*Ref No:* **Ex/EE/PC/B/T/221/2024**

**B. E. ELECTRICAL ENGINEERING SECOND YEAR SECOND SEMESTER EXAMINATION - 2024**

**SUBJECT: - ELECTRICAL INSTRUMENTATION**

Time:Three hours

Full Marks 100
(50 marks for each part)

**Use a separate Answer-Script for each part**

| No. of Questions | PART I | Marks |
|---|---|---|
| | *Answer Q.5 and any two questions from the rest.* | |
| 1. | Justify or correct ***any four*** of the following statements with suitable reasons in brief / derivations. **(CO2-K2)** | 4×05=20 |
| (a) | **When a capacitive transducer is used for thickness measurement, the design becomes complicated as the sensitivity factor and the non-linearity factor become identical.** | |
| (b) | **A multivibrator based signal conditioning circuit employing two astable multivibrators is used with capacitive transducers.** | |
| (c) | **When an RC circuit is used in an LVDT to compensate a leading phase to become zero, the RC value chosen is directly proportional to the supply frequency and inversely proportional to the time constant of the primary winding.** | |
| (d) | **In a piezoelectric transducer, the 'g-constant' and the 'd-constant' are related by the permeability of the material.** | |
| (e) | **In an LVDT, two secondary windings are connected in series aiding fashion.** | |
| 2. (a) | **Draw the construction of a piezoelectric accelerometer and give a detailed description of its operating principle. Derive its frequency response and justify that its bandwidth of operation should be $\frac{3.04}{\tau} \le \omega \le \frac{\omega_n}{5}$, where each symbol has its usual meaning.** **(CO2-K2)** | 11 |

[ Turn over

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| No. of Questions | PART I | Marks |
|---|---|---|
| 2. (b) | **How can capacitive transducers be employed for measurement of angular displacement? Does this arrangement require any separate linearization circuit? (CO2-K2)** | 05 |
| (c) | **In a capacitive humidity sensor, how can secondary variables influence the capacitance measurement? (CO2-K2)** | 04 |
| 3. (a) | **Explain in detail the operating principle of synchronous demodulation technique employed in LVDTs. Can this technique be employed in LVDTs where there is a phase shift between the input voltage and the output voltage? (CO2-K2)** | 10 |
| (b) | **A capacitor microphone system is designed using the principle of change of separation between the parallel plates. The initial separation between the capacitor plates is 0.03 mm, the overlapping area of two plates is 670 $mm^2$, and permittivity of free space is $8.854 \times 10^{-12}$ F/m. A 150V DC voltage source is connected in series with this capacitor arrangement and a resistance *R*. Derive the transfer function of this microphone system and determine the steady state gain and the time constant of the system. Considering a 5% tolerance band, if the low-frequency cut-off value is 180 Hz, determine the value of *R*. (CO2-K2)** | 10 |
| 4. | **Write short notes on <u>*any two*</u> of the following: (CO2-K2)** | 10+10 |
| (a) | **Capacitive transducers using change in overlapping area.** | |
| (b) | **Null voltage reduction in LVDT.** | |
| (c) | **Pressure measurement using diaphragm.** | |
| 5. (a) | **Why are transformer ratio bridges employed in capacitive transducers? How can a ratio transformer be employed for measurement of unknown capacitance? (CO5-K4)** | 06 |
| (b) | **"A practical implementation of a charge amplifier based piezoelectric displacement transducer system can be developed as a zero-order system."-Justify or correct this statement citing suitable reasons. (CO5-K4)** | 04 |

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**B.E. Electrical Engineering Second Year Second Semester Examination 2024**

**ELECTRICAL INSTRUMENTATION**
**PART -II**

**Time: Three Hours** **Full Marks: 100**
**(50 Marks for each part)**

**Use separate Answer-Script for each part**
**Answer *All* Questions**

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1.a) Elucidate with a diagram, the brief details of functional blocks of a cathode ray tube oscilloscope (CRO). (CO1) **[5]**

b) How the phase difference between two sinusoidal signals having same frequency can be measured with the help of CRO? (CO1) **[3]**

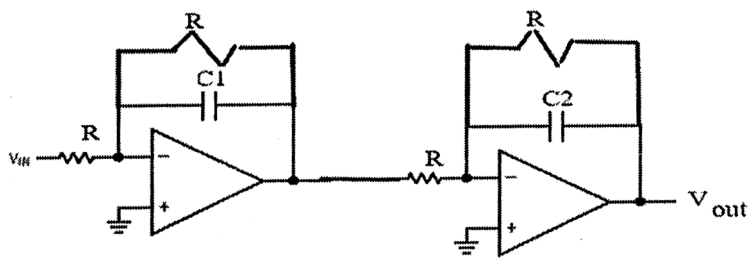
**OR**

1.a) Why a steady horizontal plate sweep voltage in saw-tooth wave shape is necessary in the function of the CRO? Draw and explain the basic operation of such a wave generating circuit. (CO1) **[2+2]**

b) Explain the necessity of matched probe for a CRO. (CO1) **[4]**

2.a) What are the main advantages of switched capacitor circuit in integrated circuit technology? (CO3) **[3]**

b) Find the equivalent switched capacitor circuit of the circuit shown below. The switching frequency is 100 khz. The value of R= 10 kohm and C1=1 nanofarad and C2 = 10 picofarad. (CO3) **[3]**




c) How can you realize a second order high pass filter using Switched Capacitor circuits? (CO3) **[6]**

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**OR**

2 a) List the basic building blocks of PLL. Explain the role of low pass filter and function of VCO in it. (CO3) **[2+2+2]**

b) A PLL based frequency translator employs a divide by $N$ counter. The reference frequency is 10 khz. Find $N$ for translating frequency from 50 khz to 130 khz. Illustrate with suitable schematic diagram. (CO3) **[4]**

c) Explain ***lock range*** and ***capture range*** of a PLL. (CO3) **[2]**

3. a) The step size of a 9-bit D/A converter is 10.3 mv. If all the zeros represent 0 volt, what output is produced if the input is **101101111**?
What are the limitations of the weighted resistor type D/A converter? (CO4) **[2+3]**

b) The analog value corresponding to digital signals of 000 and 001 are 0V and 0.625V respectively. Plot the transfer function curve of this DAC **with and without** an offset error of 0.5LSB. (CO4) **[5]**

c) Define settling time and monotonicity with reference to D/A converter. (CO4) **[4]**

**OR**

3 a) For the ADC circuit shown in the figure below what will be the digital output? Give the reasons in support of your answer. (CO4) **[6]**

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**Answer *All* Questions**

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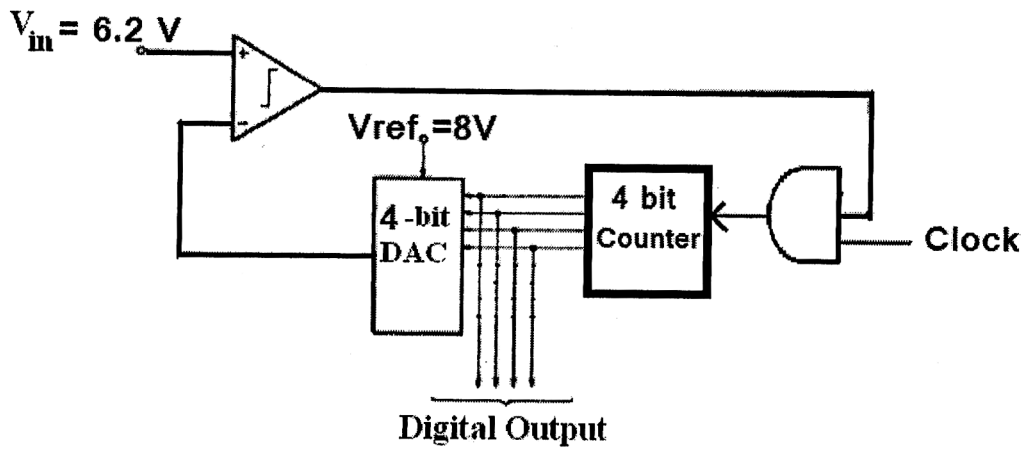


b) What is the function of sample and hold amplifier circuit in ADC? (CO4) **[4]**

c) Explain **gain** and **linearity** errors of an ADC. (CO4) **[4]**

4. a) Mention the differences between the properties of Butterworth and Chebyshev filters. Explain why the -3dB cut-off frequency of a normalized Chebyshev filter is greater than 1rad/sec.? (CO6) **[3+2]**

b) Draw the circuit diagram of Sallen-Key second order band-pass filter circuit. Write down the expression for transfer function of a band-pass filter in terms of center frequency $\omega_0$ rad/sec., bandwidth B rad/sec and passband gain 0dB. How this filter can be converted to band-stop filter without altering the specification. (CO6) **[2+2+2]**

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c) The filter circuit shown below resembles which type of filter? Determine the transfer function and quality factor (Q) of this filter circuit.
**Assume $R_A$ = 33kΩ, $R_B$= 10 kΩ and $C_A$=$C_B$= 100 microF.** (CO6) **[1+4]**