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UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION	**:**	**2010/2011**
TITLE OF PAPER	**:**	**ELECTRONICS II**
COURSE NUMBER	**:**	**P312**
TIME ALLOWED	**:**	**THREE HOURS**
INSTRUCTIONS	**:**	**ANSWER ANY FOUR 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) State four improvements in amplifier performance that could be derived from applying negative feedback. (4 marks)

(b) (i) Draw the block diagram of an amplifier with negative feedback and label it. (3 marks)

(ii) Derive an expression for the closed-loop gain, A_f of an amplifier with negative feedback to show the relationship between A_f and the open-loop gain, A. (4 marks)

(iii) Under what conditions would A_f be made primarily independent of A and stable even when there are changes in amplifier parameters? Give your answer with reference to the expression for A_f that was derived in section (b)(ii) of this question. (4 marks)

(c) An amplifier with negative feedback has an open-loop gain of - 600. The feedback factor is 0.01. When the transistor in the amplifier circuit becomes faulty and is replaced, the open-loop gain is found to increase by 20%.

(i) Determine the percentage change in the closed-loop gain of the amplifier. (8 marks)

(ii) Comment on the results obtained in section (c)(i) of this question. (2 marks)

QUESTION 2

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(a) Derive a general expression for the magnitude of the transfer function of an RC low-pass filter, in terms of the signal frequency, f and the cut-off frequency, f_{co}. (9 marks)

(b) For the high pass filter shown in Figure 2.1,

(i) Find the cut-off frequency in hertz. (2 marks)

(ii) Find the magnitude of v_{out} when v_{in} has a frequency 1 kHz. (4 marks)

(iii) Find the phase angle between v_{out} and v_{in}, when v_{in} has a frequency of 5 kHz. (3 marks)

(c) The band pass filter shown in Figure 2.2 has a centre frequency of 10 kHz.

(i) What should be the quality factor if the bandwidth of the filter is to be greater than 1 kHz? (3 marks)

(ii) Calculate the capacitance of the capacitor. (4 marks)

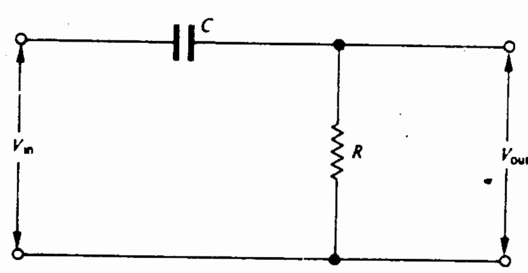

Figure 2.1

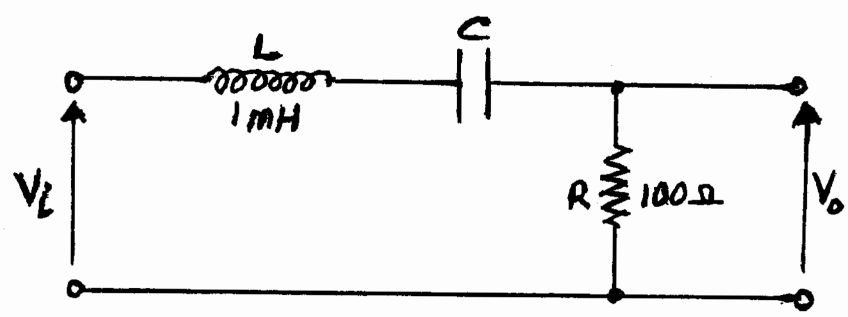

Figure 2.2

QUESTION 3

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(a) Figure 3.1 shows the circuit diagram of a free-running multivibrator.

(i) Explain, briefly, how this multivibrator works. (6 marks)

(ii) Sketch the waveforms observed at the base and collector of each of transistors T_1 and T_2. (8 marks)

(b) The following is a charging equation that indicates how the voltage across any of the two capacitors shown in Fig. 3.1 varies with time. It is of the exponential form:

$$v = 2V_{cc}\left[1 - \exp\left(\frac{-t}{C_1 R_3}\right)\right].$$

(i) Explain what the factor of 2 in the equation means, with reference to the waveforms generated by the multivibrator. (3 marks)

(ii) Use this equation to demonstrate that when $R_1 = R_2 = R$ and $C_1 = C_2 = C$, the frequency of any of the waveforms referred to in section (a)(ii) above can be expressed as follows:

$$f = \frac{1}{1.38RC}$$ (6 marks)

(iii) Calculate the period of oscillation with reference to Figure 3.1. (2 marks)

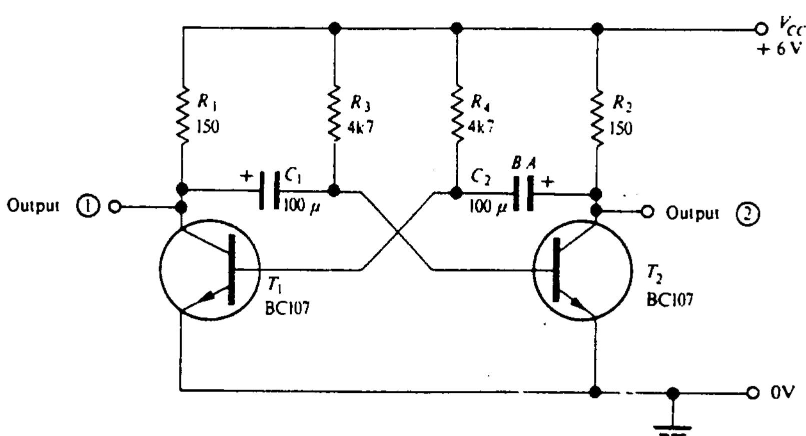

Figure 3.1

QUESTION 4

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(a) List five key characteristics of a 741 op-amp. (5 marks)

(b) (i) Draw the circuit diagram of an operational integrator and label it. (2 marks)

(ii) Derive an expression to show that the output voltage of the integrator is proportional to the integral of the input voltage. (4 marks)

(c) Use operational amplifiers and appropriate components to design a circuit that obeys the following relationship between the output, v_o and the input, v_i.

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

Ensure that your analysis is as clear as possible. Label all the components in the circuit you have designed. (14 marks)

QUESTION 5

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(a) Draw the circuit diagram of an emitter follower, together with a small signal model of the follower and label the diagrams. (4 marks)

(b) Show that the voltage gain of an emitter follower is given by the following expression:

$$A_v = \frac{(1+\beta)R_E}{r_\pi + (1+\beta)R_E}$$

where β, R_E *and* r_π have the usual meaning. (7 marks)

(c) State *three* important properties on an emitter follower. (3 marks)

(d) With the aid of the small signal model of an emitter follower, derive an expression for the input resistance of the follower. (3 marks)

(e) A BJT is used to build a common-collector amplifier. Given that the emitter load resistance is 2 kΩ, the a.c. current gain of the transistor is 100 and the input resistance of the transistor, r_π is 1 kΩ, calculate

(i) the voltage gain of the amplifier. (3 marks)

(ii) the input resistance of the amplifier. (2 marks)

(iii) the output resistance, if the internal resistance of the voltage source is 1 kΩ. (3 marks)