UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE AND ENGINEERING
DEPARTMENT OF PHYSICS

MAIN EXAMINATION, MAY 2018

TITLE OF PAPER	:	ELECTRONICS II
COURSE NUMBER	:	PHY 312
TIME ALLOWED	:	THREE HOURS
INSTRUCTIONS	:	Answer **FOUR** (4) questions only.
	:	Each Question carries **25 Marks**
	:	Marks for different Sections are shown in far Right margin.

THIS PAPER HAS 6 PAGES, INCLUDING THIS ONE.

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1. (a) What is a band pass filter? [2]

   (b) Show that the transfer function of a series RLC band pass filter shown in Figure 1 may be written in the form

$$H(j\omega) = \frac{K}{1 + jQ\left(\frac{\omega}{\omega_o} - \frac{\omega_o}{\omega}\right)}$$

   and identify the symbols in the expression. [8]

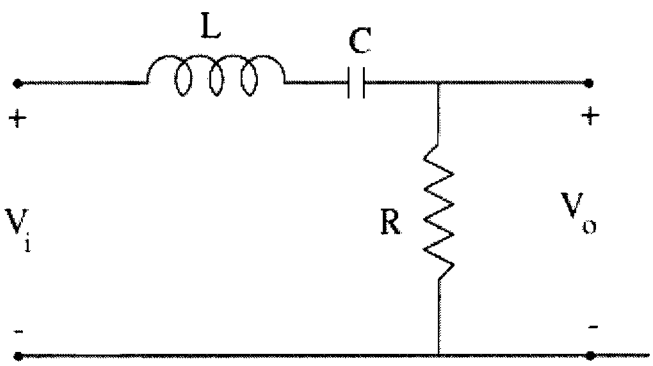

Figure 1: RLC band pass filter

   (c) Given a RLC band pass filter with a lower cutoff frequency of 1 kHz and a bandwidth of 3 kHz, determine the center frequency and Q of this circuit. [6]

   (d) Sketch the circuit diagram of a terminated RC low-pass filter and derive a general expression for the magnitude of its transfer function in terms the signal frequency f, and the cut-off frequency f_c. [9]

2. (a) In automated control systems, the output is usually optimized by a feedback mechanism. Distinguish between positive feedback and negative feedback. **[2]**

   (b) State six advantages of negative voltage feedback in amplifiers. **[3]**

   (c) Using a circuit diagram, derive an expression for the gain A_f of an amplifier with feedback in terms of the gain, A, of the amplifier without feedback and the feedback factor k. **[6]**

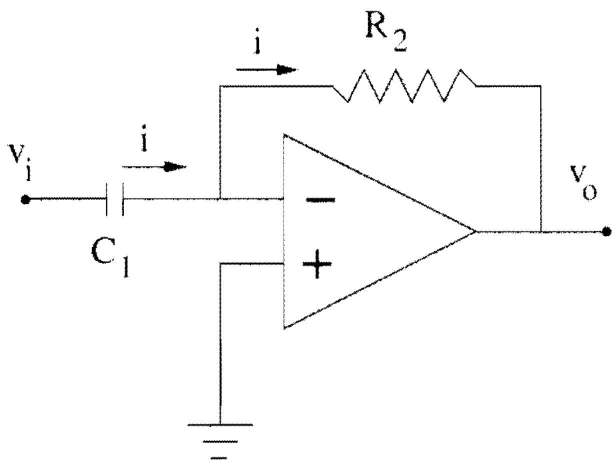

Figure 2: Differentiator Amplifier

   (d) Figure 2 shows the circuit of differentiator amplifier.

      i. Derive the expression for the output, V_{out} in terms of the input V_i, R_2 and C_1. **[4]**

      ii. Derive the expression for the voltage transfer function of the circuit, and mention the limitation of the amplifier. **[4]**

      iii. How would you modify the above circuit to overcome the limitation mentioned in (d) ii? **[3]**

      iv. Sketch $|H(j\omega)|$ with frequency and explain the behavior of the response function. **[3]**

3. (a) Draw the circuit diagram of an op-amp and label all the terminals. [2]

(b) List the most important assumptions of an ideal op-amp and briefly explain the consequences of each in simplifying the op-amp equivalent circuit. [6]

(c) Figure 3 shows a difference amplifier circuit.

i. Show that [4]

$$V_o = \left(1 + \frac{R_f}{R_1}\right)\left(\frac{R_3}{R_2 + R_3}\right) V_2 - \frac{R_f}{R_1} V_1$$

ii. If $R_1 = R_2 = R_3 = R_f$ and $V_1 = -1.0\ V$ (dc) and $V_2 = 0.1 \sin \omega t$, sketch V_o for at least one cycle. [2]

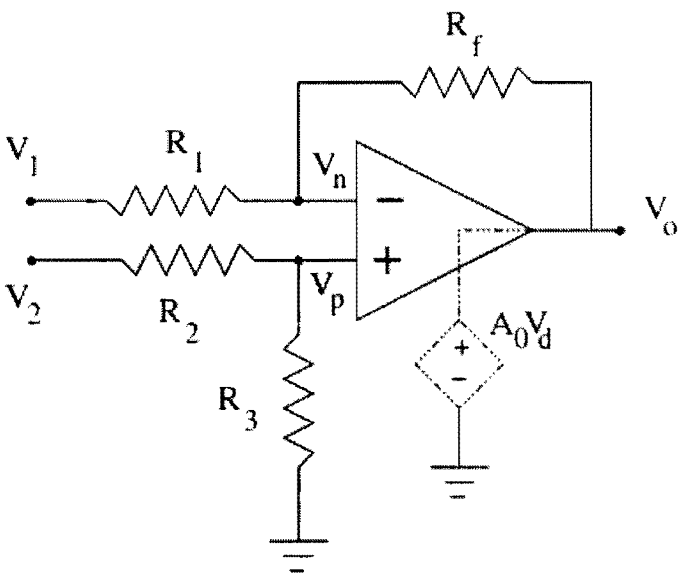

Figure 3: Difference amplifier

(d) Use operational amplifiers and appropriate components to design a circuit that obeys the following relationship between the output voltage, v_o and the input voltage, v_i: [11]

$$v_o(t) = 3x10^{-4}\frac{dv_i}{dt} + 10\int v_i dt$$

4. (a) State the Barkhausen condition necessary for oscillation to occur. **[2]**

   (b) A 3-stage RC Phase Shift Oscillator is required to produce an oscillation frequency of 6.5kHz. If 1nF capacitors are used in the feedback circuit,

      i. calculate the value of the frequency determining resistors. **[2]**

      ii. calculate the value of the feedback resistor required to sustain the oscillations. **[2]**

      iii. draw the circuit diagram of the above oscillator. **[2]**

   (c) i. Sketch a labeled circuit diagram of a Wien-Bridge Oscillator which utilizes a two-stage amplifier **[3]**

      ii. Describe the priciple of operation of the Wien-Bridge oscillator. **[12]**

      iii. Calculate the frequency of oscillation of this oscillator when $R = 10$ kΩ and $C = 0.01$ μF. **[2]**

5. (a) Sketch the circuit diagram of a physical (not an ideal) operational integrator and label it. [2]

(b) i. The input voltage of the operational integrator is $v_{in} = 0.5 \sin 100t$. The capacitance of the feedback capacitor, $C_f = 1.0\ \mu$F while the external resistance at the input of the integrator, $R_{in} = 100$ kΩ. Find the expression for v_{out} as a function of time for the integrator. [7]

ii. Sketch graphs of v_{in} and v_{out} as a function of time on the same axes. Label both axes. [3]

(c) Define the following concepts as they pertain to amplifiers

i. Bandwidth [1]

ii. Slew rate [2]

(d) The circuit diagram in Figure 4 is a voltage-to-current converter with $I_L = gV_i$. Find the value of g and show that it is independent of R_L. (Assume OpAmp is ideal). [10]

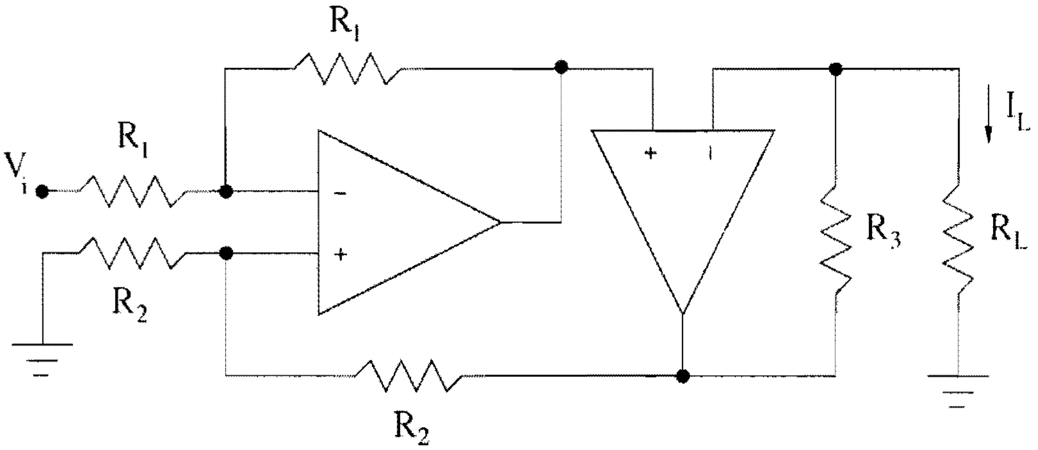

Figure 4: Voltage-to-Current Convertor

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