Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner should assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given importance (Not applicable for subject English and Communication Skills).

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner should give credit for any equivalent figure/figures drawn.

5) Credits to be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer (as long as the assumptions are not incorrect).

6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept

1 Attempt any TEN of the following : 20

1 a) Define accuracy and tolerance.

Ans:

Accuracy: The degree of exactness (closeness) of a measurement compared to the expected (desired) value. OR

It is the ability of a device or a system to respond to a true value of a measured variable under reference conditions. OR

Closeness with which the instrument reading approaches the true value of the quantity being measured is known as accuracy. 1 mark

Tolerance : Ability of an item or system to withstand high levels of stress or overloading without suffering irreparable harm. OR

Allowable departure from a specification or standard, considered non-harmful to the functioning of a part, process, or product over its life cycle. 1 mark

OR

The difference between standard instrument reading and measuring instrument reading is known as error and if this error is permissible then it is called as tolerance.

1 b) Give two examples of active and passive transducer.

Ans: Active Transducers

1. Thermocouple
2. Piezoelectric Transducer
3. Solar Cell/ Photovoltaic cell
4. Tacho generator

1 mark [½ mark/ example]

Passive Transducers :

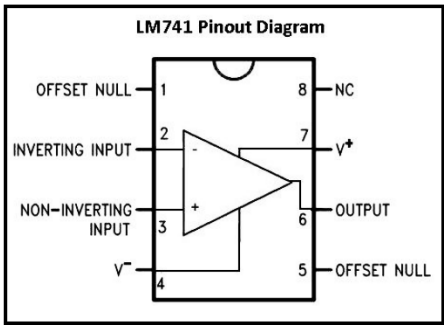
1. Thermistor
2. RTD
3. LVDT
4. Strain Gauge
5. Electromagnetic flowmeter.
6. Capacitive transducers. Etc.

Or Any other relevant example.

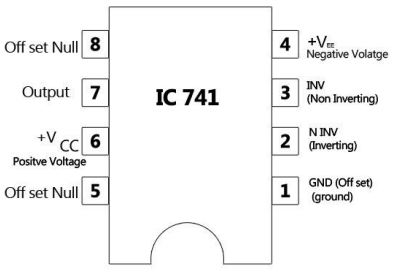
1 mark [½ mark/ example]

1 c) Draw the pin configuration of IC74l OP-AMP.

Ans :



OR



[½ mark per 2 pin labelling]

1 d) Define the following.

(i) CMMR (ii) Slew rate

Ans :

CMMR:-The CMRR is defined as the ratio of the powers of the differential gain over the common-mode gain, measured in positive decibels (thus using the 20 log rule): As differential gain should exceed common-mode gain, this will be a positive number, and the higher the better. 1 mark

$$CMRR = \frac{A_{DM}}{A_{CM}}$$

OR

It is defined as the ratio of differential voltage gain A_d to common mode voltage gain Acm.

Slew Rate: - Maximum rate of change of output voltage for a large, overloading input step.

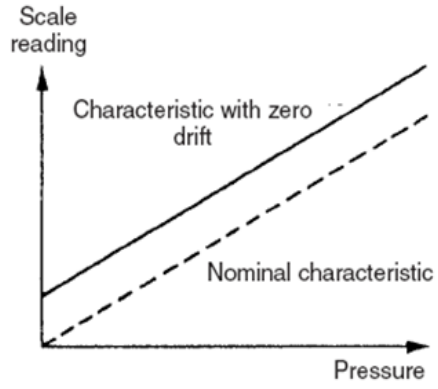
OR 1 mark

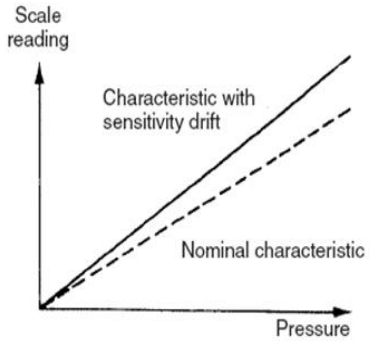
It is defined as the maximum rate of change of output voltage per unit time.

$$S_R = \frac{dV_o}{dt}|_{maximum} \quad V/\mu sec$$

1 e) Draw the input / output characteristics for sensitivity drift and zero drift.

Ans:





1 mark Per character-ristic [total 2 marks]

1 f) State seebeck effect.

Ans:

Seebeck effect: - The Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances. If the two conductors or semiconductors are connected together through an electrical circuit, direct current (DC) flows through that circuit. 2 marks

OR

When two conductors of dissimilar metals are joined together to form a loop (thermocouple) and two unequal temperatures T1 and T2 are interposed at two junctions J1 and J2, respectively, Then an infinite resistance voltmeter detects the electromotive force E, or if a low resistance ammeter is connected, a current flow I is measured

1 g) List four factors to be considered while selecting a transducer.

Ans: any 4 four [½ mark/ factor] [Total 2 marks]

1. Operating Principle
2. Sensitivity
3. Operating Range
4. Accuracy
5. Cross Sensitivity
6. Errors

7. Transient And Frequency Response
8. Loading Effect
9. Static Characteristic
10. Ruggedness

1 h) State the working principle of turbine flow meter.

Ans:

Principle: The flowing fluid impinges on the turbine blades (rotor), imparting a force to the blade surface which causes the rotation of the rotor. The speed of the rotation is directly proportional to the fluid velocity. The rotar consist of small permanent magnets. When rotar rotates this magnetic field also rotates. The speed of rotation monitored in most of the meters by magnetic pickup coil, which generates pulses. Total number of pulses gives the total flow. So the amount of emf induced depends upon the flow rate. — 2 marks

i) List two types of signal converters.

Ans:

1. Voltage to Current converter.
2. Current to Voltage converter.
3. Digital to analog Converter.
4. Analog to Digital Converter.
5. Voltage to frequency converter.

Any 2, [2 marks]

j) Name the metals used for resistance thermometer.

Ans :

1. Copper
2. Platinum
3. Nickel
4. Tungsten
5. Gold

Any 2, [2 marks]

k) List four dynamic characteristics.

Ans :

1. Speed of response
2. Lag
3. Fidelity
4. Dynamic error

½ mark each [Total 2 marks]

l) List two advantages of electrical transducer.

Ans :

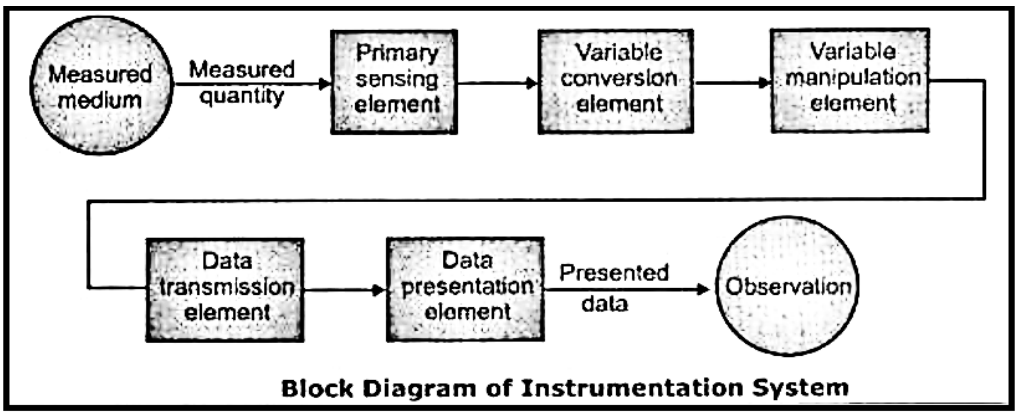
1. Electrical signals can be easily attenuated or amplified and can be bought up to the level suitable for various devices.
2. The power requirement of transducers is very small.
3. The electrical output of transducer can be easily used, transmitted and processed for the purpose of measurement.
4. The reduced effect of friction and other mechanical nonlinearities.
5. Due to IC technology, electrical & electronic systems are compact, having less weight and compact.
6. Reduce effect of mass inertia problems

1 mark per advantage Any 2, [2 marks]

2

2 a) Draw the block diagram of instrumentation system and state the function of each component.

Ans:



2 marks

Fig. Block diagram of instrumentation system

Primary Sensing Element: primary sensing element of system is that which first receives energy from the measured medium and produces an output depending in some way on the value of measured quantity.

Variable Conversion Element: A variable conversion element merely converts the output signal of the primary sensing element into a more suitable variable or condition useful to the function of the instruments.

Variable Manipulation Element: It manipulates the signal represented by some physical variable, to perform the intended task of an instrument. In the manipulation process, the physical nature of the signal is preserved. 2 marks

Data Transmission Element: It transmits the data from one element to other element.

Data presentation Element: It performs the translation function, such as the simple indication of a pointer moving over a scale or recording of a pen moving over a chart.

2 b) Explain the working of an electromagnetic flow meter with neat diagram.

Ans:

- It consist basically a pair of insulated electrodes buried flush in the opposite sides of a non- conducting , nonmagnetic pipe carrying the liquid whose flow is to be measured.
- The pipe is surrounded by an electromagnet which produces a magnetic field. The arrangement is analogous to a conductor moving across a magnetic field. Therefore, voltage is included across the electrode. This voltage is given by:-

E= *Blv* volt

where *B*= flux x density; Wb/m2,

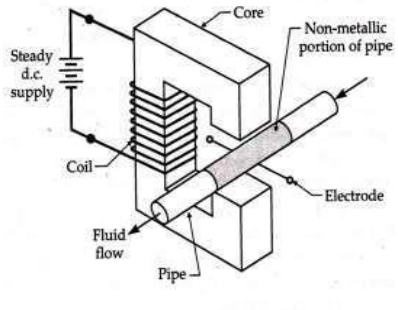


Fig. Electromagnetic flow meter.

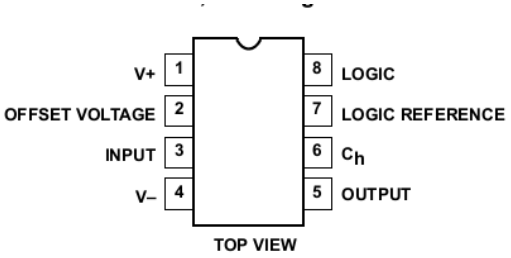
2 marks

l = length of conductor = diameter of pipe; m,
And v = Velocity of conductor (flow); m/s

- Thus, assuming a constant magnetic field, the magnitude of the voltage appearing across the electrode will be directly proportional to velocity.
- Thus conductor (liquid in motion) cuts the magnetic field, hence emf is induced in the liquid. This emf is collected by two electrodes which is proportional to the flow rate of liquid.i.e.rate of cut of flux.

2 marks

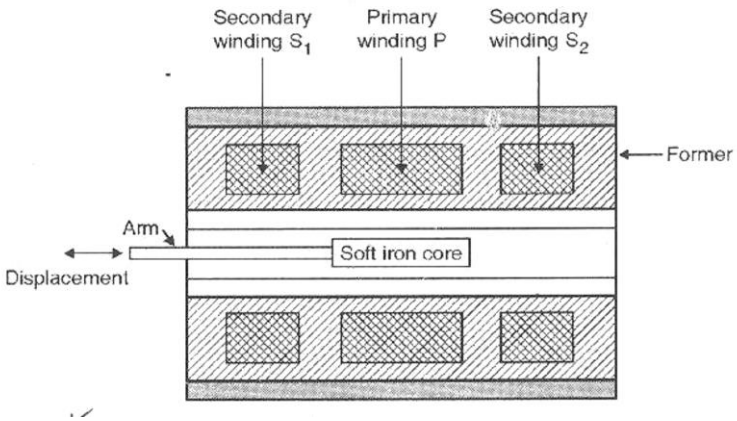
2 c) Label the pin No I to 8 of pin diagram of LF 398 as shown in Fig No. 1.
Ans:



[½ mark per 1 pin labeling]

PIN 1 ---- $+V_{cc}$
PIN 2 ---- Offset
PIN 3 ---- $+V_{input}$
PIN 4 ---- $+V_{EE}$
PIN 5 ---- Output
PIN 6 ---- Hold Capacitor
PIN 7 ---- Ground (logic reference)
PIN 1 ---- Hold Signal (Logic Input)

2 d) Draw constructional diagram of LVDT. State its working principle.
Ans:



2 marks

Principle: It works on the principle of variable inductance. The inductance is varied according to the displacement. This is achieved either by varying the mutual inductance between the two coils. It is having a primary & two secondary windings wound over a hollow former and a soft iron core slides inside the hollow former. The position of movable core determines the flux linkage between the AC excited primary winding and each of the secondary winding.

2 marks

2 e) Define the following terms.
(i) Precision , (ii) Resolution, (iii) Measuring lag, (iv) Dynamic error
Ans:

1. **Precision:** It is the measure of consistency or repeatability of measurements.

OR

The closeness with which the individual measurements are departed or distributed about the average of number of measured value.

1mark each characteristic

2. **Resolution:** Resolution is the term used to describe the number of dots, or pixels, used to display an image. The smallest to be distinguished magnitude from the measured value.

OR

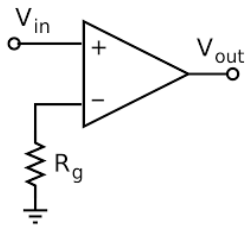
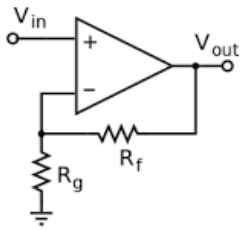
The smallest change in a measured variable to which an instrument will respond is called resolution. OR
If input to an instrument is varied slowly from any arbitrary (non-zero) value, the output does not change at all until a certain increment is exceeded. This increment is called as resolution.

3. **Measuring lag:** Every system takes some time, whatever small it may be, to respond to the change in the measured variable. This retardation or delay in the response of a system is called measurement lag.
4. **The dynamic error**: It represents a measure of the inability of a system to adequately reproduce the amplitude of the input signal for a particular input frequency.

OR

It is the difference between the true value of the variable to be measured, changing with time and the value indicated by the measurement system.

2 f) Compare open loop and closed loop configuration of OP-AMP with neat diagram. (Any four points)
Ans :

S.N.		Open Loop OPAMP	Closed Loop OPAMP
1.	Circuit Diagram		
2.	Gain	Voltage gain is very high. Gain is uncontrollable.	Voltage gain is low as compared to open loop. Gain is controllable & depends on external passive components.
3.	Bandwidth	Bandwidth is low	Bandwidth is high
4.	Application	Comparator, square wave generator,waveshaping circuits	It is used in ac,dc signal amplifier, oscillator ,Instrument amplifier circuits etc.

1 mark each point [total 4 marks]

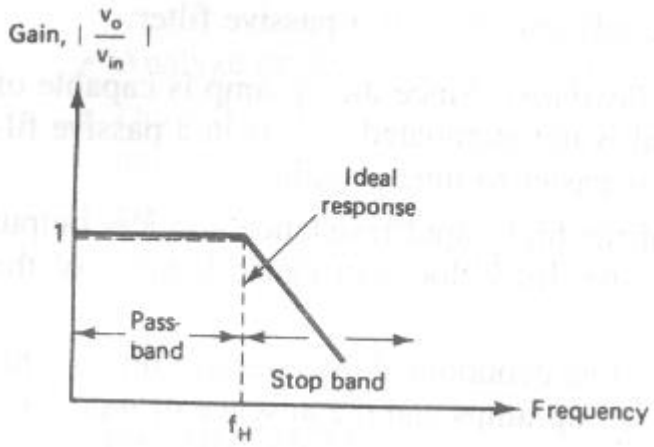
5.		No feedback is taken from output	A feedback signal is taken from output

3 Attempt any FOUR of the following: 16

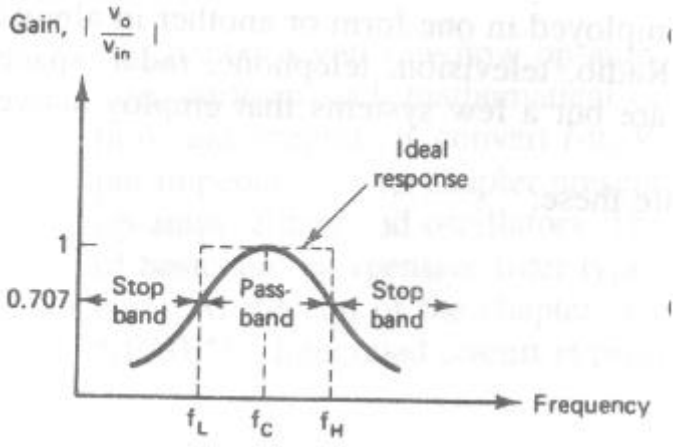
3 a) Draw ideal characteristics of i) Low pass filter ii) High pass filter iii) Band pass filter iv) Band stop filter

Ans:

Low pass filter

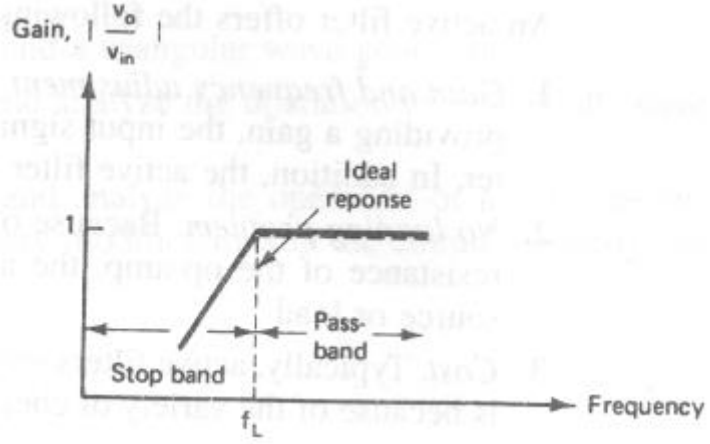


Band pass filter

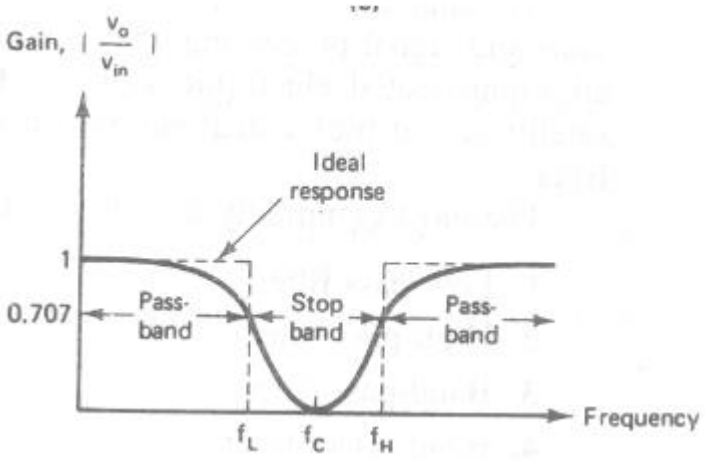


1 mark for each correct characteristics

High pass filter



Band stop filter



(Note-Dashed line represents ideal characteristics of the filter)

3 b) Draw and explain block diagram of multichannel DAS.

Ans:

It consists of multiple input sensors or transducers to sense various input parameters.

Output of each transducer is signal conditioned so as to get a standardized instrumentation signal.

It allows multiplexing of multiple channel sensors. Analog scanner or multiplexer select any one input at a time.

A number of channels are used according to the number of inputs.

S/H circuit is used to store one signal which other in ADC which speed up conversion and increases overall efficiency of DAS

Digital output of ADC is processed in data processing unit.

2 Marks for diagram & 2 Marks for suitable Explanation

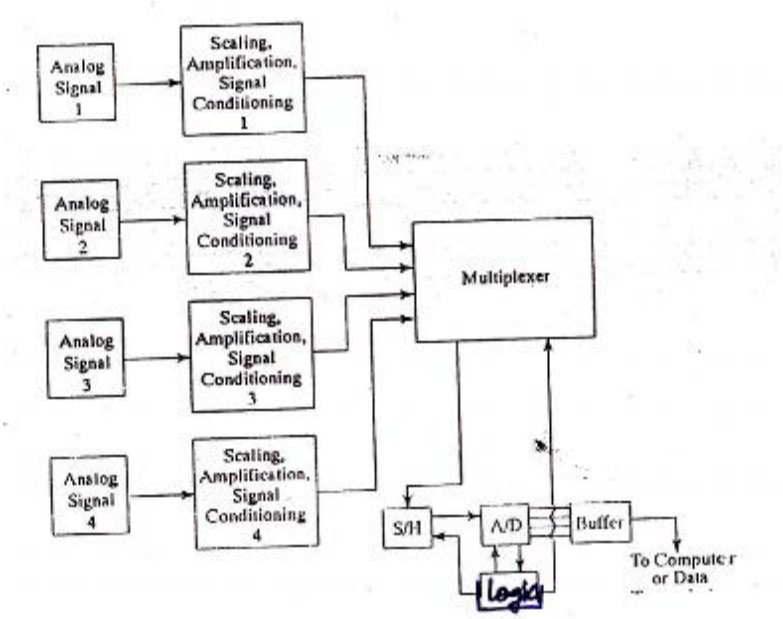


Diagram of multi-channel DAS

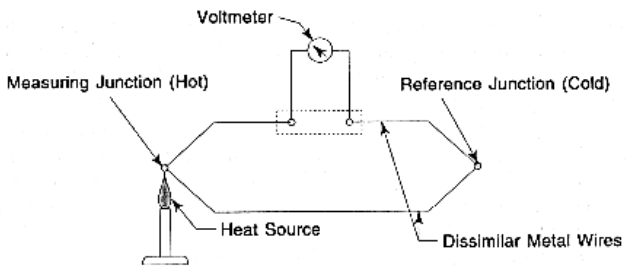
3 c) What is thermocouple? Explain its working

Ans:

Thermocouple is the simplest electrical temperature sensitive device. As results are reproducible with thermocouple thus it provides a reliable method of temperature measurement. It is an active transducer which does not require external power. It is widely used in industrial applications to monitor temperatures of liquid and gases in storage and flowing in pipes and ducts. They are used in industrial furnace as well as for temperature measurement in cryogenic range. 1 mark

Working Principle

The working principle of thermocouple is related to following effects as,



1 mark for Diagram

Thermocouple

a) Seeback effect

If closed circuit is formed of two dissimilar metals and two junctions are at different temperatures, an emf is induced in a closed loop which in turn causes an electrical current flow round the circuit. Current flows from copper to iron at hot junction and iron to copper at cold junction.

b) Peltier effect

When loop is formed of two dissimilar metals and if externally (current) emf was forced to flow through the circuit. One of junctions gets heated while other will be cooled. Amount of heat liberated or absorbed when unit current passes for unit time is called peltier coefficient.

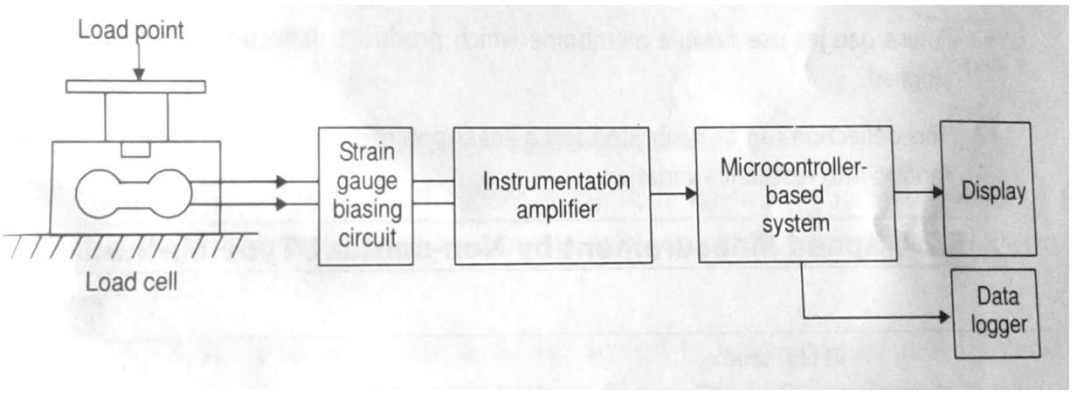
2 marks for working principle.

c) Thomson effect

When current of electricity flows along a copper wire whose temperature varies from point to point. Heat is liberated at any point P when current at P in same direction and absorbed at P when current flows in opposite direction to heat flow.

3 d) Explain the force measurement using Load Cell.

Ans:



2 mark For Diagram

&

2 marks for explanation

1. The load cell is device that is used to convert force into an electrical signal.
2. The force applied is sensed by strain gauge mounted on mechanical structure.
3. A Wheatstone bridge is used to bias the strain gauge.
4. Sometime more than one strain gauges are used for accuracy.
5. Output of bridge is given to instrumentation amplifier.
6. Microcontroller based system acquires the signal and convert into digital format.
7. Digital data is either displayed or stored on hard disk or hard copy is taken.

OR

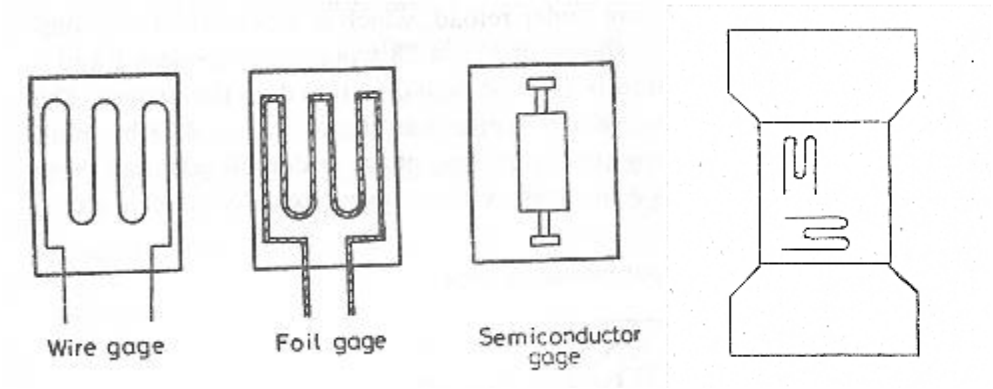
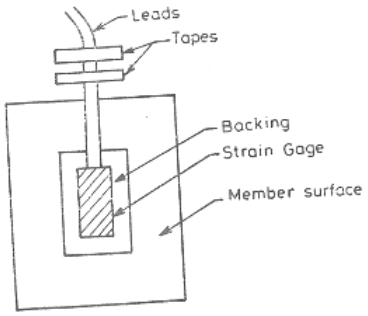


Fig. Gauges used with Load cell

Load cell is one of the simplest configurations of bonded strain gauge transducers. It measures deformation produced by force or weight. Load cell consists of cylindrical or rectangular column. On its side strain gauges are mounted. As load is applied, calibrated steel column deflects and bonded strain gauges measure the strain produced. Desired range of 20Kg to 20000Kg is obtained by variations in mass and design of load column. Load cells are used to measure such variables as weight, force, thrust, compression, tension etc. Generally these devices are calibrated so that force is directly related to resistance change. Forces as high as 5MN can be measured with appropriate load cell

3 e) Explain with neat sketch construction and working of bonded strain gage
Ans:



2 mark For Diagram

Strain Gage in bonded position

Construction and working :

1. These gauges may be of metallic, semiconductor material or in the form of grid of fine resistance wire of about 0.025mm or less than it in diameter in different shapes such as linear, helical or metal foil etc.
2. Materials used in construction of strain gages are
   1) Gauge wire material
      It is basic sensing element Ex Nichrome, Constantan, Nickel, platinum, Manganin, soft iron etc.
   2) Base (Carrier) material
      It is used to support the wire Ex Paper or Teflon or Bakelite is commonly used. For limited operation material like Epoxy, fiber glass is used.

& 2 marks for explanation

3) Adhesives
It is bonding material to stick the gauge wire to the base. Ex- Epoxy cement, Bakelite cement, ethyl cellulose cement, nitrocellulose cement.

3.The grid of wire is fixed with carrier (base) with an adhesive material as listed
4.The grid wire is covered with protective layer of thin sheet to avoid any mechanical damage.
5. The specific shape of the grid permits a uniform distribution of applied stress or strain. The carrier is bonded.
6. As the strain or stress is applied to gage, the resistance of gage will change which is available across the gauge leads.

3 f) Write comparison between magnetic flow meter and turbine flow meter on basis of accuracy cost pressure drop and application.
Ans:

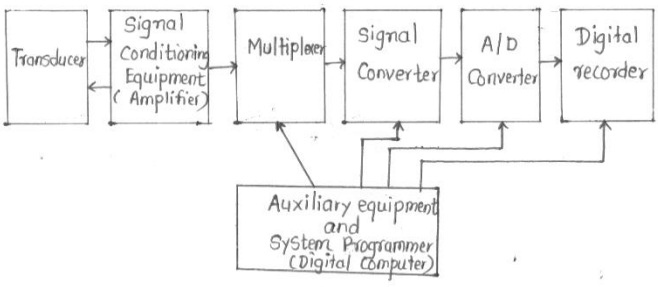
Comparison on basis of	Magnetic Flow Meter	Turbine Flow Meter
accuracy	It is less accurate.	Its accuracy is good.
cost	Its cost is less.	Its cost is high.
pressure drop	It has very low pressure drop.	It allows fairly low pressure drop.
Application.	It is used in i) High corrosive applications. ii) Applications involving measurement of erosive slurries. iii) As bidirectional meter for handling extremely low flows and very high volume flow rate.	It is used in i)military applications ii) In blending system for petroleum industry. iii) In aerospace and aero borne applications,

1 mark for each point

(relevant 4 points only)

4 Attempt any FOUR of the following. 16 marks

4 a) Draw block diagram of generalized Data acquisition system. State function of each block.
Ans:



Generalised diagram of Digital DAS.

2 mark For Diagram

&

2 marks for function (Any four blocks)

The various blocks/components and their functions are stated as below,
1.Transducer
They convert physical quantity into electrical signal which is acceptable in Data acquisition system.

2.Signal Conditioning equipment
It is necessary to perform certain operation like amplification, attenuation on signal before it is transmitted to next stage in order to bring it in desired form acceptable by it. This is called signal conditioning associated with the equipment.

3.Multiplexer
Multiplexing is the process of sharing a single channel with more than one input. Multiplexer accept more than one analog inputs and connects them sequentially to one measuring instrument .It is named as scanner.

4.signal Converter
It translates the analog signal to a form acceptable by analog to digital converter.

5. Analog to Digital Converter
An A/D converter converts the analog voltage to its equivalent digital form. The output of A/D converter may be fed to digital display devices for visual display or recorder.

6.Auxilliary equipment's
This contains device for system programming functions and digital data processing. Some of typical functions are linearization or limit comparison of signal. These functions may be performed by individual device or digital computer.

7. Digital Recorder
Records the information in digital form with type written pages, floppy disk, magnetic tape etc.

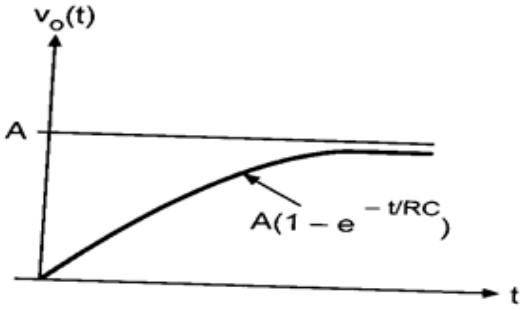
8. Digital Printer
After all test have been completed and data generated it is necessary to record the number or in some cases reduce data in more significant form. Digital printer provides a high quality hard copy of record.

4 b) Write stepwise procedure to carry out calibration.
Ans:
Steps to Calibrate Instruments:
1. Calibration procedure involves a comparison of particular instrument to be calibrated with either primary or secondary standard or instrument of known accuracy.
2. When transducer is calibrated it will acts as test instrument while meter and generator acts as standard instrument.
3. When meter is calibrated it will acts as test instrument while source or generator acts as standard instrument.
4. Deviation of test instrument (meter) from standard value is compared with allowable performance limit.
5. If deviation is within allowable performance limit specified by accuracy or

1 mark each step (variations allowed with the gist being parallel to given)

within tolerance of measurement.
6. If Deviation crosses the allowable performance limit then meter parameter is adjusted to or some faulty components are replaced to remove error.

4 c) Draw the response of first order instrument to step input and explain it.
Ans:
The Response is shown in fig.



2 marks for correct response

The T.F. of First order system is ,

$$\frac{V_0(s)}{V_i(s)} = \frac{1}{1 + sRC}$$

For Unit Step input $V_i(s) = \frac{1}{s}$

1 Mark for TF

$$\text{So, } V_0(s) = \frac{1}{s(1+sRC)} = \frac{A'}{s} + \frac{B'}{1+sRC}$$

Where : A' = 1 and B' = - RC

$$Vo(s) = \frac{1}{s} - \frac{RC}{1+sRC} = \frac{1}{s} - \frac{1}{s} + \frac{1}{RC}$$

Taking Laplace inverse,

1 M for ILT

$$Vo(t) = 1 - e^{\frac{-t}{RC}} \Rightarrow Css + ct(t)$$

$$Css = 1 \text{ and } ct(t) = - e^{\frac{-t}{RC}}$$

The response is purely exponential

4 d) Define Transducer and Give classification of transducer with one example each.
Ans:
Transducer is the device which converts one form of energy into another.
Transducers are classified as
A] Based on Physical Phenomenon
i) Primary transducer. Ex- Bourdon tube
ii) Secondary transducer Ex-LVDT

B] Based on Power type classification
i) Active transducer Ex- Piezoelectric Crystal, Thermocouple etc.
ii) passive transducer Ex-Thermistors, strain Gauges

C] Based on type of output
i)Analog transducer Ex- Strain Gauges, Potentiometers
ii) Digital transducers Ex- Rotary Encoder

D] Based on Transduction phenomenon
i) Transducer (Electrical) Ex-Thermistor
ii) Inverse Transducer(Mechanical) Ex- Bourdon Tube, Bellows

Def.1 mark & Any three based classification with one example (1 mark each)

4 e) Define the following term related to OP-AMP i) Supply voltage rejection ratio ii) Output voltage swing iii) Input offset voltage iv) Input bias current
Ans:
Supply voltage rejection ratio (SVRR)
It is the ratio of change in input offset voltage (Vio) of the op-amp caused due to change in power supply voltage.

Output voltage swing (Vomax)
It is the maximum peak to peak output voltage that can be obtained without the waveform getting clipped or distorted.

Input offset voltage(Vio)

It is the difference of voltage that must be applied between the two input terminals of an op-amp to null the output.

Input bias current (I_B)
It is the average current flowing into the inverting and noninverting input terminals of op-amp.

1 mark for each correct Definition

4 f) Give the comparison between thermistor and RTD. (Any four points)
Ans:

Thermistor	RTD
Made of metallic oxides such as cobalt, manganese, nickel etc.	Made of metals which are good conductors of electricity

	e.g. copper, platinum Nickel
PTC and NTC both types are available	Have Positive temperature coefficient of resistance.
Temperature range: -50 C to 300 C	Temperature range: -100 C to 650 C
It has nonlinear temperature versus resistance curve.	It has linear temperature versus resistance curve.
As made of metal oxide they are less time stable	As made of metal they are more stable
They have less reproducibility and more hysteresis.	They have better reproducibility and low hysteresis.
Thermistor are quite small in size	Relatively bigger in size

1 mark for each point (relevant 4 points only)

5 Attempt any FOUR of the following: 16

5 a) Draw and explain pressure measurement using diaphragm type transducer.

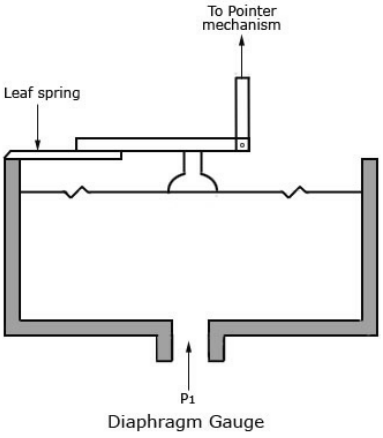
Ans:

A diaphragm type pressure transducer is used for low pressure measurement. They are commercially available in two types: Metallic and Non-metallic.

Working:

The diagram of diaphragm pressure gauge is shown in the figure. When a force acts against a thin stretched diaphragm, it causes a deflection of the diaphragm with its center deflecting the most.

If the pointer or mechanical movement is connected to the LVDT or other secondary transducer then it converts mechanical action into electrical output.

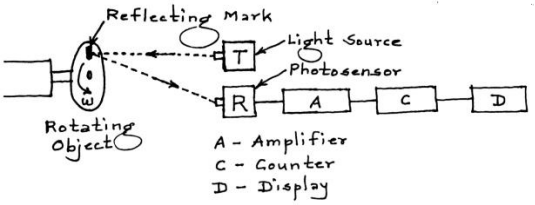


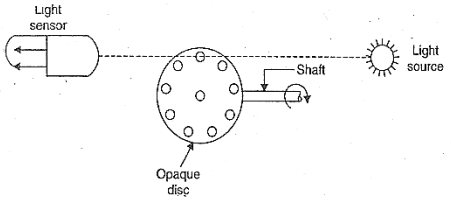
2 marks for figure + 2 marks for explanation = 4 marks

5 b) Explain construction and working principle of photo electric type non-contact tachometer with diagram.

Ans:

Photo electric type non-contact tachometer:





1 mark for any one figure

Principle: The light passes through the holes available on the rotating disc with a

specific interval, depends on the angular speed of the disc having equidistant holes. The frequency of this light pulses is measure of the angular speed of the disc.

Construction: 1 mark

- This method of measuring speed of rotation consists of mounting an opaque disc on the rotating shaft. (relevant to figure)
- The disc has a number of equidistant holes on its periphery. At one side of the disc a light source is fixed like LED and on other side of the disc and in the line of the light source, a light sensor like phototube or some photosensitive semi conducting device is placed. 2 marks (relevant to figure)

When the opaque portion of the disc is between the light source and light sensor, the latter is un-illuminated and produces no output. But when hole appears between the two, light falling upon the sensor produces an output pulse.

5 c) Write four objectives of Data Acquisition System.

Ans:

Objectives of Data Acquisition System:

1. The DAS must acquire the necessary data at correct speed and at the correct time.
2. It must use all of the data efficiently to inform the operator about the state of the plant.
3. It must monitor the operation of the plant so that optimum online safe operations are maintained.
4. It must provide effective human communication service which helps in identifying the problem areas.
5. It must be able to collect, summarize and store data properly for diagnosis and record purpose.
6. It must be able to compute unit performance indices using online real time communication.
7. It must be flexible. Expansion facility for future requirement must be provided.
8. It must be reliable and should not have downtime greater than 0.1%.

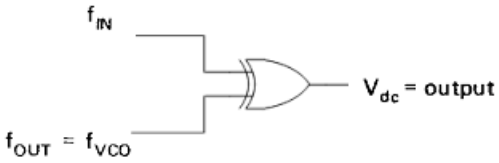
1 mark for each of any four objectives

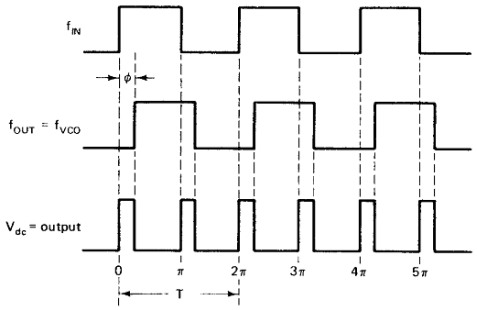
5 d) Draw and explain circuit diagram of phase detector.

Ans:

Phase Detector:

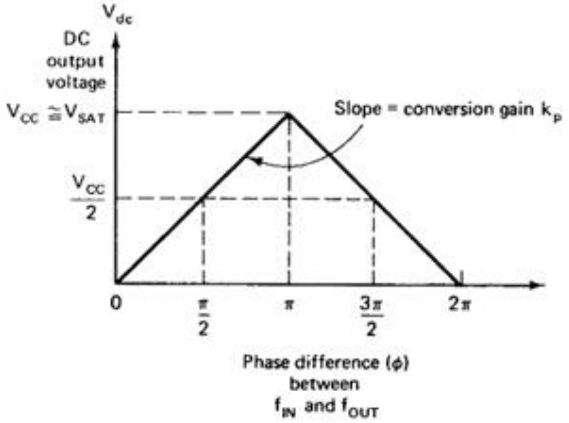
Phase detector compares the input frequency and the VCO frequency and generates a DC voltage i.e. proportional to the phase difference between two frequencies. X-OR type of phase detector is generally used if the f_{in} and f_{out} are square waves. X-OR type of phase detector uses X-OR gate such as CMOS type 4070. The output of X-OR gate is high only when F_{in} or F_{out} is high. F_{in} is leading F_{out} by Φ degrees. The DC output voltage of X-OR phase detector is a function of the phase difference between its two inputs.





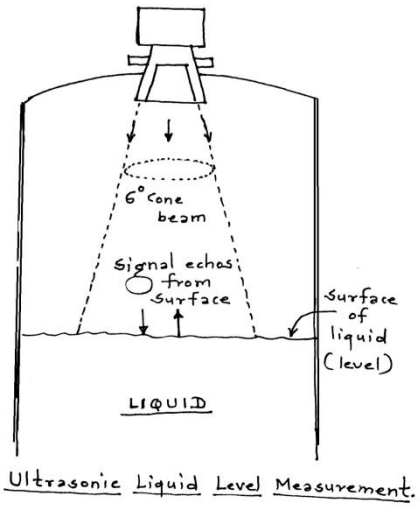
This graph indicates that maximum DC output voltage occurs when phase difference is π radians or 180^0. The slope of curve between 0 & π radians is the conversion gain Kp of the phase detector which is given by

$$Kp = \frac{Vcc}{\pi}$$



[Note: explanation of any other detector such as edge triggered or monolithic phase detector should be considered]

5 e) Explain with diagram liquid level measurement using ultrasonic method.
Ans:



Ultrasonic Liquid Level Measurement.

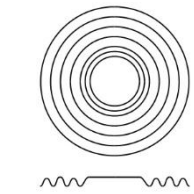
Ultrasonic level sensors work on the "time of flight" principle using the speed of sound. The sensor emits a high-frequency pulse, generally in the 20 kHz to 200 kHz range and then listens for the echo. The pulse is transmitted in a cone, usually about 6° at the apex. The pulse impacts the level surface and is reflected back to the sensor, now acting as a receiver and then to the transmitter for signal processing.
Basically, the transmitter divides the time between the pulse and its echo by two, and that is the distance to the surface of the material. The transmitter is designed to listen the highest amplitude return pulse (the echo) and mask out all the other ultrasonic signals in the vessel.

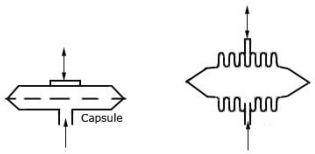
1 mark for diagram
3 marks for explanation

5 f) Draw the neat sketch of the diaphragm. Explain its construction and working.
Ans:
Diaphragm:
The diaphragm is flexible disc, either flat or with concentric corrugation, which is made from sheet metal of precise dimensions, mainly divided into

i) Corrugated single diaphragm
ii) Capsule diaphragm

The pressure deflection characteristics of both flat and corrugated diaphragms have been well investigated.
When the pressure is applied on the diaphragm, it is elongated due to the property of elasticity and we can measure the pressure.


Single Corrugated Diaphragm

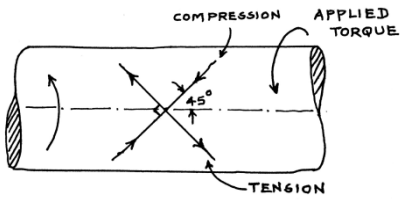


Diaphragm Capsule

2 marks for sketch
1 mark for construction
1 mark for working

6 Attempt any FOUR of the following: 16

6 a) Define torque. Explain measurement of torque using torque cell.
Ans:
Torque: 1 mark
Torque is defined as that force which tends to produce rotation. Specially, it is the moment due to tangential force.
T = L W, where T is the torque, L is the length of the force arm and W is the force. 1 mark for figure
The in-line rotating sensor for larger torques consists of a metal shaft with bonded strain gauges (or load cell) electrically connected in the form of a Wheatstone bridge. Figure illustrates the stresses acting on a rotating shaft subjected to torsion.
The strain gauges are kept on the shaft at



2 marks for explanation

precisely 45° to the shaft axis to sense compressive and tensile deformation due to torsion. The Wheatstone bridge output is proportional to torsion and hence the torque.

6 b) Define stress and strain. List types of strain gauges.

Ans:

Strain:

It is the relative change in shape or size of an object due to externally applied force. 1 mark

$$strain = \frac{extension\ (change\ in\ length)}{original\ length}$$

$$\varepsilon = \frac{\Delta L}{L}$$

Stress:

It is defined as the force per unit area of a material. 1 mark

i.e. $stress = \frac{Force}{Cross-sectional\ Area} = \frac{F}{A}$

$$\sigma = \frac{F}{A}$$

Types of Strain Gauges:

i) Metallic strain gauge
   a) Unbonded metallic strain gauge
   b) Bonded metallic strain gauge
ii) Semiconductor type strain gauge

1 mark for each of two types

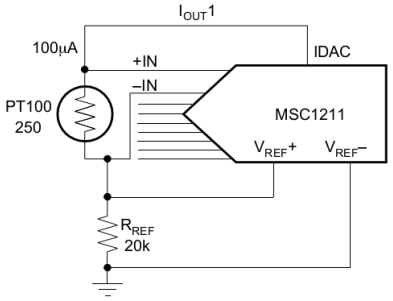
6 c) Draw and explain ratio metric conversion.

Ans:

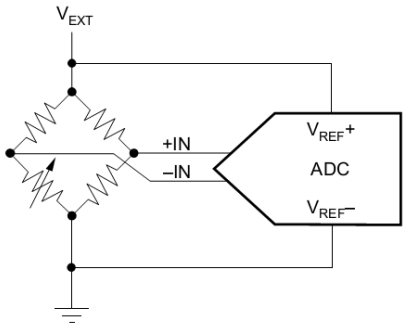
The measurement of a voltage is actually being used to measure another quantity such as resistance. In such instances, the measurement can be set up to read the resistance more directly as a ratio to a reference resistor. By putting the same current through both the sensor resistance and the reference resistor, the ADC result will be a measure of the ratio of the two resistors. 2 marks for relevant explanation

$$\text{ADC result} = \frac{i_{EXCITE} \bullet R_{Sense}}{i_{EXCITE} \bullet R_{REF}}\left(2^N - 1\right) = \frac{R_{Sense}}{R_{REF}}\left(2^N - 1\right)$$

As one can see, the accuracy of the measurement is now set with the reference resistor. The current is no longer critical to the accuracy of the measurement. All that is required is that the current does not change during the conversion, or over-



Ratiometric RTD Measurement



Bridge Circuit Ratiometric Measurement

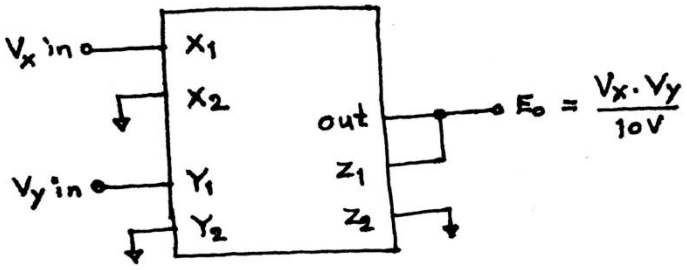
1 mark for each diagram

range either the reference or analog inputs of the ADC. Since it is much easier (and cheaper) to purchase high precision resistors than voltage references, the accuracy can be set to a higher level.
An example ratio-metric circuit using a resistance temperature detector (RTD).

Here RTD is considered as example but any other resistive transducer can be considered as an example like strain gauge etc.

OR

1. Different configurations for ratio metric measurement are shown below.
2. The multiplier operates by converting the two input voltages to be multiplied into currents and generating an output current which is the ratio of the product of the two input currents to reference current.
3. The multiplier can be used as modulators and demodulators as gain control elements and in power measurements.



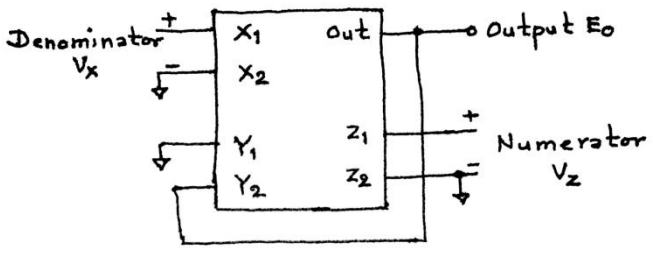
Basic Relationship :

$$(X_1 - X_2)(Y_1 - Y_2) = 10V(Z_1 - Z_2)$$

$$V_x \cdot V_y = 10 \cdot V \cdot E_o$$

ANALOG MULTIPLIER

4. The multiplier can also be used to provide division and square rooting.
5. The divider uses the multiplier in a feedback configuration.
6. Division enables fixed and variable gain elements to be constructed and ratio metric measurement to be made.

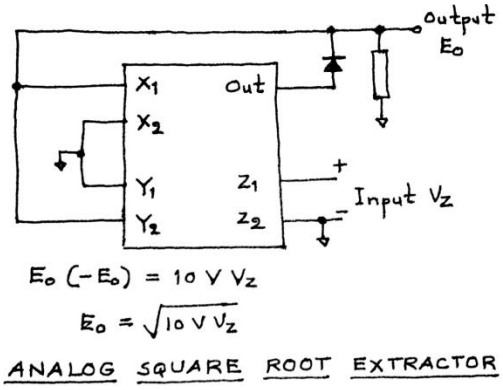


$$V_X(-E_o) = 10V V_Z$$

$$E_o = -10 \cdot \frac{V_Z}{V_X}$$

ANALOG DIVIDER

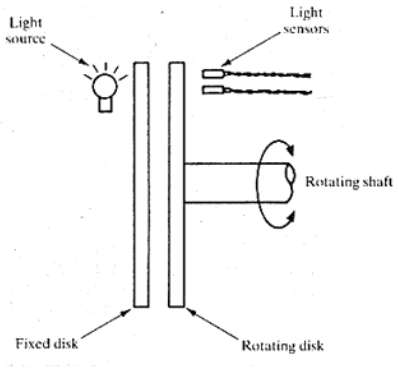
7. The square root extractor can be used in vector amplitude and R.M.S. computations and in linearizing the outputs from flow meters based on different pressure devices.



6 d) Explain rotary motion measurement system using optical encoder.

Ans:

1. Optical encoder consists of a pair of disks one which is fixed and one which rotates with the body whose angular (rotary) displacement is being measured.
2. Each disk is opaque but has pattern of window cut on it.
3. Fixed disc has only one window and the light source aligned with this so that light shines through all the time.
4. Two light detectors are positioned beyond the second disk so that one is aligned with each track of windows.



2 marks For Diagram & 2 marks for relevant explanation

5. As second disk rotates light alternately enters and does not enter the detectors as windows and then opaque regions of disk pass in front of them.
6. These pulses are fed to counter with the final count after motion is ceased corresponding to angular position of moving body relative to starting position.

6 e) Give the difference between active and passive transducers.
(Any four points)

Ans:

Active Transducer	Passive Transducer
Don't require external power for operation	Require external power supply for operation
It is also called self-generating transducer	It is also called Externally powered transducer
Operate under energy conversion principle	Operate under energy controlling principle

1 mark for each of any four points

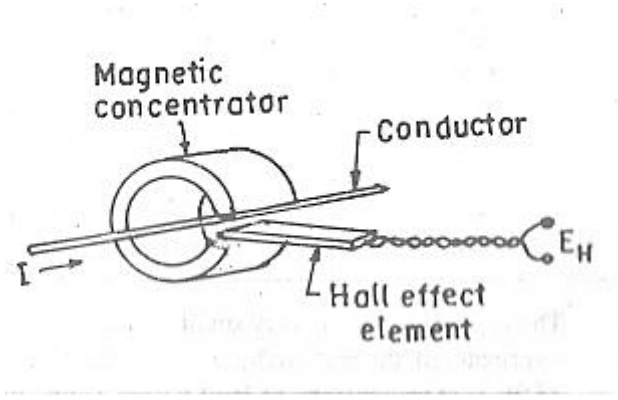
Circuit is simple	Circuit is complex
Active bridge is not required	Active bridge is required
Ex-Thermocouple, piezoelectric	Ex Thermistor, Strain Gauges

6 f) Explain AC Current RMS indication using Hall effect transducer.

Ans:

Measurement of current using Hall effect transducer:

It serves to measure current in conductor without the need for interrupting the circuit and without making electrical connection between the conductor circuit and meter. A current (dc or ac) passes through the conductor and sets up magnetic field around the conductor. The magnetic field is proportional to current. A hall effect transducer is placed in slotted ferromagnetic tube which acts as magnetic concentrator. The voltage produced at the output terminals is proportional to the magnetic field strength hence proportional to current flowing in the conductor

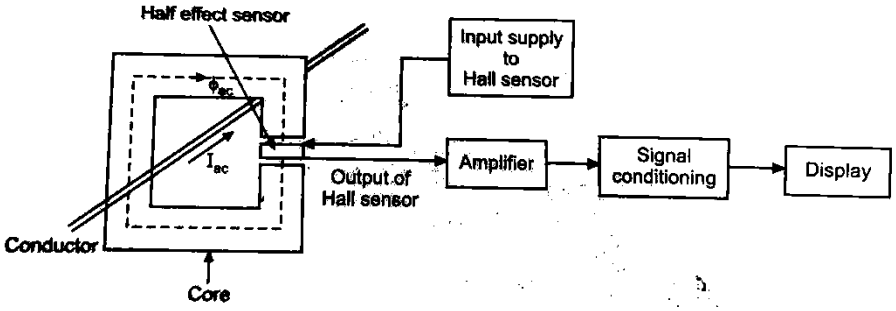


2 marks for diagram

2 marks for relevant explanation

OR

1. As shown in fig an iron core of suitable dimensions as per design is constructed.
2. A small cut is made or the slot is made on one of its limbs to place the Hall Effect sensor.
3. The conductor carries a.c current which is to be measured. This conductor is placed in the core as shown in fig.
4. I_{ac} produces magnetic flux (ϕ_{ac}) in the core.
5. This flux passes through the core and the air gap in which the Hall Effect sensor is placed.
6. The Hall Effect sensor produces output V_H which is proportional to the flux density in the air gap.
7. The flux density is produced due to I_{ac}, hence $V_H \alpha B \alpha I_{ac}$.
8. So we can measure I_{ac} in term of V_H.
9. The output voltage V_H is amplified using amplifier circuit.
10. In signal conditioning the scaling of signal is done such that display shows the value of I_{ac} directly.


Half effect sensor
Input supply to Hall sensor
Amplifier
Signal conditioning
Display
Output of Hall sensor
Conductor
Core