Al-Mustaqbal University
College of Engineering and Technologies
Department of Electrical Engineering techniques
Class: 2nd
Instruments and measurements
Lecture1: Basic Concepts of Measurements
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1.1 Introduction

Measurement generally involve using an instruments as a physical means for determining a quantity or variable.

The instrument serves as an extension of human faculties where without the instrument aid, the human faculties become incapable of performing the measurement process.

The art of measurement is a wide discipline in both engineering and science encompassing the arts of detection, acquisition, control an analysis of data. It involves the measurement, recording and displaying of physical, chemical, mechanical and optical parameters. It playing a vital role in all branches of scientific research and industrial process.

Recent advances in electronics, physics and material sciences and technologies have resulted in the development of sophisticated and high precision measuring instruments.

Instrumentation refers to the science and technology of developing and using instruments to measure, monitor, and control physical quantities or processes. This field encompasses the design, construction, and application of instruments for scientific and industrial purposes.

Instrumentation is essential in various areas, including:

- Engineering: Monitoring and controlling industrial processes.
- Medical: Diagnosing and treating patients by measuring vital signs.
- Research: Collecting precise data for experiments in physics, chemistry, biology, and other sciences.

In essence, instrumentation ensures that accurate measurements are taken, data is collected, and systems are controlled effectively.

The use of instrumentation in systems like power plants, industries, process and automatic productions has contributed significantly to the developing of economy and tremendous saving in time and labor involved.

1.2 Measuring System Configuration

The simplest measuring system consists of four functional units as illustrated in the block diagram shown in Figure 1.1.

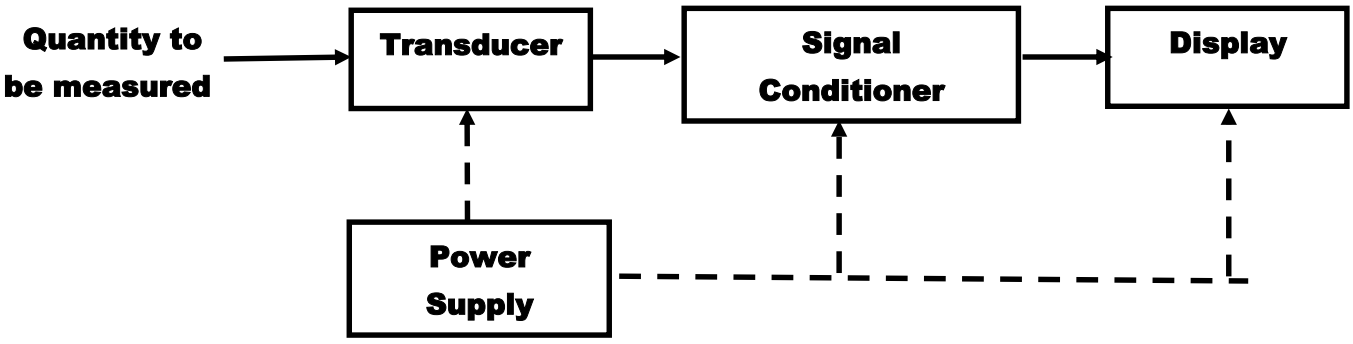

Figure 1.1 Block Diagram of Measurement System

The quantity to be measured may be electric quantity, force, pressure, level, stain, displacement, temperature, ……, etc.

The input quantity for most instrumentation systems is a non-electrical quantity. In order to use electrical methods and techniques for measurement, the non-electrical quantity is generally converted into an electrical form by a device called 'transducer'. Therefore, the transducer is defined as a device which converts the energy from one form to another.

The signal conditioner includes all system elements that are used to perform the necessary and distinct operations in the measurement sequence between the transducer unit and the output device. The signal conditioning unit may perform linear processes like amplification, attenuation, integration, differentiation addition, subtraction, ……, etc. or perform a nonlinear processes like modulation, demodulation, sampling, filtering, clamping, chopping, squaring, multiplication by another function, ……., etc.

The display devices are used to display the required information about the measurements. The display device may be analogue panel meter, digital display, graphical recorder, magnetic tape recorder, cathode ray oscilloscope , Light-emitting diodes (LED), Liquid crystal display (LCD) and touchscreen display.

The power supply provides the required excitation to the transducer and the necessary electrical power to the signal conditioner and the display device.

1.3 Methods of Measurements

Basically, there are two types of measurements:

1. Direct Method

In this method of measurement, the quantity to be measured is compared directly against a standard of some kind of quantity. In spite of the simplicity of the direct method of measurement, it suffers from the following disadvantages:

1. It is not always possible, feasible and practicable.
2. The involvement of human in this method makes it inaccurate and less sensitive.

2. Indirect Method

This method of measurement is used when the direct method is impractical or impossible.

It is important to select the suitable method of measurement according to the following points:

1. Apparatus available.
2. Accuracy desired.
3. Time required.
4. Difficulties in measurement.
5. Conditions of measurement.

1.4 Classification of Instruments

Instruments can be divided into separate classes according to several criteria. These classifications are useful for broadly establishing several attributes of particular instruments such as accuracy, cost, and general relevance for different applications.

1. According to the types of Instruments

The history of development of instruments encompasses three types:

a. Mechanical Instruments

Mechanical instruments are very reliable for static and stable conditions, but they are unable to respond rapidly to measurement of dynamic and transient conditions. This is due to the fact that these instruments having moving parts which are rigid, heavy and bulky. Figure 1.2 depicts three types of the mechanical instruments.

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Figure 1.2 Mechanical instruments

b. Electrical Instruments

Electrical methods of indicating the output of transducers are more rapid than the mechanical methods. But, the electrical systems normally depend upon a mechanical meter movement as indicating devices. This mechanical movement has some inertia and therefore these instruments have a limited time response. The construction of an electrical measuring instrument is shown in Figure 1.3.

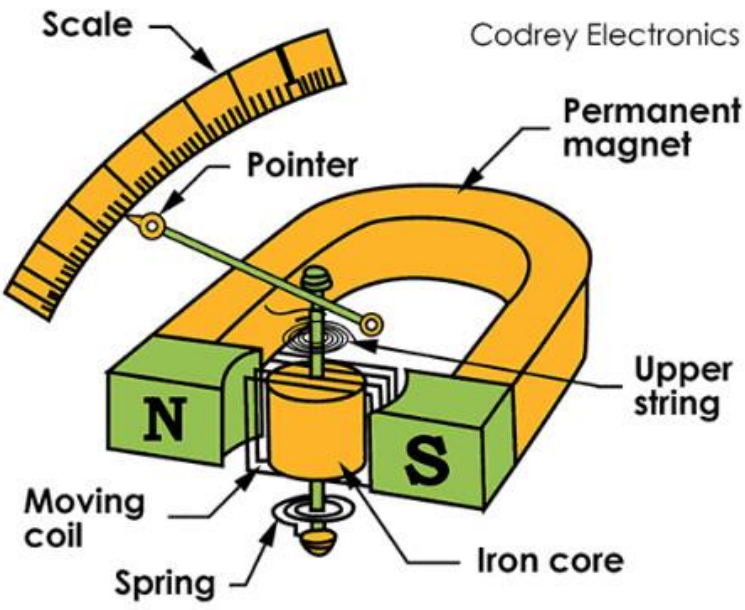

Figure 1.3 Electrical measuring instrument

c. Electronic and Digital Instruments

Electronic and digital instruments are becoming more reliable on an account of the improvements in the design and manufacturing process of semiconductor devices. Also, these instruments have the ability of storing the measurement information in the case of digital instruments. A digital instrument is shown in Figure 1.4.

Figure 1.4 A digital instrument

2. Passive and Active instruments

Instruments are subdivided into passive or active ones according to whether the instrument output is entirely produced by the quantity being measured or whether the quantity being measured modulates the magnitude of some external power source.
An example of a passive instrument is the pressure-measuring device shown in Figure 1.5. The pressure of the fluid is translated into a movement of a pointer against a scale.

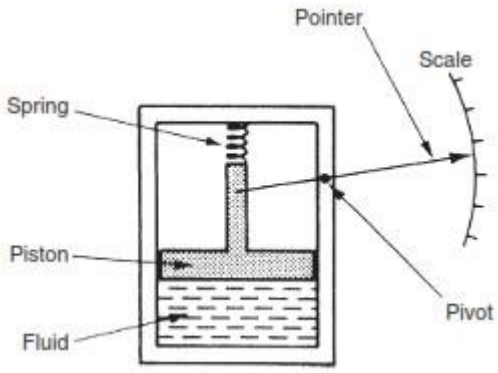

Figure 1.5 Passive pressure gauge

An example of an active instrument is a float-type fuel tank level indicator as shown in Figure 1.6. Here, the change in fuel level moves a potentiometer arm, and the output signal consists of a proportion of the external voltage source applied across the two ends of the potentiometer. The energy in the output signal comes from the external power source, where the primary transducer float system is merely modulating the value of the voltage from the external power source.

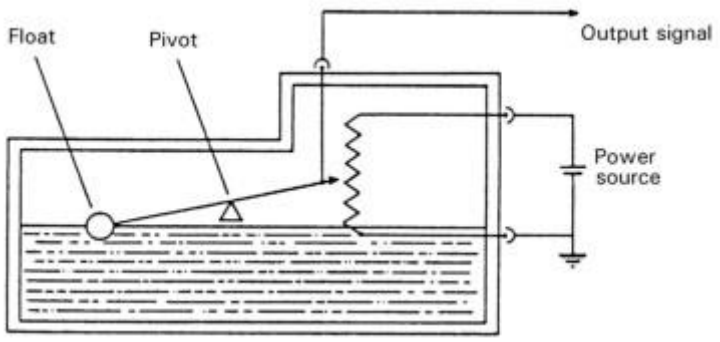

Figure 1.6 Active fuel tank level measuring instrument

3. Deflection-type and Null-type instruments

The pressure gauge shown in Figure 1.5 is a good example of the deflection-type instrument, in which the value of the quantity being measured is displayed in

terms of the amount of movement of a pointer. An alternative type of pressure gauge is the dead-weight gauge shown in Figure 1.7, which is a null-type instrument. Here, weights are put on top of the piston until the downward force balances the fluid pressure. Weights are added until the piston reaches a datum level, known as the null point or reference mark. Pressure measurement is made in terms of the value of the weights needed to reach this null position.

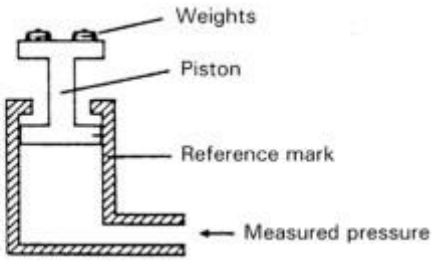

Figure 1.7 Dead-weight pressure gauge as a null-type

4. Smart and non-smart instruments

The advent of the microprocessor has created a new division in instruments between those that incorporate a microprocessor (smart) and those that do not. Figure 1.8 depicts the architecture of a smart instrument.

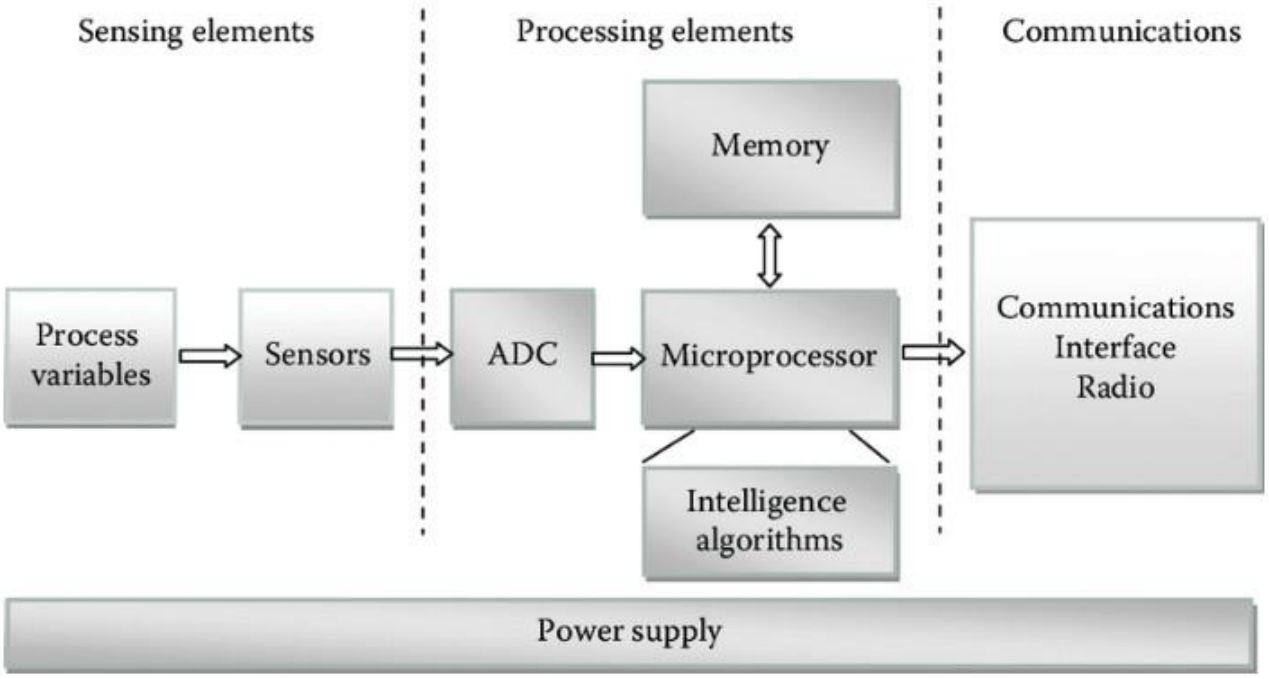

Figure 1.8 Architecture of smart instrument

1.5 Functions of Instruments

Instruments and measuring systems have the following main functions:

1. Indicating and Monitoring Function

By this function, the information is supplied by the measuring instrument as a deflection of a pointer or as a digit number at a particular instant.

2. Recording Function

In this case, the instrument makes a written record, usually on a paper, of the value of the quantity under measurement against some other variable such as time.

3. Controlling Function

This is one of the most important function especially in the field of industrial control process where, the instrument uses the information to control the original measured quantity.

4. Experimental Engineering Analysis Function

This function of measuring instruments is useful for solution of engineering problems, testing the validity of the theoretical prediction, determination of system parameters, ……, etc.

Examples– L1

Ex1.1 Define the following terms:
(1) Measurement (2) Instrumentation

Sol.
(1) Measurement: using an instruments as a physical means for determining a quantity or variable.
(2) Instrumentation: The technology of using instruments to measure and control the physical and chemical properties of materials.

Ex1.2 Classify the measuring instruments.

Sol.
Instruments can be classified according to:
1. The type of instruments.
2. Passive and active instruments.
3. Deflection-type and null-type instruments.
4. Smart and non-smart instruments.

Ex1.3 Classify the instruments according to their types.

Sol.
1. Mechanical instruments.
2. Electrical instruments.
3. Electronic and digital instruments.

Ex1.4 List the functions of the measuring instruments.

Sol.
1. Indicating and monitoring function.
2. Recording function.
3. Controlling function.
4. Experimental engineering analysis function.

Ex1.5 List the methods of measurements.

Sol.
1. Direct method.
2. Indirect method.

Ex1.6 List the points according to which the suitable method of measurement can be used.

Sol.
1. Apparatus available.
2. Accuracy desired.
3. Time required.
4. Difficulties in measurement.
5. Conditions of measurement.