TOPIC: Biomedical device and system design

Q.1 Explain the electrophysiology of the human heart, and define the design requirements for a multichannel electrocardiograph. Provide a comprehensive design of digital multichannel electrocardiograph down to general circuit diagrams level and procedural flowcharts.

TOPIC: Biosensors, optics and integrated sensor design

Q.1 Consider a non-ideal opamp with gain A, input resistance Ri and output resistance Ro. The opamp is used to make a unity gain amplifier (voltage follower/buffer). Find the transfer function, the input resistance and the output resistance of the amplifier. What happens as the opamp approaches ideality?

Q.2 With reference to an analog to digital converter, what do the following mean (a) resolution, (b) sample clock, (c) dynamic range, (d) least significant bit, (e) integral and differential non-linearity.

Q.3 What are three sources of noise that limit a photodetector? What are their origins and how can they be minimized?

Field of Study Examination, Feb 24 2017

Subject area: Biomedical Engineering

This question paper has 1 page (not including this cover page).

This question paper has 3 questions.

Answer a minimum of one question and at most three questions from this subject area.

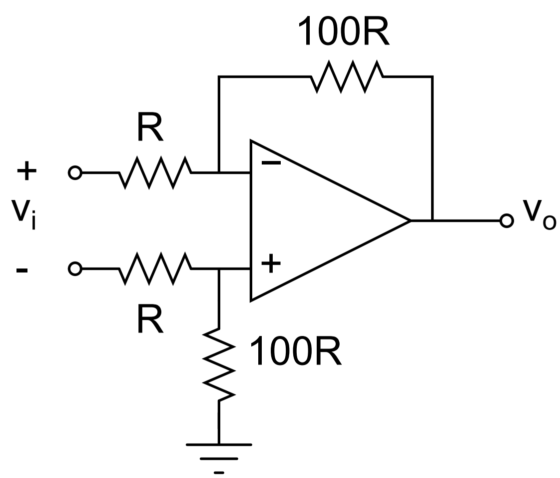
Use a separate booklet (i.e., blue booklet) for the answers to questions in this subject area.

1. Design a 16-channel digital electromyograph to record the EMG activity of the human biceps muscle (frequency range 5-450 Hz). Provide the necessary patient protection. Determine the sampling frequency. Show pseudocode of the digitization process. Provide at least one possible avenue to reduce or eliminate motion artifacts.

2. Describe the origin of an action potential in context of ion channels and cell membrane properties. Sketch a sample action potential with an approximate time and amplitude scale. Identify the phases of the waveform and relate them to membrane properties. Draw the Hodgkin-Huxley model of an excitable cell and relate it to an actual cell ie explain what each of the circuit element relates to physiologically.

3. This question has 3 parts (a)-(c).

   Consider the differential amplifier shown below.



   (a) Assuming the opamp has an open loop gain of A and an input resistance of R_i, calculate the input resistance of the differential amplifier. What happens as the opamp approaches ideality ie A and R_i go to infinity.

   (b) Assume the opamp above is ideal and $R = 1$ kΩ. It is used for biopotential measurements using electrodes with a 1 MΩ resistance. Would the measurement work? Why or why not?

   (c) In context of your answer to (b), explain what you could do to improve the measurement. How would you do that?