The Open University of Sri Lanka
B.Sc. Degree Programme- Level 05
Final Examination 2021/2022
PHU5303 - Data Acquisition and Signal Processing
Duration: Two (2) Hours

Date: 28.10.2022   **Time: 2.00 p.m. – 4.00 p.m.**

ANSWER ANY FOUR (04) QUESTIONS ONLY.

1. (a)

i.   Briefly discuss the basic processing stages of a computer-aided data acquisition system
ii.   With the aid of circuit diagrams explain how to use the following temperature sensors in data
      acquisition systems.
          A. Thermistor
          B. PN junction thermometer

   (b)
i.   Draw a diagram of a photomultiplier tube
                   A. Mark and name all the parts of the photomultiplier tube
                   B. Write down the function of each part mentioned in the photomultiplier tube
ii.   Briefly discuss the usage of the Cerenkov detector

Figure 01
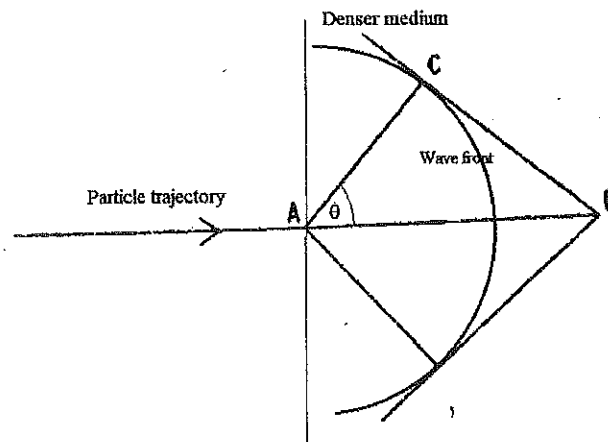
iii. Figure 01 shows an electron travelling through a medium of refractive index of n with a velocity v.
      Derive an expression for $\cos\theta$.
iv.   Assume that an electron move through the water with the momentum of 1 GeV/c. The
      momentum (p) of a relativistic particle can be expressed as follows $p = \dfrac{m\beta}{\sqrt{1-\beta^2}}$

      Where m is the rest mass of the electron of 0.5 MeV, β is the ratio of the velocities of the
      moving electron and the emitted radiation. Calculate β (Velocity of light c- $2.997 \times 10^8\ ms^{-1}$)
v.   Find the velocity of the electron.
vi.   If the refractive index of water is 1.33 show that the Cerenkov radiation is emitted by the
      electron.

2. (a)

   i.   Draw a circuit diagram of an Op-amp follower/ Unity gain circuit.

   ii.   Briefly discuss how to use the Op-amp follower/ Unity gain circuit in a data acquisition system

   iii.   Using a comparator, design a circuit to convert a sine wave into a square wave with 10 V peak to peak output.

   (b)

   i.   Using the proper values for resistors, design a non-inverting amplifier with a voltage gain of 11.

   ii.   Using a non-inverting amplifier, construct a multi-range voltmeter for the following ranges 0 - 0.1 V, 0 - 0.25 V and 0 - 0.5 V

   iii.   Briefly discuss the advantages of using the above multi-range voltmeter over an analogue voltmeter.

3. (a)

   i.   Explain briefly why noise plays a major role in a data acquisition system

   ii.   Describe briefly the following types of noise.

       A.   Johnson Noise

       B.   Shot Noise

       C.   Environmental Noise

   (b)

   i.   Draw low pass RC and RL filters circuits

   ii.   Write down the voltage transfer ratio for both types of filters mentioned in part (i). Define the symbols used in your answer.

   iii.   A detector produces a range of frequencies from 4 kHz to 6 kHz. In addition, it picks up a noise with a 15 kHz frequency.

       A.   Find the cutoff frequency for a suitable low pass filter for removing the noise.

   B.   Calculate the resistance (R) and capacitance (C) to design a RC filter for that purpose.

4.

   i.   Why is spectrum analysis useful in signal processing stages of a data acquisition system?

   ii.   Explain the theory behind the spectrum analysis by writing down the relevant equations.

   iii.   Fourier analyze the following square waveform of period $T=1/f_0$ to find its spectrum.
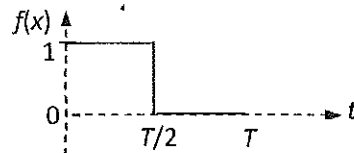
   iv.   Hence draw the power spectrum of the above signal.

   v.   If the signals of the above spectrum needs to be digitized, what would be the maximum sampling interval that avoids aliasing?

5.

    i.   Define the terms (i) Range (ii) Resolution (iii) Quantization error and (iv) sampling error in relation to analogue to digital conversion of signals.

    ii.   Write down two methods to convert a digital signal to an analogue signal. Discuss the advantages and disadvantages of these two methods.

    iii.   Briefly explain how an analogue signal is converted to a digital signal with the counter ADC given in the following block diagram.
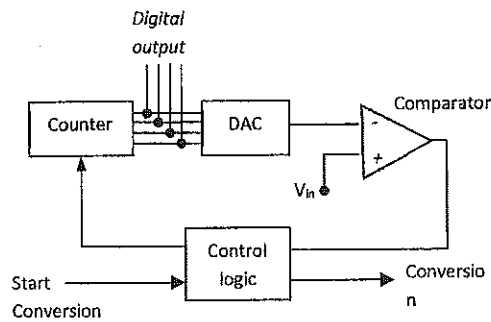
    iv.   What are the differences of tracking ADC and successive approximation register (SAR) ADC when compared with the counter ADC?

    v.   A 4 bit SAR ADC has an internal DAC with 0-8 V range. Write down the sequence the SAR would go through to convert a 2 V analogue input to a digital output.

6.

    i.   The EPROM labeled 2716 has two kilobytes of memory. If the data bus of this chip is 8 bit, calculate the width of the address line.

    ii.   Illustrate with the help of a diagram, how to construct a 32 kilobit (4096×8) memory using 2716 chips.

    iii.   Discuss the tasks of (i) programme counter, (ii) A and B accumulators and (iii) flag registers of a typical microprocessor.

    iv.   Explain how these registers help in the sequence of general operation of a microprocessor when run a programme.

    v.   Write a simple assembly language programme to subtract 2 from 3 and draw a diagram to illustrate how this programme is stored in a memory starting from address 10_h.