

# Introduction to Instrumentation System:

## Instrument :

An instrument may be defined as a device for determining magnitude of a quantity for a physical variable.

## Measurement and Measurement System :

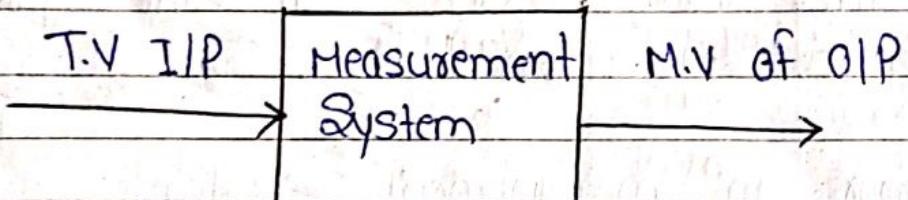


Fig: Block diagram of measurement system.

T.V → True value of quantity.

M.V → measured value of quantity.

Instrumentation is the operation for determining the value of the quantity. A measurement or instrumentation system is a means used to carry-out the measurement. It generally involve using an instrument as a physical means of determining a quantity or variable.

The purpose of measurement system is to give the user numerical value corresponding to the variable be measured. For variety of reasons, the numerical value may not actually be the true value of the variable.

Due to various errors, the measured values (M.V) will not be exactly equal to true value (T.V) of the quantity under Measurement.

### # Error in measurement system:

$$\text{Error} = T.V - M.V$$

$$\% \text{ Error} = \frac{T.V - M.V}{T.V} \times 100 \%$$

(1) Gross Error      (2) Systematic Error      (3) Random Error.

(a) Instrumental Error

(b) Environmental Error

### (1) Gross Error

All errors committed by the user are included in gross error. The error includes the error due to calculation, observation connection etc.

### (2) Systematic Error

① Instrumental Error : All the errors due to the short coming of instruments comes under instrumental error. The error includes the error due to less accuracy in the scale calibration, the error due to improper tension in the string.

### ② Environmental Error

All the errors due to the effect of surrounding comes under environmental error such as error due to effect of change in temperature, pressure, humidity also the error due to the effect of external electrostatic and magnetic field.

### ③ Random Error

Random error occurs due to the random variation of physical quantity. To minimize the random error, statistical analysis

must be applied only after minimizing gross error and systematic errors.

#

## Components of an Instrumentation or Measurement System :

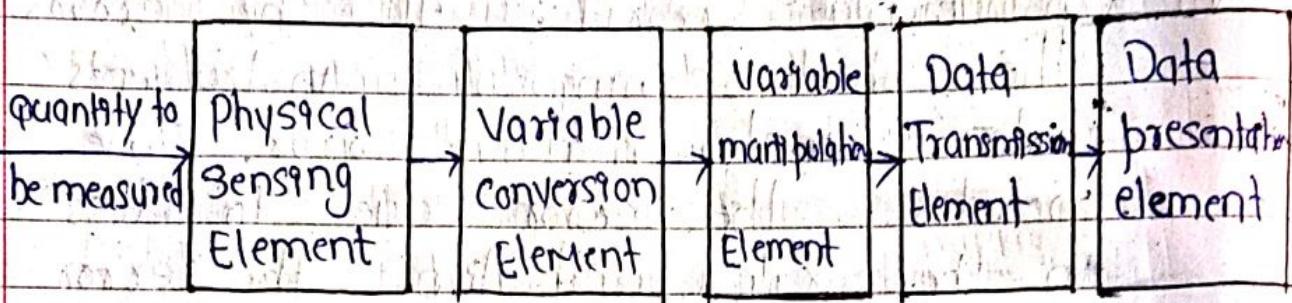


Fig: Block Diagram of Instrumentation System.

Instrumentation is a physical system which is a collection of physical objects combined in such a way that to give the desire output or response. It is a group of devices so combine by nature or art to form an integral whole and to function operate or move in a union.

An electronic amplifier composed many component is an example of instrumentation system as shown above.

## # Components of an Instrumentation or Measurement System.

An instrumentation system contains the following functional elements.

### 1) Primary Sensing element:

The primary sensing elements converts one form of energy (non-electrical) to another form (electrical) of energy. The physical quantity to be measured in the first place is sensed and detected by element which gives the output in different analogous form.

This output is then converted into an electrical signal by transducer. The first stage of instrumentation system is known as detector transducers stage.

### 2) Variable conversion element:

The output of primary sensing element may be electrical signal of any form like voltage, current, frequency, or some other electrical parameters. Sometime this output is not suited to the system for the instrument to be performed the desire function. It may be necessary to convert these output to

desire form while preserving the information content of the original signal.

Voltage to Current, analog to digital conversion are the example of variable conversion element.

3)

### Variable Manipulation Element :

The function of this element is to manipulate the signal presented to it preserving the original nature of the signal. Manipulation means changing numerical value according to definite value but preservation of physical nature of variable. eg: electrical Amplifier.

4)

### Data Transmission Element :

When the elements of instruments are physically separated, it becomes necessary to transmit data from one place to another. An element performing such function is known as data transmission element.

During satellite communication, tracking, control signals are sent from earth-station to satellite using radio-link known as

## Data transmission elements.

### 5) Data presenting Element :

The information about the quantity under measurement has to be conveyed or transferred to the person handling the instrument or the system for monitor or control or analysis purpose. It must be put into a form known by one of human sense. The element which performs such translation is called data presentation element. Visual display device, magnetic tape are the example of data presentation element.

## # Types of Instrumentation System

### i) Analog Instrumentation :

Analog System are configured entirely of component that measure, transmit, display or record data in only analog form. Such analog system find lower accuracy and required wide band width. It contains a pointer or needle.

## 27 Digital Instrumentation :

Digital system are configured entirely of component that measure, transmit, display or record data in only digital form. Such system find less noise, high accuracy. It contains digital display unit.

### # Comparison between Analog and Digital Instrument

S.N	Factor	Analog Instrument	Digital Instrument.
1)	Information Factor.	As the position of pointer against the calibrated scale.	As a number on digital display.
2)	presence of moving part.	Moving part involve.	Does not involve.
3)	Possibility of human error.	Exists.	Does not exist.
4)	Rate of change of parameter.	These instrument enable the operator to judge the rate of change of parameter by observing the pointer.	Digital display unit doesn't give any reading of digital meter is fast.
5)	Time required to observe parameter.	Reading of analog system takes some time.	Reading of digital meter is fast.
eg:		Filter circuits, Audio-completer etc	Traffic control, Digital TV.

# TYPES OF SIGNALS:17 Analog ~~System~~ Signal.

07 Digital Signal.

## 17 Analog Signal :

The Signal whose ~~signal~~ amplitude, varies continuously for all the time with time i.e both amplitude and time are continuous over their respective interval.

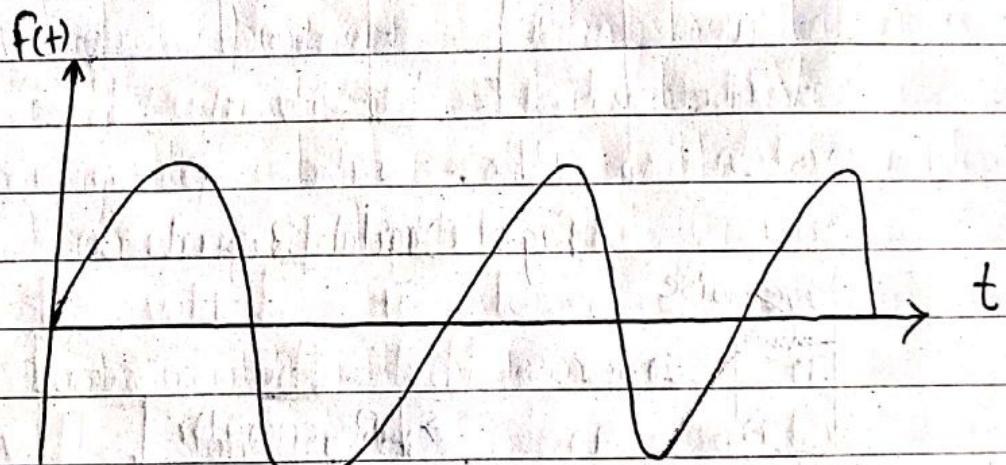
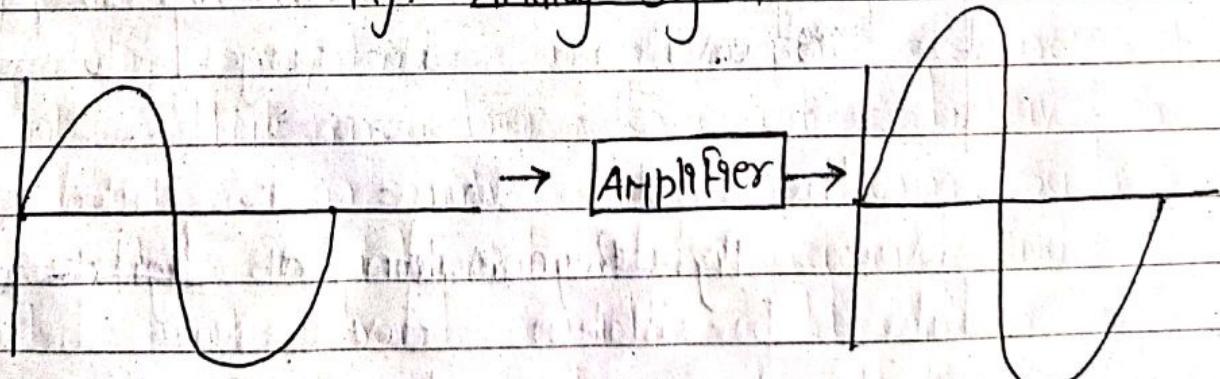


fig: Analog Signal



IIP Signal

OIP Signal

fig: Amplification of analog signal

27

## Digital Signal / Discrete Signal :

Digital signals are those signals that are obtained when discrete time signals are quantized and then coded. It is defined only at discrete stand of time. Independent variables takes only discrete values which are usually uniformly spaced.

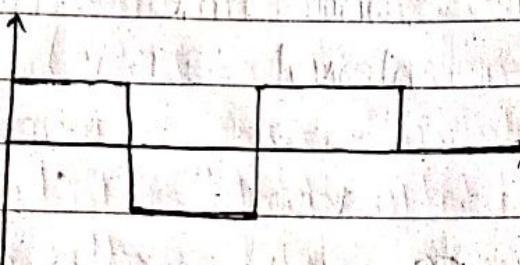


Fig: Digital Signal

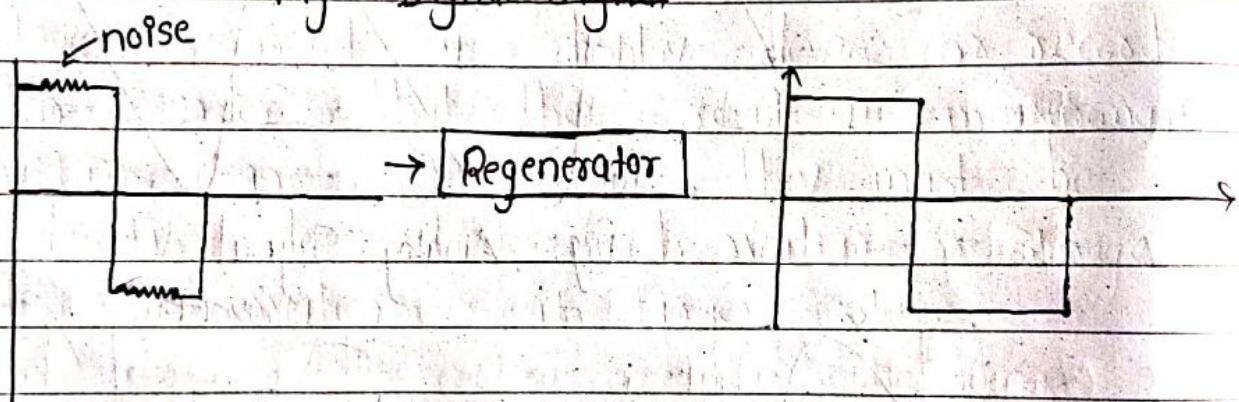


Fig: Regeneration of digital signal :

## # Signal Conditioning and Transmission:

The quantity is detected and transduced into an electrical form in most of the cases before transmission. The output of first stage has to be modified before it becomes usable and satisfactory to drive the signal presentation stage. Measurement of dynamic physical quantities required faithful representation of their analog or digital output obtained from the intermediate stages i.e. Signal Conditioning stage.

The Signal conditioning equipment may be required to do linear processes like amplification, attenuation, integration, differentiation, addition and subtraction. They are also required to do non-linear process like Modulation, detection, Sampling, filtering etc. The Signal conditioning in many situations is an excitation and amplification for passive transduction. Excitation is needed for primary transducers like potentiometer like because they do not produce their own signal.

The excitation may be shown by ac or dc voltage source. The active transducer like piezo-electric crystal does not required an external source for excitation because they produce their own signal, only amplification is required.

## # Output devices:

The last stage of the measurement system is the data presentation stage which consist of data presentation element. This stage consist of display device or recorder. In order that the result of measurement systems are meaningful, they must be display for stand observation or storage for observation at larger stage.

The first device is called display device while second is a recorder. The data presentation device may be called as output device. The types of output devices are;

- 1 Single number output device,
- 2 Time domain output device,
- 3 Machine Interpretable device.

CRO → Cathode Ray Oscillation

CRD → Cathode Ray Display

Page No.

Date: / /

### 17 Single Number Output Device:

These devices are designed to indicate the value of some particular quantity under condition such that the value to be measured can be regarded as time invariant over the time interval during which measurement is made. The time for which single numbers represent a value is very short and hence reading may have to be taken after certain interval of time:

Eg: Digital display device.

### 27 Time Domain Output Devices:

If the value of the quantity are to be taken as a function of time, the indicating instrument or digital display device are no longer satisfactory except for application where output varies in very slow rate. For fast changing output i.e. where the signal wave form or shape is the desire information for general purpose CRO is used. However, where a permanent record of the variation of output with time is kept, CRD photographic is used.

3.

### Machine Interpretable Device:

In Modern application it is necessary that the output data should be in such a form as it can be read by the machine. For eg: magnetic tape, punch-card, tele-type writer.

The machine interpretable output can either be in analog or digital form.

A signal recorded on a magnetic tape is in analog form while the signal recorded in Floppy disk, hard-disk are in digital form.