UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION	**:**	**MAY 2008**
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 7 PAGES, INCLUDING THIS PAGE.

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QUESTION 1

(a) List four characteristics of an amplifier which are modified by negative feedback. (4 marks)

(b) Draw a feedback amplifier in block-diagram form. Identify each block, and state its function. (5 marks)

(c) A bipolar transistor has a current gain of -150, a collector load resistor of 3000Ω and input resistance of 1000 Ω.

(i) Calculate the voltage gain of the circuit. (2 marks)

(ii) Calculate its voltage gain when negative feedback is applied with a feedback factor of 0.05. (3 marks)

(d) An amplifier has a voltage gain of -650. If 0.5% of the output voltage is fed back to the input as negative feedback, calculate the % change in the gain with negative feedback when the open-loop gain falls by 25%. (11 marks)

QUESTION 2

(a) State the two conditions that must be satisfied by a circuit to sustain oscillations. (4 marks)

(b) (i) Sketch the circuit of a phase-shift oscillator that uses a bipolar junction transistor and an RC ladder network. Explain how it works. (8 marks)

(ii) Derive an expression for the attenuation coefficient of the RC ladder network in terms of the angular frequency ω, as well as the capacitive and resistive components of the network. Assume that the resistors in the network are of the same value. The same applies to the capacitors. (8 marks)

(c) The Wien bridge network shown in Fig. 2.1 is used to build a frequency-dependent sinusoidal oscillator.

(i) Mention the distinctive benefits of using this type of oscillator. (3 marks)

(ii) Calculate the frequency of operation of this oscillator if the frequency-determining resistors are each 10 kΩ and the frequency-determining capacitors are each 0.01 μF. (2 marks)

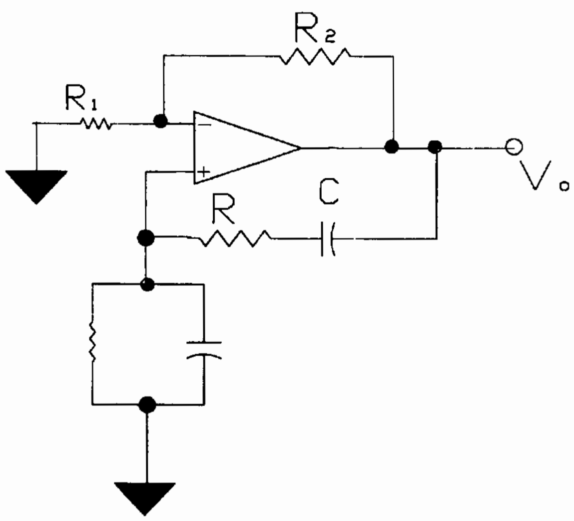

Fig. 2.1

QUESTION 3

(a) Draw the circuit of an emitter follower, together with its equivalent circuit. Label the diagrams. (5 marks)

(b) With the aid of labelled block diagrams explain, in detail, the concept of impedance matching for optimum voltage transfer between a signal source and a load, with specific reference to an emitter follower. (12 marks)

(c) Derive the following expression for the output resistance of an emitter follower:

$$r_{out} = \frac{R_G + r_\pi}{1 + h_{fe}}$$

where R_G represents the internal resistance of the voltage source. The other symbols have the usual meaning. (8 marks)

QUESTION 4

(a) Describe four important characteristics of an ideal operational amplifier. (4 marks)

(b) A Darlington pair is a useful device in operational amplifiers. It consists of transistors Q1 and Q2 of current gain h_{fe1} and h_{fe2} respectively, as shown in Fig. 4.1. Show that the current gain of the pair is given by

$$h_{fe} \approx h_{fe1} \times h_{fe2}$$ (5 marks)

(c) Calculate and sketch v_{out} as a function of time for the waveform given in Fig. 4.2 which represents an input to an operational differentiator. (9 marks)

(d) Calculate the voltage gain of the circuit shown in Fig. 4.3. (3 marks)

(e) For the circuit shown in Fig. 4.4 calculate the output voltage when $R_1 = R_2 = R_3 = 10\text{k}\Omega$, $R_4 = 100\text{ k}\Omega$, $V_1 = 0.1$ V, $V_2 = 0.5$ V and $V_3 = 0.25$ V. (4 marks)

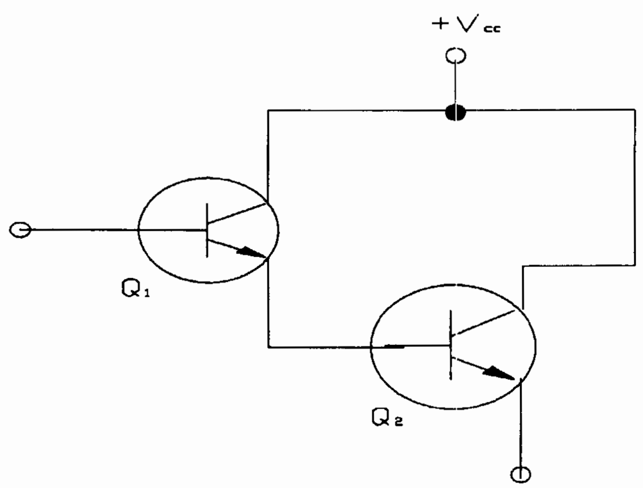

Fig. 4.1

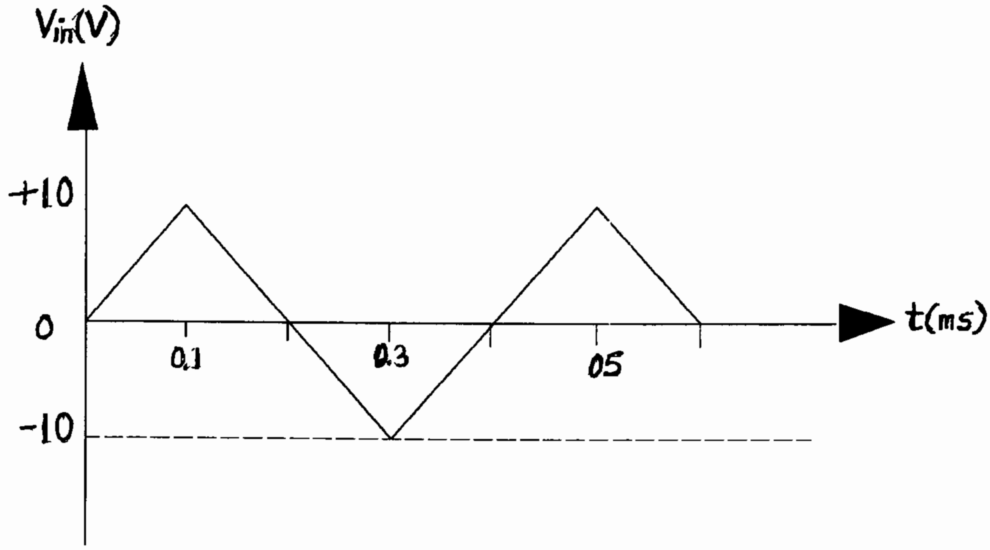

Fig. 4.2

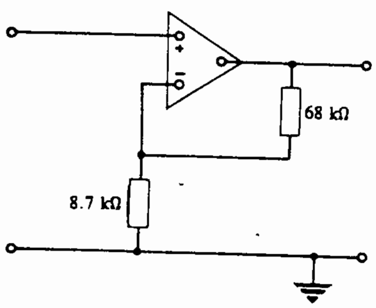

Fig. 4.3

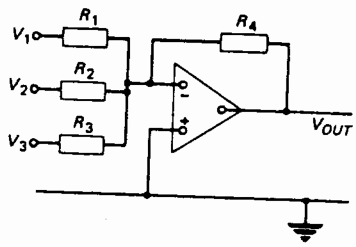

Fig. 4.4

QUESTION 5

(a) (i) Find the inductance of the high-pass filter circuit shown in Fig. 5.1, if T(s) = 0.50 at a frequency of 50 MHz. (7 marks)

(ii) What is the phase difference between V_i and V_o at this frequency? (2 marks)

(b) The diagram in Fig. 5.2 represents a bandreject filter.

(i) Show that the magnitude of the transfer function of the bandreject filter is given by the following relationship:

$$|T(s)| = \left[1 + \frac{1}{\left(\frac{\omega L}{R} - \frac{1}{\omega RC}\right)^2}\right]^{-\frac{1}{2}}$$ (5 marks)

(ii) Use the equation in (b)(i) to derive an expression for the resonant frequency of the filter. (4 marks)

(c) (i) What is the function of a bandpass filter? Sketch a graph of $|T(s)|$ against f to illustrate your point. Label it. (5 marks)

(ii) Use a block diagram to demonstrate how you can build a bandpass filter using a lowpass filter and a highpass filter. (2 marks)

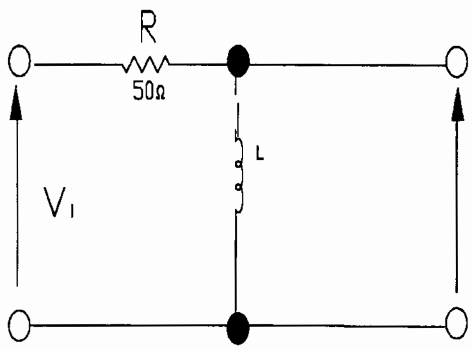

Fig. 5.1

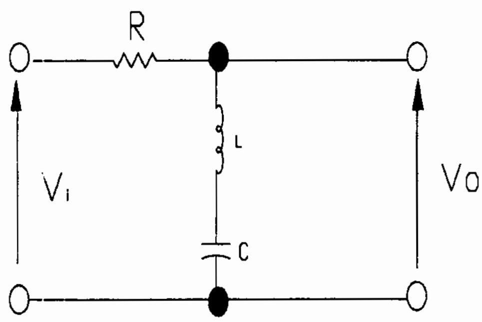

Fig. 5.2