00095

The Open University of Sri Lanka
Faculty of Natural Sciences
B.Sc. Degree Programme

Department	: Physics
Level	: 05
Name of the Examination	: Final Examination
Course Code and Title	: PHU5303-Data Acquisition and Signal Processing
Academic Year	: 2023/ 2024
Date	: **21st October 2023**
Time	: **1.30 pm- 3.30 pm**
Duration	: **2 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **06** questions in **06** pages.
3. Answer any **04** questions only. All questions carry equal marks.
4. Answer for each question should commence from a **new page**.
5. Draw fully labelled diagrams where necessary
6. Having any unauthorized documents/ mobile phones in your possession is a punishable offense
7. Use blue or black ink to answer the questions.
8. Circle the number of the questions you answered in the front cover of your answer script.
9. Clearly state your **index number** in your answer script

Boltzmann constant (k) = 1.38×10^{-23} JK^{-1} Charge of an electron = 1.602×10^{-19} C

Question No: 01

A.

(i) What is the function of a transducer in a data acquisition system? (03 Marks)

(ii) List one input transducer and one output transducer for the following Physical Variables. (03 Marks)

(a) Temperature
(b) Displacement
(c) Sound

(iii) Passive transducers are embedded using different methods. The bridge circuit is one method of embedding passive transducers as shown in figure 01.

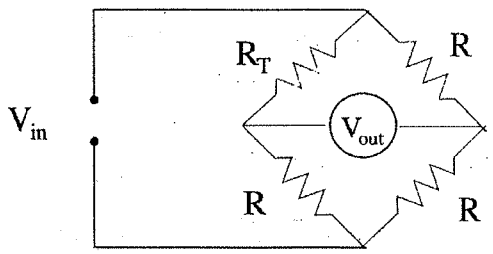

Figure 01

Show that the output voltage of the circuit is given by (04 Marks)

$$V_{out} = \left[\frac{R}{R + R_T} - \frac{1}{2}\right] V_{in}$$

B.

(i) Briefly explain the function of the following radiation detectors. (06 Marks)

a. Photomultiplier tube
b. Cerenkov detector

(ii) Explain why the Cerenkov detector is very useful in detecting high energy particles. (04 Marks)

(iii) State the purpose of attaching a Photomultiplier tube with a Cerenkov detector. (05 Marks)

Question No: 02

00095

A

(i) Briefly explain the noise associated with electrical signals. (05 Marks)

(ii) State two (02) experimental techniques based on signal averaging used to detect signals buried in noise. (04 Marks)

(iii) 1 μA current of a signal produced by a transducer is fed into an amplifier of input impedance of 1 MΩ at room temperature (30 ^{0}C). Calculate the signal to noise ratio of the input signal of the amplifier within the band width of 1 MHz. (Shot noise current is given by $I_s = \sqrt{2eI\Delta f}$ and Johnson noise voltage is given by $V_J = \sqrt{4kTR\Delta f}$ where symbols have their usual meaning). (06 Marks)

B

(i) Explain the importance of Filter circuits in signal processing. (02 Marks)

(ii) Briefly describe a high pass filter with a proper circuit diagram. (02 Marks)

(iii) A frequency generator produces signals of frequencies less than 4 kHz. It has been found that 10 kHz noise is also produced due to heat generated in the circuit and mixed with the signal. Design a simple RC high pass filter to remove this noise. Find a suitable value for the capacitor when the resistor is 1 kΩ. (06 Marks)

Question No: 03

A

i. State the characteristics of an ideal operational amplifier. (03 Marks)

ii. A summing amplifier is shown below in figure 02.

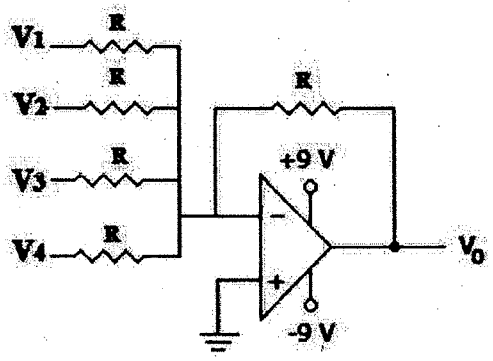

Figure 02

Show that the output of the summing amplifier is, Vout = - (V_1+V_2+V_3+V_4)

(04 Marks)

iii. An arrangement of a summing amplifier is given in figure 03. Find the V_{out} for the given input voltages of the summing amplifier assuming that supply voltages are + 9 V and – 9 V.

(08 Marks)

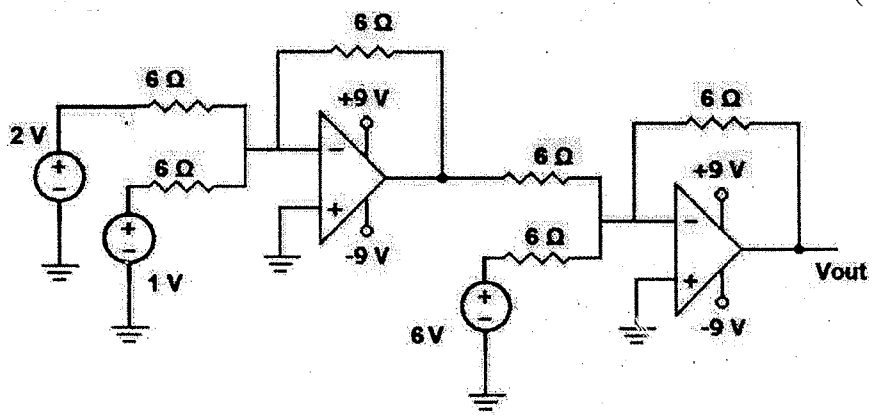

Figure 03

B.

Write short notes about any **two of the** following topics. (10 Marks)

(i) Voltage Follower

(ii) Integrating Amplifier

(iii) Differential Amplifier

(iv) Differentiating Amplifier

(v) Comparator

Question No: 04

A.

(i) Briefly explain about signal aliasing. (03 Marks)

(ii) The performance of a singer is to be recorded by sampling and storing the sampled values. In digitization of the signals, the used sampling rate is 32 kHz. What is the maximum frequency component that can be digitized with this sampling rate without causing aliasing?

(02 Marks)

B.

An electrical signal f (t) is given by

$$f(t) = \begin{cases} 1, & if \quad -T < t < 0 \\ 0, & if \quad 0 < t < T \end{cases}$$

(i) Sketch a waveform of the signal in the interval $-2T < t < 2T$. (02 Marks)

(ii) Write down the Fourier expansion of a function f(x) of period T_0 and the expressions for the coefficients A_n and B_n in the Fourier series. (05 Marks)

(iii) Find the coefficients A_n and B_n for the waveform given above. (05 Marks)

(iv) Show that the Fourier series for the function f(t) given above in the interval $-T < t < T$ is

(05 Marks)

$$f(t) = \frac{1}{2} - \frac{2}{\pi}\left[\sin t + \frac{1}{3}\sin 3t + \frac{1}{5}\sin 5t + ..\right]$$

(v) Sketch the power spectrum of the waveform. (03 Marks)

Question No: 05

00095

A.

(i) State the methods used to convert an analogue signal to a digital signal comparing their conversion speeds in the ascending order of conversion time. (03 Marks)

(ii) A block diagram of a Counter ADC is shown in figure 04. Describe its operation sequence when converting an analogue signal to a digital signal. (05 Marks)

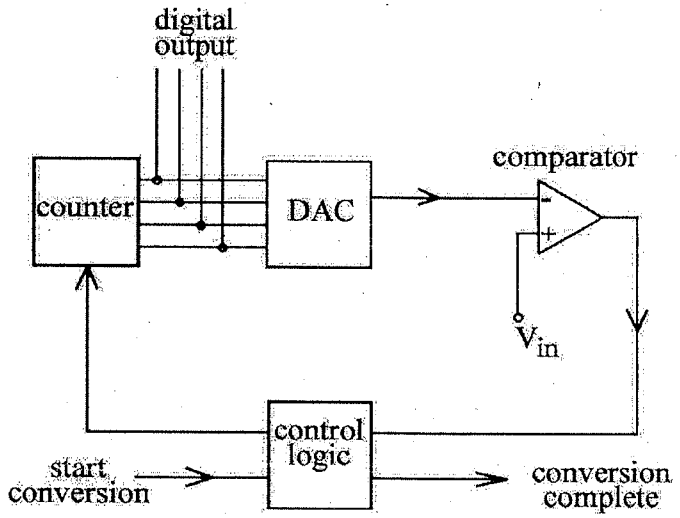

Figure 04

(iii) Explain the advantage of upgrading a Counter ADC to a Tracking ADC. (04 Marks)

(iv) Explain the principle of the Successive Approximation ADC. (04 Marks)

B.

(i) Briefly describe about Range, Resolution, Conversion time of an ADC. (03 Marks)

(ii) Assume that a sinusoidal signal with a peak value of 5 V is being digitized using an 8-bit Counter ADC and the counter operates at 10 kHz.

a) Calculate the resolution of the ADC. (02 Marks)

b) What will be the maximum conversion time of the ADC. (02 Marks)

c) Propose an enhanced approach to decrease the conversion time the Counter ADC. (02 Marks)

Question No: 06

A.

(i) What are the tasks of following registers in a of a typical microprocessor?
(a) program counter (b) A and B accumulators (c) flag register (06 Marks)

(ii) What is meant by the terms mnemonics, assembly language and machine language in computer programming. (03 Marks)

(iii) Write down the meaning of each mnemonics in the following simple assembly programme written for a microprocessor. (07 Marks)

Assembly language	Machine language
MOVE A, 00	01 00
MOVE B, O3	02 03
ADD A, B	07
DEC B	04
CMP B, 00	06 00
JG 14	09 14
NOP	0B

B.

D2716 is an UVEPROM chip and it has pins labeled Vcc, $\overline{WE}$, $\overline{CE}$ and $\overline{OE}$ in addition to the address and data pins, You can construct an external memory using 2716 chip as in figure 5.

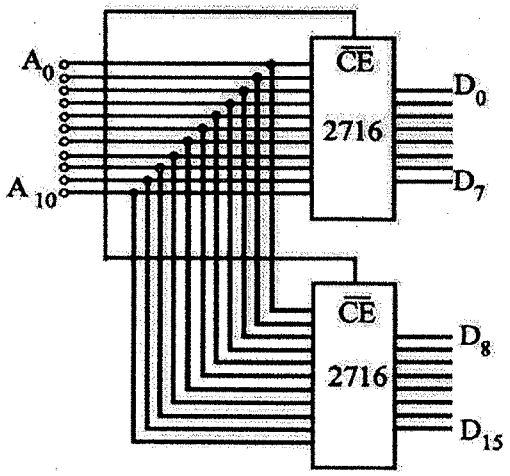

Figure 05

(i) What are the functions of the pins $\overline{WE}$, $\overline{CE}$ and $\overline{OE}$? (03 Marks)

(ii) What should be the size of the address bus and the data bus in the above construction? (03 Marks)

(iii) Determine the size of the memory in the above construction. (03 Marks)

****