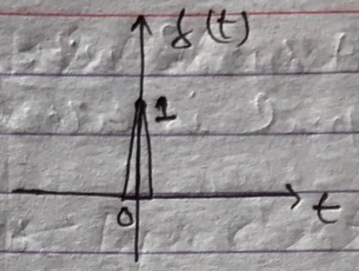
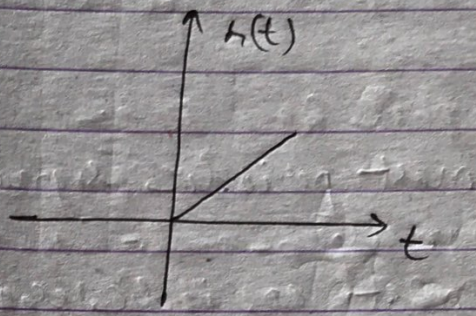
(vii) Unit Impulse signal :-

$$\delta(t) = \begin{cases} 1 & \text{for } t = 0 \\ 0 & \text{otherwise} \end{cases}$$



(viii) Ramp signal :-

$$r(t) = \begin{cases} t & \text{for } t \geq 0 \\ 0 & \text{otherwise.} \end{cases}$$



Chapter :- 6

Output Devices (3 hrs) :-

Imp ① Graphic Recorder.

ⓐ Strip chart Recorder. Eg. ECG machine

ⓑ X-Y Recorder

② Magnetic Tape Recorder.

One of the important consideration in an instrumentation system is the method by which the data acquired is recorded. A recorder records electrical and non-electrical quantities as a function of time. The recording method should be consistent with the type of system. If we are dealing with wholly analog system, then analog recording techniques should be used. On the other hand, if the system has a digital output, digital recording devices are used. Thus, there are two types of recording devices:

(i) Analog Recorders and

(ii) Digital Recorders.

Analog Recorders:-

They can be broadly classified into:

✓ (i) Graphic Recorders
(ii) Oscillographic Recorders
✓ (iii) Magnetic Tape Recorders

Graphic Recorders:-

Graphic Recorders are devices which display and store a pen-and-ink record of the history of some physical event. Basic elements of a recorder include a chart for displaying and storing the recorded information, a stylus moving in a proper relationship to the paper and suitable means of interconnection to couple the stylus to the source of information. It is of two types:-

(i) Strip chart Recorders:-

A strip chart Recorder records one or more variables with respect to time. It is an X-t recorder.

(ii) X-Y Recorders:-

An X-Y recorder records one or more dependent variables with respect to an independent variable.

Strip Chart Recorder :-

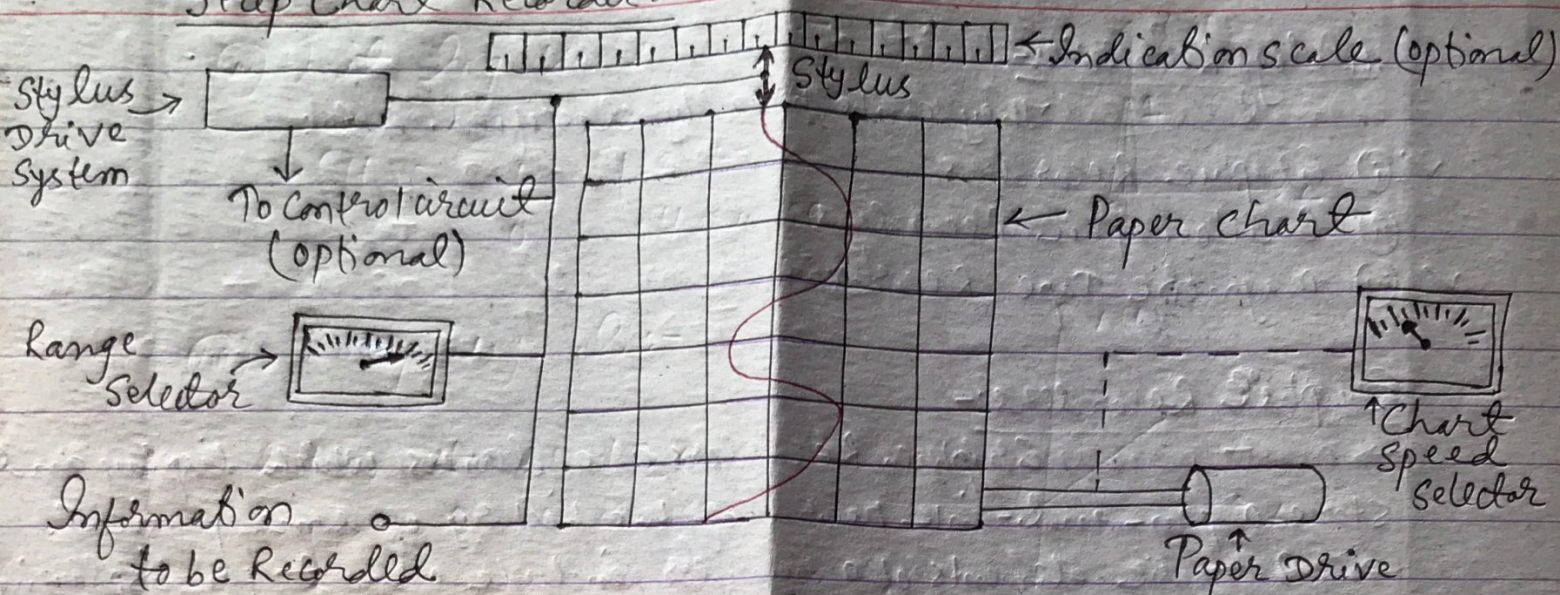


Fig. Strip chart Recorder

Figure shows basic constructional features of a strip chart recorder. A strip chart recorder consists of :

① A long roll of graph paper moving vertically.

② A system for driving the paper at some selected speed. A speed selector switch is generally provided. chart speeds of 1-100 mm/s are usually used.

③ A stylus for making marks on the moving graph paper. The stylus moves horizontally in proportional to the quantity being recorded.

④ A stylus driving system which moves the stylus in a nearly exact replica or analog of the quantity being recorded.

⑤ A range selector switch is used so that input to the recorder drive system is within the acceptable level.

Most recorders use a pointer attached to the stylus. This pointer moves over a calibrated scale thus showing the instantaneous value of the quantity being recorded. An external control ckt for the stylus maybe used.

It is used to indicate, record and control, and used in refineries, steel plants, paper mills etc.

ROLL No. NAME

X-Y Recorder :-

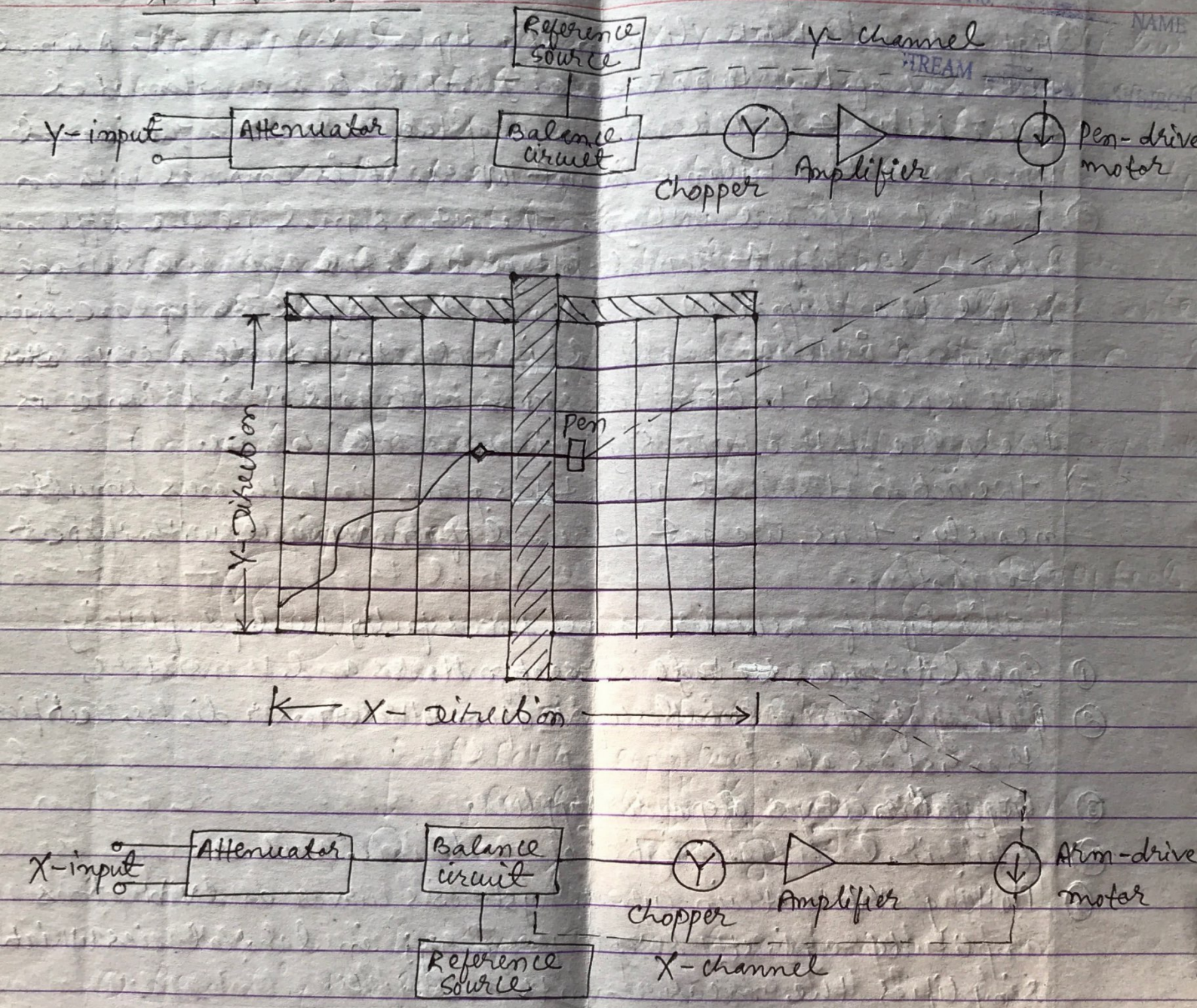


Fig. X-Y Recorder

An X-Y Recorder consists of a pair of servo-systems, driving a recording pen in two axes through a proper sliding pen and moving arm arrangement with reference to a stationary paper chart. Attenuators are used to bring the input signals to the levels acceptable by the recorder.

Figure shows a block diagram of a typical X-Y recorder. A signal enters each of the two channels. The signals are attenuated to the inherent full scale range of the recorder. The signal then passes to a balance circuit where it is compared with an internal reference voltage. The error signal i.e the difference between the input signal voltage and the reference voltage is fed to a chopper which converts d.c. signal to an a.c. signal. The signal is then amplified in order to actuate a servomotor which is used to balance the system and hold it in balance as the value of the quantity being recorded changes.

The action described above takes place in both axes simultaneously. Thus, we get a record of one variable with respect to another.

This type of recorder can be successfully used for

1. Speed torque characteristics of motors.
2. Plotting of characteristics of vacuum tubes, zener diodes, rectifiers, transistors etc.
3. Regulation curves of power supplies.
4. Electrical characteristic of materials.
5. Plotting stress-strain curves, hysteresis curves and vibrations amplitude against swept frequency; in laboratories which simplifies the measurements and tests.

Magnetic Tape Recorder:-

The strip chart recorder and x-y recorder are basically low frequency recorders but magnetic tape recorders have response characteristics which enable them to be used at higher frequencies. Therefore, magnetic tape recorders are extensively used in instrumentation system.

Recording data in such a way that it can be retrived or reproduced in electrical form again, is frequently desirable and necessary. magnetic tape recordings the most common and most useful way of achieving this.

A magnetic tape recorder consists of the following basic components:

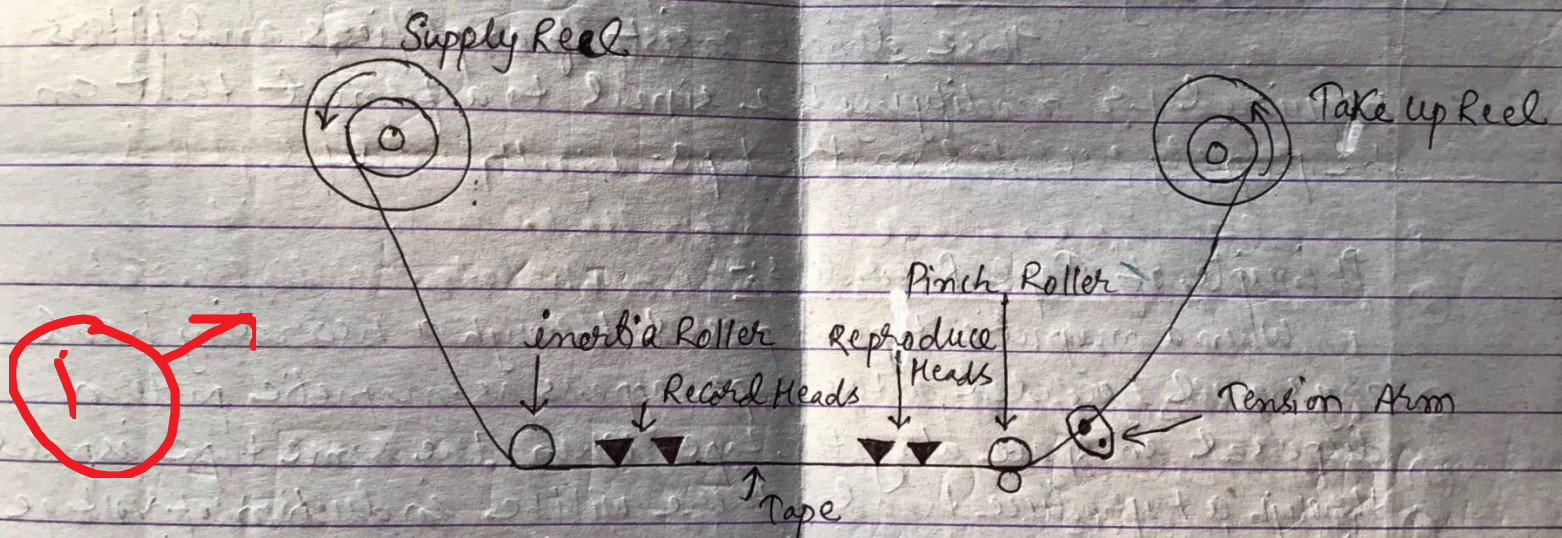


Fig: Tape Transport mechanism

① Recording Head:-

This device responds to an electrical signal in such a manner that a magnetic pattern is created in a magnetisable medium.

② Magnetic Tape:-

It is composed of a coating of fine magnetic iron oxide particles (Fe_2O_3) on a plastic ribbon. A typical tape is 12.7 mm wide and 25.4 μm thick.

③ Reproducing Head:-

It detects the magnetic pattern stored in them and converts it back to original electrical signal. It is similar in appearance to that of a recording head.

④ Tape Transport mechanism:-

This mechanism moves the tape along the recording or the reproducing heads at a constant speed. The tape mechanism must be capable of handling the tape during various modes of operation without straining, distorting or wearing the tape. Arrangements for fast winding and reversing are also provided.

⑤ Conditioning Devices:-

These devices consist of amplifiers and filters required for modifying the signal to a format that can be properly recorded on the tape.

Principle of Tape Recorders:-

When a magnetic tape is passed through a recording head, any signal recorded on the tape appears as magnetic pattern dispersed in space along the tape. When the same tape is passed through a reproduce head, there will be induction of voltage in the tape by magnetization. The induced voltage is proportional to the rate of change of flux linkages given by

$$e_{rep} \propto N \frac{\partial \phi}{\partial t}$$

Where N is the number of turns of the winding put on the reproduce head.

Thus, the output signal from the reproduce head is a derivative of the input signal. The magnitude of the output signal is not only proportional to the flux recorded on

the tape but also the frequency of the recorded signal.

Advantages of Magnetic Tape Recorders:-

1. Magnetic tape recorders have wide frequency range.
2. They have a low distortion.
3. The magnitude of the electrical input signal is stored in magnetic memory and this signal can be reproduced whenever desired.
4. The recorded signal is immediately available with no time loss in processing and can be played back as many times as desired without loss of signal.
5. When the information has been processed, the tape can be erased and reused to record a new set of data.
6. It permits multi-channel recording.
7. Data maybe recorded at very fast speeds (1.52 or 3.05 m/s) and played back at speeds (4.76 or 2.38 cm/s) slow enough to be recorded with low frequency recorders.

Indicating instruments:-

An instrument is a device for determining the value or magnitude of quantity or variable. Indicating instruments are those instruments which indicate the magnitude of a quantity being measured. They generally make use of a dial and a pointer for this purpose. Eg. Ordinary voltmeters, ammeters and wattmeters.

Chapter :- 7 (3hrs)

Data Acquisition Systems:-

Data acquisition systems via analog signals are used in communications, electronic and medical applications. Conversion to digitized systems is widely used today because complex circuits are low cost, accurate, simple to implement.

Data-acquisition systems are used to measure and record analog signals in basically two different ways:

(i) Signals which originate from direct measurement of electrical quantities: These signals may be d.c. or a.c. voltages, frequency or resistance, etc.

(ii) Signals which originate from use of transducers.

Components of an Analog Data Acquisition System:-

An analog data acquisition system typically consists of some or all of the following elements:-

① **Transducers:-**

It is desirable that an emf. obtained from the transducer proportional to the quantity being measured, is used as an input to the data-acquisition system. Transducers such as thermocouples, strain gauge bridges, piezo-electric devices and photosensitive devices are used.

② **Signal Conditioning Equipment:-**

It includes any equipment that assists in transforming the output of transducer to the desired magnitude or form required by the next stage of the data acquisition system. Signal conditioners may include devices for amplifying, refining or selecting certain position of signals. Examples of signal conditioning equipment include voltage amplifiers, servo systems, temperature control devices for thermocouple junctions etc.

③ Multiplexer :-

Multiplexing is the process of sharing a single channel with more than one input. It is a means of using the same transmission channel for transmitting more than one quantity. Thus, a multiplexer accepts multiple analog inputs and connects them sequentially to one measuring input. Multiplexing becomes necessary in measurement systems when the distance between transmitting and receiving points is large and many quantities are to be transmitted. If a separate channel is used for each quantity, the cost of installation, maintenance, and periodic replacement becomes large and hence, a single channel is used, shared by the various quantity. It may by TDM or FDM.

④ Calibrating Equipment :-

Before each test there is a pre-calibration and often after each test there is a post-calibration. This usually consists of a millivolt calibration of all input circuits and shunt calibration of all bridge type transducer circuits.

⑤ Integrating Equipment :-

It is often desirable to know the integral or summation of a quantity. An analog integrating circuit can be used for a qualitative test. It has the possible danger of becoming overloaded and also its accuracy is low. Thus, digital techniques are normally used for integration purposes.

⑥ Visual Display Devices :-

They are required for continuous monitoring of the input signals. Examples are CROs, numerical displays, panel mounted meters etc.

⑦ Analog Recorders :-

They are the means for recording data in analog form. Examples are strip chart recorders, magnetic tape recorders etc.

⑧ Analog Computers :-

An analog computer maybe used as a data reduction device. The output voltage of an analog computer can either be recorded in analog form or be converted to a digital form for recording and further computations.

⑨ High Speed Cameras and TV Equipment :-

Closed circuit TV is used to enable the operator to make visual observations of the test. Also, high speed cameras are employed to obtain a complete visual record of the process for further analysis.

Digital Data Acquisition System :-

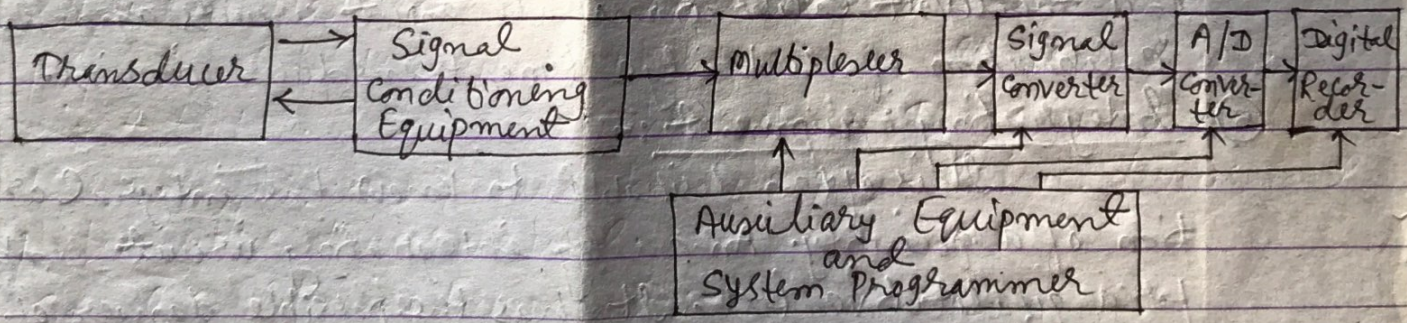


Fig. Digital Data Acquisition System.

A digital data acquisition system may include some or all of the components shown. The various components and their functions are described below:

① Transducers :-

They convert a physical quantity into an electrical signal which is acceptable by the data acquisition system.

ROLL No. NAME SUBJECT

② Signal conditioning Equipment:- } Already described on
③ Multiplexer:- } Analog Data Acquisition System.

④ Signal converter:-

A signal converter translates the analog signal to a form acceptable by the A/D converter. Example is an amplifier for amplifying the low-level signal voltages produced by the transducers.

⑤ A/D converter:-

An A/D converter converts the analog voltage to its equivalent digital form. The output of the A/D converter may be fed to digital display devices for visual display or may be fed to digital recorders for recording. It may be fed to digital computer for data reduction and further processing.

⑥ Digital Recorder:-

They record information in digital form either in optical devices or in magnetic devices.

⑦ Auxiliary Equipment:-

This contains devices for system programming functions and digital data processing. Typical functions such as linearization and limit comparision of signals. Example is a digital computer.

Uses of Data Acquisition Systems:-

Data acquisition systems are being used in a variety of industrial and scientific areas including aerospace, biomedical and telemetry industries. The type of data acquisition system to be used depend upon the application and the intended use of recorded input data.

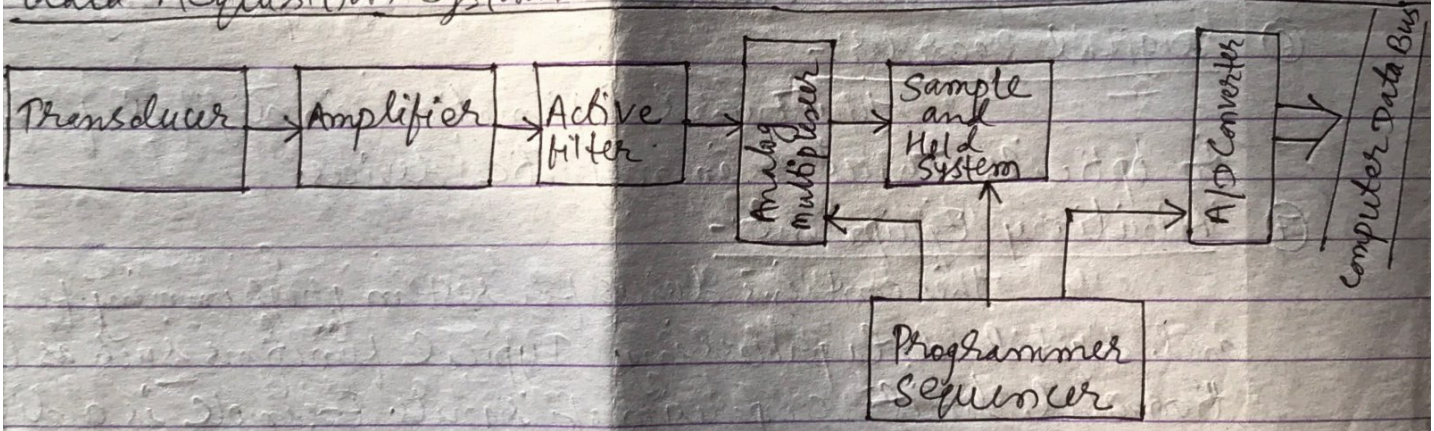
Analog data acquisition systems are used when wide

frequency width is required or when lower accuracies can be tolerated.

Digital Data Acquisition systems are used when the physical quantity being monitored has a narrow bandwidth i.e. when the quantity varies slowly. They are also used when high accuracy and low per channel cost is required.

Digital data Acquisition systems are in general more complex than analog systems both in terms of instrumentation involved and the volume, and complexity of the data they can handle.

Modern Digital Data Acquisition system / modern trends in data Acquisition system:-



The input to the system is a physical parameter, such as temperature pressure, flow, acceleration or position, which are analog quantities. The parameter is first converted into an electrical signal by means of a transducer; Once in electrical form, all further processing is done by electronic circuits.

Next an amplifier or signal conditioner boosts the amplitude of the transducer output signal to a useful level for further processing. Transducer outputs may be microvolt or millivolt level signals, which are then amplified to 1 to 10 V levels. Furthermore

the transducer output may be a high impedance signal, a differential signal with common-mode noise, a current output, a signal superimposed on a high voltage or a combination of these. The amplifier, in order to convert such signals into a high level voltage, may be one of several specialised types.

The amplifier is frequently followed by a low-pass active filter, which reduces high-frequency signal components, unwanted electrical interference noise or electronic noise from the signal. The amplifier is sometimes also followed by a special nonlinear analog function circuit that performs a nonlinear operation (squaring, multiplication, division, rms conversion, log conversion or linearization) on the high-level signal.

The processed analog signal next goes to an analog multiplexer, which sequentially switches between a number of different analog input channels. Each input is in turn connected to the input of the multiplexer for a specified period of time by the multiplexer switch. During this connection time, a sample-hold circuit acquires the signal voltage and then holds its value while an analog to digital converter converts the value into digital form. The resultant digital word goes to a computer data bus or to the input of a digital circuit.

Thus, the analog multiplexer, together with the sample-hold, time shares the A/D converter with a number of analog input channels. The timing and control of the complete data-acquisition system is done by a digital circuit called a programmer-sequencer, which in turn is under control of the computer. In some cases, the computer itself may control the entire data-acquisition system.