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Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

Semester II Examinations 2004 / 2005

Exam Code(s)	2BG121
Exam(s)	2nd Year Biomedical Engineering
Module Code(s)	EE212
Module(s)	Biomedical Electronics and Instrumentation
Paper No.	2
Repeat Paper	No
External Examiner(s)	Professor S. McLaughlin
Internal Examiner(s)	Professor D. J. Wilcox
	Dr. M. Duffy
	Mr. Fergal O'Malley

Instructions: Answer **three** questions.
All questions carry equal marks.

Duration	2 hours
No. of Pages	4 (including cover)
Department(s)	Electronic Engineering
Course Co-ordinator(s)	Maeve Duffy, Fergal O'Malley

Requirements:
MCQ
Handout
Statistical Tables
Graph Paper
Log Graph Paper
Other Material

1.

(a) Explain clearly what is meant by the half-cell potential in biopotential electrodes. **[5 marks]**

(b) The differential amplifier circuit shown in Fig. 1 is used to amplify EMG signals. Assume ideal properties for the operational amplifier (Op Amp) in the following calculations :

(i) Using the principle of superposition, derive an expression for the output voltage, $v_o(t)$, in terms of input voltages, $v_1(t)$ and $v_2(t)$, and specify the circuit gain.

(ii) If the circuit has a CMRR of 60 dB, calculate the output voltage for input electrode voltages of $v_1(t) = 0.4 + 0.006$ Sin $(40\pi t)$ and $v_2(t) = 0.4 - 0.003$ Sin $(40\pi t)$.

[12 marks]

(c) Calculate the change in differential gain of the amplifier caused by skin resistance of 5 kΩ at each input, and suggest a suitable method for preventing this change. **[3 marks]**

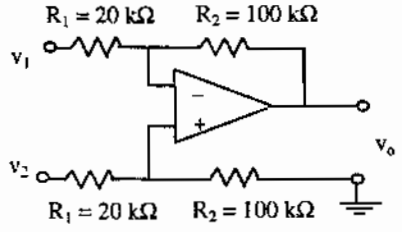

Fig. 1 Differential amplifier

2.

(a)

(i) Draw the block diagram of a general digital signalling processing system and briefly explain the significance of each element of the system. **[5 marks]**

(ii) Explain what advantages *digital processing* of signals offers in the design of biomedical electronics equipment. **[5 marks]**

(b)

(i) Draw a circuit diagram of a parallel encoded 3 bit 'flash' analogue to digital converter with a 10 volt reference voltage. Briefly explain the principle of operation of this converter. **[4 marks]**

(ii) A biomedical signal is sampled at regular time intervals and the voltages at each of these times are presented in the table below. If these samples are applied to the A/D converter you have drawn in part (b) (i) determine the output bit pattern at each time interval. **[6 marks]**

Time (ms)	*Signal Voltage*
0	*3.4V*
2.5	*7.9V*
5	*4.1V*
7.5	*-3.2V*
10	*-1.4V*

Contd.

3.

(a) A certain biomedical instrument gives a 4 bit digital output as shown in Fig. 3.1 below. You are required to design a basic digital to analogue converter based upon an inverting operational amplifier configuration. The converter is to have four binary inputs, which will have values of 0V or 5V only. The circuit is to give an output voltage equal in magnitude to the decimal value of the binary number applied at the input. The output voltage will be negative. Give a full circuit diagram for the DAC design and calculate the output voltages for all possible input binary combinations. **[14 marks]**

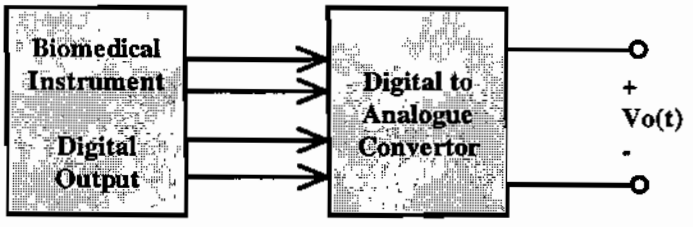

Fig. 3.1

(b) The diagram of Fig. 3.2 shows a biomedical signal sensing circuit, providing an input to an analogue circuit, which will carry out some useful processing of the signal. Outline the significance of the input and output resistances of the sensing circuit and the processing circuit. Explain with the aid of diagrams how and why a unity gain buffer could be used within this system. **[6 marks]**

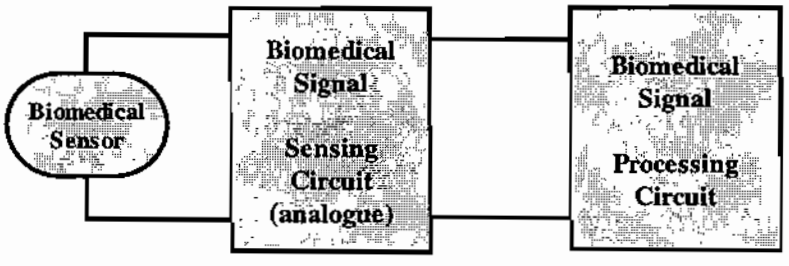

Fig. 3.2

Contd.

4.

(a) Clearly describe the function of each of the following blocks, when applied in a typical ECG measurement system : **[9 marks]**

(i) Analog multiplexer
(ii) Right leg drive circuit
(iii) Opto - data coupler

(b) The differentiator circuit shown in Fig. 4(a) is to be used to detect the QRS complex in an ECG measurement system.

(i) For this circuit, write an expression for the output voltage, $v_o(t)$, as a function of the input voltage, $v_i(t)$.
(ii) If the threshold voltage for the detector is to be set at ± 5 V, calculate the value of resistance, R, needed to detect the QRS signal given in Fig. 4(b) if a capacitor, C = 10 μF is used.
(iii) Calculate the maximum amplitude of 50 Hz noise that can be tolerated at the input of the circuit if the output noise voltage must be lower than 50 mV.

[11 marks]

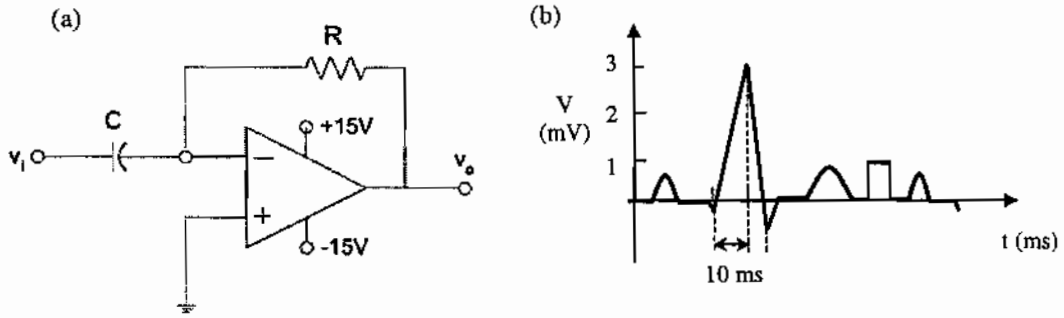

Fig. 4(a) Differentiator circuit, (b) typical ECG waveform