Transducers

Introduction

- Basically transducer is defined as a device, which converts energy or information from one form to another. These are widely used in measurement work because not all quantities that need to be measured can be displayed as easily as others. A better measurement of a quantity can usually be made if it may be converted to another form, which is more conveniently or accurately displayed.

Introduction(cont'd)

- For example, the common *mercury thermometer* converts variations in temperature into variations in the length of a column of mercury. Since the variation in the length of the mercury column is rather simple to measure, the mercury thermometer becomes a convenient device for measuring temperature.

Introduction(cont'd)

- On the other hand, the actual temperature variation is not as easy to display directly. Another example is *manometer, which* detects pressure and indicates it directly on a scale calibrated in actual units of pressure.

Introduction(cont'd)

- Thus the transducer is a device, which provides a usable output in response to specific input measured, which may be physical or mechanical quantity, property or condition. The transducer may be mechanical, electrical, magnetic, optical, chemical, acoustic, thermal nuclear, or a combination of any two or more of these.

Mechanical transducers

- are simple and rugged in construction, cheaper in cost, accurate and operate without external power supplies but are not advantageous for many of the modern scientific experiments and process control instrumentation owing to their poor frequency response, requirement of large forces to overcome mechanical friction, in compatibility when remote control or indication is required, and a lot of other limitations. All these drawbacks have been overcome with the introduction of electrical transducers.

ELECTRICAL TRANSDUCERS

- Mostly quantities to be measured are non-electrical such as temperature, pressure, displacement, humidity, fluid flow, speed etc., but these quantities cannot be measured directly. Hence such quantities are required to be sensed and changed into some other form for easy measurement.
- Electrical quantities such as current, voltage, resistance. inductance and capacitance etc. can be conveniently measured, transferred and stored, and therefore, for measurement of non-electrical quantities these are to be converted into electrical quantities first and then measured.

ELECTRICAL TRANSDUCERS(cont'd)

- The function of converting non-electrical quantity into electrical one is accomplished by a device called the electrical transducer. Basically an electrical transducer is a sensing device by which a physical, mechanical or optical quantity to be measured is transformed directly, with a suitable mechanism, into an electrical signal (current, voltage or frequency). The production of these signals is based upon electrical effects which may be resistive, inductive, capacitive etc in nature.

ELECTRICAL TRANSDUCERS(cont'd)

- The input versus output energy relationship takes a definite reproducible function. The output to input and the output to time behavior is predictable to a known degree of accuracy, sensitivity and response, within the specified environmental conditions.

BASIC REQUIREMENTS OF A TRANSDUCER

- The main function of a transducer is to respond only for the measurement under specified limits for which it is designed. It is, therefore, necessary to know the relationship between the input and output quantities and it should be fixed. Transducers should meet the following basic requirements.

Basic Requirements Of a Transducer (cont'd)

- Ruggedness. It should be capable of withstanding overload and some safety arrangement should be provided for overload protection.
- Linearity. Its input-output characteristics should be linear and it should produce these characteristics in symmetrical way.
- Repeatability. It should reproduce same output signal when the same input signal is applied again and again under fixed environmental conditions e.g. temperature, pressure, humidity etc.

Basic Requirements Of a Transducer (cont'd)

- High Output Signal Quality. The quality of output signal should be good i.e. the ratio of the signal to the noise should be high and the amplitude of the output signal should be enough.
- High Reliability and Stability. It should give minimum error in measurement for temperature variations, vibrations and other various changes in surroundings.
- Good Dynamic Response. Its output should be faithful to input when taken as a function of time. The effect is analyzed as the frequency response.

Basic Requirements Of a Transducer (cont'd)

- No Hysteretic. It should not give any hysteretic during measurement while input signal is varied from its low value to high value and vice-versa.
- Residual Deformation. There should be no deformation on removal of local after long period of application.

Classification Of Transducers

- The transducers may be classified in various ways such as on the basis of electrical principles involved, methods of application, methods of energy conversion used, nature of output signal etc.

Classification Of Transducers(cont'd)

- ***Primary and Secondary Transducers:*** Transducers, on the basis of methods of applications, may be classified into primary and secondary transducers. When the input signal is directly sensed by the transducer and physical phenomenon is converted into the electrical form directly then such a transducer is called the primary transducer.

1-Primary and Secondary Transducers(cont'd)

- For example a thermistor used for the measurement of temperature fall in this category. The thermistor senses the temperature directly and causes the change in resistance with the change in temperature. When the input signal is sensed first by some detector or sensor and then its output being of some form other than input signals is given as input to a transducer for conversion into electrical form, then such a transducer falls in the category of secondary transducers.

Primary and Secondary Transducers(cont'd)

- For example, in case of pressure measurement, bourdon tube is a primary sensor which converts pressure first into displacement, and then the displacement is converted into an output voltage by an LVDT. In this case LVDT is secondary transducer.

2-Active and Passive Transducers.

- . Transducers, on the basis of methods of energy conversion used, may be classified into active and passive *transducers.Self-generating type transducers i.e. the transducers, which* develop *their* output *the form of electrical voltage* or *current without* any auxiliary *source,* are called the active transducers. Such transducers draw energy from the system under measurement. Normal such transducers give very small output and, therefore, use of amplifier becomes essential.

Active and Passive Transducers(cont'd)

- Transducers, in which electrical parameters i.e. resistance, inductance or capacitance changes with the change in input signal, are called the passive *transducers.* These transducers require external power source for energy conversion. In such transducer electrical parameters *i.e.* resistance, inductance or capacitance causes a change in voltages current or frequency of the external power source. These transducers may draw sour energy from the system under measurement. Resistive, inductive and capacitive transducer falls in this category.

3-*Analog and Digital Transducers*

- Transducers, on the basis of nature of output signal, may be classified into analog and digital transducers. Analog transducer converts input signal into output signal, which is a continuous function of time such as thermistor, strain gauge, LVDT, thermo-couple etc. Digital transducer converts input signal into the output signal of the form of pulse e.g. it gives discrete output.

Analog and Digital Transducers(cont'd)

- These transducers are becoming more and more popular now-a-days because of advantages associated with digital measuring instruments and also due to the effect that digital signals can be transmitted over a long distance without causing much distortion due to amplitude variation and phase shift. Sometimes an analog transducer combined with an ADC (analog-digital convector) is called a digital *transducer.*

Transducers and Inverse Transducers.

- Transducer, as already defined, is a device that converts a non-electrical quantity into an electrical quantity. Normally a transducer and associated circuit has a non-electrical input and an electrical output, for example a thermo-couple, photoconductive cell, pressure gauge, strain gauge etc. An inverse transducer is a device that converts an electrical quantity into a non-electrical quantity. It is a precision actuator having an electrical input and a low-power non-electrical output.

Transducers and Inverse Transducers(cont'd)

- For examples a piezoelectric crystal and transnational and angular moving-coil elements can be employed as inverse transducers. Many data-indicating and recording devices are basically inverse transducers. An ammeter or voltmeter converts electric current into mechanical movement and the characteristics of such an instrument placed at the output of a measuring system are important. A most useful application of inverse transducers is in feedback measuring systems.

Selection Of Transducers

- In a measurement system the transducer (or a combination of transducers) is the input element with the critical function of transforming some physical quantity to a proportional electrical signal. So selection of an appropriate transducer is most important for having accurate results.

Selection Of Transducers(cont'd)

- The first step in the selection procedure is to clearly define the nature of quantity under measurement (measurand) and know the range of magnitudes and frequencies that the measurand is expected to exhibit. Next step will be to examine the available transducer principles for measurement of desired quantity. The type of transducer selected must be compatible with the type and range of the quantity to be measured and the output device.

Selection Of Transducers(cont'd)

- In case one or more transducer principles are capable of generating a satisfactory signal, decision is to be taken whether to employ a commercially available transducer or build a suitable transducer. If the transducers are available in the market at a suitable price, the choice will probably be to purchase one of them, otherwise own transducer will have to be designed, built and calibrated.

Selection Of Transducers(cont'd)

- The points to be considered in determining a transducer suitable for a specific measurement are as follows:
- ***Range***. The range of the transducer should be large enough to encompass all the expected magnitudes of the measurand.
- ***Sensitivity***. The transducer should give a sufficient output signal per unit of measured input in order to yield meaningful data.
- ***Electrical Output Characteristics***. The electrical characteristics-the output im-pedance, the frequency response, and the response time of the transducer output signal should be compatible with the recording device and the rest of the measuring system

Selection Of Transducers(cont'd)

- ***Physical Environment***. The transducer selected should be able to withstand the environmental conditions to which it is likely to be subjected while carrying out measurements and tests.
- Such parameters are temperature, acceleration, shock and vibration, moisture, and corrosive chemicals might damage some transducers but not others.

Selection Of Transducers(cont'd)

- ***Errors***. The errors inherent in the operation of the transducer itself, or those errors caused by environmental conditions of the measurement, should be small enough or controllable enough that they allow meaningful data to be taken.
- However the total measurement error in a transducer-activated system may be reduced to fall within the required accuracy range by adopting the following techniques.

Errors(cont'd)

- Calibrating the transducer output against some known standards while in use under actual test conditions. This calibration should be performed regularly as the measurement proceeds.
- Continuous monitoring of variations in the environmental conditions of the transducer and correcting the data accordingly.
- Controlling the measurement environment artificially in order to reduce possible transducer errors. Artificial environmental control includes the enclosing of the transducer in a temperature-controlled housing and isolating the device from external shocks and vibrations.