UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

108

SUPPLEMENTARY EXAMINATION 2013/2014

TITLE OF PAPER	:	ELECTRONICS II
COURSE NUMBER	:	P312
TIME ALLOWED	:	THREE HOURS
INSTRUCTIONS	:	ANSWER <u>ANY FOUR</u> OUT OF 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) (i) What is meant by inverse feedback? (3 marks)

(ii) What is meant by the Barkhauszen criterion? (3 marks)

(b) State the distinct advantages of inverse feedback to an amplifier. (3 marks)

(c) An amplifier has an open-loop gain of magnitude A. A fraction B of its output signal voltage is fed back to the input so as to subtract from the signal at the input.

Derive an expression for the overall voltage gain with feedback. (5 marks)

(d) An amplifier has the following properties:

Open-loop gain = –500
Feedback is applied with a feedback factor of 0.2

(i) What is the loop gain? (2 marks)

(ii) Find the voltage gain with feedback. (2 marks)

(iii) Determine the percentage fall in gain with feedback if the open-loop gain of the amplifier falls by 20 per cent. (7 marks)

QUESTION 2

(a) (i) Draw the circuit diagram of an astable multivibrator. (2 marks)

(ii) Explain how the astable multivibrator works and assume that when the d.c. power supply is switched on, current rises faster in transistor T_1 in relation to transistor T_2. The d.c. supply voltage is 9 V. (6 marks)

(iii) Sketch the waveforms observed at the base and collector of transistor T_1 to show how the voltage varies with time. (6 marks)

(b) (i) Write an expression for the frequency of oscillation of a phase shift oscillator that is designed of a BJT amplifier and a phase-shift ladder network. The ladder network is made up of equal resistors and equal capacitors. (2 marks)

(ii) Consider each of the capacitors to have a fixed capacitance $C = 0.01\ \mu F$ whilst each of the resistances can be varied from $2\ k\Omega$ to $200\ k\Omega$.

Calculate the minimum and maximum frequencies which can be generated by the oscillator. (6 marks)

(iii) Explain why the open-loop gain of the amplifier used in the phase shift oscillator must be of magnitude ≥ 29. (3 marks)

QUESTION 3

(a) With the aid of a circuit diagram and appropriate equations, explain how you would measure the input resistance of a device, such as an amplifier. (5 marks)

(b) Consider an RC low-pass filter with component values R = 10.61 kΩ and C = 0.015 μF,

(i) Find the cut-off frequency of the filter, in Hertz. (2 marks)

(ii) Find the magnitude of v_o when v_i has a frequency 500 Hz, 1 kHz, and 2 kHz. (7 marks)

(iii) Using the values of v_o calculated in (ii), sketch v_o versus frequency. (3 marks)

(c) (i) Calculate v_{out} as a function of time for the circuit shown in Fig. 1, given that $v_{in} = A\sin\omega t$, A = 500 mV and $\omega = 100$ rad.s^{-1}. (4 marks)

(ii) Sketch graphs of v_{out} and v_{in} against time. (4 marks)

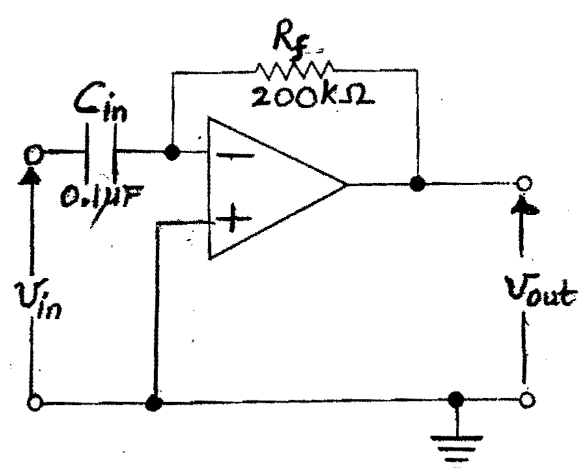

Fig. 1

QUESTION 4

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(a) Fig. 2 shows an operational integrator.

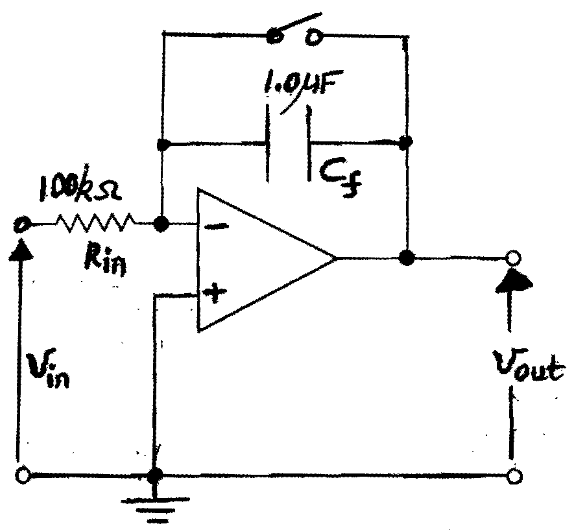

Fig. 2

(i) What is the relationship between v_{out} and v_{in} for a circuit of this type? (1 mark)

(ii) Calculate v_{out} as a function of time if v_{in} = -10 mV. Sketch a graph of v_{out} and v_{in} as a function of time. Label the graph. (5 marks)

(iv) Calculate v_{out} as a function of time when v_{in} is a sinusoidal waveform with a frequency of 100 Hz and a peak value of 10 V. Sketch v_{out} and v_{in} as a function of time on the same graph. Label the graph. (9 marks)

(b) Use op-amps to design a circuit which corresponds to the following ideal relationship between the output and input voltages:

$$v_{out} = -(v_{in} - 2 \times 10^{-4} \int v_{in} dt)$$ (10 marks)

QUESTION 5

(a) Consider the RLC bandpass filter shown in Fig. 3.

(i) Derive an expression for the magnitude of the transfer function of this filter. (5 marks)

(ii) Derive the expression for the resonant frequency. (4 marks)

(iii) Calculate the value of the resonant frequency? (2 marks)

(iv) What is the Q-factor? (2 marks)

(v) Find the cut-off frequencies, f_1 and f_2. (6 marks)

(vi) Find the bandwidth. (1 mark)

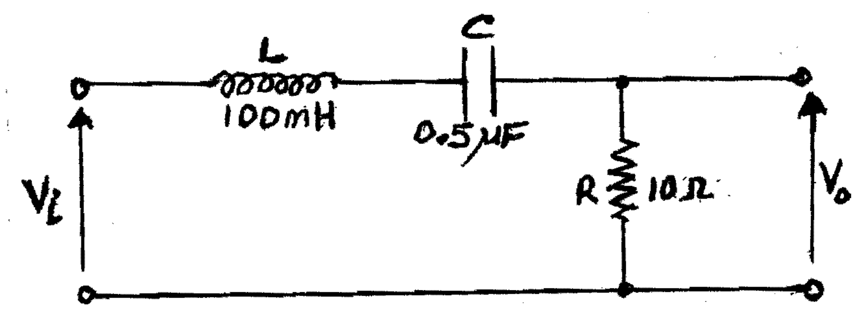

Fig. 3

(b) Calculate the phase difference between v_{out} and v_{in}, for the high-pass filter shown in Fig. 4, given that the frequency of the input voltage is 20 kHz. (5 marks)

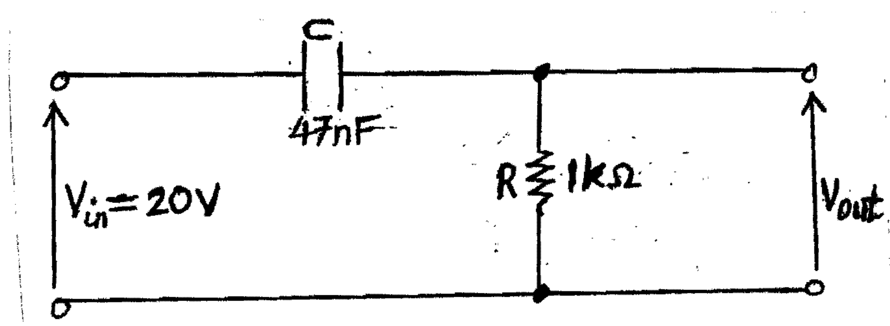

Fig. 4