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University of Swaziland
Faculty of Science and Engineering
Department of Electrical and Electronic Engineering

Main Examination 2017

Title of paper: Analogue Design I / Analogue Electronics I

Course Number: EEE321 / EE321

Time allowed: 3 hours

Instructions:

1. **EE321 students** answer any **FOUR (4)** questions in **section A**
2. **EEE321 students** answer any **THREE (3)** questions in **section A** and **ONE (1)** question in **section B**
3. Each question carries 25 marks
4. Marks for each question are shown at the right hand margin

This paper contains 7 pages including this one.

This paper should not be opened until permission has been granted by the invigilator.

Section A

Question 1

a) State the three modes of operation of an NPN transistor and tabulate the bias conditions of the junctions. [6]

b) For the circuit **Figure 1** below determine the node currents I_C , I_B and I_E and determine the mode of operation of the transistor for $\beta = 100$. [8]

c) Draw the voltage transfer characteristics of a BJT and explain how the output signal is affected by the location of quiescent point (Q-point). [5]

d) Describe how to find the current i_D of a MOSFET in terms of the charge Q per unit length and the electron drift velocity. Assume a small v_{DS} is applied to the transistor. [6]

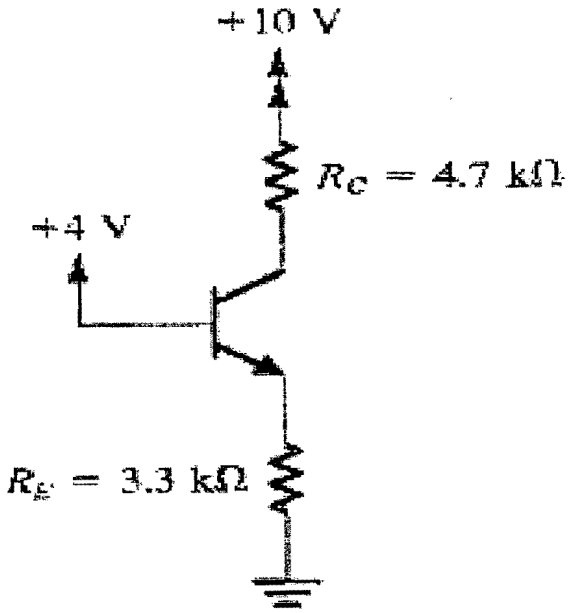

Figure 1

Question 2

In the circuit **Figure 2,** v_{sig} is a small sine wave signal with zero average. The transistor β is 100, $V_{BE} = 0.7V$, $V_T = 25mV, I_C = 0.5mA$, $R_C = 20k\Omega$. $R_L = 10k\Omega$ and $r_0 = 200k\Omega$.

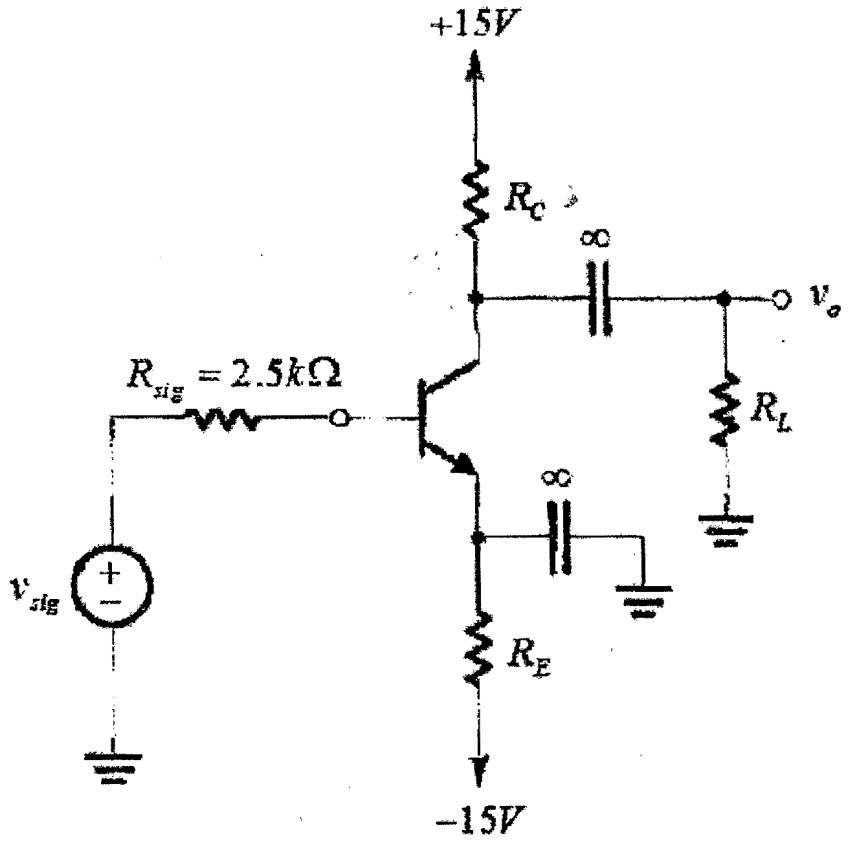

Figure 2

a) Draw the small signal equivalent circuit of the amplifier. [3]

b) Determine the overall voltage gain, $\frac{v_0}{v_{sig}}$. [10]

c) For a 0.08 μm process technology for which $t_{ox} = 15nm$ and $\mu_n = 550cm^2/V.s$. Given that the transistor is operating in saturation with $I_D = 0.2mA$ with $\frac{W}{L} = 20$, Find

i) C_{ox} [2]

ii) k'_n [3]

iii) V_{ov} [4]

d) An op-amp has a slew rate of $10V/\mu S$, full-power bandwidth, $\omega_M = 2 \times 10^6\ rad/sec$ What is the rated output voltage, v_{0max}? [3]

Question 3

Consider the Common-source amplifier circuit, **Figure 3(a)** below.

a) Draw the small signal equivalent circuit. [3]

b) Find

i) The input resistance R_{in} [2]

ii) The voltage gain G_V [4]

iii) The output resistance R_{out} [3]

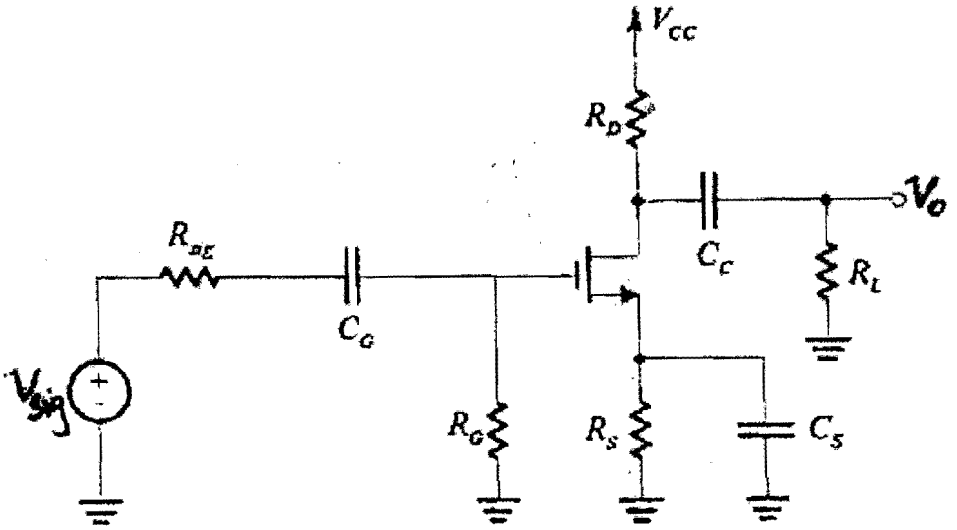

Figure 3 (a)

c) Given the circuit shown in **Figure 3 (b)** below, $R_1 = 100k\Omega$, $R_2 = 50\ k\Omega$, $R_C = 5k\Omega, R_E = 3k\Omega$, $\beta = 100, V_{BE} = 0.7V$

i) Calculate the following DC parameters $V_{BB}, I_B, I_E, I_C, V_C$. [10]

ii) Draw the resultant circuit, and label all the parameters correctly. [3]

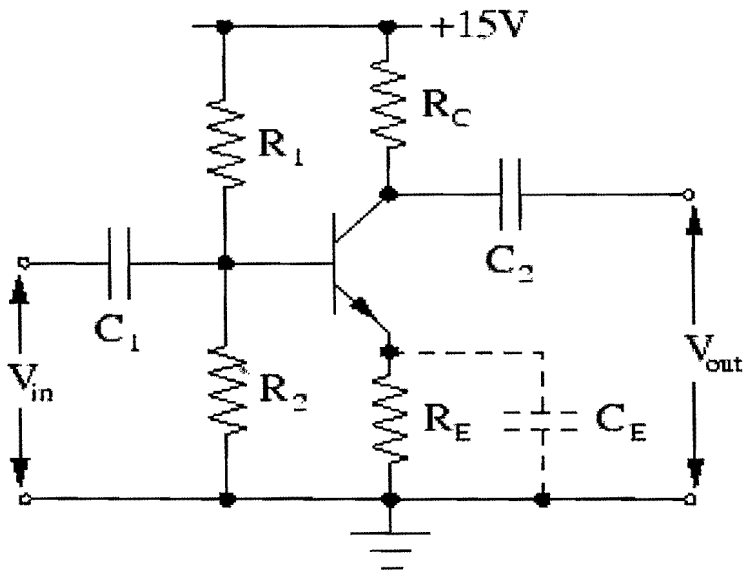

Figure 3 (b)

Question 4

a) A BJT operating at $I_C = 2mA$ has $C_\mu = 1pF$ $C_\pi = 10pF$ and $\beta = 150$. Calculate:

i) f_T [4]

ii) f_β [4]

b) For the op-amp inverting integrator circuit,

i) Draw and label the circuit diagram. [3]

ii) Determine the voltage across the capacitor. [4]

iii) Determine output voltage. [2]

c) Using an ideal op-amp, design the inverting low-pass amplifier circuit shown in **Figure 4** having a pole frequency of 3kHz [8]

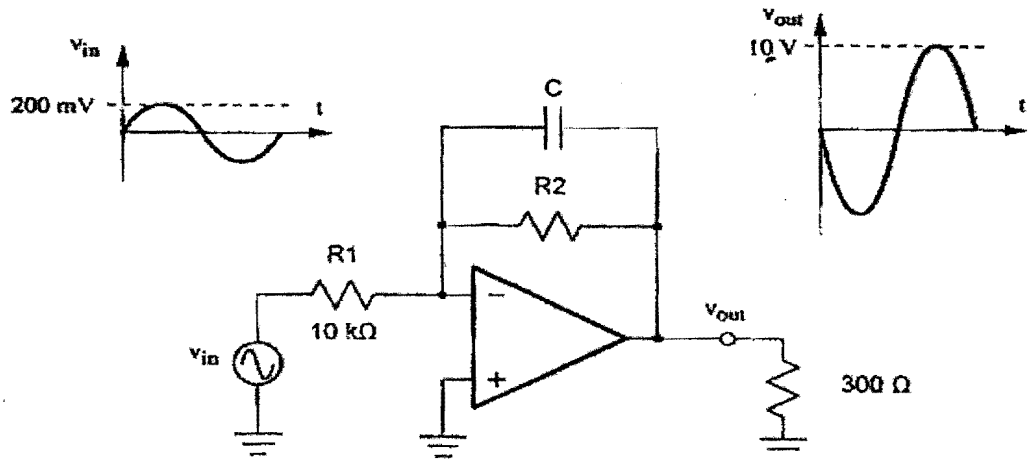

Figure 4

Question 5

Consider the common-emitter amplifier shown in **Figure 5** under the following conditions: $R_{sig} = 5k\Omega$, $R_1 = 33k\Omega$, $R_2 = 22k\Omega$, $R_E = 3.9k\Omega$, $R_C = 4.7k\Omega$, $R_L = 5.6k\Omega$, $V_{CC} = 5V$, $r_0 = 300k\Omega$, $\beta = 120$, dc collector current, $I_C = 0.3mA, V_T = 25mV, C_\mu = 1\,pF$, $f_T = 700MHz$, $r_x = 50\Omega$, Find

a) C_π [7]

b) The upper-3dB frequency f_H [18]

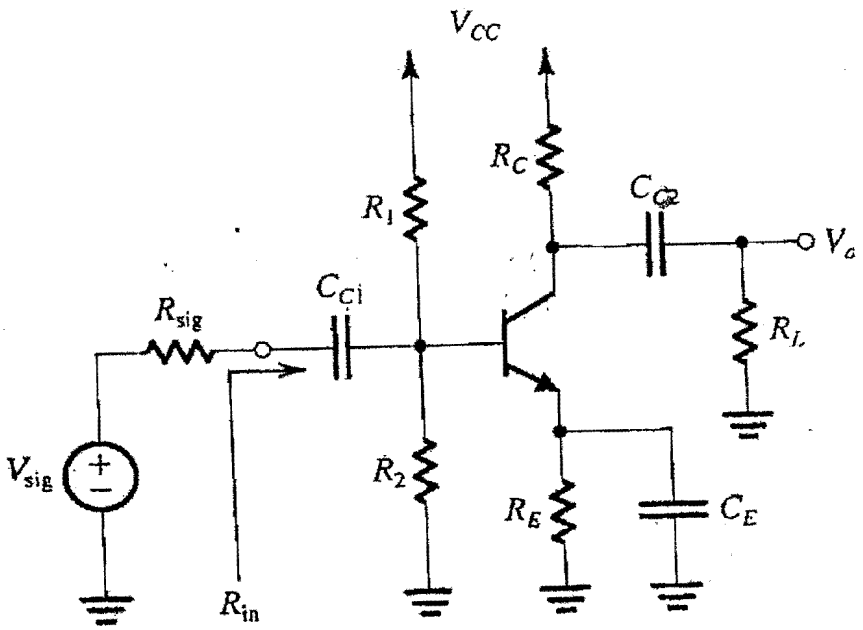

Figure 5

Section B

Question 6

a) List and describe the four elements of a regulator circuit. [8]

b) State three types of regulators [3]

c) In the circuit **Figure 6** below

i) Identify the type of regulator. [2]

ii) Identify the four elements listed above. [4]

iii) Find the output voltage. [3]

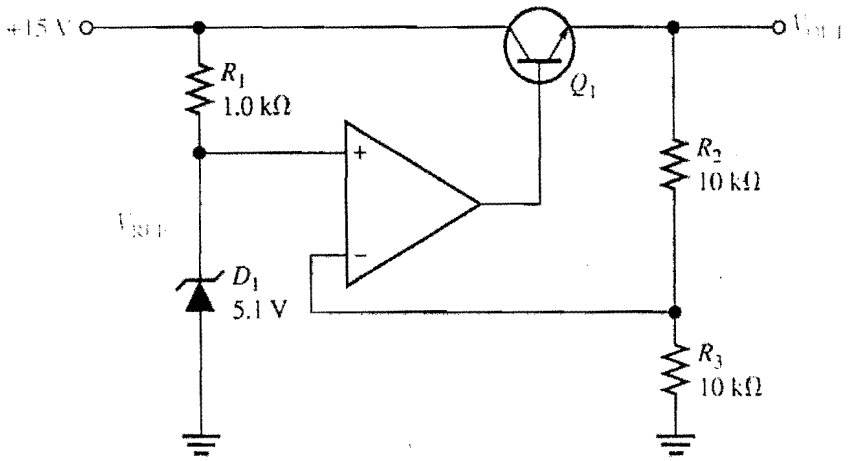

Figure 6

d) For a half-wave rectifier, show that the efficiency $\eta = 0.405$ [5]

Question 7

a) State a regulator type of your choice and do the following

i) Draw the circuit diagram. [3]

ii) Describe the operation of the regulator. [6]

iii) Write the equations of the output voltage and the associate currents. [4]

b) For a rectifier of your choice

i) Draw the circuit diagram. [3]

ii) Find the RMS values of the load voltage and the load current. [9]