Ollscoil na hÉireann, Gaillimh *GX*_____
National University of Ireland, Galway

Semester II Examinations, 2003/2004

Exam Code(s)	2BN1
	2BP1
Exam(s)	Second Year Electronic Engineering
	Second Year Electronic and Computer Engineering
Module Code(s)	EE211
Module(s)	Analogue Systems Design I
Paper No.	1
Repeat Paper	Special Paper
External Examiner(s)	Professor S. McLaughlin
Internal Examiner(s)	Professor D.J. Wilcox
	Dr. J. Breslin
	Dr. M. Duffy

Instructions: Answer 5 questions.
All questions carry equal marks.

Duration	3hrs
No. of Answer books	1
Requirements:	
Handout	
MCQ	
Statistical Tables	
Graph Paper	Yes
Log Graph Paper	Yes
Other Material	
No. of Pages	6
Department(s)	Electronic Engineering

1.

(a) For the half-wave rectifier circuit with an ideal diode as shown in Fig. 1:

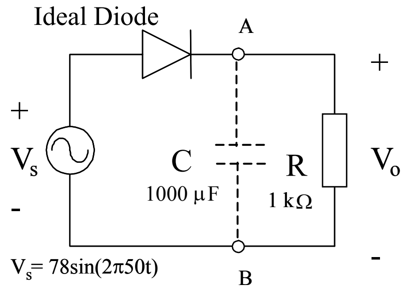

Fig. 1. Half-wave rectifier circuit

(i) Sketch the output waveform V_o without the capacitor C in the circuit. **[2 marks]**

(ii) Describe the effect on V_o of placing the capacitor C in parallel with the load, i.e. between points A and B in the circuit. **[3 marks]**

(iii) Calculate the percentage ripple if C is included. **[2 marks]**

(iv) Explain how this circuit could be modified to function as a peak detector. **[2 marks]**

(b) For the Zener diode voltage regulator circuit given in Fig. 2:

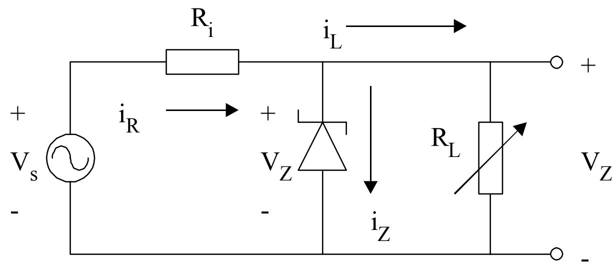

Fig. 2. Zener diode voltage regulator

(i) Sketch the i_D vs. v_D characteristic for a Zener diode showing the various regions of operation. **[2 marks]**

(ii) In which region does the Zener diode operate for the voltage regulator application shown? **[1 mark]**

(iii) For varying source voltage and load current, analyse the circuit to determine the proper range of values for R_i that will allow the diode to maintain a constant output voltage (by keeping the Zener current between its minimum and maximum values). **[6 marks]**

(iv) Define percentage regulation for the Zener diode voltage regulator. **[2 marks]**

[cont'd]

2.

(a) Clearly explain the purpose of biasing a transistor. **[3 marks]**

(b) Using the exact method of calculation, determine the DC values of V_B, V_C, V_E and I_B, I_C and I_E for the BJT in the circuit of Fig. 3. **[7 marks]**

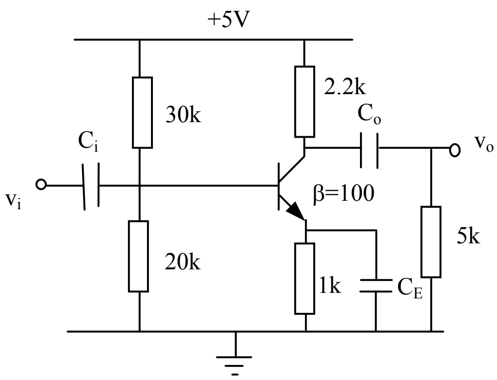

Fig. 3. Common emitter amplifier circuit

(c) Describe the function of the capacitors C_i and C_o in the circuit of Fig. 3. What is the purpose of C_E ? Calculate the AC voltage gain of the circuit (with the 5k load included). **[8 marks]**

(d) Plot two periods of the output voltage, v_o, for a sinusoidal input voltage, v_i, with 20 mV amplitude. **[2 marks]**

3.

(a) Describe the semiconductor make-up of an n-channel depletion metal-oxide field effect transistor (D-MOSFET). Clearly explain the depletion mode of operation. **[5 marks]**

(b) Sketch the typical I-V characteristic curves for an n-channel D-MOSFET, with depletion and enhancement regions clearly marked. **[5 marks]**

(c) Calculate the DC bias levels for the circuit of Fig. 4 if the MOSFET has values of I_{DSS} = 240 mA and $V_{GS(off)} = -5$ V. **[10 marks]**

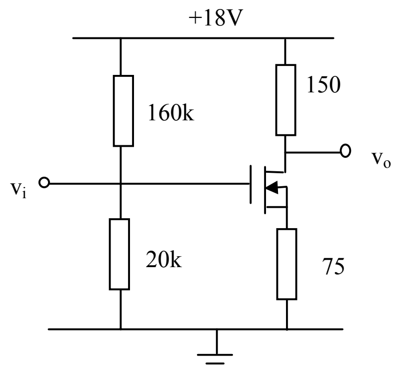

Fig. 4. MOSFET DC biasing circuit

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4.

(a) Derive an expression for the output voltage, v_o, in terms of the voltages v_1, v_2 and v_3 in the circuit of Fig. 5. State clearly any assumptions made in your derivation. **[4 marks]**

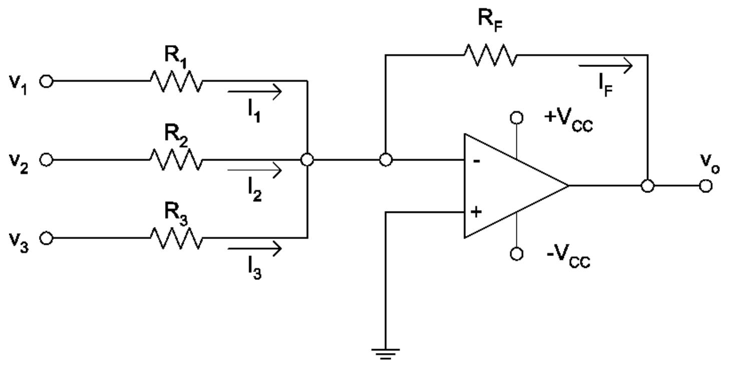

Fig. 5. Op Amp summing circuit

(b) Give two advantages of active filters over passive filters. Draw the circuit diagram of a first order active high-pass filter and derive the transfer function for the circuit. **[8 marks]**

(c) Calculate the values of resistor(s) and capacitor(s) required to provide a first order active high-pass filter with cut-off frequency of 2.5 kHz and a pass band gain of 5 (A_F = 5). Sketch the frequency response of the resulting filter. **[8 marks]**

5.

(a) Given that I_E = 1 mA, calculate the following quantities for the Box Model of the amplifier circuit in Fig. 6 : **[8 marks]**

(i) open circuit gain
(ii) input resistance
(iii) output resistance
(iv) overall system gain

(b) The transistor in Fig. 6 is a 2N2222 device with parameters : C_e = 20.8 pF, C_c = 7.62 pF and τ_F = 412 ps. Find the upper and lower 3 dB cutoff frequencies, and sketch the Bode gain plot. **[12 marks]**

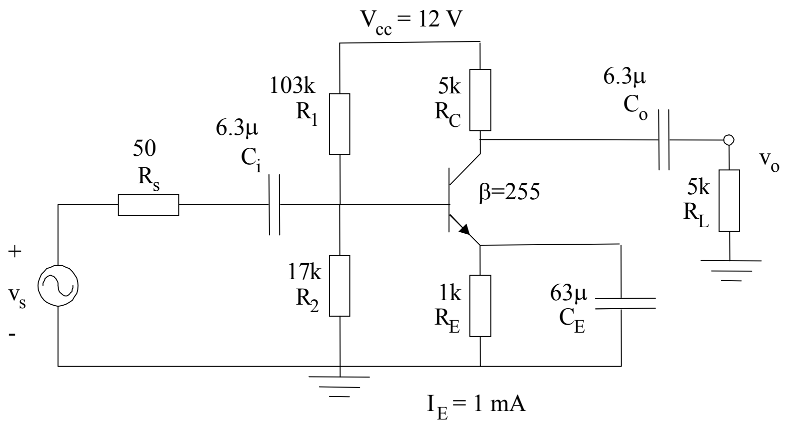

Fig. 6. Common Emitter amplifier circuit

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6.

A moving coil meter with an internal resistance of 1 kΩ and a full-scale deflection current rating of 0.5 mA is to be used in the design of a DC ammeter.

(a) Describe the circuit required to increase the input current range of the meter. Use this circuit to design an ammeter with input range of 1 A. **[5 marks]**

(b) Calculate the total resistance of the ammeter designed in part (a). Determine the percentage error caused by using it to measure I_o in the circuit of Fig. 7(a). **[4 marks]**

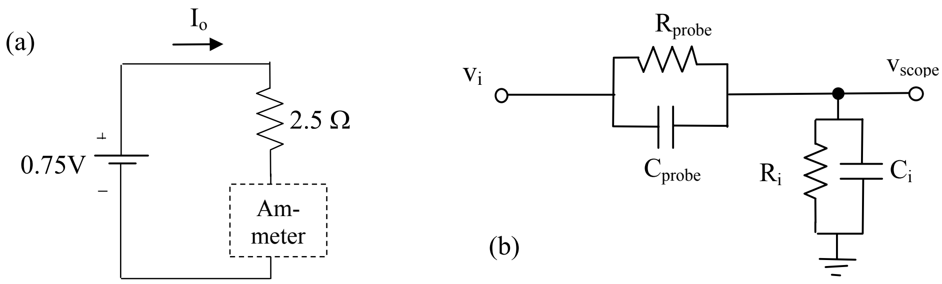

Fig. 7(a) Current test circuit, (b) Circuit model of oscilloscope with probe

The circuit diagram of a ×10 probe connected to an oscilloscope is shown in Fig. 7(b).

(c) Explain why $R_{probe}C_{probe}$ must equal R_iC_i for accurate display of input voltage waveforms. **[6 marks]**

(d) Design a ×10 oscilloscope probe with R_{total} = 20 MΩ and C_{total} = 15 pF. **[5 marks]**

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7.

A resistive strain gauge circuit consists of two active elements and 2 dummy elements as shown in Fig. 8. When subjected to pressure, the strain on both active gauges increases, causing their resistance to increase by ΔR as shown.

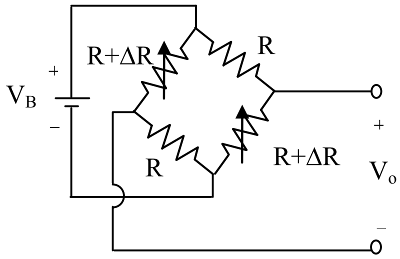

Fig. 8. Strain gauge bridge circuit

(a) Define what is meant by the following terms as they relate to sensors : **[6 marks]**

- (i) accuracy
- (ii) range
- (iii) sensitivity
- (iv) resolution

(b) Give two reasons why Wheatstone bridge circuits are used in building sensor circuits. **[4 marks]**

(c) Answer each of the following for the sensor in Fig. 8 : **[6 marks]**

- (i) Write an expression for the output voltage as a function of ΔR, R and V_B.
- (ii) Calculate the percentage linearity error for R = 3.5 kΩ and ΔR = 3.5 Ω.
- (iii) Draw a bridge configuration with zero linearity error. Include an expression for its output voltage

(d) Draw a block diagram for a sensor circuit that provides a digital output with a current sink. Explain the operation of the current sink. **[4 marks]**