UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE & ENGINEERING

DEPARTMENT OF PHYSICS

MAIN EXAMINATION	:	**2013/2014**
TITLE OF PAPER	:	**ELECTRONICS II**
COURSE NUMBER	:	**P312**
TIME ALLOWED	:	**THREE HOURS**
INSTRUCTIONS	:	**ANSWER ANY FOUR OUT OF THE FIVE QUESTIONS** **EACH QUESTION CARRIES 25 MARKS** **MARKS FOR DIFFERENT SECTIONS ARE SHOWN IN THE RIGHT-HAND MARGIN**

THIS PAPER HAS 6 PAGES, INCLUDING THIS PAGE.

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QUESTION 1

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(a) Consider an amplifier with an open-loop gain of -500, without feedback. If the closed-loop gain is -25,

(i) What will be the feedback factor? (3 marks)

(ii) What will be the percentage decrease in closed-loop gain if the open-loop gain falls by 10%? (9 marks)

(b) Explain how positive feedback occurs. (3 marks)

(c) Explain why the amplifier used in a phase shift oscillator must have an open-loop gain A = -29. (2 marks)

(d) The oscillator shown in Fig. 1 is designed using an operational amplifier.

(i) What type of oscillator is this? (1 mark)

(ii) Describe, briefly, the principle of operation of this oscillator. (5 marks)

(iii) What is the frequency of oscillation of this oscillator ? (2 marks)

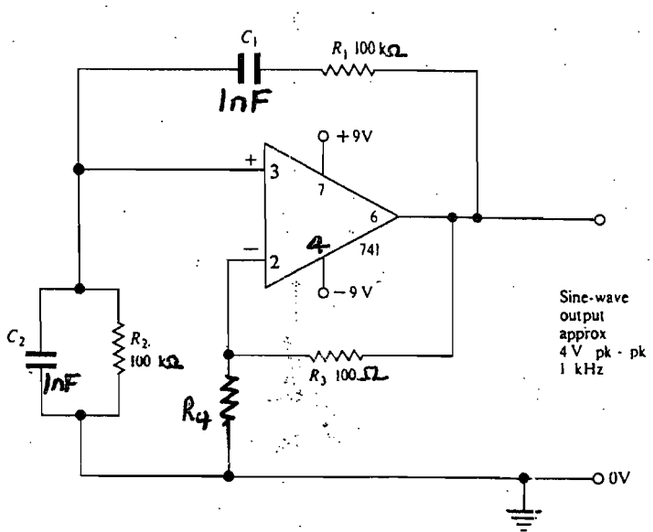

Fig. 1

QUESTION 2

(a) Fig. 2 shows a free-running multivibrator.

(i) Describe the principle of operation of this circuit. Assume that when the power supply is switched on transistor T_2 has just started conducting whilst T_1 has just switched off. (5 marks)

(ii) Draw the waveforms observed at points A, B, C and D and label them. (14 marks)

(b) The capacitor C_2 in Fig. 2 charges exponentially through R_4, in the form:

$$v_C = 2V_{cc}\left[1 - exp\left(\frac{-t}{R_4 C_2}\right)\right]$$

Use this equation to show that the frequency of oscillation of the free-running multivibrator is

$$f_0 = \frac{1}{1.38RC}$$

where $C = C_1 = C_2$ and $R = R_1 = R_2$. (6 marks)

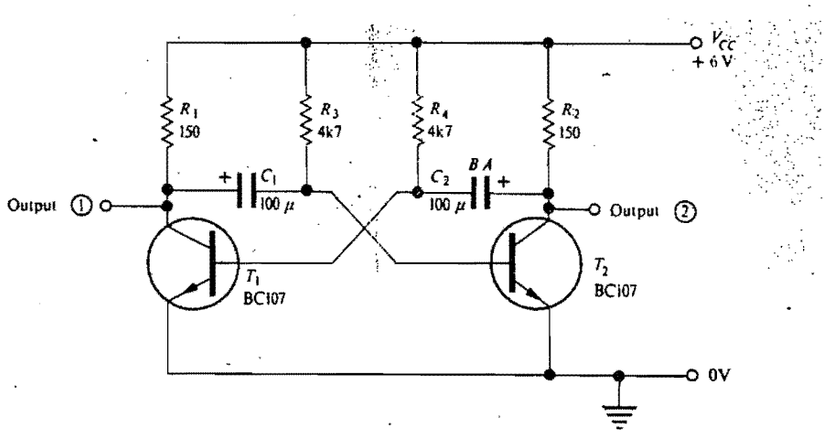

Fig. 2

QUESTION 3

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(a) The block diagram in Fig. 3.1 illustrates the architecture of an operational amplifier, such as the 741 type. State the functions of each of the four stages of the amplifier and explain, in detail, the role played by a Darlington pair. (10 marks)

(b) Fig. 3.2 shows an inverting operational amplifier. Show that the closed-loop gain of the amplifier is given by

$$A_f \cong \frac{-R_f}{R_1}$$

State all assumptions made in your derivation. (7 marks)

(c) Use an operational amplifier(s) to design a circuit which corresponds to the following ideal relationship between the output and the input voltages:

$$v_{out} = -(v_1 - \int v_2 dt).$$ (8 marks)

Label the circuit diagram you have designed and show the values of the components used.

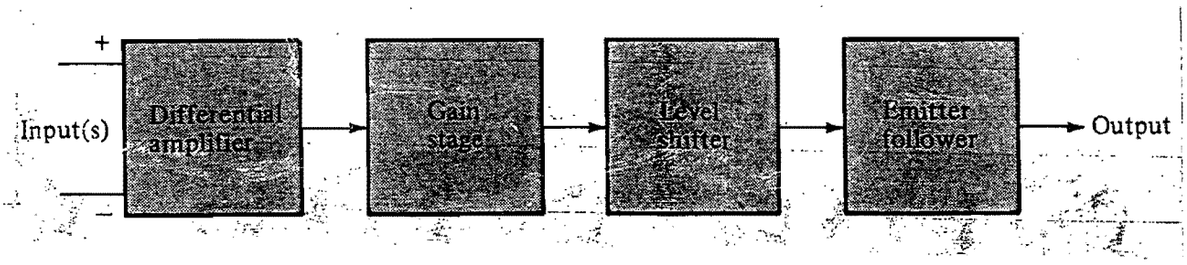

Fig. 3.1

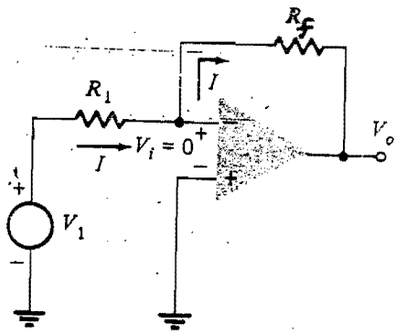

Fig. 3.2

QUESTION 4

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(a) Show that the magnitude of the transfer function of an RC low-pass filter is given as

$$|T(s)| = \left|\frac{V_0(s)}{V_i(s)}\right| = \frac{1}{\sqrt{1+\left(\frac{f}{f_{c0}}\right)^2}}$$

(8 marks)

(b) A simple RC filter is to be used as a low-pass filter with a cut-off frequency of 1 kHz.

(i) What should be the capacitance, C of the capacitor if the resistance, R is to be 1 kΩ? (2 marks)

(ii) By how much would the output be attenuated at the cut-off frequency (in dB)? (3 marks)

(iii) Calculate the phase difference between the output and input voltages of the low-pass filter at the cut-off frequency. (2 marks)

(c) A band-stop filter is designed using a capacitor, an inductor and a resistor, with component values equal to 0.1 μF, 0.2 H and 20 Ω, respectively.

(i) Sketch the circuit diagram of the filter. (2 marks)

(ii) What is the quality factor of the filter? (5 marks)

(iii) What is the lower cut-off frequency? (3 marks)

QUESTION 5

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(a) Fig. 4 shows a schematic diagram of a two-input analog multiplier. Explain briefly how this circuit works. (7 marks)

(b) With the aid of a detailed diagram of the summing amplifier, show that the output voltage, V_0 of the analog multiplier is given by:

$$V_0 = \frac{-(V_1 V_2)}{I_0 R}$$

where the symbols have their usual meanings. (8 marks)

(c) With the aid of diagrams, derive an appropriate equation to demonstrate how you would measure the output resistance of a voltage source, such as a power supply. (10 marks)

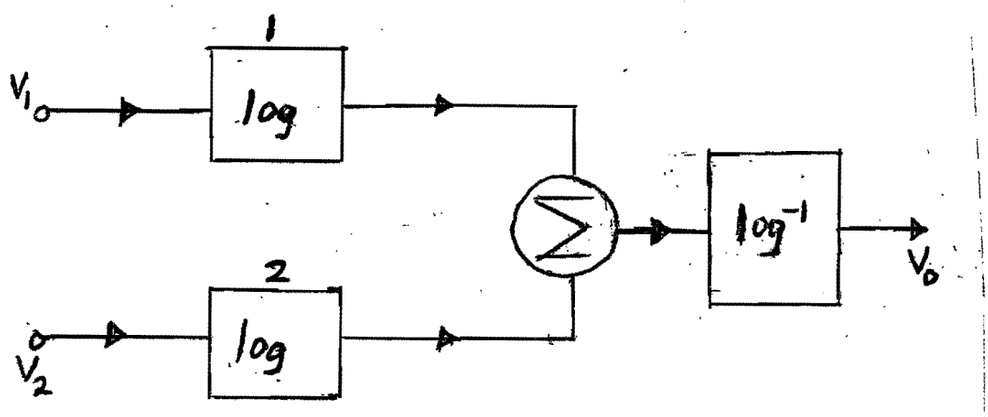

Fig. 4