Transducers

For

Instrumentation Engineering

By

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Syllabus for Transducers

Transducers: Resistive, Capacitive, Inductive, Piezoelectric, Hall Effect Sensors and Associated Signal Conditioning Circuits, Transducers for Industrial Instrumentation, Displacement (Linear And Angular), Velocity, Acceleration, Force, Torque, Vibration, Shock, Pressure (Including Low Pressure), Flow (Differential Pressure, Variable Area, Electromagnetic, Ultrasonic, Turbine and Open Channel Flow Meters) Temperature (Thermocouple, Bolometer, RTD (3/4 Wire), Thermistor, Pyrometer and Semiconductor), Liquid Level, Ph, Conductivity and Viscosity Measurement.

Analysis of GATE Papers

Year	Percentage of Marks	Overall Percentage
2016	7.00	12.10%
2015	10.00	
2014	9.00	
2013	10.00	
2012	13.00	
2011	10.00	
2010	8.00	
2009	15.00	
2008	15.00	
2007	24.00	

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"Picture yourself vividly as winning and that alone will contribute immeasurably to success."

...Harry Fosdick

CHAPTER 1

Classification of Transducers

Learning Objectives

After reading this chapter, you will know:

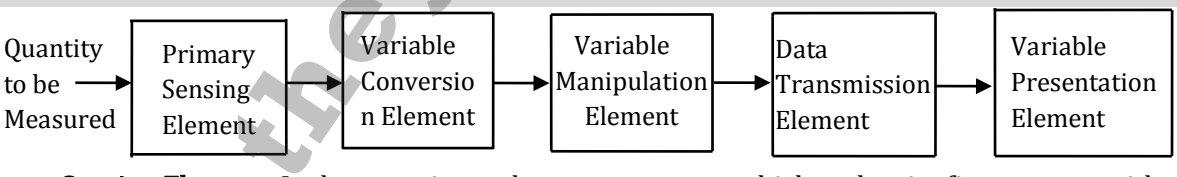
1. Generalized Measurement System
2. Transducers
3. Mechanical Devices as Primary Detectors
4. Characteristics and Choice of Transducers

Introduction

The measuring process is one in which the property of an object or system under consideration is compared to an accepted standard unit, a standard defined for that particular property.

It is important to have a systematic organization and analysis of measurement systems. An instrument may be defined as a device or a system which is designed to maintain a functional relationship between prescribed properties of physical variables and must include ways and means of communication to a human observer.

Generalized Measurement system



Primary Sensing Element: Is the quantity under measurement which makes its first contact with the primary sensing element of a measurement system.

Variable Conversion Element: The output of the primary sensing element is converted to some other suitable form for the instrument to perform desired function.

Variable Manipulation Element: The function of this element is to manipulate the signal presented to it and preserving the original nature of the signal.

Data Preserving Element: This element conveys the information about the quantity under measurement to the personal handling of the instrument or the system for monitoring, control & analysis purposes.

- The measurand in an instrumentation system makes contact with a primary detection element or input device.
- The measurand or the input signal is called an "information" for measurement system.
- The information may be in the form of physical phenomenon or it may be an electrical signal.

- The process of detection and conversion of the information into an acceptable form requires energy.
- The ideal situation is, the energy required for above purpose is supplied from outside, not from measurand.
- So that the measurand is not distorted and the analogous output of the detection is a faithful representation of measurand.

Example: A _____ element is that Part of a Transducer which responds to a physical phenomenon or change in a physical phenomenon.

(A) Sensing
(B) Transduction
(C) Resistive
(D) Inductive

Solution: **[Ans. A]**

Primary sensing element → The quantity under measurement (any physical phenomenon) makes its first contact with the sensing element of a measurement system, thus it responds to a physical phenomenon.

Example: Some of the Functional Building Blocks of the measurement System are: PSE (Primary Sensing Element), VCE (Variable Conversion Element), DTE (Data Transmission Element), VME (Variable Manipulation Element), DPE (Data Presentation Element).
The Correct Sequential Connection of the functional Building Blocks for an electronic Pressure gauge will be:

(A) PSE, VME, VCE, DPE, DTE
(B) PSE, VCE, VME, DTE, DPE
(C) DTE, DPE, VCE, PSE, VME
(D) PSE, VCE, DTE, DPE, VME

Solution: **[Ans. B]**

A generalized measurement system should have a systematic organization for the measurement of given physical phenomenon and building blocks should have a correct sequential connections for an electronic pressure gauge.

Transducers

1. The input quantity for the most instrumentation system is a non electrical quantity. In order to use electrical methods and techniques for measurements, manipulation, or control, non electrical quantity is generally converted into an electrical form by a device called Transducer.
2. We can define Transducer as a device which, accurately transforms energy from one form to another.
3. Another name for Transducer is 'PICK – UP'.
4. The reason for Transforming a physical phenomenon into an electrical form is that the electrical output can be easily used, transmitted and processed for the purpose of measurement.
5. The relationship between the physical parameter and its resulting electrical signal must be a Linear one.
6. Transducers mainly consists of two parts.
   a) Sensing Element: It is that part of a transducer which responds to a physical phenomenon or a change in a physical phenomenon.
   b) Transduction Element: It transforms the output of a sensing element to an electrical output.

Classification of Transducers

The transducers can be classified as:

(i) On the basis of transduction form used
(ii) As primary and secondary transducers
(iii) As passive and active transducers
(iv) As analog and digital transducers
(v) As transducers and inverse transducers

(i) **On the basis of transduction form used:** The transducers can be classified on the basis of principle of transduction as resistive, inductive, capacitive etc., depending upon how they convert the input quantity into resistance, inductance or capacitance respectively.

(ii) **Primary and Secondary Transducers**

- The first transducer which converts physical phenomenon into displacement, pressure, velocity etc. which is to be accepted by next stage is known as "Primary Transducer".
- The output of the primary transducer is converted subsequently into a usable output by a device called "Secondary Transducer"

(iii) **Passive and Active Transducers**

Passive Transducers: They derive the power required for transduction from an auxillary power source. They also derive part of the power required for conversion from the physical quantity under measurement.
They are also known as "Externally Powered Transducers"
E.g.: Resistive, inductive and capacitive transducers.

Active Transducers: They do not require an auxillary power source to produce their output. They are also known as self – generating type since they develop their own voltage or current output.
E.g.: piezoelectric, photovoltaic cells etc.

(iv) **Analog and Digital Transducers:** The transducers can be classified on the basis of the output which may be continuous function of the output which may be a continuous function of time or the output may be discrete steps.

Analog Transducers: These Transducers convert the input quantity into an analog output which is a continuous function of time.
E.g.: LVDT, Thermocouple etc.

Digital Transducers: These transducers convert the input quantity into an electrical output which is in the form of pulses.

(v) **Transducers & Inverse Transducers**

Transducer: A transducer can be broadly defined as a device which converts a non – electrical quantity into an electrical quantity.

Example: L.V.D.T, Resistive and Capacitive Transducers as well.

Inverse Transducer: An inverse transducer is defined as a device which converts an electrical quantity into a non – electrical quantity.

Note: Generally a inverse transducer is a output transducer.

E.g.: Indicating Instruments, Pen Recorders, Oscilloscope.

Mechanical Devices as Primary Detectors

Type	Operation
A. Contacting Spindle, Pin or Finger	Displacement to displacement
B. Elastic member	
1. Prooving ring	Force to displacement
2. Bourdon tube	Pressure to displacement
3. Bellows	Pressure to displacement
4. Diaphragm	Pressure to displacement
5. Spring	Force to displacement
C. Mass	
1. Seismic mass	Forcing function to displacement
2. Pendulum scale	Force to displacement
3. Manometer	Pressure to displacement
D. Thermal	
1. Thermocouple	Temperature to electric current
2. Bimetallic	Temperature to displacement
3. Temp – slik	Temperature to phase
E. Hydropneumatic	
1. Static	
(a) Float	Fluid level to displacement
(b) Hydrometer	Specific gravity to displacement
2. Dynamic	
(a) Orifice	Velocity to pressure
(b) Venturi	Velocity to pressure
(c) Pitot tube	Velocity to pressure
(d) Vanes	Velocity to force
(e) Turbines	Linear to angular velocity

Types of Electrical Transducers

Electrical Parameter and Class of Transducer	Principle of Operation	Typical Application
A. Resistance		
Potentiometer device	Positioning of the slider by an external force varies the resistance in a potentiometer or a bridge circuit	Pressure, Displacement
Resistance strain gauge	Resistance of a wire or semiconductor is changed by elongation or compression due to externally applied stress	Force, Torque, Displacement
Pirani gauge or hot wire meter	Resistance of a heating element is varied by convection cooling of a stream of gas.	Gas Flow, Gas Pressure
Resistance thermometer	Resistance of pure metal wire with a large positive temperature co-efficient of resistance varies with temperature	Temperature, Radiant Heat
Thermistor	Resistance of certain metal oxides with negative temperature coefficient of resistance varies with temperature	Temperature, Flow
Resistance Hydrometer	Resistance of a conductive strip changes with moisture content.	Relative Humidity
Photoconductive cell	Resistance of the cell as a circuit element varies with incident light	Photo-Sensitive Relay
B. Capacitance		
Variable capacitance pressure gauge	Distance between two parallel plates is varied by an externally applied force	Displacement, Pressure
Capacitor microphone	Sound pressure varies the capacitance between a fixed plate and a movable diaphragm.	Speech, Music, Noise
Dielectric gauge	Variation in capacitance by changes in the dielectric or dielectric constant	Liquid Level, Thickness