modify the circuit in Figure 1 to achieve mid-band small-signal voltage gain (with 0 degree phase difference) of less than the answer you obtained in Part (c). State any assumptions made to simplify your calculations. (LTspice simulation is not required.)

[10 marks]

Submission of the Report

All calculations should be hand-written (not on electronic devices but papers). Discussions and other comments can be type-written.

Your submission should consist of a **single PDF file**, containing the calculations, comments and printouts from LTspice. You must name your file "**###.pdf**", where ### is your FULL NAME.

The **individual.asc file**, which contains the circuit that you have created while doing your coursework, must also be submitted. You must name the file "**###.asc**", where ### is your FULL NAME.

Please submit the PDF and ASC files separately, i.e. ***don't zip*** *the files.*

(Note: Include assumptions (if any) that you have made, with justifications.)

Marking Criteria:
Correct calculations, plots with labels and explanations, when required. Pay attention to the steps involved.