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 may try to assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more 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 may give credit for any equivalent figure drawn.

5) Credits may 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.

6) In case of some questions credit may be given by judgement 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. a) i) Dynamic Characteristics : ½ mark for each point [any four]

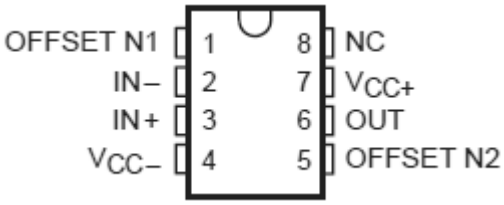
- Fidelity
- Speed of response
- Dynamic error
- Lag
- Frequency Response

1. a) ii) Types of Strain Gauges : ½ mark for each point [any four]

- Unbonded metal strain gauge
- Bonded metal wire strain gauge
- Bonded metal foil strain gauge
- Vacuum deposited thin metal film strain gauge
- Sputter deposited thin metal film strain gauge
- Bonded semiconductor strain gauge

- Diffused metal strain gauge

1. a) iii)



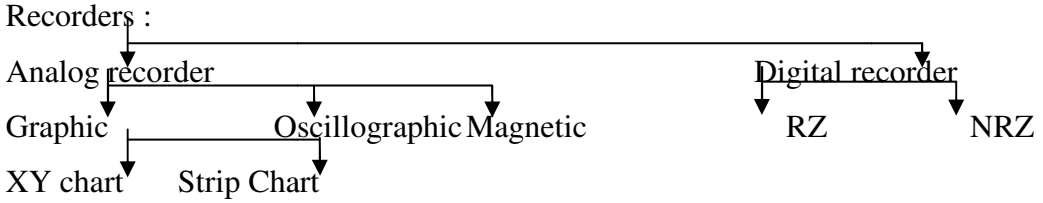
½ mark for labeling 2 pins

1. a) iv) Signal Conditioning :

1. Output of transducer element is usually too small to operate an indicator or a recorder.
2. It is suitably processed and modified in the signal conditioning element so as to obtain the output in the desired form.
3. The signal conditioning equipment may be required to do linear processes like amplification, attenuation, integration, differentiation, addition, subtraction etc.
4. They are also required nonlinear processes like modulation, demodulation, sampling, filtering, clipping, clamping etc.

First 2 points are compulsory [1mark] Next 2 points or description [1 mark]

1. a) v) Recorders :



1 mark for analog type 1 mark for Digital type

1. a) vi) Relative humidity: Ratio of mass of water vapour present in a given volume of gas to the mass of water vapour necessary to saturate the same volume of gas at the same temperature. 1 mark

Absolute humidity: The mass of water vapour present in a unit volume of gas. 1 mark

1. a) vii) Pilot devices : ½ mark for each point [any four]

- Pushbuttons
- Double pushbuttons
- Mushroom pushbuttons
- Emergency stop pushbuttons

- Selector switches, two and three positions
- Selector switches, two and three positions
- Pilot lights
- Buzzers
- Buzzers
- Float switch
- Temperature switch
- Relay
- Reed Relay etc.

1. a) viii) Accuracy : 1 mark

It is defined as degree of closeness or correctness of the measured value to the true value. OR

Ability of a device or a system to respond to a true value of a measured variable under reference conditions.

Precision : It is the degree of exactness for which an instrument is designed or intended to perform. OR 1 mark

It is a measure of the reproducibility of the measurements. OR

It is a measure of the degree of agreement within a group of measurement

1 b) i)

Repeatability	Reproducibility
Describes the closeness of output readings when the same input is applied repetitively over a short period of time, with the same measurement conditions, same instrument and observer, same location and same conditions of use maintained throughout i.e. when measurement conditions are constant	Describes the closeness of output readings for the same input when there are changes in the method of measurement, observer, measuring instrument, location, conditions of use and time of measurement i.e. when measurement conditions vary

1 mark each

Sensitivity	Resolution

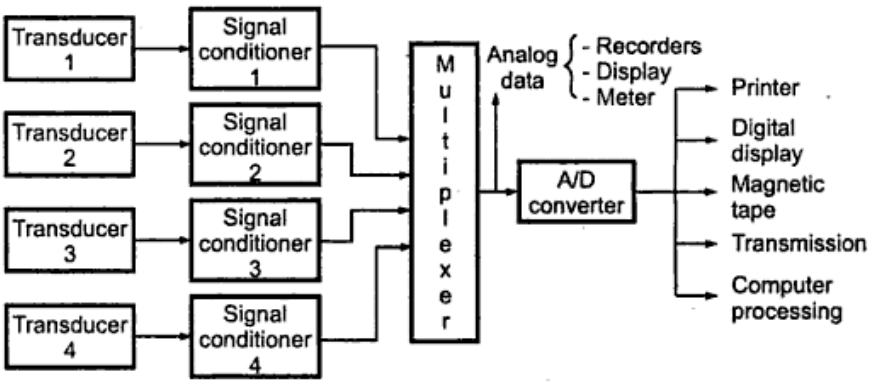
Ratio of change in output to the change in input which causes it, at steady state condition.	Least incremental value of input or output that can be detected, caused or discriminated by the measuring device.	1 mark each

1 b) ii) Classification of Transducers : Any four classes [1 mark each]

1. Active [e.g. thermocouple] and Passive [e.g. bourdon tube]
2. Analog [e.g. diaphragm] and digital [e.g. photoelectric]
3. Primary[e.g. bellows] and secondary [e.g. LVDT]
4. Electrical[e.g. LVDT] and mechanical [e.g. bourdon tube]
5. Transducer [e.g. strain gauge] and inverse Transducer [e.g. thermocouple]

Note : here few examples are given examiner's should consider other correct examples.

1 b) iii Data Acquisition System : diagram 2 marks



Generalised data acquisition system

The various components of the digital data acquisition system are as follows.

1. Transducers

They convert the physical quantity into a proportional electrical signal which is given as a input to the digital data acquisition system.

2. Signal Conditioners

They include supporting circuits for amplifying, modifying or selecting certain positions of these signals.

3. Multiplexers

The multiplexer accepts multiple analog inputs and connects them sequentially to one measuring instrument.

Description in short 2 marks

5. Analog to Digital Converters (A/D converter)

The analog to digital converter converts the analog voltage to its equivalent digital form. The output of the analog to digital converter may be fed to the digital display devices for display or to the digital recorders for recording. The same signal may be fed to the digital computer for data reduction or further processing.

6. Auxillary Equipments

The devices which are used for system programming functions and digital data processing are included in the auxillary equipments. The typical functions of the auxillary equipment includes linearization and limit comparison of the signals. These functions are performed by the individual instruments or the digital computer.

7. Digital Recorders

They record the information in digital form. The digital information is stored on punched cards, magnetic tape recorders, type written pages, floppies or combination of these systems. The digital printer used provides a high quality, hard copy for records minimizing the operator's work.

2 a) RVDT: Rotary Variable Differential Transformer

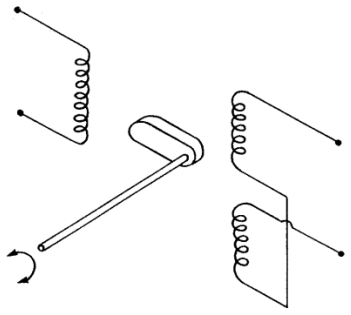


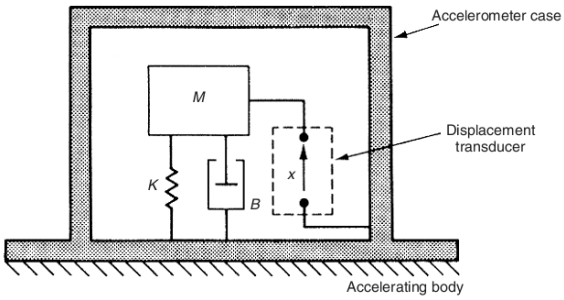
Diagram
[1 mark]

Principle : Rotary Variable Differential Transformer (RVDT) is an electromechanical transducer that works on mutual inductance principle which provides a variable alternating current (AC) output voltage that is linearly proportional to the angular displacement of its input shaft. When energized with a fixed AC source, the output signal is linear within a specified range over the angular displacement. 1½ marks

Construction : Consists of transformer with single primary winding and two secondary windings connected in the series opposing manner shown in Figure. Object whose angular displacement is to be measured is physically attached to the specially shaped core that varies the mutual inductance between the windings as it rotates, of the transformer, so that all motions of the body are 1½ marks

transferred to the core.

2 b) Accelerometer :



1 mark

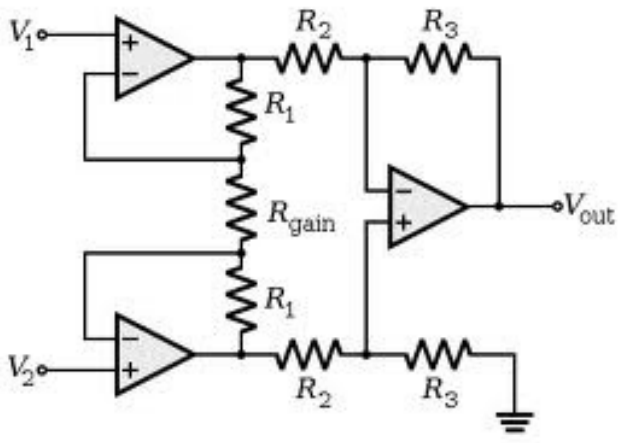
Construction: It is having a simple mass (m) attached to a spring of stiffness (k) that in turn is attached to a casing, as illustrated in figure. The mass used in accelerometers is often called the seismic-mass or proof-mass. In most cases the system also includes a dashpot to provide a desirable damping effect. The dashpot with damping coefficient (c) is normally attached to the mass in parallel with the spring.

2 marks

Principle : When the spring mass system is subjected to linear acceleration, a force equal to mass times acceleration acts on the proof-mass, causing it to deflect. This deflection is sensed by a suitable means and converted into an equivalent electrical signal.

1 mark

2 c) Instrumentation Amplifier :



1 mark

Most of the transducers outputs are generally very low level signals which are not sufficient to drive the next stage of the system. And also in many cases transducers

are mounted on a piece of equipments which are remote from control room. Due to which signal which itself is low gets subjected to noise & atmospheric interference. Hence special amplifiers called instrumentation amplifier is used for amplification of such a signals which is having high CMRR, high input impedance to avoid loading effect, low power consumption etc. 2 marks

Features :

- very low DC offset
- low drift
- low noise
- very high open-loop gain
- very high common-mode rejection ratio
- very high input impedances

Any two features 1 mark

2 d) Characteristics :

i) The system can be expanded considering future requirements. This cannot interrupt the existing work system. The expansion of the data loggers is very simple and efficient.

ii) It has really good reliability. It is designed to operate continuously without any interruption even under worst industrial conditions.

iii) The required or specified accuracy is maintained throughout the period used.

iv) This interfaces with the operator with very easy, logical but simple manner. Hence it is very easy to operate, understand and expand.

2 characteri-stics 2 marks

Basic Operation of Data Logger :

i) Basic operation of data logger is to automatically make the record of readings of various instruments located at various places in the plant. It measures & records data very quickly & accurately without any efforts.

ii) It can measure the output from almost all type of transducers & log the values automatically.

iii) It can detect the output going beyond limit & take the corrective action.

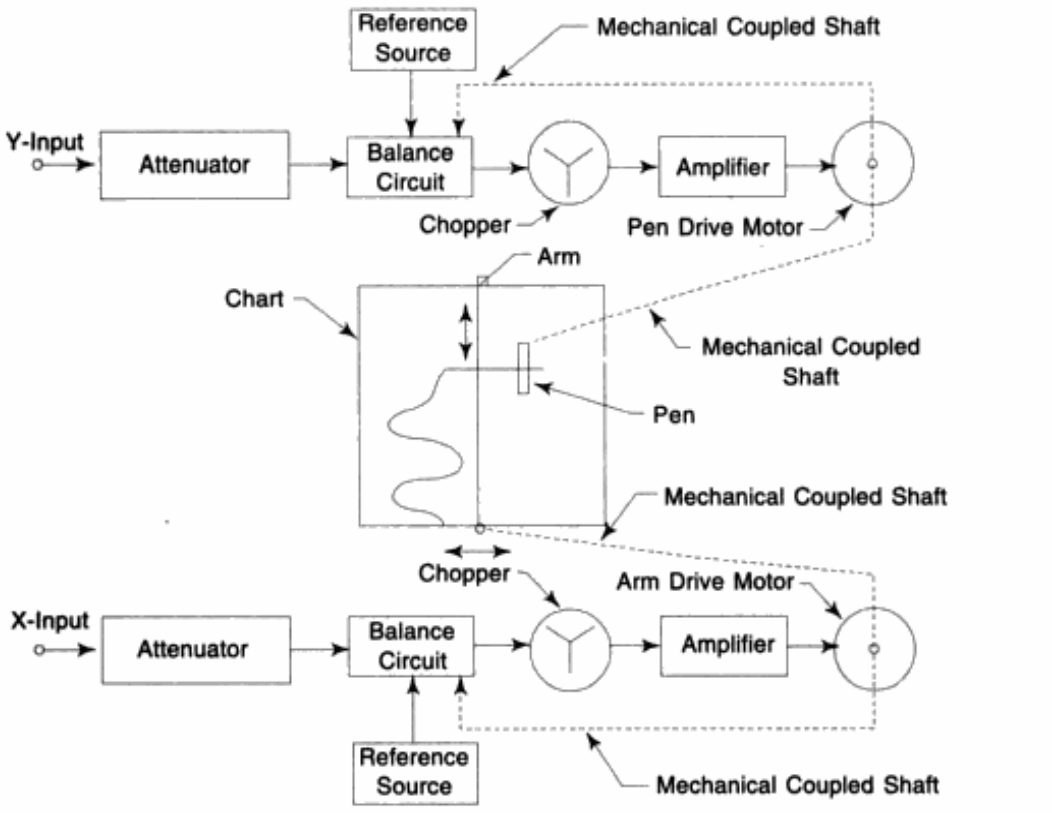
Operation 2 marks

2 e)

Parameter	Data Acquisition System	Data Logger
Oparation	It samples the real world	It samples the real world

		data & convert it into digital form	data & convert it into digital form as well records it over the time	
	Operation complexity	Data can be transmitted over long as well as short distance & record ir	It automatically makes a record of reading from instruments located at different parts of the plant	Any four points 4 marks
	Comprehension	It is less comprehensive than data logger	It is highly comprehensive than DAS	
	Accuracy	DAS is less accurate	It is more accurate	
	Basic parts	Sensors with necessary signal conditioning, multiplexer, storage, display system	Input scanner, signal conditioner, A/D converter, programmer.	
	Applications	Aircraft control system, process control system etc.	Power plant, cement plant, R & D departments of different process plants.	

2 f) X-Y chart Recorder :



2 marks

- X-Y recorder is an instrument for the graphic recording of the relationship between two variables.
- The printing stylus moves in both X and Y directions against fixed chart. One self balancing potentiometer circuit moves a recording stylus in the X- direction and another self balancing potentiometer circuit moves the recording stylus in the Y-direction at right angle to the X-direction, while the paper remains stationary.

2 marks

- The signal enters each of the two channels through input attenuators where they are adjusted to the inherent recorder full-scale range. The signal then passes to a balance circuit where it is compare with an internal reference voltage. The error signal is fed to a chopper which converts d.c. signal to a.c. signal. The signal is then amplified in order to drive a servomotor which is used to balance the system. Thus, a record is made of one variable with respect to another.

3 a)

S.N	Analog Recorder	Digital Recorder
1	The data is recorded by using pen (stylus) on a chart or graph paper	The data is recorded & then stored in magnetic tape
2	Data cannot be stored permanently	Data can be stored permanently
3	Less accuracy	High accuracy
4	Analog data can be recorded directly	Analog data is recorded by using A/D converter
5	The information can't be fed to digital computer	The information can be fed to digital computer for processing & control
6	Low speed	High speed
7	Less amount of data are recorded in large space	Large amount of data are recorded in small space
8	Few inputs can be recorded at a time	Many inputs can be recorded at a time

Any four points 4 marks

3 b) Modified Frequency Modulation[MFM] :

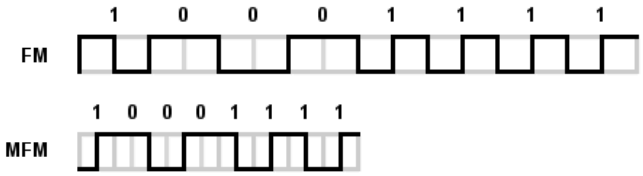
- MFM is a modification to the original frequency modulation scheme for encoding data on single-density floppy disks and some early hard disk drives. It is also called as a multiple frequency modulation. ½ mark
- MFM reduces the number of flux reversals incorporated for clock pulses, allowing for greater data density. It is used with a data rate of 250 – 500 kbit/s (500 – 1000 kbit/s encoded) on industry standard 5¼" and 3½" ordinary and high density diskettes. ½ mark
- MFM improves on FM by reducing the number of flux reversals inserted just for the clock. Instead of inserting a clock reversal at the start of every bit, one is inserted only between consecutive zeros. When a 1 is involved there is already 1 mark

a reversal (in the middle of the bit) so additional clocking reversals are not needed.

- When a zero is preceded by a 1, we similarly know there was recently a reversal and another is not needed. Only long strings of zeros have to be "broken up" by adding clocking reversals. 1 mark
- The table shows the encoding pattern for MFM (where "R" represent a flux reversal and "N" represent no flux reversal). The average number of flux reversals per bit on a random bit stream pattern is 0.75. The best case (a repeating pattern of ones and zeros, "101010...") would be 0.25, the worst case (all ones or all zeros) would be 1:

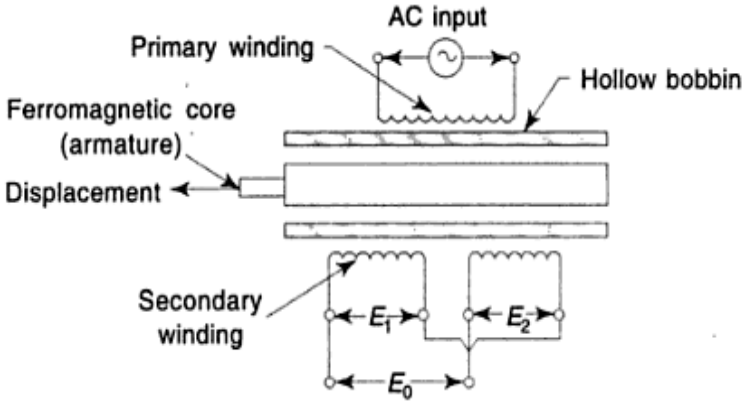
Bit Pattern	Encoding Pattern	Flux Reversals Per Bit	Bit Pattern Commonality In Random Bit Stream
0 (preceded by 0)	RN	1	25%
0 (preceded by 1)	NN	0	25%
1	NR	1	50%
Weighted Average		0.75	100%

- Since the average number of reversals per bit is half that of FM, the clock frequency of the encoding pattern can be doubled, allowing for approximately double the storage capacity of FM for the same areal density. 1 mark



FM and MFM encoding write waveform for the byte "10001111".

3 c)



2 marks

Principle : Any physical displacement of the core causes the voltage of one secondary winding to increase while simultaneously, reducing the voltage in the other secondary winding. The difference of the two voltages appears across the output terminals of the transducer and gives a measure of the physical position of the core and hence the displacement. 2 marks

3 d)

Parameter	RTD	Thermistor	Any four points 1 mark each
Principle	The resistance of certain wires varies with variation in temperature	Whenever two dissimilar metals are joined to form two junctions and one is subjected to high temperature and another to low temperature then emf is induced proportional to temperature difference between them.	
Material Used	Platinum, Copper, Nickel, Tungsten etc.	Iron-constantan, chromel-constantan, chromel-alumel, platinum-rhodium etc.	
Sensitivity	Low compared to Thermistor	High Sensitivity	

Linearity	Almost Linear	Linear at higher temperature
Output Equation	$R=R_o(1+\alpha_o\Delta T)$	$E = a T + b T^2$.
Cost	High cost	Medium
Range	-270°C to +2800°C	-200°C to +3000°C
Application	Laboratory as well as industrial application	Industrial furnace, temperature measurement in cryogenic range

3 e) Pilot devices are mechanically or electrically actuated control circuit devices. 1 mark

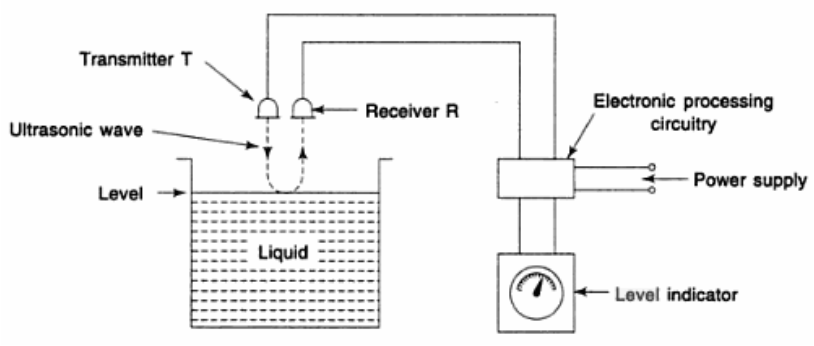
Functions of Pilot Devices:

1. Protection to operators from unsafe conditions.
2. Provide control in electrical starters.
3. Operate at faster rate than that of normal switches hence used for safely.
4. Process of energizing or reenergizing pneumatic timing relays can be controlled by pilot devices.

Any three 1 mark each

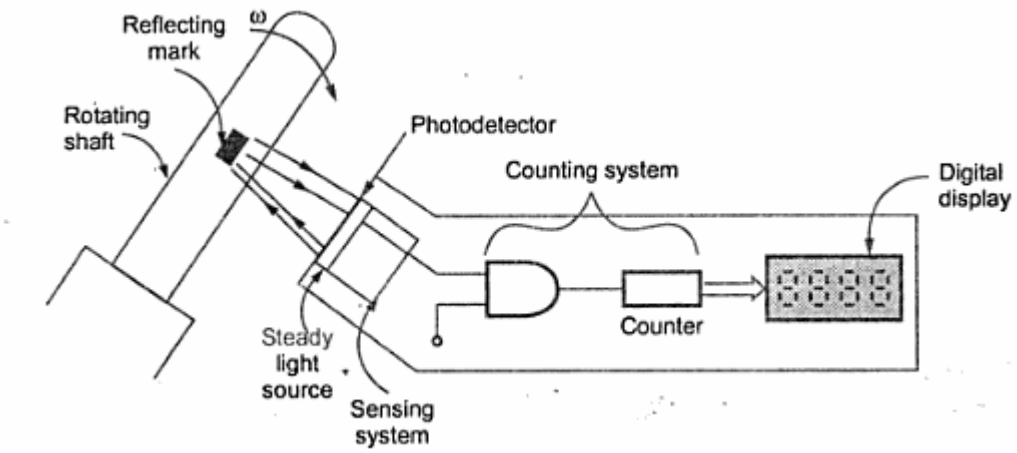
3 f) Measurement of liquid level using Ultrasonic Method. 2 marks

1. In this design, the level sensor [ultrasound transceiver or transmitter and receiver] is located at the top of the tank in such a way that it sends out the sound waves in the form of bursts in downward direction to the fluid in the tank under level measurement.
2. As soon as the directed sound waves hits the surface of the fluid, sound echoes gets reflected and returned back to the sensor.
3. The time taken by the sound wave to return back is directly proportional to the distance between sensor and the material in the tank.
4. This time duration is measured by the sensor which is then further used to calculate the level of liquid in the tank.



2 marks

4 a) Digital tachometer : Photo electric Type :



1 mark

A piece of reflective tape or reflecting mark in the form of chalk mark is affixed at a point on the shaft of the rotating object. The steady light source is focused on the reflecting mark from the tachometer. The light gets reflected from the mark, which is sensed by a photodetector. It produces an electrical signal in the form of a pulse.

1 marks

The reflected light produces one pulse per revolution. The electronic counting system consists of a gate and counter. The gate has gate length control as one input and a pulse from photodetector as the other input. The gate remains open for the time decided by gate length control. The counter counts the number of pulses available in the gate period. As pulse and revolution relation is known, the counter converts the information into a speed.

1 mark

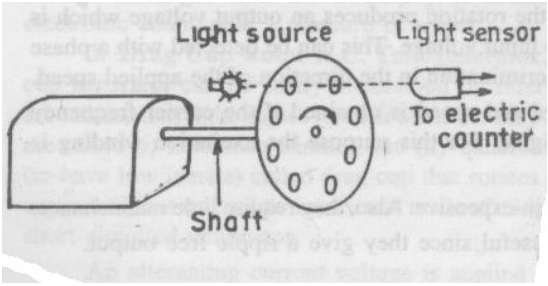
For photoelectric tachometer, the speed in r.p.s. is given by,

$$\text{Speed(n) (in r.p.s.)} = \frac{\text{Pulses per second}}{\text{Number of slots}}$$

1 mark

OR

OR



1 mark

- It consists of mounting an opaque disc on the rotating shaft. The disc has number of equidistant holes on its periphery.
- At one side of the disc a light source is fixed and at the other side of the disc, and on line with the light sensor such as a photo tube or some photosensitive semi-conducting device is placed.

1 mark

- When the opaque portion of the disc is between the light source and the light sensor, the latter is un-illuminated and produces no output. But when a hole appears between the two, the light falling upon the sensor produces an output pulse.
- The frequency at which these pulses are produced depends upon the number of holes in the disc and its speed of rotation.

1 mark

N = f / Hn

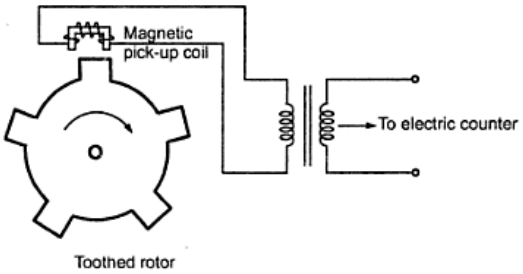
N = speed of roatation
f = frequency of pulses
Hn = no. of holes on circular disc

1 mark

OR

OR

Magnetic Pick type :



1 mark

The magnetic pick-up coil is nothing but a small permanent magnet with a coil wound on it. When the toothed rotor rotates, the reluctance of the air gap between pick-up and the toothed rotor varies. This gives rise to induced e.m.f. in the magnetic pick-up coil. The output is observed in the form of pulses. 1 mark

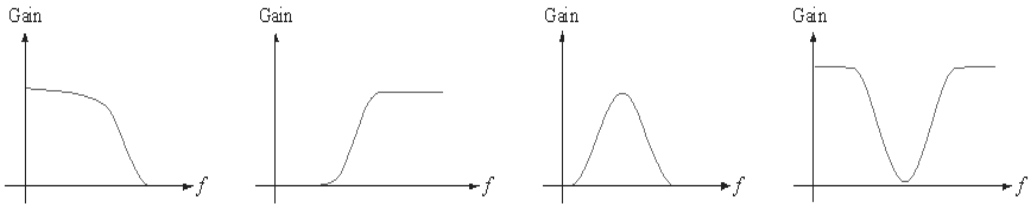
The number of teeth of the rotor and its speed decides the frquency of pulses of induced e.m.f. So the frequency of pulses can be measured using electronic counter, while the number of teeth is known ; then the speed of rotation is given by, 1 mark

$$\text{Speed (n) (in r.p.s.)} = \frac{\text{Pulses per second (P)}}{\text{Number of teeth (N)}} = \frac{P}{N} \text{ r.p.s.}$$

or $n = \frac{P}{N} \times 60$ r.p.m. 1 mark

4 b) • • Name of filters ½ mark

i)Low pass filter ii)High pass filter iii)Band pass filter iv)Band stop filter Each

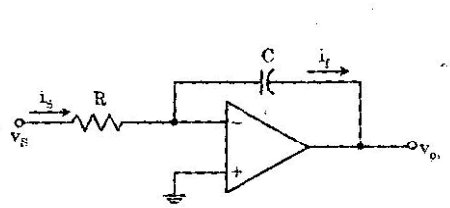


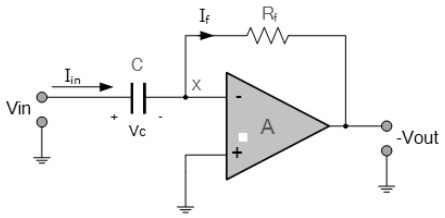
Low-pass High-pass Band-pass Band-stop

Graphs ½ mark Each

4 c) Integrator : Differentiator :

1 mark Each diagram



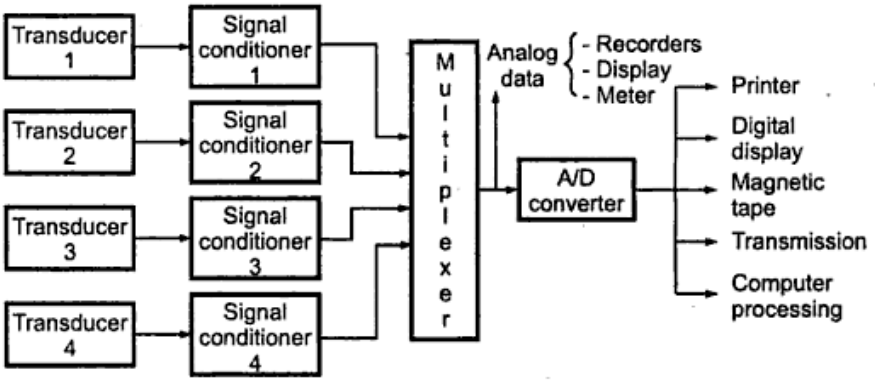


$$Vo = -1/(CR) \int Vs\, dt$$

$$Vo = -(Rf\, C)\, dVin/dt$$

1 mark Each Equation

4 d) Data Acquisition System : Diagram 2 marks



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description 2 marks

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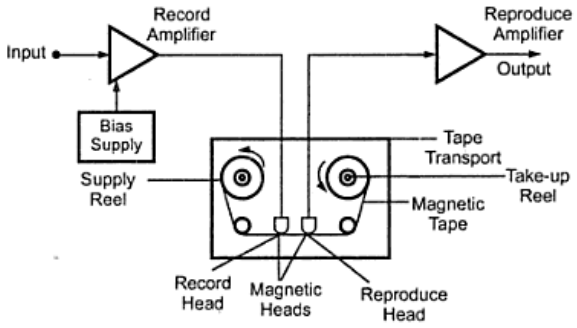
4 e) Magnetic Tape Recorder :



2 marks

Principle :

When a magnetic tape is passed through a recording head, the signal to be recorder appears as some magnetic pattern on the tape. This magnetic pattern is in accordance with the variations of original recording current. The recorded signal can be reproduced back by passing the same tape through a reproducing head where the voltage is induced corresponding to the magnetic pattern on the tape. 1 mark

When the tape is passed through the reproducing head, the head detects the changes in the magnetic pattern i.e. magnetization. The change in magnetization of particles produces change in the reluctance of the magnetic circuit of the reproducing head, inducing a voltage in its winding. The induced voltage depends on the direction of magnetization & its magnitude on the tape. The emf thus induced is proportional to the rate of change of magnitude of magnetization $E \alpha N(d\Phi/dt)$ 1 mark

4 f) Selection Criterion of transducer : Any four

1. Operating principle	2. Sensitivity	1 mark
3. Operating range	4. Accuracy	each
5. Transient & frequency response	6.Loading effects	
7. Environmental compatibility	8.Stability & reliability	
9. Cross sensitivity	10. Errors	
11. Insensitivity to unwanted signals.	12. Usage & ruggedness	
13. Electrical aspects	14. Static characteristics	

5 a) Principle : A thermistor is a type of resistor whose resistance varies significantly

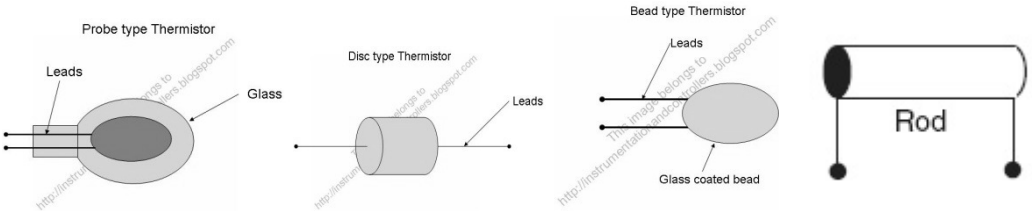
with temperature, more so than in standard resistors. OR 1 mark

Some of the semiconductor material exhibits the property that, their resistance changes as there is a change in temperature surrounding.

Materials : Sintered mixture of semiconductor metal oxides such as manganese, nickel, cobalt, copper, iron, uranium, doped 1 mark

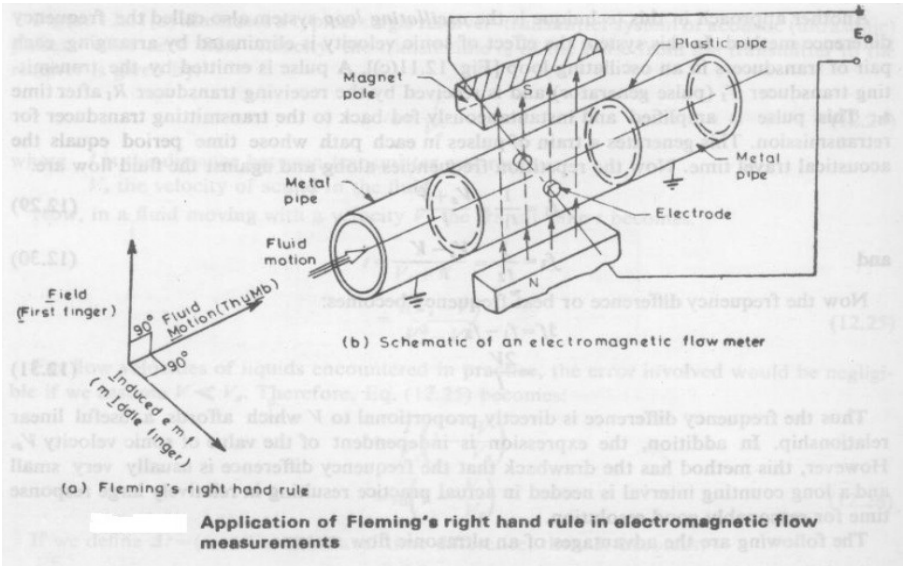
polycrystalline ceramic containing barium titanate ($BaTiO_3$) and other compounds.

Types :



½ mark Each type

5 b) Electromagnetic Flowmeter :



Application of Fleming's right hand rule in electromagnetic flow measurements

2 marks

- Works on faraday's law of electromagnetic induction.
- Fluid flowing through flow tube is considered as moving current carrying conductor.
- Electromagnets produces steady magnetic field.
- Emf is produced proportional to fluid velocity.

1 mark

- Output equation:-

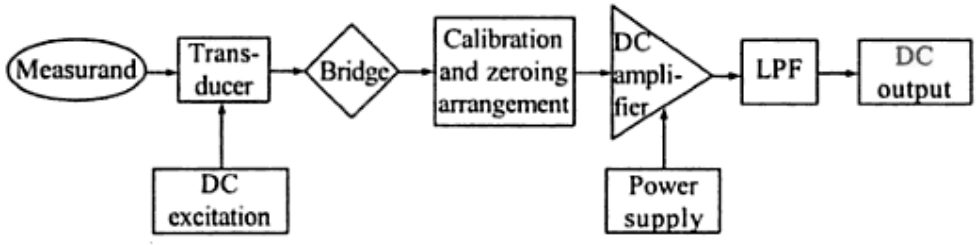
  E= Blv

1 mark

Where, B=Magnetic field density, l= Length of conductor, V= Velocity if

conductor/velocity of fluid, E= Generated emf.

5 c) DC Signal Conditioning System :



2 marks

Transducer : If the input transducers used are passive transducers like potentiometer, strain gauge, thermistor etc. Then external excitation is required. Here in this system DC excitation is used. ½ mark

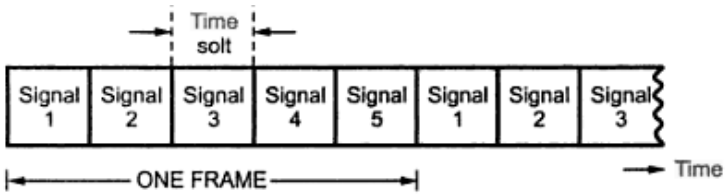
Bridge & DC excitation : The measurand is sensed by the passive transducer and converted into electrical signal with help of bridge & excitation. Here mostly the wheatstone bridge is used. The bridge can be balanced & calibrated by using potentiometer. ½ mark

DC Amplifier : the calibrated output is then amplified by the DC amplifier. It should have following characteristics

1. It may need balanced differential inputs giving a high CMRR. ½ mark
2. It should have extremely good thermal & long term stability.
3. Easy to calibrate at low frequency.
4. Able to recover from an overload condition.

Low Pass Filter : removes high frequency components or noise from data signal. ½ mark

5 d) Time Division Multiplexing :



1 mark

- In TDM signal to be transmitted is sampled sequentially & the resulting pulse code is used to modulate the carrier. The same carrier is ued to transmit different pulses one after another sequentially. Each signal to be transmitted is alloted a time slot.

- Only one signal modulate the carrier frequency at any time, no added equipment & no increase in bandwidth is required while multiplexing.
- The number of sequential channels that can be handled is limited by the time span required by any one channel pulse& the interval between the samples.
- Thus each signal occupies entire bandwidth. The adjacent time slots are seperated from each other with the time guard bands.
- It can be used to multiplex analog as well as digital signals

1 mark description

Advantages :

- Suitable for transmission of digital information or signals.
- It is possible to store digital signals & change of datarate.

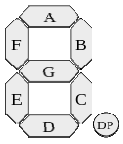
1 mark [any one]

Disadvantages :

- Synchronization is important
- Frame timing must be achieved & maintained

1 mark [any one]

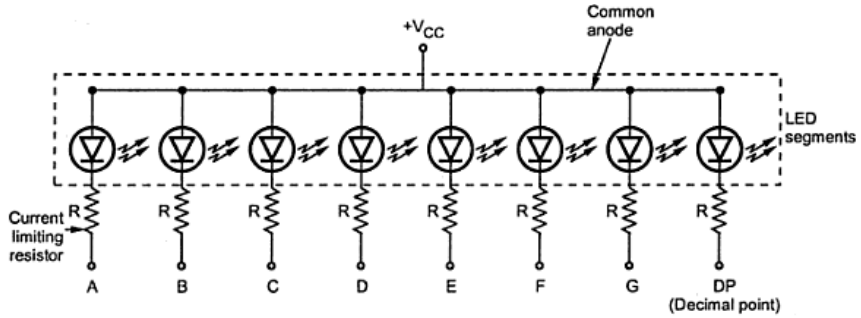
5 e) Seven Segment Display :



½ mark

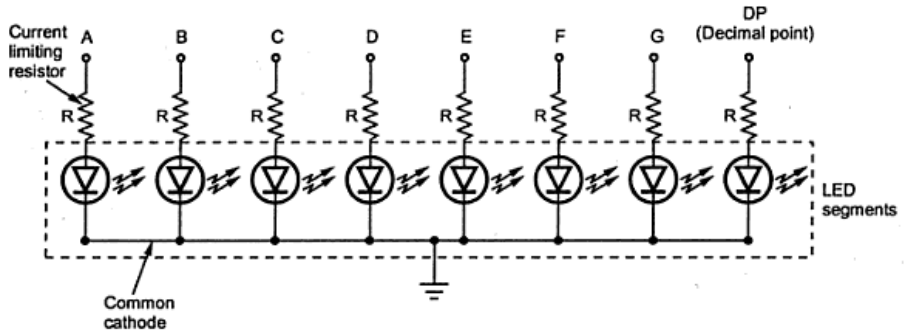
- A dispaly consists of seven LEDs arranged in a seven segments is called 7 segment display. The seven segments are arranged in arectangular manner & labelled as A to G. Each LED is called segment because it forms a part of the digit to be displayed.
- By forward biasing LEDs we can display the digits 0 to 9.
- There are two types of 7 segment displays viz. Common anode and common cathode display.
- Common Cathode Dispaly : in this all anodes of LEDs are connected together & connected to +Vcc. A current limiting resistor is required to be connected in between each LED & ground.

1½ marks



1 mark

- Common Anode Dispaly : in this all cathodes of LEDs are connected together & connected to ground. A current limiting resistor is required to be connected in between each LED & +Vcc supply.



1 mark

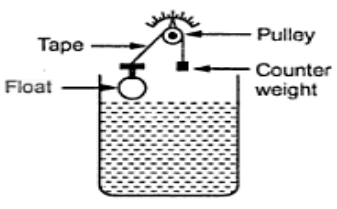
5 f) Methods of speed measurement: contact and non contact type. ½ mark

Answer and marking scheme as of Q 4 a) (here 1/2 mark less for diagram all other marks same as 4 a))

6 a) Method : Float type level sensing

- The above method is simple and less costly. 1 mark
- Also tank cab be kept below ground level.
- Large temperature range.
- Direct indication, no requirement of electrical supply.

Float gauges



Float gauge

1 mark diagram

This method is based on the principle that a floating body experiences a buoyant force equal to the weight of liquid it displaces. Due to this, level of the liquid changes, thus the float action gives the measure of liquid by transferring its action to the pointer mechanism.

The floats used may be of cylindrical, disc or spherical shape. Generally a hollow metallic spherical float or cylindrical or disc shaped ceramic floats are used. Some times, nickel plated copper floats are also used.

1 mark description

Advantages :

- Contineous & Direct measurement is posible
- Low cost & reliable design
- Large temperature range liquid can be handled by this method

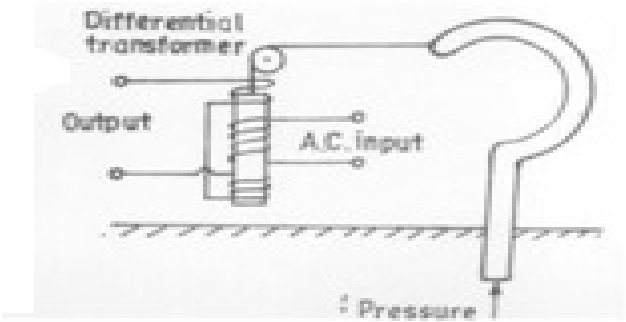
Disadvantages :

- Operation is limited to moderate pressure
- They are tailored to tank geometry.

1 mark [any one advantage & disadvantage]

6 b) Pressure measurement by using bourdon tube : 2 marks detail description

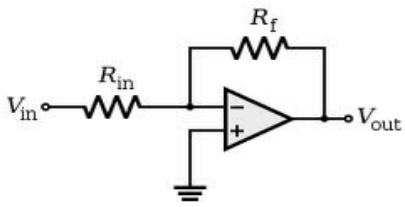
The LVDT is used as a secondary transducer for measurement of pressure with bourdon tube acting as the primary transducer. The pressure is converted into displacement by bourdon tube and displacement is converted into voltage by LVDT and the measured voltage will be in proportional to the applied pressure at bourdon tube.



2 marks Diagram with proper labeling

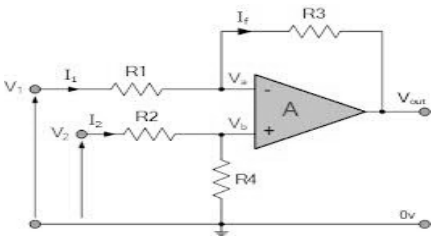
6 c) Inverter & Subtractor : 1 mark Each diagram

Inverter :



Vo = -Vi

Subtractor :



$V_{OUT} = (R_3/R_1)(V_2 - V_1)$

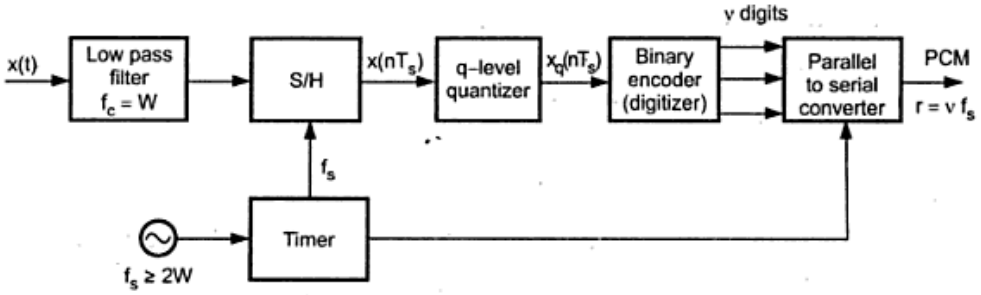
1 mark Each equation

6 d) Digital Modulation : The modulation system or technique in which the transmitted signals is in the form of digital pulses of constant amplitude , frequency & phase is 1 mark

called digital modulation. There are 3 techniques of digital modulation viz. pulse code modulation, delta modulation, adaptive delta modulation.

Pulse code Modulation :

PCM Generator :



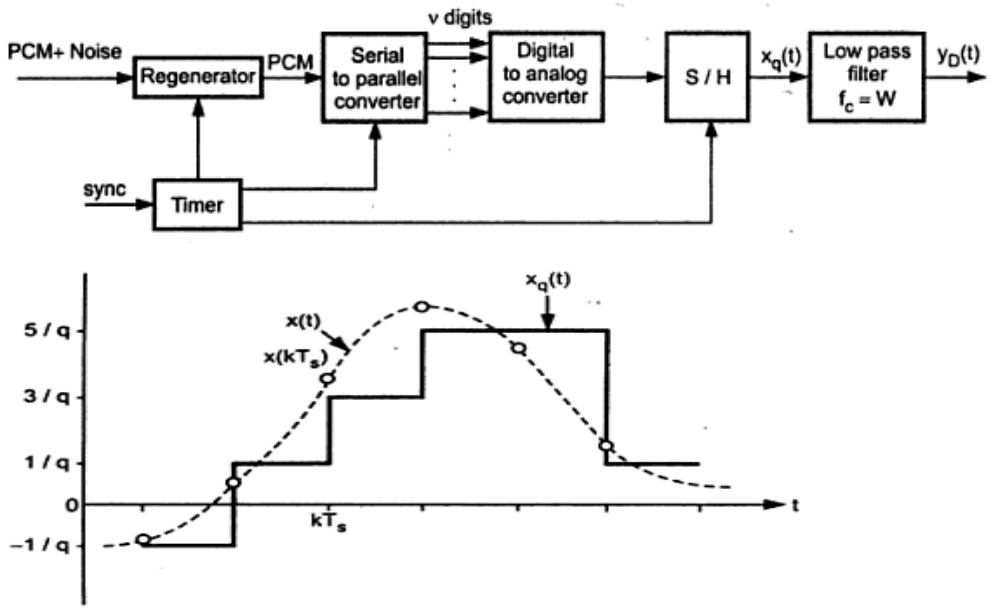
1mark

The pulse code modulator technique samples the input signal $x(t)$ at frequency $f_s \geq 2W$. This sampled 'Variable amplitude' pulse is then digitized by the analog to digital converter. The parallel bits obtained are converted to a serial bit stream.

In the PCM generator of above figure, the signal $x(t)$ is first passed through the low-pass filter of cutoff frequency 'W' Hz. This low-pass filter blocks all the frequency components above 'W' Hz. Thus $x(t)$ is bandlimited to 'W' Hz. The sample and hold circuit then samples this signal at the rate of f_s. Sampling frequency f_s is selected sufficiently above Nyquist rate to avoid aliasing i.e., $f_s \geq 2W$

A q-level quantizer compares input $x(nT_s)$ with its fixed digital levels. It assigns any one of the digital level to $x(nT_s)$ with its fixed digital levels. It then assigns any one of the digital level to $x(nT_s)$ which results in minimum distortion or error. This error is called *quantization error*. Thus output of quantizer is a digital level called $x_q(nT_s)$.

PCM Receiver :



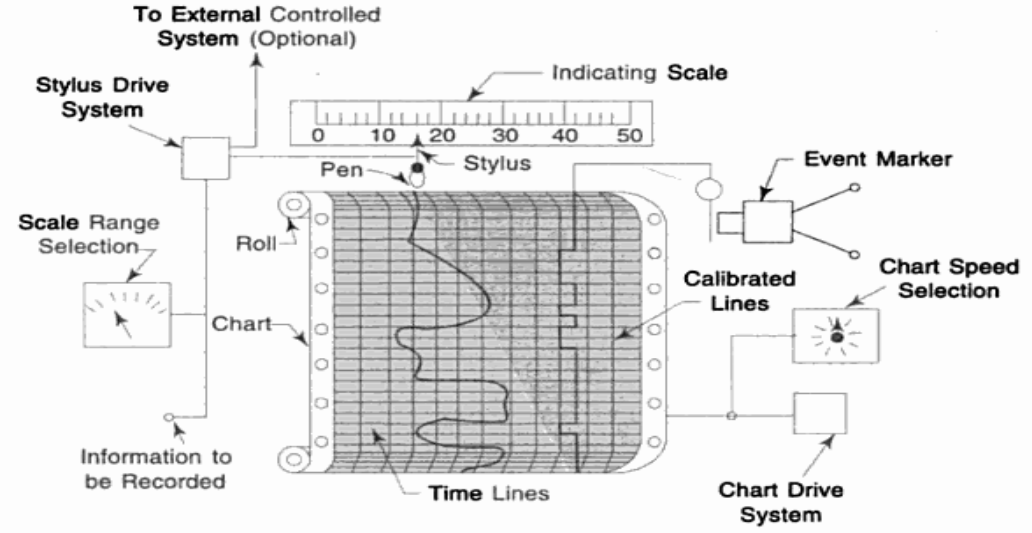
1mark

Reconstructed signal

The digital word is converted to its analog value $x_q(t)$ along with sample and hold. This signal, at the output of S/H is passed through lowpass reconstruction filter to get $y_D(t)$. As shown in reconstructed signal of it is impossible to reconstruct exact original signal $x(t)$ because of permanent quantization error introduced during quantization at the transmitter. This quantization error can be reduced by increasing the binary levels. This is equivalent to increasing binary digits (bits) per sample. 1mark

Therefore the choice of these parameters is made, such that noise due to quantization error (called as quantization noise) is in tolerable limits.

6 e) Strip Chart Recorder :



2 marks

- It consists of long roll of graph paper known as chart, moving vertically, and is usually graduated in rectilinear coordinates. The chart is usually driven by a synchronous motor equipped with a speed selector switch to change the chart speed conveniently in fixed increments.
- A stylus is used for making marks on the moving chart which moves horizontally, proportional to the quantity being recorded.
- A range selector is used so that the input to the recorder drive system is within the acceptable level.
- To eliminate overprinting entirely because of coincidence of records, the minimum chart speed required can be calculated from the following formula: 2 marks

Minimum chart speed, in/hr. = 225/printing interval, sec