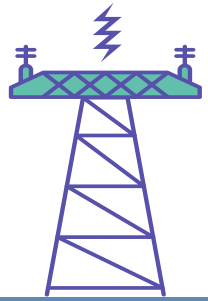
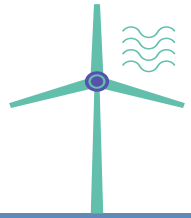
ELECTRONIC MEASUREMENTS

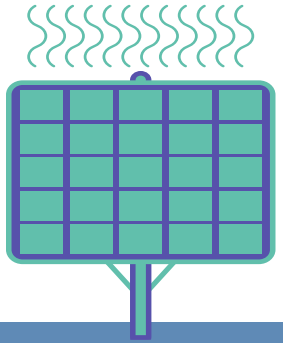
Second YEAR

By

Dr. Eman Ahmed Awad Megahed







Course contents

CH1

Concept of Measurement system

CH2

Analog Meters

CH3

Measurement of Resistance

CH4

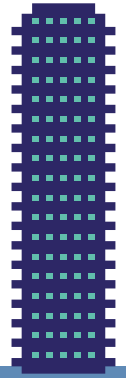
Power Measurement

CH5

Cathode Ray Oscilloscope

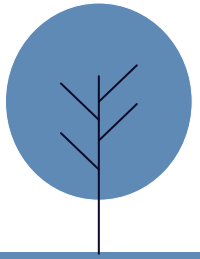
CH6

Electronic Instruments



Concept of Measurement system

Chapter 1



Dr : Eman A. Awad

Chapter Content

CH1: Concept of Measurement system

- Introduction
- Measurement System and Its Elements
- Methods of Measurement
- History of Development of Instruments
- Analog and Digital Instruments
- Classification of Instruments

1. INTRODUCTION

Measurements

Measurement is essentially the act, or the result, of a quantitative comparison between a given quantity and a quantity of the same kind chosen as a unit.

The physical embodiment of the unit of measurement is called a ***standard.***

The device used for comparing the unknown quantity with the unit of measurement or a standard quantity is called a ***measuring instrument.***

2. Measurement System and Its Elements

Elements of Measurement System

- Primary Sensing Element
- Variable Conversion Element
- Variable Manipulation Element
- Data Presentation Element

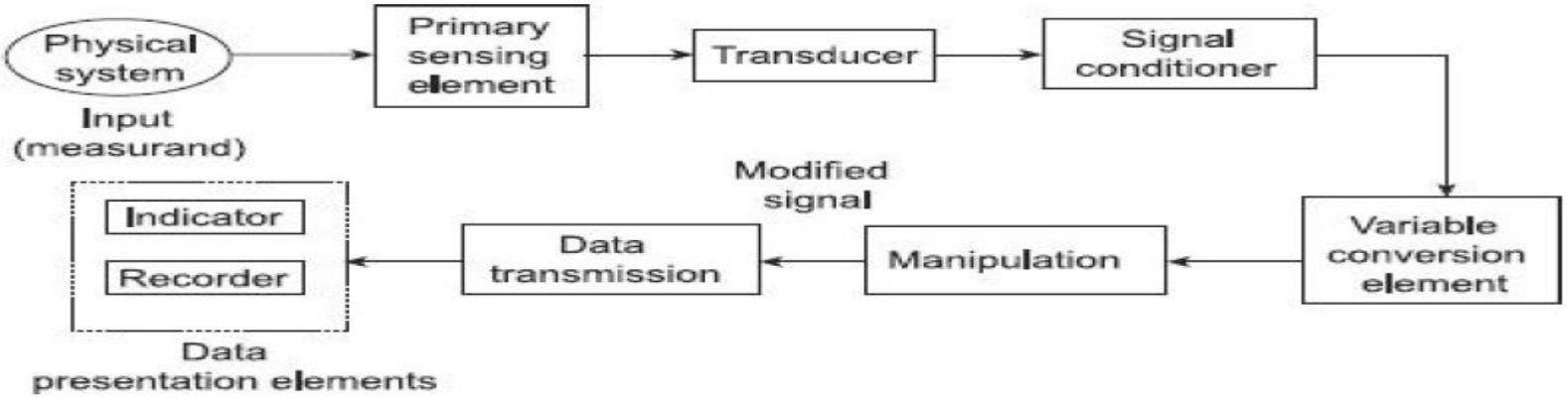


Figure 1.5 *Generalized measurement system*

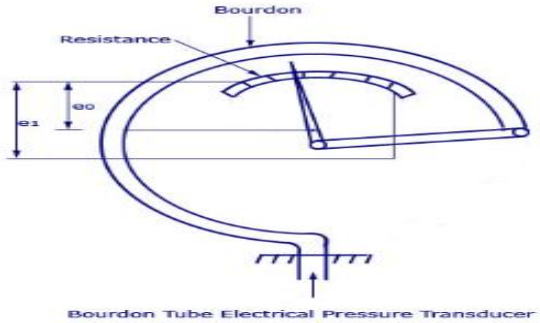
2. Measurement System and Its Elements

Primary Sensing Elements

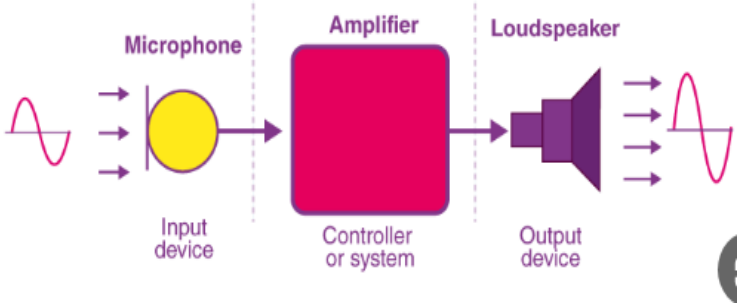
- It is an element that is sensitive to the measured variable.
- The physical quantity under measurement, called the measured.
- Primary sensing elements may have a non-electrical input and output such as a spring, manometer or may have an electrical input and output such as a rectifier.
- In case the primary sensing element has a non-electrical input and output, then it is converted into an electrical signal by means of a transducer.
- The transducer is defined as a device, which when actuated by one form of energy, is capable of converting it into another form of energy.

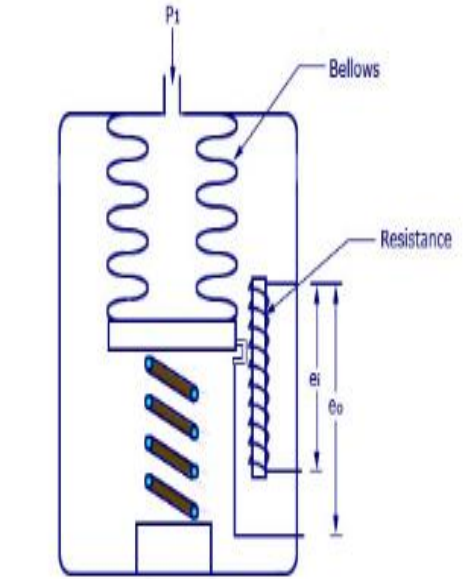
2. Measurement System and Its Elements

Primary Sensing Elements

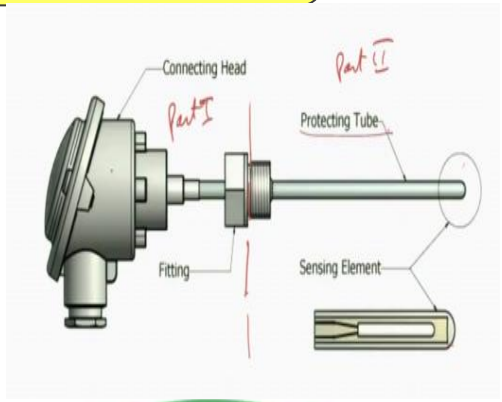


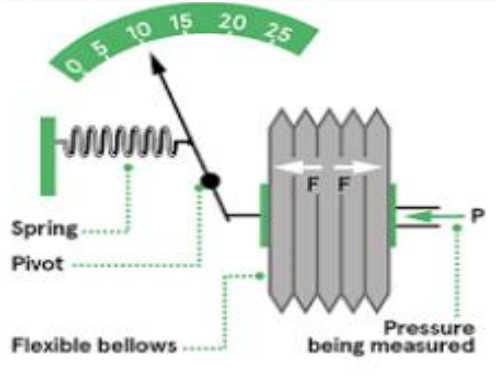
Bourdon Tube Electrical Pressure Transducer





Bellows Type Electrical Pressure Transducer





2. Measurement System and Its Elements

Variable Conversion Elements

- the output is in the form of an electrical signal, may be voltage, current, frequency, which may or may not be accepted to the system.
- For performing the desired operation, it may be necessary to convert this output to some other suitable form while retaining the information content of the original signal.
- For example, if the output is in analog form and the next step of the system accepts only in digital form then an analog-to-digital converter will be employed.

2. Measurement System and Its Elements

Manipulation Elements

- Sometimes it is necessary to change the signal level without changing the information contained in it for the acceptance of the instrument.
- For example, an electronic amplifier converts a small low voltage input signal into a high voltage output signal.

Data Presentation Elements

- The function of the data presentation elements is to provide an indication or recording in a form that can be evaluated by an unaided human sense or by a controller.
- Such a device may be in the form of analog or digital format.

3. Methods of Measurement

- The measurement methods can be classified as

1. Direct comparison methods
2. Indirect comparison methods

Direct comparison methods

In direct measurement methods the unknown quantity is measured directly such as measurement of current by an ammeter, voltage by voltmeter, resistance by ohmmeter, power by wattmeter etc.

3. Methods of Measurement

Direct comparison methods

- Direct methods of measurement are of two types, namely, deflection methods and comparison methods.

- **In deflection methods**: the value of unknown quantity is determined by means of measuring instrument having a scale graduated to the quantity under measurement directly such as measurement of current with an ammeter.

- **In comparison methods** the unknown quantity is determined by direct comparison with standard of the given quantity such as measurement of emf by comparison with the emf a standard cell.

3. METHODS OF MEASUREMENT

Indirect Comparison Methods

- In indirect measurement methods the unknown quantity is determined by measuring other functionally related quantities and calculating the desired quantity rather than measuring it directly.
- For example: resistance of a conductor may be determined by measuring voltage across the conductor, V and current flowing through the conductor, I and then calculating it by Ohm's law i.e., R = V/I.

4. History of Development of Instruments

Mechanical Instruments

- Mechanical instruments are very reliable for static and stable conditions. They are unable to respond rapidly to the measurement of dynamic and transient conditions due to the fact that they have moving parts that are rigid, heavy and bulky and consequently have a large mass.

Electrical Instruments

- When the instrument pointer deflection is caused by the action of some electrical methods then it is called an electrical instrument.
- These are too slow for to-day requirements of fast measurements

4. History of Development of Instruments

4. History of Development of Instruments

Electronic Instruments

- Electronic instruments use semiconductor devices.
- Most of the scientific and industrial instrumentations require very fast responses. Such requirements cannot be met with by mechanical and electrical instruments.
- In electronic devices, since the only movement involved is that of electrons, the response time is extremely small
- With the use of electronic devices, a very weak signal can be detected by using pre-amplifiers and amplifiers.

5. Analog and Digital Instruments

1. Analog Instruments

- The signals of an analog unit vary in a continuous fashion and can take on infinite number of values in a given range.
- Fuel gauge, ammeter and voltmeters, wrist watch, speedometer fall in this category.

2. Digital Instruments

- Signals varying in discrete steps and taking on a finite number of different values in a given range are digital signals and the corresponding instruments are of digital type.

6. Classification of Instruments

1. **Absolute Instruments**

- The instruments of this type give the quantity to be measured in terms of instrument constant and its deflection.
- Such instruments do not require any comparison with any other standard instrument.
- Such instruments are seldom used except in standard laboratories

2. **Secondary Instruments**

- Indicating Instruments
- Recording Instruments
- Integrating Instruments

6. Classification of Instruments

2. Secondary Instruments

- convert the energy of the unknown quantity directly into energy that deflects the moving element of the instrument.
- The value of the unknown quantity being measured by reading the resulting deflection. Ammeters, voltmeters, wattmeters, fall in this category.

(i) Indicating Instruments

- Indicating instruments are those which indicate the magnitude of an electrical quantity at the time when it is being measured.
- The indications are given by a pointer moving over a calibrated (pregraduated) scale.

6. Classification of Instruments

(ii) Integrating Instruments

Integrating instruments are those which measure the total amount of either quantity of electricity (ampere-hours) or electrical energy supplied over a period of time.

(iii) Recording Instruments

Recording instruments are those which keep a continuous record of the variation of the magnitude of an electrical quantity to be observed over a definite period of time.

6. Classification of Instruments

Manual and Automatic Instruments

- In case of manual instruments, the service of an operator is required.
- In an automatic type of instrument, no operator is required all the time.

Self-operated and Power-operated Instruments

- Self-operated instruments are those in which no outside power is required for operation.
- The power-operated instruments are those in which some external power such as electricity, compressed air, hydraulic supply is required for operation.

6. Classification of Instruments

Deflection and Null Output Instruments

In a deflection-type instrument,

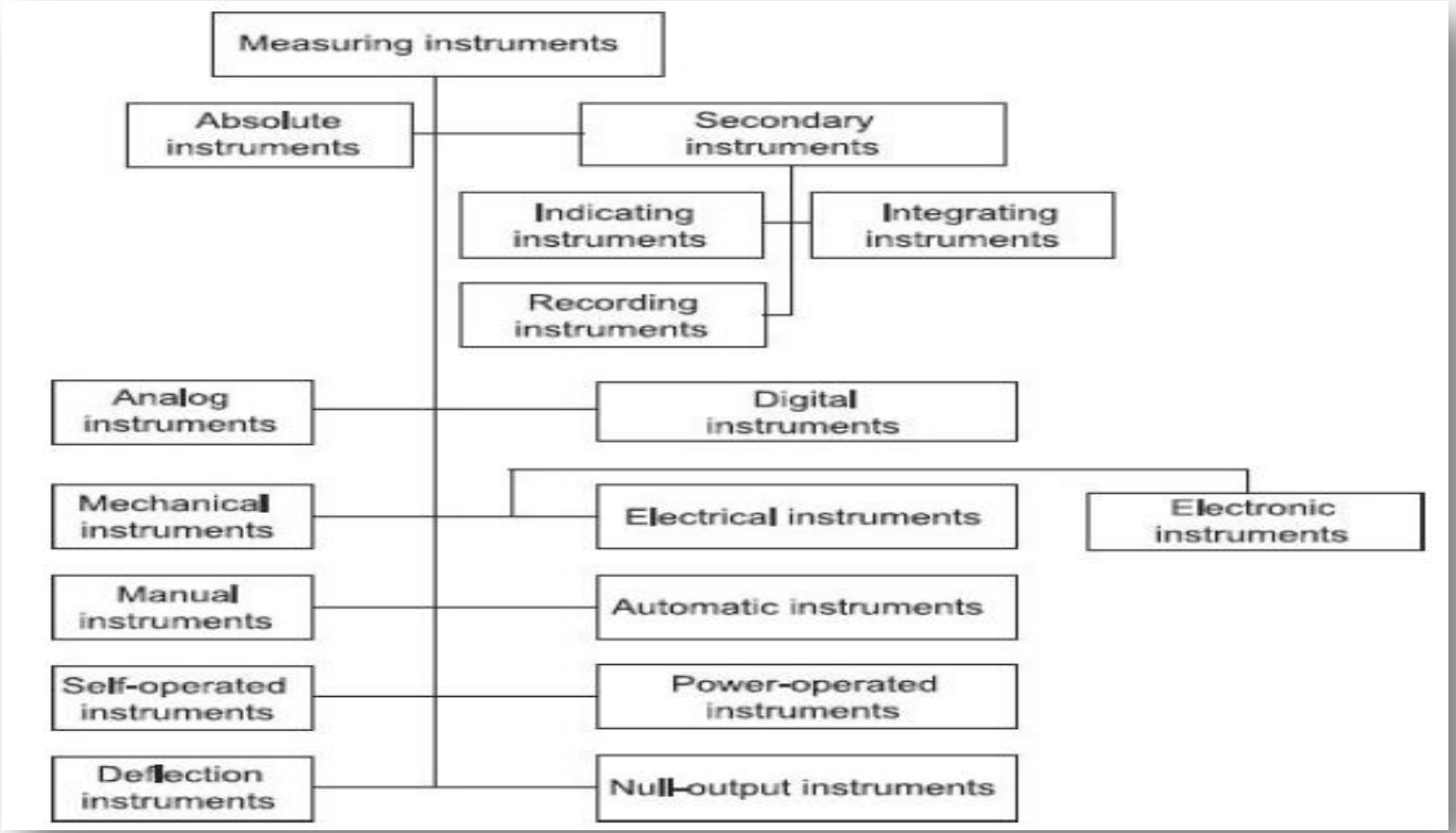
- the deflection of the instrument indicates the measurement of the unknown quantity.
- The measured quantity produces some physical effect which deflects or produces a mechanical displacement in the moving system of the instrument.
- The deflection or the mechanical displacement at this point gives the value of the unknown input quantity.
- These type of instruments are suited for measurement under dynamic condition. Permanent Magnet Moving Coil (PMMC), Moving Iron (MI), etc.,

6. Classification of Instruments

Deflection and Null Output Instruments

In null-type instruments,

- a zero or null indication leads to determination of the magnitude of the measurand quantity.
- These are more accurate and highly sensitive as compared to deflection-type instruments.
- A dc potentiometer is a null- type instrument.


Measuring instruments
Absolute instruments
Secondary instruments
Indicating instruments
Integrating instruments
Recording instruments
Analog instruments
Digital instruments
Mechanical instruments
Electrical instruments
Electronic instruments
Manual instruments
Automatic instruments
Self-operated instruments
Power-operated instruments
Deflection instruments
Null-output instruments

End of Lecture 1