CHAPTER 6

OUTPUT DEVICES

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6.1 INDICATION 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. The generally make use of a dial and a pointer for this purpose.

For example; voltmeter, ammeter, wattmeter

Essential system of indicating instruments are,

a) **A deflections system**

It is that part of the instrument mechanism which utilize some physical effect of electric current or voltage to produce a mechanical force. This deflection or force causes the system along with the pointer attached to it to move from its zero position. The magnitude of the deflection force depends on the value of electrical quantity to be measured.

b) **A controlling system**

It is the part of the instrument which brings into play a force called controlling force. This force opposes the deflection force and increases with the increase in the deflection of the moving system, to limit its movement. The pointer is brought to rest at a position where the two opposing forces *i.e.*, deflection and controlling forces are equal.

Types of controlling system

i) Spring control

ii) Gravity control

c) A damping system

It is that part of the instrument which provides damping force to damp the oscillations of the pointer before come to a rest. Because of the inertia, the pointer of the instrument oscillates about its final deflected position for some time before coming to rest. This causes the waste of time in taking reading, thus damping force act as a brake to prevent the oscillations of the moving system and brings the pointer to its final deflected position quickly.

6.2 MAGNETIC DATA RECORDERS

The magnetic tape recorders are used for high frequency signal recording. The basic components of magnetic tape recorder are,

a) Recording head

Its construction is similar to that of transformer having toroidal core with a coil. The fine air gap length 5 - 15 μm is shunted by passing magnetic tape. When the current used for recording is passed through the coil wound around magnetic core, it produces magnetic flux. The magnetic tape having iron oxide particles passes the head, the magnetic flux produced gets linked with the iron oxide particles and these particles get magnetized. The state of magnetization of the oxide as it leaves the gap is retained, thus the actual recording takes place at the trailing edge of the gap.

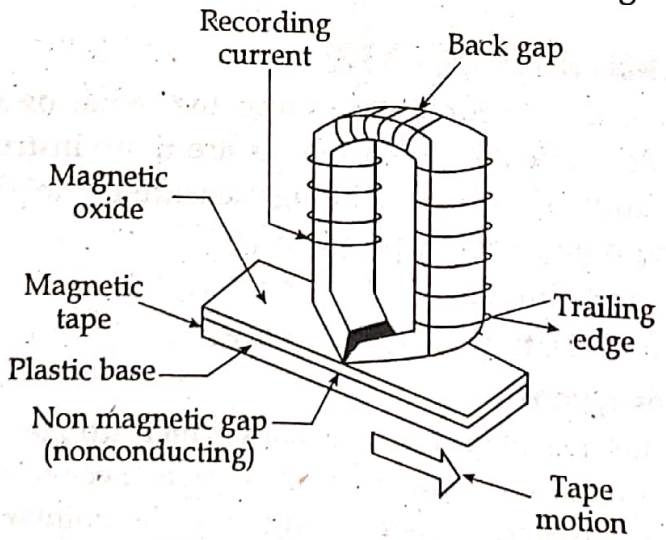

Figure: Recording head

Any signal recorded on the tape appears as a magnetic pattern dispersed in space along the tape, similar to the original coil current variation with time.

b) Magnetic tape

It is made of a thin sheet of tough, dimensionally stable plastic, one side of which is coated with a magnetic material. Typically, the plastic base is polyvinyl chloride or polythene terephthalate. The magnetic coating consists of a dispersion of very small particles of iron oxide on a plastic blinder.

c) Reproducing head

Its function is to detect the stored magnetic pattern and to convert it back to original electrical signal. It is similar in appearance to that of recording head.

d. Tape transport mechanism

Figure below shows the tape transport mechanism. It moves the magnetic tape along the recording head or reproducing head with a constant speed. The magnetic tape is wound on reel. There are two reels, one is called as supply reel and other is called as take up reel. Both reels rotate in same direction. The transportation of the tape is done by using reel and take up reel. The rollers are used to drive and guide the tape.

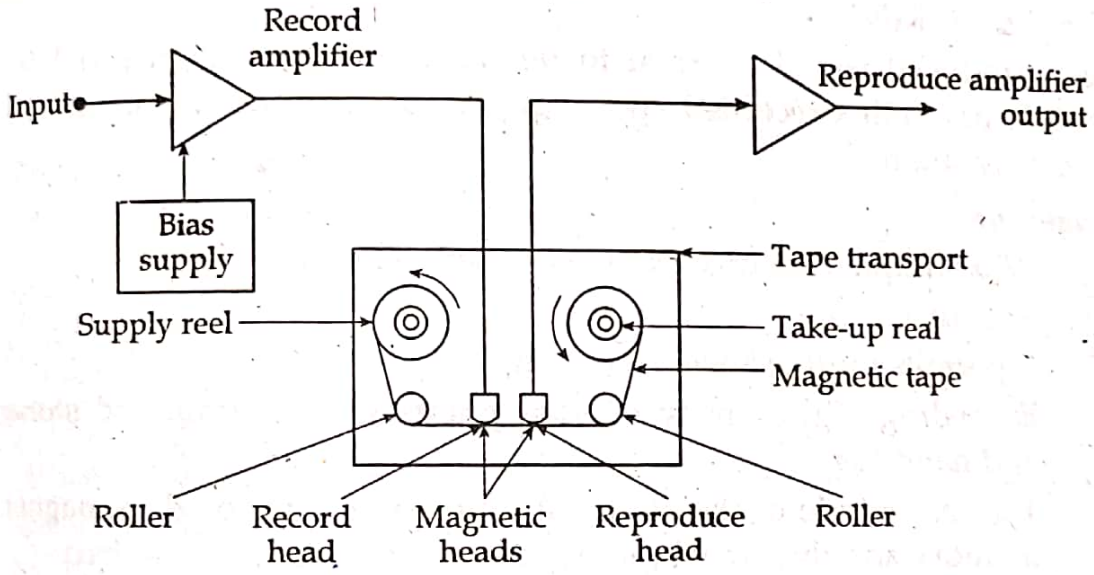

Figure: Tape transport mechanism

The tape transport mechanism performs the following tasks:

i) To handle the tape without straining and wearing it.
ii) To guide the tape across magnetic heads with great precision.
iii) To maintain uniform and sufficient gap between the tape and heads.
iv) To maintain proper tension of magnetic tape.

e) Conditioning devices

These devices consists of amplifiers and filters to modify signal to a format that can be properly recorded on tape. Amplifier amplifies the signal to be recorded while filters remove unwanted ripple quantities.

Operating Principle

When a magnetic tape passes through a recorders head, the signal to be recorded appears as some magnetic pattern on tape. The 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 induced corresponding to the magnetic pattern on the tape. The induced voltage depends on the direction of magnetization and its magnitude on the tape. The emf thus produced is proportional to the rate of change of magnitude of magnetization,

$$e \propto N \frac{d\phi}{dt}$$

where, N = Number of turns of the winding put on reproducing head

Let assume that the original signal is A sinω.

The current in the recording head winding and the flux produced will be proportional to this voltage.

$$\phi = K_1 \cdot A \sin \omega t$$

where K_1 is constant

Thus the voltage induced in the reproducing head winding is,

$$e_{rep} = N\frac{d\phi}{dt} = \frac{Nd}{dt}(K_1 A \sin \omega t) = K_1 NA\, \omega \cos \omega t = K_2 A\, \omega \cos \omega t$$

where, $K_2 = K_1N$.

The reproduced signal is equal to derivative of input signal and it is proportional to flux recorded and frequency of recorded signal. *i.e.*, It act as a differentiator.

Advantages

i) Wide frequency range from DC to several mHz
ii) Low distortion
iii) It permits multichannel recording
iv) Exceeding high density of data points giving simplified storage and handling.
v) The magnitude of the electrical input signal is stored in magnetic memory and this signal can be reproduced whenever desired.
vi) Data can be recorded very fast speed and played back at speeds slow enough to be recorded with low frequency recorders.
vii) 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.

Applications

i) Communication surveillance and spying
ii) Medical research
iii) Data recording and analysis on missiles, air crafts and satellites
iv) Industrial research and production monitoring and control.
v) As a medium for transfer of files to another devices and for back up of files.

6.3 STRIP CHART, X-Y DISPLAY AND PLOTTER

6.3.1 Strip Chart Recorder

A chart recorder is an electromechanical device that records an electrical or mechanical input trend onto a piece of paper (chart). Chart recorders may record several inputs using different color pens and may records onto strip charts or circular charts. Chart recorders may be entirely mechanical with clockwise mechanisms or electro mechanical with an electrical clockwork mechanism for driving the chart (with mechanical or

pressure inputs) or entirely electronic with no mechanical components at all (a virtual chart recorder).

The strip chart recorder often used for the application which requires monitoring the quantity. A roll of paper is continuously moved under the pen and a continuous record is maintained. Strip chart recorders are generally multi range voltmeter with a speed range selector to control the paper feed. A strip chart recorder plots one or more parameters as a function of time. A strip is a ribbon of paper moved through the instrument at uniform speed by an electric motor.

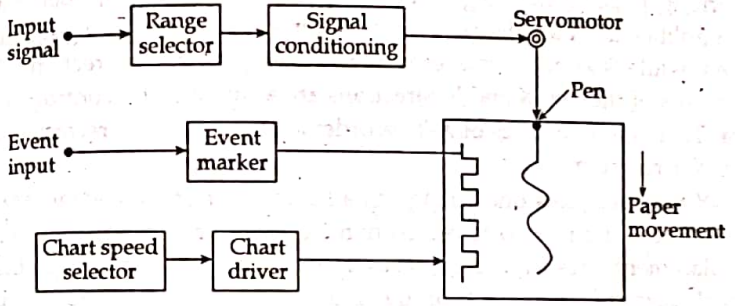

Figure: Strip chart recorder

The basic element of this recorder is pen for making and chart paper for recording data. The quantity to be measured is given as to the input to the range selector. The range selector switch keeps data within the limit. The stylus moves along the calibrated scale in accordance with input data. To get proper records of input data, signal conditioning black is used which gives proper input signal along calibrated scale. The chart paper moves vertically at a uniform speed. The speed selector selects the required speed of the chart paper movement.

There are many mechanisms for marking the marks on the chart paper. They are,

i) Pen and Ink stylus
ii) Impact printing
iii) Chopper bar printing
iv) Thermal writing
v) Optical writing
vi) Electrical writing

Advantages of strip chart recorder

i) Relatively large amount of paper can be inserted at one time.
ii) Data conversion is easier with rectangular coordinate system.
iii) More than one separate variable can be recorded on a strip chart.
iv) The rate of movement of the chart can be easily changed.

Disadvantages of strip chart recorder

i) Complicated mechanism

Application of strip chart recorder

i) In temperature recorder
ii) In sound level recording
iii) Recording amplifier drift

6.3.2 X-Y Recorder or Display Unit

X-Y recorder is an instrument which gives a graphic record of the relationship between two variables.

This system has a pen which can be positioned along the two axes with the writing paper remaining stationary. There are two amplifier units. One amplifier actuates the pen in the Y-direction as the input signal is applied while second amplifier actuates the pen in X-direction. The movements of the pen X and Y directions are automatically controlled by motor. There are two types of X-Y recorders *i.e.*, Analog X-Y recorder and digital X-Y recorder.

The X-Y recorder plots one voltage as a function of other voltage. Many times X-Y recorder is used to record non electrical physical quantity such as displacement, pressure, strain etc as a function of another non electrical physical quantity. The trace of the marking pen will be due to the combined effects of two signals applied simultaneously. In this recorder, an emf is plotted as a function of another emf.

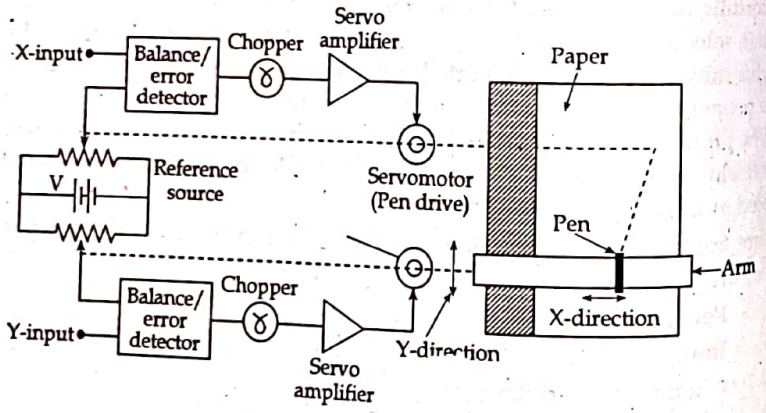

Figure: Analog X-Y recorder

A signal enters in 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 balance circuit compares attenuated signal to a fixed reference voltage. The output of error detector is a difference between the variation in input signal and reference voltage. The balancing circuit and error detector gives error signal. The error signal is DC signal. The chopper circuit converts error signal to AC signal. The signal is then applied to the servo amplifier. The servo amplifier drives servomotor which drives

writing assembly on a fixed graph paper. There are two circuits for two different inputs to be recorded. The same action take place in both axes simultaneously.

Advantages

i) Zero offset adjustments are available
ii) This recorder records the relationship between two physical quantities instantaneously.
iii) The relationship between either electrical or non electrical quantities can be recorded.

Applications

i) Plotting of stress-strain curves, hysteresis curves.
ii) Plotting speed-torque characteristics of motor.
iii) Plotting pressure-flow studies for lungs.
iv) Regulation curves of materials.
v) Pressure-volume diagrams of IC engines.
vi) Electrical characteristics of materials such as resistance versus temperature and plotting the output from electronic calculators and computers.
vii) Lift drags wind tunnel tests
viii) Plotting characteristics of vacuum tubes, zener diodes, rectitiers, transistors etc.

6.3.3 Plotter

A plotter is a computer printing device for printing vector graphics. In the past, the plotters were widely used in applications such as computer aided design, though they have generally been replaced with wide format conventional printers, and it is now common place to refer to such wide format printer as plotters. A plotter is a pen based output device that is attached to a computer for print large format graphs or maps such as construction maps or engineering drawings. The images are created by a series of many straight lines. It is used to draw high resolution graphs.

A plotter is a special output device used paper. Plotters are divided into two types;

i) Drum plotter
ii) Flatbed plotter

Main use of plotter

i) Use in computer aided design (CAD) and computer aided manufacturing (CAM) applications.
ii) Use in printing the plans for house or car parts.
iii) Use in program like auto-CAD to give graphic outputs.

6.4 BOARD EXAM QUESTIONS SOLUTION

1. **Define the output device with examples.**

[2011/S, 2012/F, 2012/S, 2013/F]

Solution:

The data presentation devices are called as output device. The output devices are not only limited to display devices for indicating the output but it is also used as control device examples: speaker, monitor, printer, projector, plotter etc.

2. **With the help of necessary diagram, explain the working principle of magnetic tape recorder, hence verify that it act as a differentiator.** [2014/F, 2016/F]

OR

Explain the magnetic tape recorder with its application.

[2011/F, 2011/S, 2012/F, 2013/F, 2013/S, 2015/F]

Solution: See the definition of 6.2

3. **Clarify the principle of operation of X-Y recorder with its application area.** [2012/S, 2013/F, 2014/S, 2015/S, 2016/S, 2018/S]

Solution: See the definition of 6.3.2 .

4. **Explain the principle of operation of strip chart recorder with its application area.** [2015/S, 2017/F, 2018/F]

Solution: See the definition of 6.3.1

5. **List the advantages of magnetic tape recorder.** [2018/F]

Solution: See the definition of 6.2

6. **Give the functional details of types of recorder which can be employed for plotting the current versus voltage curve of any transistor and diodes.** [2017/S]

Solution: See the definition of 6.3.2 *i.e.*, X-Y recorder.