The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical & Computer Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX6550 / ECX6250 Analog Electronic Systems**
Academic Year	: 2019/2020
Date	: 23rd January 2021
Time	: 1330-1630hrs
Duration	**: 3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Seven (7)** questions in **Six (6)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Relevant charts / codes are provided.
6. This is a Closed Book Test **(CBT).**
7. Answers should be in clear hand writing.
8. Do not use red colour pens.

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Q1. Consider the circuit diagram in Figure-Q1.

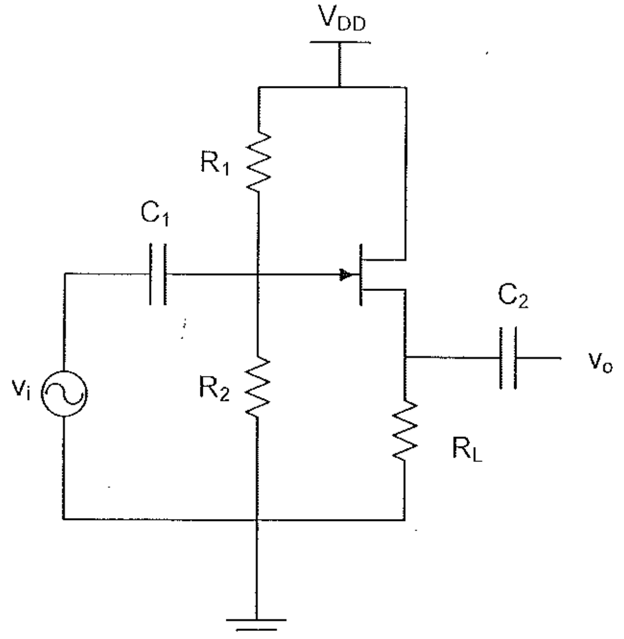

Figure-Q1

(a) Draw the high frequency equivalent circuit for the single stage amplifier shown in Figure-Q1. **(7Marks)**

(b) Clearly stating all your assumptions, find an expression for the voltage gain, A_v. **(8Marks)**

(c) Hence show that the low frequency voltage gain for this amplifier is $\frac{\mu}{\mu+1}$, where $\mu = \frac{g_m}{g_d}$. **(5Marks)**

Q2. Let the transistor in the amplifier circuit in Figure-Q2 has the following hybrid-πparameters with the usual notation. $r_{be} = 1k\Omega$, $r_{bc} = 4M\Omega$, $r_{ce} = 80k\Omega$, $C_{bc} = 3pF$, $C_{be} = 100pF$ and $g_m = 50mAV^{-1}$.
Assume the effect of all the other unmentioned parameters to be negligible.

(a) Draw the high frequency equivalent circuit for this amplifier circuit. **(6Marks)**
(b) Using Miller's theorem, simplify the equivalent circuit model. **(6Marks)**
(c) Hence, find the voltage gain of the same amplifier. **(8Marks)**

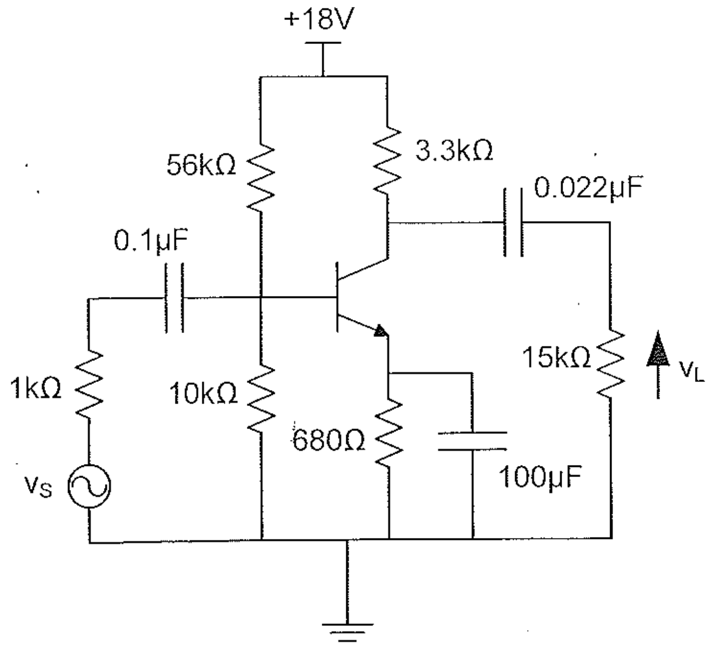

Figure-Q2

Q3. Consider the circuit in the Figure-Q3.

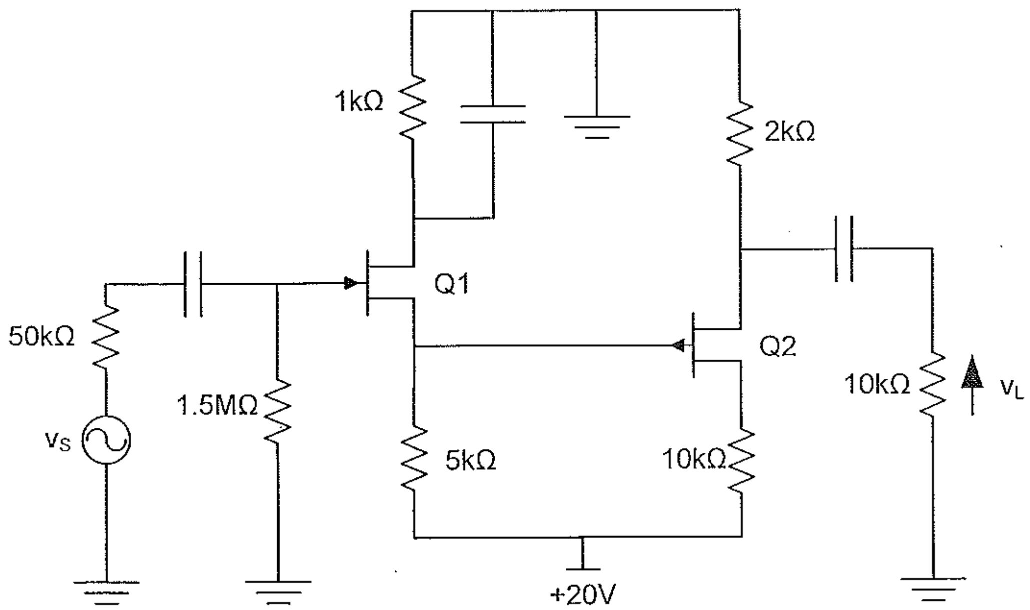

Figure-Q3

Assume that $r_{d1} = r_{d2} \to \infty$, $g_m = 1.6\ mAV^{-1}$ for both Q1 and Q2.

(a) Draw the low frequency equivalent circuit. **(8Marks)**

Hence find,

(b) Input impedance. **(4Marks)**

(c) Mid band voltage gain $\frac{v_L}{v_S}$. **(8Marks)**

Q4.

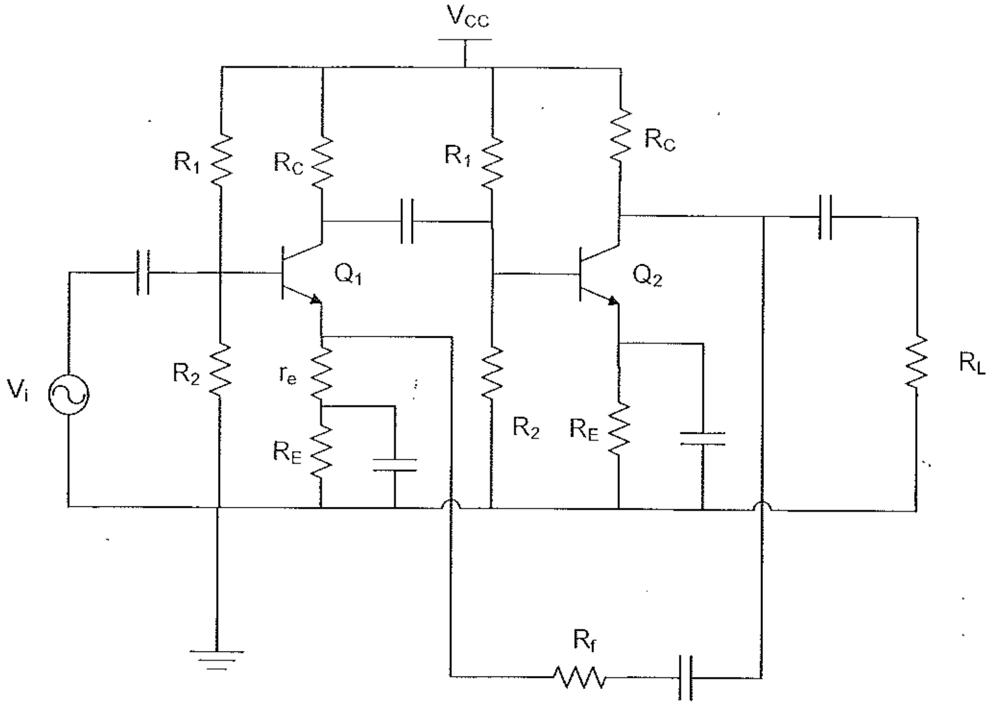

Figure-Q4

For the amplifier circuit shown in Figure-Q4, $V_{CC} = 10\ V$, $R_1 = 10k\Omega$, $R_2 = 2.2k\Omega$, $R_C = 3.6k\Omega$, $R_E = 1k\Omega$, $r_e = 100\Omega$, $R_L = 10k\Omega$ and $R_f = 4.7k\Omega$. Both transistors Q1 and Q2 are identical and have $h_{fe} = 100$, $h_{ie} = 1.2k\Omega$.

(a) Identify the type of feedback used. **(2Marks)**

(b) Consider the circuit in Figure-Q4 without the feedback. Calculate the voltage gain and the input impedance. **(10Marks)**

(c) Calculate the feedback ratio. **(4Marks)**

(d) Hence calculate the overall voltage gain with feedback. **(4Marks)**

Q5.

(a) Starting from the first principles, derive the Barkhousen criteria for oscillations to occur. **(4Marks)**

(b) Stating all your assumptions, derive an expression for the feedback factor for the circuit in Figure-Q5. **(4Marks)**

(c) Derive an expression for the forward gain. **(6Marks)**

(d) Hence find the frequency of oscillation ($C = 100\mu F$, $L_1 = L_2 = 10mH$, $R_1 = R_2$). **(6Marks)**

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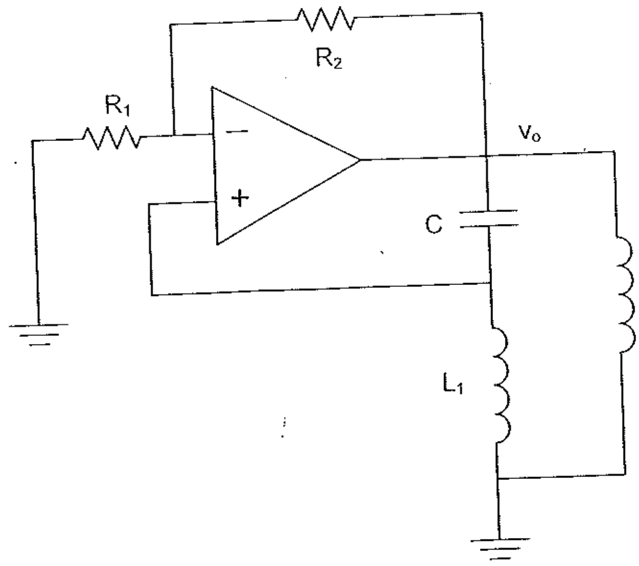

Figure-Q5

Q6. A low-pass filter circuit is shown in Figure-Q6. Assume that the op-amp is ideal.

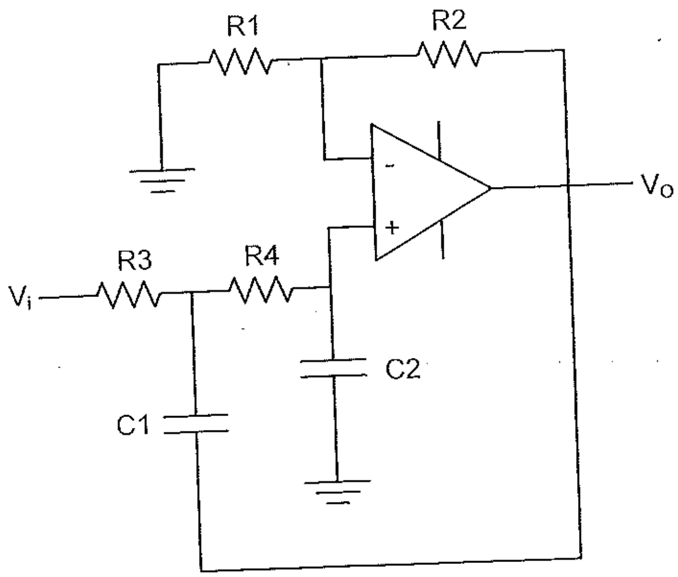

Figure-Q6

(a) For the circuit in Figure-Q6, derive the transfer function H(s). **(8 Marks)**

(b) Transfer function for a second order Butterworth filter is given by,

$$A(s) = A_0 \frac{1}{\left(\frac{s}{\omega_c}\right)^2 + \sqrt{2}\left(\frac{s}{\omega_c}\right) + 1}.$$

Hence show that the bandwidth of the above filter is given by $\frac{1}{2\pi\sqrt{R_3R_4C_1C_2}}$. **(4 Marks)**

(c) Let $R_3 = R_4$ and $C_1 = C_2$. Design a second order Butterworth filter with a bandwidth of 20Hz. **(4 Marks)**

(d) Calculate the pass band gain of the filter. **(4 Marks)**

Q7.

(a) Starting from the diode characteristic equation $I_D = I_S\left(e^{\frac{V_D}{\eta V_T}} - 1\right)$ derive an expression for the intrinsic resistance, r_e of the diode junction. **(4 Marks)**

(b) Figure-Q7(b) shows a diode-based log amplifier. Show that $V_o \propto \ln(V_{in})$. **(8 Marks)**

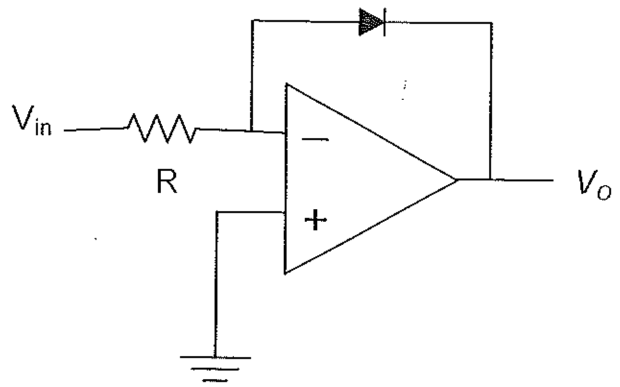

Figure-Q7 (b)

(c) Explain the operation of the precision rectifier arrangement shown in Figure-Q7 (c). **(8 Marks)**

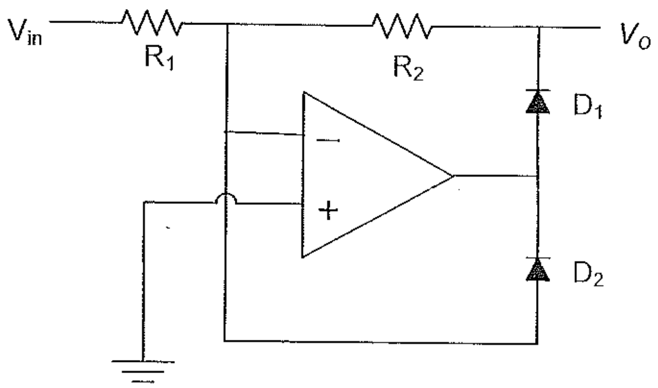

Figure-Q7 (c)