The Open University of Sri Lanka
B.Sc. Degree Programme- Level 05
Final Examination 2015/2016
PYU3164/PHU3150- Data Acquisition and Signal Processing

Duration: Two (2) Hours

Date: 07.07.2016 **Time: 1.00 p.m. – 3.00 p.m.**

ANSWER FOUR QUESTIONS ONLY.

1. (a) What do you call the transducers that are used to sense and control physical parameters in a data acquisition system? Write down one sensor for (i) Temperature, (ii) Displacement, (iii) Light and (iv) Sound that produce electrical signals without any external power supply.

   (b) Describe the operation of a photomultiplier tube with a labelled diagram explaining the function of each component. Why is a very large negative potential (-1000 V) applied to this device.

   (c) Figure 1 shows the efficiency of a photomultiplier tube vs. wave length.

   (i) Find the operation range of the photomultiplier tube and comment on the use of this device as a photo detector.

   (ii) What is meant by dark current?

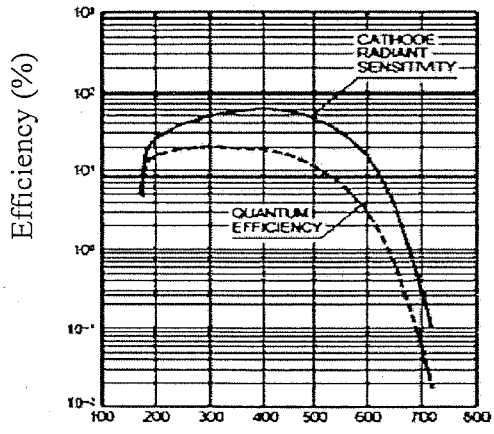


Figure 1

   (d) Write down two examples for usage of photomultiplier tubes as light detectors.

   (e) Momentum of relativistic particle is given by $p = \frac{mv}{\sqrt{c^2 - v^2}}$. Show that electrons with a momentum of 1 GeV travelling in a medium of refractive index 1.33 produce Cerenkov radiation. (rest mass of electron is 0.5 MeV and c = 2.99793×10^8 ms^{-1})

2. (a) Write down the ideal characteristics of an operational amplifier and derive the two rules of the op amp techniques based on those assumptions.

(b) Draw a potential divider circuit with resistors R_1 and R_2. If voltage V_{in} is applied across the two resistors in order, show that the voltage V_{out} across R_2 is given by $V_{out} = \frac{R_2}{R_1 + R_2} V_{in}$.

(c) i. Using the above result, obtain expressions for the voltages V_+ and V_- of the Differential Amplifier circuit given in figure 2.

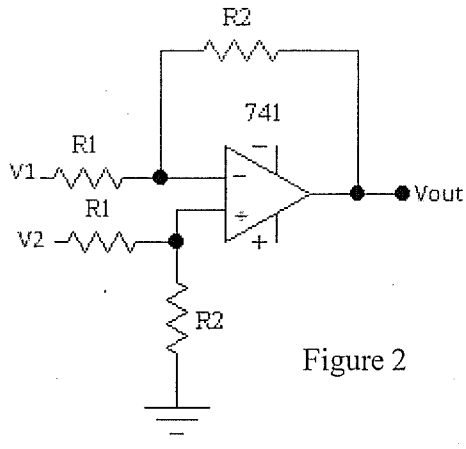


Figure 2

ii. Using the results of (c) or otherwise show that $V_{out} = \frac{(V_2 - V_1)R_2}{R_1}$ for the differential amplifier.

(d) Write down an expression for charge on the capacitor of the op-amp circuit in figure 3

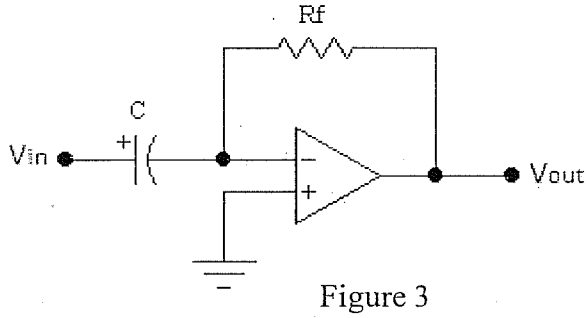


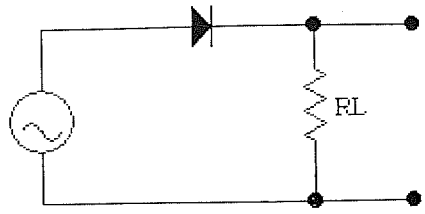
Figure 3

(e) Hence derive $V_{out} = -R_f C \frac{dv_{in}}{dt}$ for the above circuit.

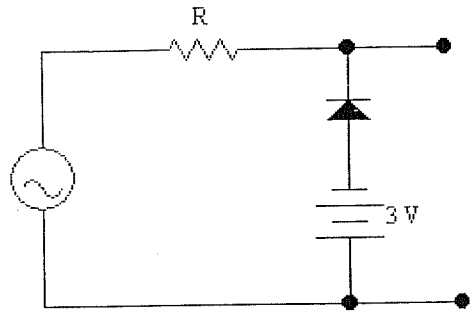
3. (a) What is meant by (i) clipping and (ii) Clamping of an electrical signal? Briefly discuss the usefulness of clipping and clamping circuits in signal processing.

(b) Draw the output wave form of the following clipping circuits given in figure 4 assuming the input to be a sinusoidal signal of 4 V.

i.



ii.



iii.

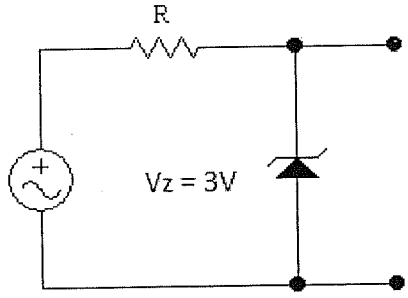


Figure 4

(c) A demodulator circuit of 550 kHz carrier frequency of an AM (Amplitude Modulated) radio receiver is shown in the figure 5.

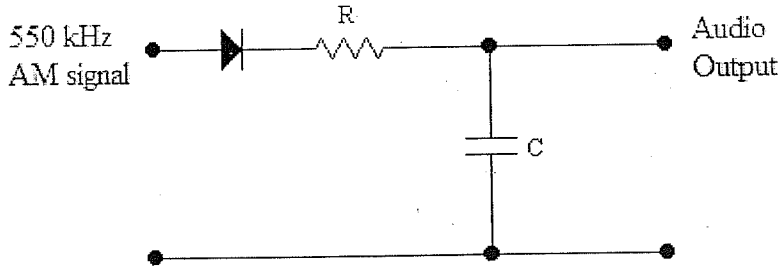


Figure 5

i. Explain the function of the diode in the circuit

ii. What type of filter is associated with this circuit?

(d) Derive an expression for the output voltage of the filter circuit in demodulator circuit in terms of R, C and the input AC voltage Vin of angular frequency ω.

(e) Assuming the cutoff frequency, ω_0 of this filter circuit to be 100 kHz, calculate a suitable value for the capacitor if R= 0.5 MΩ.

4. (a) What is meant by (i) linear circuits and (ii) non linear circuits in electronics. Write down two characteristics of a sinusoidal signal that does not change after passing through a linear circuit.

   (b) How do you write a periodic function $f(t)$ with period T_0 in Fourier Analysis?

   (c) Square wave with signal amplitude of 2 V swings between +1 V and -1 V at a frequency of 50 Hz. Plot a graph of the signal voltage vs time of this electrical signal.

   (d) Obtain the spectrum of this signal using Fourier analysis and draw the power spectrum.

   (e) Calculate the sampling interval that should be used to digitize this signal when it passes through a low pass filter of 1 KHz to avoid aliasing.

5. (a) Briefly discuss the methods used to convert an analogue signal to a digital signal comparing their conversion speeds.

   (b) Draw a block diagram of a Counter ADC and describe its operation sequence to convert analogue signal to a digital signal.

   (c) Explain the advantage of upgrading a Counter ADC to a Tracking ADC.

   (d) How do you modify a Counter ADC to a Successive Approximation ADC?

   (e) Analyze the steps followed to convert 2.3 V in a 4 bit Successive Approximation ADC with a 5 V range.

6. (a) Why does the hexadecimal number system is used in programming even though the computer understands only the binary number system?

   (b) Name the three-buses used in microcomputers and briefly explain their functions.

   (c) Motorola MC6809 processor has 16 bit address bus and 8 bit data bus.

      i. How many bits are there in a register of the memory connected with this processor?

      ii. Calculate the size of the memory accessible with this processor.

      iii. Write down the addresses of the top and bottom registers of the memory in hexadecimal.

   (d) Write a program in assembly language to add even numbers from 0 to 10.

   (e) Convert the assembly language program written in (d) to machine language and show how this programme is stored in memory starting from address 10_h with the help of a diagram. You may use the following op-codes when converting your assembly language programme into machine language.

01 - MOV A, n	02 - MOV B, n
03 - DEC A	04 - DEC B
06 - CMP B, n	07 – ADD A, B
09 - JG m	0B - NOP