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Fundamentals and Applications of Transducers Technology and Sensors in Measuring Methodology

[1]Nwosu, A.W. & [2]*Eke, V.O.C.
[1]Department of Electrical/Electronic Engineering,Anambra State University, Uli, P.M.B. 02, Anambra State, Nigeria.
[2]*Department of Computer Science,Ebonyi State University,Abakaliki, Ebonyi State, Nigeria.
E-mail: talk2nordy@yahoo.com

Abstract:This paper deals on fundamentals and application of transducer technology and sensors in measuring techniques. Emphasis are laid on the principles of sensors and transducer technology, its application in measurement and their significance in data acquisition for micro-computer data based machine or automatic control systems .More so, the discussion exclusively appended improved applications of technology, expect and remote control systems.

Keywords: Transducers; sensors;; applications; measuring instrument.

I. INTRODUCTION

As you go through the context, my mission is to create an insight by introducing a few of these sensors and transducers. However, some graphical illustration of how they can be used to obtain data for microcomputer based control in our electrical/electronic industries is appended.

Generally, sensors and transducers are used to measure the magnitude or intensity of the controlled output, though these outputs maybe non-linear, signal conditioners are used to liberalize them for proper and ideal measurement. (Seippel,R.2003)

Consequently, transducer and sensor applications are:

- **Process transducers,** which are mainly associated with process, control system.
- **Motion and force transducers,** which are mainly associated with servomechanisms.
- **Opt coupler and temperature sensor,** which are the basics of remote control techniques.

As will be seen, most process transducers incorporate some aspect of motion transducers. In this paper, microcomputer based software`s are usually employed for accurate and precise measurements. Figure 1, illustrates a simple block diagram of an automatic control process, which is microprocessor based. From the figure, the control output of the processor or plant is monitored by the sensor/transducer arrangement. The possible configurations of process transducer feedback to the processor include mechanical linkage, fluid power (pneumatic or hydraulic), Electrical, including optical coupling, RF-propagation, magnetic coupling and acoustic propagation.

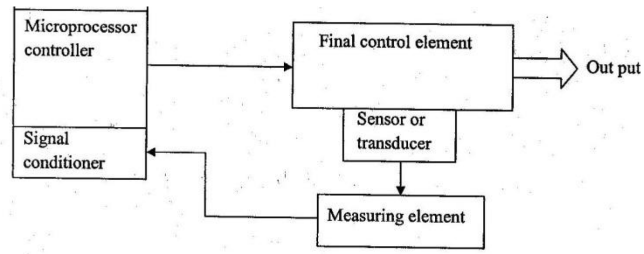

Figure 1: Simple block diagram of an automatic control process.

These transducers produce electrical signals represented in the form of:

i. D.C. Voltages or Currents amplitudes
ii. A C Voltages or Currents amplitudes, frequencies or phase.
iii. Digitized Voltages and current pulses.

Mathematical manipulations of the sensed signals in the form of Differentiation, integration, summation, root finding and square roots are also included. Signal conversion like DC-AC, AC-DC, frequency to voltage, and voltage to frequency, digital to analogue or analogue to digital conversions are not left out. All these modifications of the sensed signal make for a successful measurement with transducers and sensors for a microprocessor based system (Columbus, OH et al 1992).

II.TRANSDUCER PERFORMANCE CHARACTERISTICS

From the onset, was obvious that the performance of a transducer or sensor within a control system can be described with regards with the quantity being measured and the response of the sensor or transducer to some stipulated characteristics of the quantity. These characters may either be static or dynamic.(Bateson, R.N. 2003).

The dynamic characteristics, which are also of greatest interests, are:

- Time constants, response time and rise time
- Overshoot, settling time and damping frequency
- Frequency response

However, static performance are documented through calibrations which consist of applying a known input (quantity or phenomenon to be measured) and observing the transducers outputs in a typical calibration procedure, the input is increased in increments from the lower range limit to the upper range limit.

The range of components consists of all the allowable inputs values. However, differences between the lower and the higher input limits are called the input Span .(Berlin, H.M. and Getz, F.C.2008)

III. LOADING AND TRANSDUCER COMPLIANCE

A prime requirement for an appropriate transducer is that it can be compliant at its input. For example, a measuring voltmeter must have high input impedance in order that the voltage measurement does not significantly alter the circuit current and hence alter the value (voltage or current) being measured (Chaplin J.W. 2002)

IV.PROCESS TRANSDUCER AND APPLICATIONS

In this paper, discussion will be based on transducers mostly used in measuring and controlling process variables. These transducers are frequently encountered in industrial processes.
They include:

- Fluid pressure transducers
- Liquid level transducer
- Liquid fluid temperature transducers

Meanwhile, in this context, we will emphasis much on fluid flow and pressure measurement.

VI. FLUID PRESSURE MEASUREMENT TRANSDUCERS:

Most fluid pressure transducers are of the elastic type, in which the flow is confined in a chamber with at least one elastic wall. The deflection of this wall is taken as an induction of pressure. The bourdon tube and the bellows are examples of elastic pressure transducers, which are used in laboratory grade transducers and in some industrial control process. (Doeblin E.O.2005).

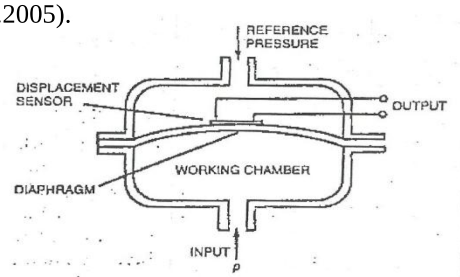

Figure 2: Diaphragm pressure transducer.

The figure 2, depicts a fluid pressure transducer its walls are made of polymerized fabrics and it is the basics of gross pressure measurement. This is where the displacement of a diaphragm is sensed by a potentiometer.
The diaphragm serves as the common plate of a differential capacitor. Webb, J. and (Greshock, K. 2003).

V. LIQUID LEVEL TRANSDUCERS:

Liquid level measurements are relatively straight forward. It involves a system of transducers categorized as contact or non-contact. Measurement of fluid flow level is always continuous, in this case, the liquid levels are always continuous, and in this case, the liquid level is measured continuously throughout its operating point (Dorf, R.C. and Bishop, R.H.2006). With reference to an already predetermined level, the transducer produces an indication of measurement, which shows or depicts the normality or abnormality of the level.

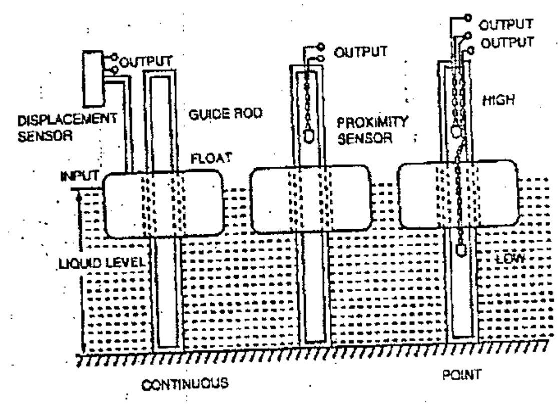

Figure 3: Float-type liquid level transducers

For those continuous and point measurements, figure (3) depicts a typical example of a single and dual point measurement transducer. Here, the displacement of the floated body is sensed by the displacement sensor and is converted to equivalent electrical signals comparable with the already existing reference level of the meter.

VII. OPTOCOUPLER AND TEMPERATURE TRANSDUCERS

In modern control systems, especially remote sensing technology where absolute isolation is required between the controlling unit and the controlled system, optic or thermal sensors usually come into play. Here they are referred to as sensors because they do not involve motion of any form.

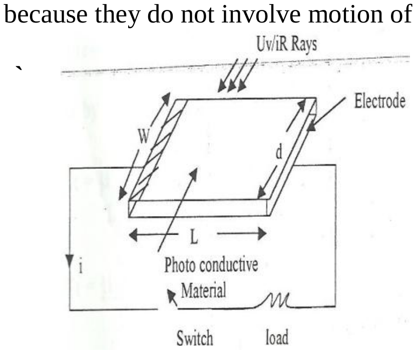

Figure 4: Basic structure of a photoconductive cell

If we represent the change in electrical conductivity by $\Delta\partial$ then

$$\Delta\partial = eNt\,(\mu n\,\tau n + \mu p\,\tau n)$$

Where μn and μp represent mobility of free electron and holes, $\tau n, \tau p$ represent the life time number of electron and holes. Finally Ni stands for the of carrier generated per second unit volume.However for cadmium sulphide, the life time of holes is usually very short. Hence it behaves solely like an n-type semiconductor where $\Delta\partial = eNt\mu n\,\tau n$

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If A represents the number of electron that flow due to the excitation by one photon, we have

A $= \frac{\tau n}{\tau t} = \frac{\mu n \mu p v}{l}$ where τt is the transit time .

A $= \frac{\tau n}{\tau t} = \frac{\mu n \mu p v}{l}$

Another interesting aspect of optoelectronics application is in fiber optics displacement transducers. However, the recent flurry of activity in fiber optic sensors has resulted in a great variety of technically sophisticated devices employing interference, polarization and wavelength modulation techniques while all these methods offer great promise for certain specific application and dedicated sensors; the intensity modulated Fiber Optic Lever Displacement Transducer(F.O.L.D.T) offers a powerful combination of simplicity, performances, versatility and low cost which makes it well suited for a wide variety of laboratory and industrial application (O'Dell, T.H. 2001)

The principal employed in F.O.L.D.T comes down to the use of an adjacent pair of fiber optic element, one to carry light from a remote source to an object or tangent whose displacement or motion is to be measured and the other to receive the light reflected from the object and carry it back to a remote photo sensitive detector. A fiber optic element is a flexible stand of glass or plastic capable of transmitting light along its length by maintaining near total internal reflection of the light accepted at its input end (figure 5)

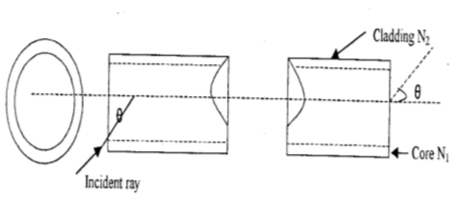

Figure 5: Fiber optic filament

The most commonly used fiber is called "step index" type and consists of an inner core to carry the light flux and an outer cladding. For total internal reflection to occur, the index of refraction of the glass in the core (N1) must be greater than the index of the refraction of the glass cladding (N2). Here the sine of the half angle of the light which will be accepted into the core is defined as the numerical aperture (N.A) and is given by the formular N.A=sin$\theta = \sqrt{N1 - N2}$

This is the maximum angle at which a light ray incident on the face of the fiber can be trapped within the core reflected along the length.

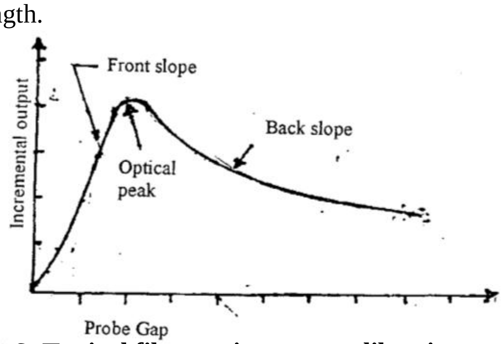

Figure 6: Typical fiber optic sensor calibration curve

Figure 6 illustrate the calibration curve of a typical fiber optic sensor measurement optical peak. The zero slope in the figure also provides a means of measuring reflectance of the target independent of gap changes. An interesting and very useful variation on this deviation is obtained when a focusing lens system is placed near the sensing end of the fiber optic probe. The result of such calibration is shown in figure 7

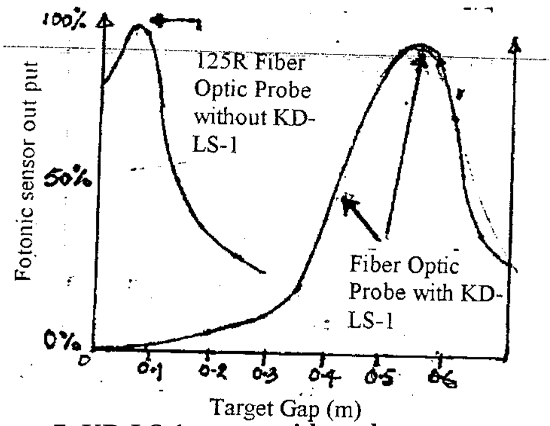

Figure 7: KD-LS-1 output with probe

VIII. CONCLUSION

The primary objectives of transducers and sensor are to aid measurement. Since measurements, which are aided by transducer sensor arrangements has found enormous application in wider areas of electrical, mechanical and electronics sectors, that has proved the necessity that transducer technology especially in automated systems and robotics should be taken seriously.

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