Chapter1

Overview of Measurements and Instrumentation

Contents

- Definition of measurement and instrumentation
- Types of measurements
- Types of instruments in measurements
- Standard of measurement
- Calibration
- Application of measurement and instrumentation

Definition

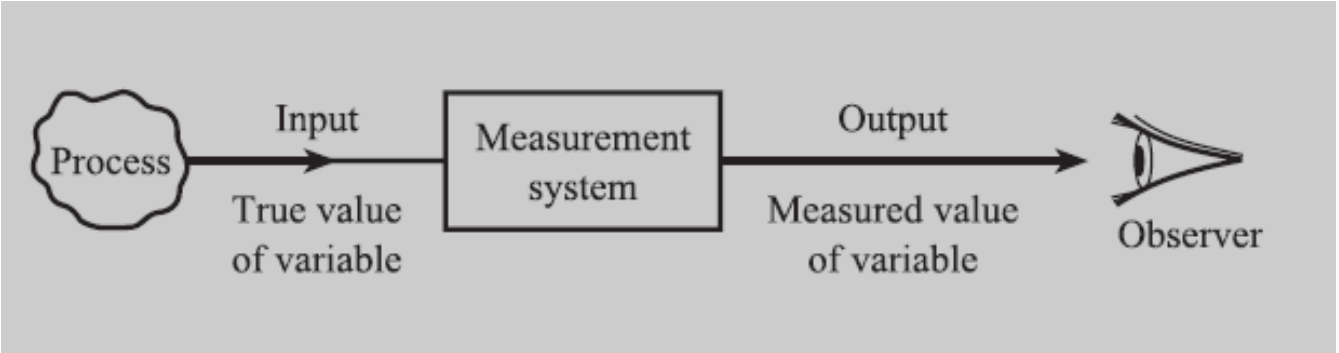
- Measurement
  - An act of obtaining information from a physical quantity.

- Instrumentation
  - Instruments used in measurement system

Terminologies

- Physical quantity: variable such as pressure, temperature, mass, length, etc.
- Data: Information obtained from the instrumentation or measurement system as a result of the measurements made from physical quantities
- Information: Data that has a calibrated numeric relationship to the physical quantity.
- Parameter: Physical quantity within defined (numeric) limits.

Purpose of a measurement system



measurand Sensor, signal conditioning, display Man, tracking control etc

Terminology

- Measurand: Physical quantity being measured.
- Calibration: Implies that there is a numeric relationship throughout the whole instrumentation system and that it is directly related to an approved national or international standard.
- Test instrumentation: It is a branch of instrumentation and most closely associated with the task of gathering data during various development phases encountered in engineering, e.g. flight test instrumentation for testing and approving aircraft.

Terminologies

- Transducer: A device that converts one form of energy to another.
- Electronic transducer: It has an input or output that is electrical in nature (e.g., voltage, current or resistance).
- Sensor: Electronic transducer that converts physical quantity into an electrical signal.
- Actuator: Electronic transducer that converts electrical energy into mechanical energy.

Why measurement?

- In the case of process industries and manufacturing industries:
  - To improve the quality of the product
  - To improve the efficiency of production
  - To maintain the proper operation.

Why instrumentation?

- To acquire data or information (hence data acquisition) about parameters, in terms of:
  - numerical values from physical quantities
  - making measurements that are not accessible.
  - producing data agreeable to analysis (mostly in electrical form)
- Data Acquisition Software (DAS) – data is acquired by the instrumentation system.

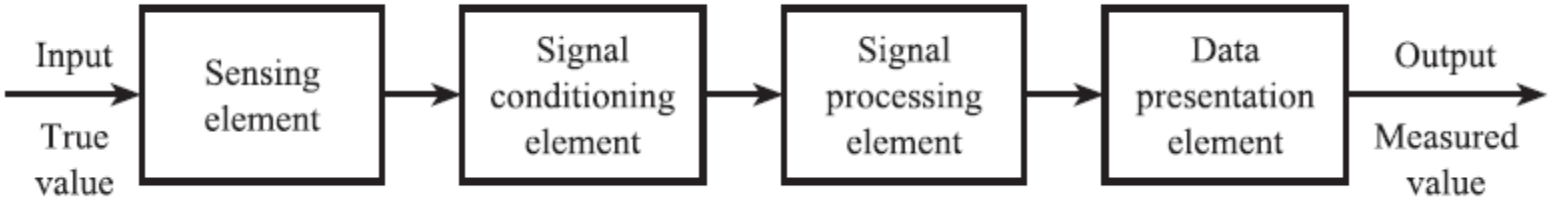
Contents

- Definition of measurement and instrumentation
- Types of measurements
- Types of instruments in measurements
- Standard of measurement
- Calibration
- Application of measurement and instrumentation

Types of measurements

- Direct comparison
  - Easy to do but… less accurate: Parameter to be measured is directly compared with either a primary standard or secondary standard.
    - e.g. to measure length of a steel bar
- Indirect comparison
  - Calibrated system, consisting of several devices to convert, process (amplification or filtering) and display the output
    - e.g. to measure force from strain gages located in a structure

Generalised measuring system



General Structure of Measuring System

- Stage 1: A detection-transducer or sensor-transducer, stage; e.g. *Bourdon tube*
- Stage 2: A signal conditioning stage; e.g. *gearing, filters, bridges*
- Stage 3: A terminating or readout-recording stage; e.g. *printers, oscilloscope*

Contents

- Definition of measurement and instrumentation
- Types of measurements
- Types of instruments in measurements
- Standard of measurement
- Calibration
- Application of measurement and instrumentation

Types of instruments in measurements

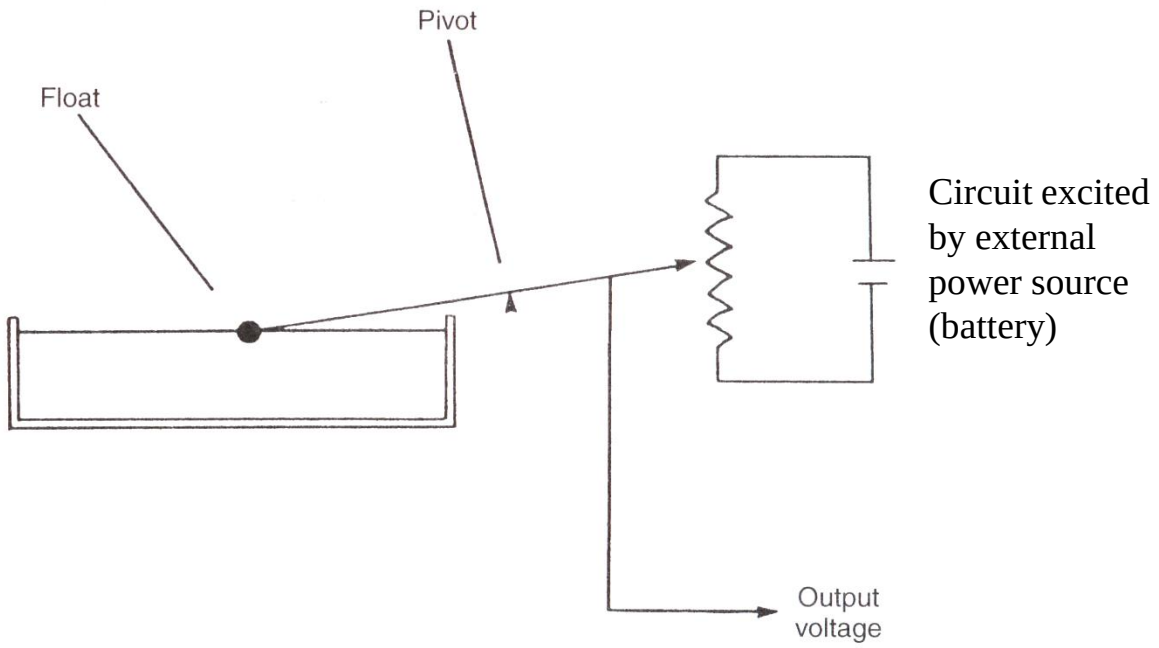
- Active Instruments
- Passive Instruments

Active Instruments

- Active Instruments
  - the quantity being measured simply modulates (adapts to) the magnitude of some external power source.

Active Instruments

- e.g. Float-type petrol tank level indicator



Petrol tank level indicator

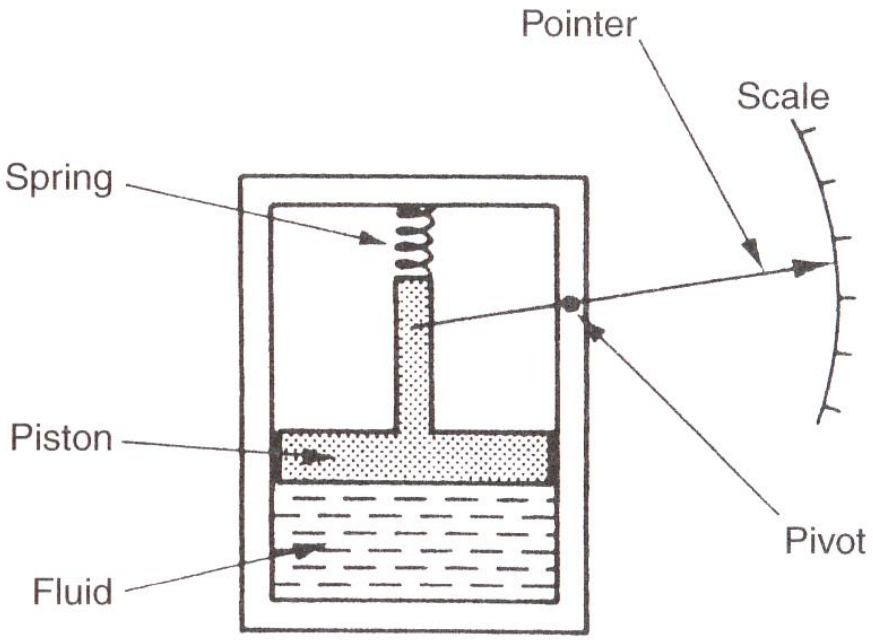
- The change in petrol level moves a potentiometer arm, and the output signal consists of a proportion of the external voltage source applied across the two ends of the potentiometer.
- The energy in the output signal comes from the external power source: the primary transducer float system is merely modulating the value of the voltage from this external power source.

Passive Instruments

- Passive Instruments
  - the instrument output is entirely produced by the quantity being measured

Passive Instruments

- e.g. Pressure-measuring device



Passive pressure gauge

- The pressure of the fluid is translated into a movement of a pointer against scale.
- The energy expanded in moving the pointer is derived entirely from the change in pressure measured: there are no other energy inputs to the system.

Continue

- Difference between active & passive instruments is the level of measurement resolution that can be obtained.

Analogue Instruments

- An analogue instrument gives an output that varies continuously as the quantity is being measured; e.g. Deflection-type of pressure gauge

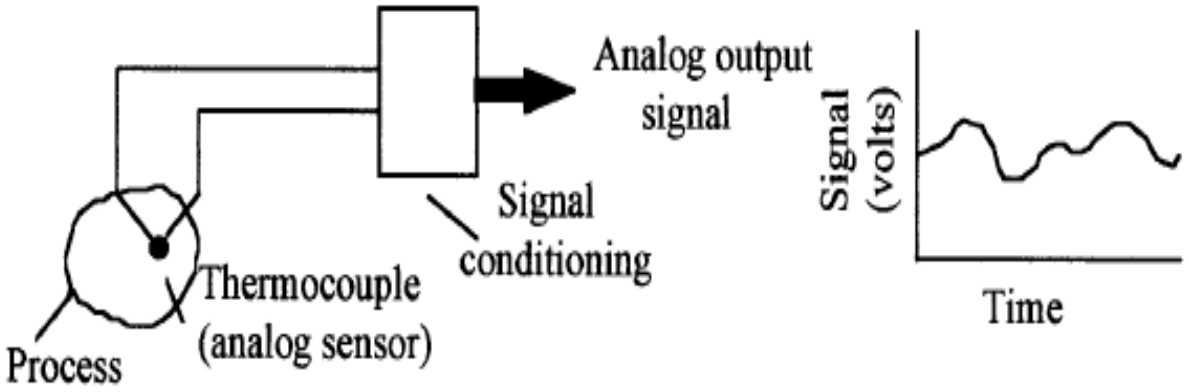


FIGURE 2.5 A thermocouple provides an analog signal for processing.

Digital Instruments

- A digital instrument has an output that varies in discrete steps and only have a finite number of values; e.g. Revolution counter

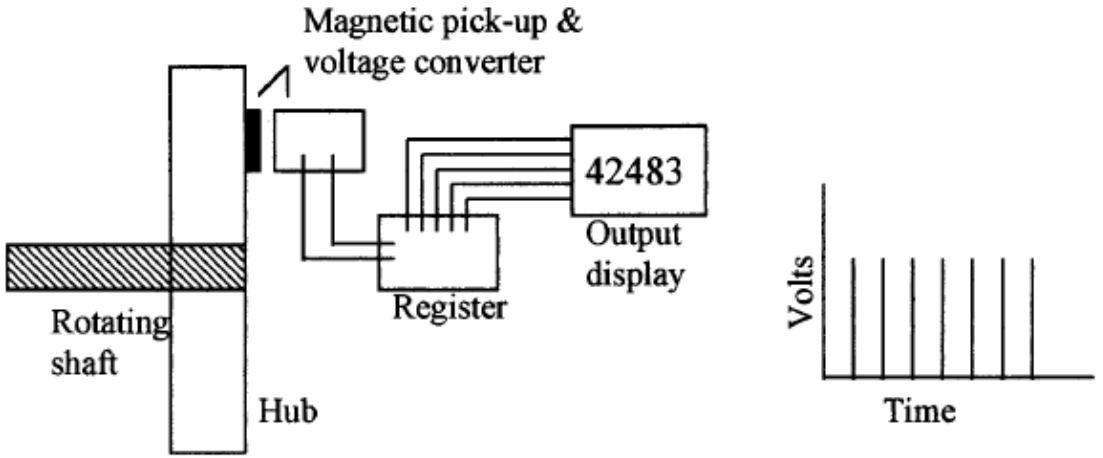


FIGURE 2.6 A rotating shaft with a revolution counter produces a digital signal.

Contents

- Definition of measurement and instrumentation
- Types of measurements
- Types of instruments in measurements
- Review in units of measurement
- Standard of measurement
- Calibration
- Application of measurement and instrumentation

Standard Of Measurement

- As a physical representation of a unit of measurement
- It is used for obtaining the values of the physical properties of other equipment by comparison methods

Examples of Standard Bodies

- International Organization for Standardization (ISO)
- International Electrotechnical Commission (IEC)
- American National Standards Institute (ANSI)
- Standards Council of Canada (SCC)
- British Standards (BS)

Contents

- Definition of measurement and instrumentation
- Types of measurements
- Types of instruments in measurements
- Review in units of measurement
- Standard of measurement
- Calibration
- Application of measurement and instrumentation

Calibration

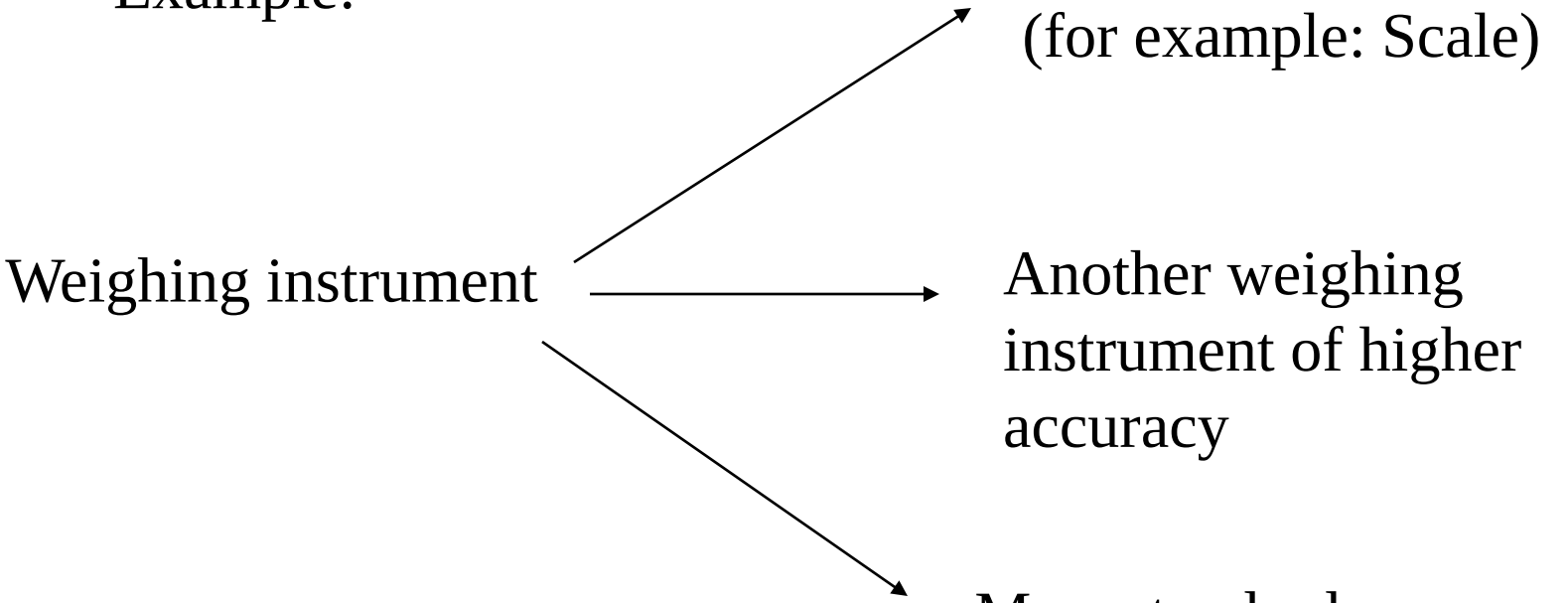
Calibration consists of comparing the output of the instrument or sensor under test against the output of an instrument of known accuracy (higher accuracy) when the same input (the measured quantity is applied to both instrument)

The procedure is carried out for a range of inputs covering the whole measurement range of the instrument or sensor
Ensures that the measuring accuracy of all instruments and sensors used in a measurement system is known over the whole measurement range, provided that the calibrated instruments and sensors are used in environmental conditions that are the same as those under which they were calibrated

Calibration involve a comparison of an instrument with either:

1. A primary standard
2. A secondary standard
3. A known input

Example:



Calibration

- The method and apparatus for performing measurement instrumentation calibrations vary widely.
- A rule that should be followed is that the calibration standard should be at least 10 times as accurate as the instrument being calibrated.
- By holding some inputs constant, varying others and recording the output(s) develop the desired static input-output relations. Many trial and runs are needed.

Contents

- Definition of measurement and instrumentation
- Types of measurements
- Types of instruments in measurements
- Review in units of measurement
- Standard of measurement
- Calibration
- Application of measurement and instrumentation

Application

- Home
  - Thermometer
  - Barometer
  - Watch
- Road vehicles
  - speedometer
  - fuel gauge
- Industry
  - Automation
  - Process control
  - Boiler control

Next Lecture

Performance of Static Characteristics in Measurement and Instrumentation

End of Lecture 1