POKHARA UNIVERSITY
FACULTY OF SCINCE AND TECHNOLOGY
SCHOOL OF ENGINEERING

Exam	Final Internal Examination 2080		
Level	B. E.	F M	100
Programme	Computer	PM	45
Year/Part	I/II	Time	3 Hrs

Subject: Instrumentation

ndidates are required to give answers in their own words as far as practicable.
e figure in the margin indicates full marks.
ttempt all the questions

1 a) What are the basics block of generalized instrumentation system? Draw the various blocks and explain their function. 8

b) Temperature was measured in a room, and the values obtained were 28.2, 16.5, 32.1, 29.7, 27.1, 19.0, 22.0, and 10.0 °C. Assuming that the random errors are present. Calculate 7

a) Arithmetic mean
b) Standard Deviation
c) Probable error of reading

2 a) Explain Kelvin's bridge with its necessary diagram. 7
b) Explain the construction and working of an Induction type Energy meter with necessary Diagram. 8
3 a) A meter having full scale deflection current of 2mA and internal resistance of 100 ohm is to be converted to 500v voltmeter. Calculate the required series resistance for the range extension of voltmeter. 7
b) Briefly explain about the digital data acquisition system with block diagram. 8
4 a) Explain the basics characteristics of operational amplifier. Explain the working principle of instrumentation amplifier 8
b) List out the various types of ADC. Briefly explain the working principle of Delta-Sigma ADC 7
5 a) What is wave analyzer? Explain frequency selective wave analyzer in detail. 8
b) Why we need spectrum analyzer? Draw the block diagram of spectrum analyzer and explain each block. 7
6 a) Explain about Digital Storage Oscilloscope with necessary Diagram. 8
b) Design an instrumentation system to measure the temperature of hot water inside the tank using RTD with digital read out. 7
7. Write Short notes on (*Any Two*) 2*5
a) Nixie Tube
b) Low Capacitive probes
c) PMMC

SOE Paper

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Q no. 1 (a)

General block diagram and components of an instrumetation system are shown below

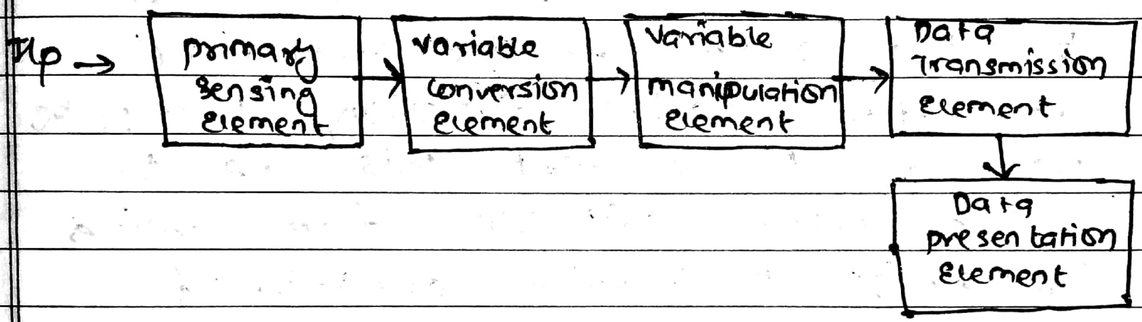

Fig :- functional component of an instrumen- -tation system.

(a) primary sensing Element :-

The first contact of the measurement is occured in this section of the block diagram. The primary sensing unit has the signal sensors or the transducers. These transducers helps to convert the variable being measured to the suitable form of energy and the rest of measurement system capable to give a value to the input variable.

eg :- i/p (tempr) → [Thermocouple] → o/p (small emf)

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b) Variable Conversion Element :-

The o/p of primary sensing element may be electrical signal of any form. It may be a voltage, current, a frequency or some other electrical parameter. Sometimes this o/p is not suited to the system for the instrument to perform desire function. it may be necessary to convert this o/p to some other suitable form while preserving information content of original signal.

Variable manipulation element :-

The function of element is to manipulate the signal presented to it preserving original nature of signal. manipulation here means only a change in numerical value of signal. signal Amplification and attenuation task is performed in the variable manipulation element.

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d) Data Transmission element :-

The elements of an instrumentation system are actually physically seperated, it becomes necessary to transmit data from one unit to another. The element that performs this function is called a data transmission element. Data transmission is done either through wire line or wireless transmission media.

e) Data presentation Element :-

The information about the quantity under measurement has to be conveyed to the personnel handling the instrument or the system for monitoring, control or analysis purpose. The information conveyed must be in the form of display unit

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Q no. 1 (b)

The data are

$x_1 = 28.2$ $\quad d_1 = x_1 - \bar{x} = 5.125 \quad d_1^2 = 26.265625$

$x_2 = 16.5$ $\quad d_2 = -6.575 \quad d_2^2 = 43.230625$

$x_3 = 32.1$ $\quad d_3 = 9.025 \quad d_3^2 = 81.450625$

$x_4 = 29.7$ $\quad d_4 = 6.625 \quad d_4^2 = 43.890625$

$x_5 = 27.1$ $\quad d_5 = 4.025 \quad d_5^2 = 16.200625$

$x_6 = 19.0$ $\quad d_6 = -4.075 \quad d_6^2 = 16.605625$

$x_7 = 22.0$ $\quad d_7 = -1.075 \quad d_7^2 = 1.155625$

$x_8 = 10.0$ $\quad d_8 = -13.075 \quad d_8^2 = 170.955625$

$$\boxed{\Sigma d_i^2 = 400.155625}$$

(a) Arithematic mean $(\bar{X}) = \dfrac{x_1 + x_2 + \cdots + x_8}{8}$

$$= \frac{184.6}{8}$$

$$= 23.075$$

(b) S.D $(\sigma) = \sqrt{\dfrac{d_1^2 + d_2^2 + \cdots + d_8^2}{n-1}}$

$$= \sqrt{\frac{400.155625}{7}} = 7.560759835$$

(c) probable error :- $0.6745\ \sigma$

$$= 0.6745 \times 7.560$$

$$= 5.0997$$

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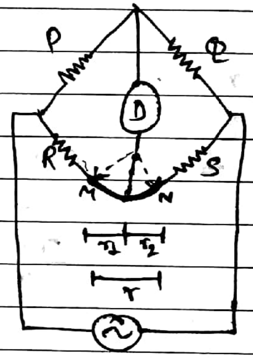
Q no. 2 (a)

Kelvin bridge :- Wheatstone bridge can be used for measuring few ohms to several kilo-ohms, but errors in result is measured in low resistance. This is b/c of wheatstone bridge is modified & kelvin's bridge is obtained.



Kelvin bridge is a modification of wheatstone bridge & can also be used to measure value of resistance below (1Ω).

We know;

$$\frac{r_1}{r_2} = \frac{P}{Q} \quad \text{--- (I)}$$

From Bridge Balanced condition.

$$Z_1 Z_4 = Z_2 Z_3$$

$$P(S + r_2) = Q(R + r_1)$$

$$\frac{P}{Q}(S + r_2) = (R + r_1) \quad \text{--- (II)}$$

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we know;

$$\frac{r_1}{r_1+r_2} = \frac{P}{P+Q} \quad \text{—(iii)}$$

$$\frac{r_2}{r_1+r_2} = \frac{Q}{P+Q} \quad \text{—(iv)}$$

also,

$r_1 + r_2 = r$

now (iii) & (iv) becomes

$$\frac{r_1}{r} = \frac{P}{P+Q}, \quad \& \quad \frac{r_2}{r} = \frac{Q}{P+Q}$$

$$r_1 = \left(\frac{P}{P+Q}\right)r \quad \& \quad r_2 = \left(\frac{Q}{P+Q}\right)r$$

now (ii) becomes

$$\frac{P}{Q}\left(S + \left(\frac{Q}{P+Q}\right)r\right) = \left(R + \left(\frac{P}{P+Q}\right)r\right)$$

$$\frac{PS}{Q} + \frac{\cancel{Q}\, r\, P}{(P+Q)\cancel{Q}} = R + \frac{Pr}{P+Q}$$

$$R = \frac{PS}{Q}$$

$$\boxed{\therefore RQ = PS}$$

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Q.no. 2(b)

Induction Type energy meter :-

→ Energy meters are integrating instruments, used to measure quantity of electric Energy supplied to a circuit in given time. These are also known as kilowatt meter.

There are several types of energy-meter among those, the induction type meter are most common form of a.c Energy meters. It is used in domestic and industrial application.

Single phase induction Type Energy meter:-

→ The constructions and working principle of Operation principle of single phase Energy meter is.

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Construction :-

The construction of energy meter consists of mainly four parts.

(i) Driving system
(ii) moving system
(iii) Braking system
(iv) Registering system.

(1) **Driving system :-**

The driving system of meter consists of two electromagnets. The core of these electromagnets are made of sillicon - steel laminations. These are two coil's wounded on the electromagnet.

(2) **moving system :-**

moving system consists of an aluminium disk mounted on a light alloy shaft. The disk is placed between series and shunt magnets. The ϕ (flux) produced by shunt magnet is proportional to voltage (V).

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(3) **Braking system :-**

Braking system is provided by a permanent magnet placed near the edge of aluminium disc.

(4) **Registering system :-**

The Registering system keeps records of rotation of disc continuously. It ~~constis~~ consists contain kind of gear mechanism. The gear assembly runs the pattern of adometer and numeric display is formulated.

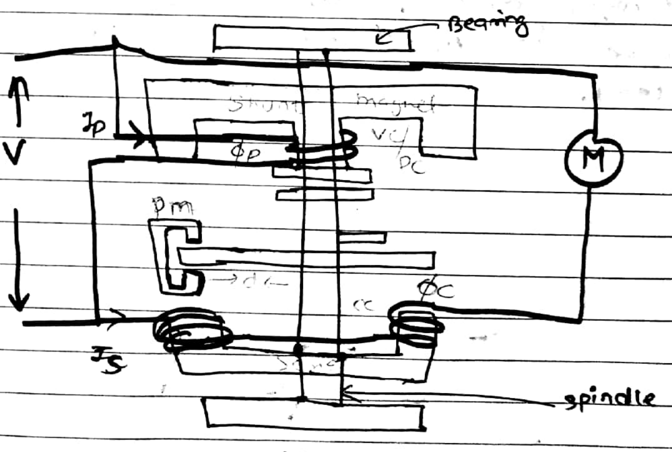

fig :- 1 ϕ Energy meter.

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Working :-

for operation, the supply voltage is applied across pressure coil which is highly inductive a having large no. of turns. The current produces flux, (ϕp), lly, ~~Ip~~ current Is produces flux (ϕc)

Since, ϕc & ϕp are alternating in nature, they induced emf is generated. The produced emf make eddy current which flow through disk. Due to which torque is produced and disk rotates.

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Q no. 3(a)

A meter having full scale deflection current of 2mA & internal resistance 100 Ω is to be converted to 500 V voltmeter. Calculate reqd series resistance for the range extension of voltmeter.

Sol:

$I_g = 2mA = 2\times10^{-3}$ A

$R_g = 100\Omega$

$\therefore V_g = I_g \times R_g = 2\times10^{-3}\times100$

$= 0.2V$

$$\frac{V}{V_g} = 1 + \frac{R}{R_g}$$

$$\frac{V}{V_g} - 1 = \frac{R}{R_g}$$

$$R_g \times \left(\frac{500}{0.2} - 1\right) = R$$

$$100 \times \left(\frac{500}{0.2} - 1\right) = R$$

$\therefore R = 249900\Omega$

$= 249.9 k\Omega$

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Ans 3(b)

Data Acquisition system is the system which collects, stores and distributes the information.

Digital Data Acquisition system:

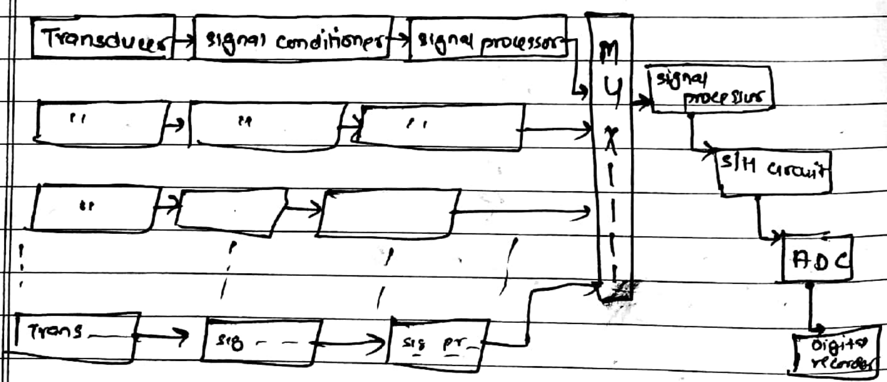

fig: Block-diagram of multichannel Digital DAS.

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According to the Block diagram, the transducer converts the physical phenomenon to electrical signal. Signal conditioner perform conversion of i/p signal from Transducer to suitable form of signal.

- If the strength of signal is very low, the signal processor processes and amplifies the signal, which helps to drive the circuit easily.
- The signal is then passed mux (multiplexer). A mux is a device in which multiple input is inputted & which gives ~~sig~~ single o/p.
- The o/p of mux could be of low strength so a signal processor is used to amplify the respective signal.
- The signal is then passed to S/H circuit. S/H circuit samples and holds the signal.
- The sampled signal is passed to ADC [Analog to Digital converter].
- Then the signal is stored in Digital recorder.

Ans: 4(a)

Operational Amplifier is a device made up of three circuits
- Differential Amplifier
- voltage Amplifier
- push-pull Amplifier.

used for Amplifying Ac and Dc both signals.

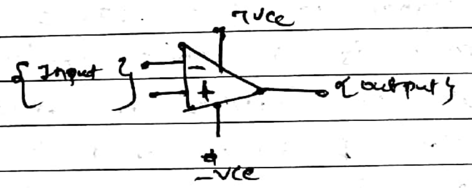


fig :- o/p Amp (symbol)

Basic characteristics of operational Amplifier

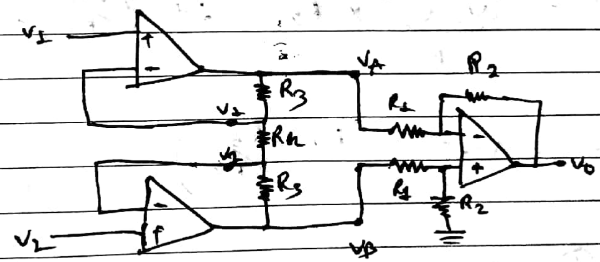
1) Infinite Bandwidth so that any frequency signal from 0 to ∞ can be amplified without attenuation.
2) Infinite slew rate so that o/p voltage changes occurs simultaneously with i/p voltage change
3) Infinite common mode Rejection Ratio (CMRR) so that o/p common mode noise is zero.
4) Infinite input impedance
5) Infinite open loop voltage gain
6) Zero output impedance & 7) zero output resistance.

(Instrumentation Amplifier)

→ Instrumentation Amplifier is a dedicated differential Amplifier with extremely high input impedance

Instrumentation Amplifier is supperior than other because

1) selectable gain with high gain accuracy
2) high CMRR.
3) Low drift errors
4) Low o/p impedance.



from Differential Amplifier

$$V_o = \frac{R_2}{R_1}(V_A - V_B) \quad \text{--- (5)}$$

PG DAS

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since current across R_G ;

$$I_G = \frac{V_1 - V_2}{R_G} \quad — (11)$$

since, the Amplifier is ideal so, no current passes through terminals, so,

$$I_G = \frac{V_A - V_B}{R_G + 2R_3}$$

$$\therefore (V_A - V_B) = I_G \times (R_G + 2R_3) \quad — (10)$$

from (10) & (11)

$$(V_A - V_B) = \frac{(V_1 - V_2)}{\cancel{R_G}} \times \cancel{R_G} \left(1 + \frac{2R_3}{R_G}\right)$$

$$V_A - V_B = (V_1 - V_2)\left(1 + \frac{2R_3}{R_G}\right)$$

now (7) becomes

$$V_o = \frac{R_2}{R_1}(V_A - V_B)$$

$$= \boxed{\underbrace{\frac{R_2}{R_1}}_{\text{gain of 2nd stage}} \underbrace{\left(1 + \frac{2R_3}{R_G}\right)}_{\text{gain of 1st stage}} (V_1 - V_2)}$$

$\therefore$ o/p = total gain × input difference

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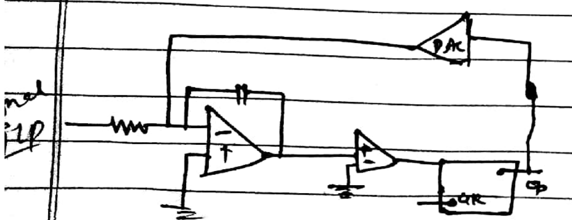
Q no. 4 (b)

ADC (Analog to digital converter) are devices / circuits which converts analog i/p signal to binary digital ie Binary equivalent of it.

There are following Types of ADC
(1) flash type ADC
(2) Dual slope ADC
(3) successive Approximation Type ADC
(4) counter Type ADC
(5) Delta-sigma ADC.

Delta sigma ADC :-

Comp + data



Delta sigma ADC is type of analog to digital data converter commonly used in applic where high precision is required, such as audio processing, instrumentation & some sensor application

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(1) oversampling
(2) Delta modulation
(3) digital filtering
(4) Decimation

Qno. 5 (a)

Wave Analyzer :- The electronic instrument used to Analyze wave is called wave analyzer. It is also ~~sis~~ called signal analyzer. It is mainly design to measure the relative amplitude of signal.

frequency selective wave analyzer :- The wave analyzer used for analyzing the signals of (20Hz to 20kHz) Audible frequency range.

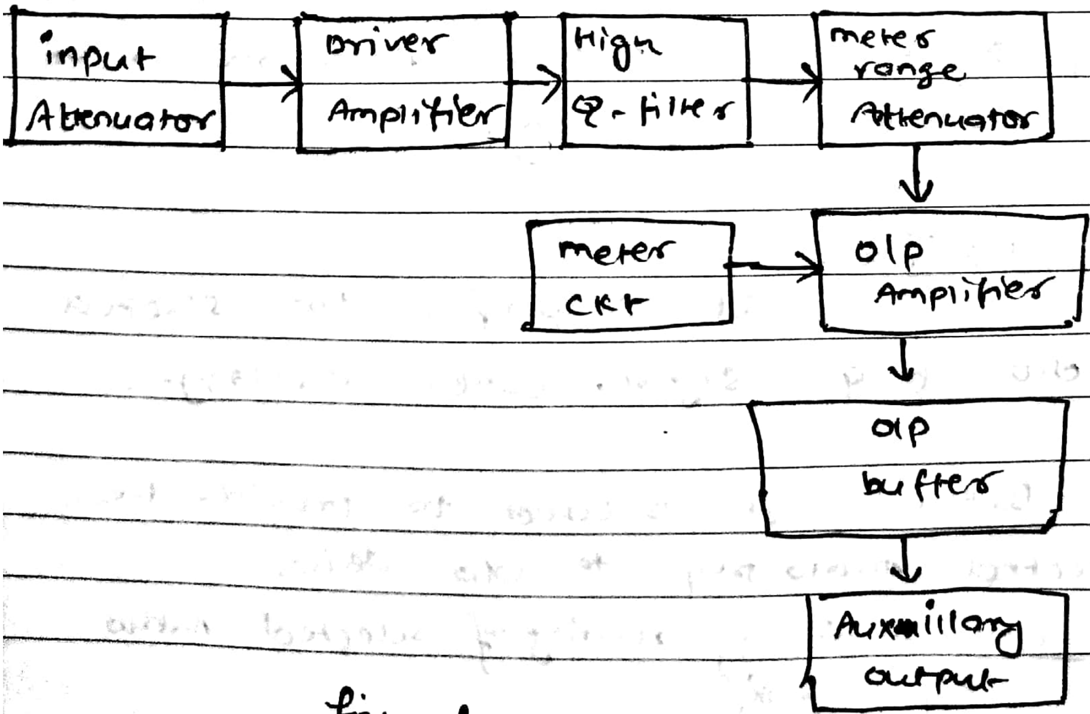

fig:- freq-selective wave Analyzer.

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1. Input Attenuator :- The Audio frequency signal is to be analyzed in i/p Attenuator. If the signal Amplitude is too large, then it can be attenuated by input attenuator.

2. Driver Amplifier :- It amplifies the received signal whenever necessary.

3. High -Q- filter :- It is used to select desired frequency and reject unwanted frequency. It consists of two RC section & two filter amplifiers & all these are cascaded with each other.

4. meter range Attenuator :-
It selects Audio-freq signal as input & Attenuate the o/p whenever necessary.

5. o/p Amplifier :-
It Amplifies the selected Audio-freq signal, when necessary.

6. o/p Buffer :- It is used to provide the selected Audio freq to o/p device.

7. meter ckt :- display reading of selected Audio freq. signal.

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Ans 5.(b)

Spectrum Analyzer :-
The electronic instrument used for analyzing and display waves in frequency domain is called spectrum analyzer.

We need spectrum analyzer :-

1. frequency Analysis :-
They allow for precise exami-nation of frequency. This is used in field like telecommunication.

2. signal Trouble shooting :-
Spectrum analyzer helps to identify and trouble issue in signals, such as interference noise etc. It helps to maintain quality & reliability of communication system.

3. Bandwidth Analysis :-
They are used to determine the Bandwidth of signal Accurately.

(Design, testing & maintain of RF circuits.)

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④ Radio frequency (RF) Analysis:- They helps to analyze RF signal, which is crucial for designing & troubleshooting wireless communication radar & more.

⑤ Research & development

⑥ Security & monitoring :- To allocate un authorized interfering signal & protect in communication network.

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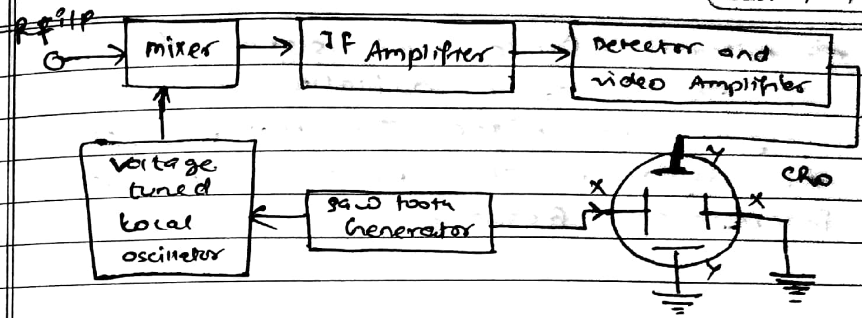

fig :- Block diagram of Spectrum Analyzer.

① Saw tooth generator :- Saw tooth generates saw tooth signals. They supply a ramp voltage.

② Voltage tuned local oscillator :-

③ Horizontal plate of CRO (X) :- The signal from saw tooth generator is also passed to horizontal plate of CRO.

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(4) ~~~~ mixer :- Since RF signal & Tuned local oscillator passes signal to mixer. The mixer mixes the signal. The produce produce intermediate frequency.

(5) If Amplifier :- Now this frequency is given to If Amplifier, which is going to Amplify the signal.

(6) Detector & video Amplifier :- The Amplified signal is passed in detector & video Amplifier & giving to vertical plates of CRO (Y)

& CRO gives display of Amplitude v/s frequency

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Q no. 6(a)

Digital storage oscilloscope :- The instrument which converts analog signal into digital format & stores in digital memory.

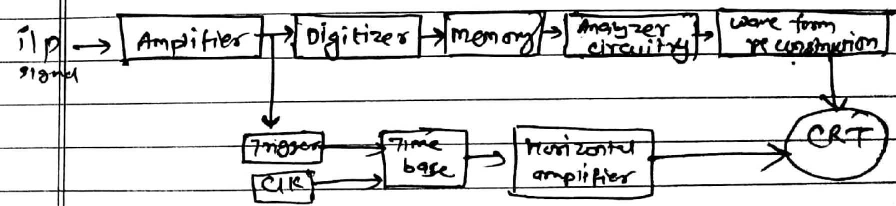

fig :- Digital storage oscilloscope. (DSO)

(1) Amplifier :- The input signal is attenuated & amplified with input amplifier.

(2) Digitizer :- The o/p of Amplifier goes to Digitizer. The digitizer changes the Analog signal into Digital with ADC circu

(3) memory :- The A/D converted is passed in memory & memory stores it.

1st stage

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6(b) Design an instrumentation system to measure the tempr of hot water inside a tank using a RTD with digital o/p

→ Designing an instrumentation system to measure the tempr of hot water inside a tank using RTD (Resistance Tempr Detector) with digital readout involves several components & considerations.

Components.

1. **RTD sensors** :- Choose appropriate RTD sensors with desired temperature range & accuracy.
2. **signal conditioning circuit** :- we will need a signal conditioning circuit to convert resistance change of RTD into a measurable voltage. This includes typically a wheatstone bridge
3. **Data acquistion system** :- DAS connects with RTD & perform analog to digital conversion (ADC).
4. Display :- Implenting a digital read out display such as LED, LCD display to show tempr measurement
5. powersupply : provides a stable power supply for system component.

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system design steps,

① mount the RTD sensor in tank so that it's immersed in hot water,

② connect RTD sensor to signal conditioning circuit. The circuit should provide excitation voltage & convert it into voltage signal;

③ connect o/p of signal conditioning to data acquisition system device.

~~consider features like~~

④ program DAS to calculate (necessary calculation) & display tempr.

⑤ Test the system to verify Accuracy

⑥ consider feature such as data logging, alarm for tempr & remote monitoring if needed

⑦ calibration of error detection for accurate tempr

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7 (a) Nixie Tube

A Nixie tube or cold cathod display is an electronic device used for displaying numericals or other information using glow discharge. Nixie tubes are display device that were popular on mid 20th century. They are neon gas filled tube with cathode shaped like numerical or symbols. Tube is filled with a gas with low pressure mostly neon & small amount of argon, ~~a specific~~ ~~cathode light up~~ in a penning mixture. when voltage is applied a specific cathode light up, display corresponding character. Nixie tube have a vintage asthetic & ~~retro~~ emits a warm orange glow. They are often used in retro styled clocks & other decorative application.

(b) Low capacitive probe :-

Low capacitance probe are specialized sensors used in various applications to measure capacitance with minimal impact on electrical circuit being measured.

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These probes are designed to have very low capacitance (removable), which is essential in applications where the capacitance of measurement.

1. High frequency measurement
2. Impedance matching
3. oscilloscope probe
4. minimizing loading effect

These probes comes in different design & with various features, so choosing the right one depends on factor like freq. range, voltage level & nature of signal,