Electrical Measurement and Instrumentation







LCR METERS

Power Measurements in 3 phase circuit by

- (a) Two wattmeter method
- (b) Three wattmeter method

Transducer

Measurements of Temperature

LCR meter

An LCR meter is a type of electronic test equipment used to measure the inductance (L), capacitance (C), and resistance (R) of an electronic component.



Advantages of an LCR meter

1. One thing that is evident is that it is compact and a three in one sort of a measuring unit which is obviously preferable.

2. Other than this it is also worth mentioning here that an LCR meter is quite accurate and gives the readings with a high precision.

3. It can also tell about the angle between the voltage and the current measure if needed.

4. It is easy to calibrate and quick to use, the user just needs to connect the two probes of the meter to the DUT as shown below:

Transducer

This article is about an engineering device. For the similarly named concept in computer science, see Finite state transducer.

A transducer is a device that converts energy from one form to another. Usually a transducer converts a signal in one form of energy to a signal in another.

□ Transducers are often employed at the boundaries of automation, measurement, and control systems, where electrical signals are converted to and from other physical quantities (energy, force, torque, light, motion, position, etc.). The process of converting one form of energy to another is known as transduction.







various types of transducer



measurement of strain gauge

A strain gauge is a device used to measure strain on an object. Invented by Edward E. Simmons and Arthur C. Ruge in 1938, the most common type of strain gauge consists of an insulating flexible backing which supports a metallic foil pattern. The gauge is attached to the object by a suitable adhesive, such as cyanoacrylate.[1] As the object is deformed, the foil is deformed, causing its electrical resistance to change. This resistance change, usually measured using a Wheatstone bridge, is related to the strain by the quantity known as the gauge factor.

strain gauge





force measurement

In physics, a force is any interaction that, when unopposed, will change the motion of an object. A force can cause an object with mass to change its velocity (which includes to begin moving from a state of rest), i.e., to accelerate. Force can also be described intuitively as a push or a pull. A force has both magnitude and direction, making it a vector quantity. It is measured in the SI unit of newtons and represented by the symbol F.

- The original form of Newton's second law states that the net force acting upon an object is equal to the rate at which its momentum changes with time. If the mass of the object is constant, this law implies that the acceleration of an object is directly proportional to the net force acting on the object, is in the direction of the net force, and is inversely proportional to the mass of the object.
- Concepts related to force include: thrust, which increases the velocity of an object; drag, which decreases the velocity of an object; and torque, which produces changes in rotational speed of an object. In an extended body, each part usually applies forces on the adjacent parts; the distribution of such forces through the body is the internal mechanical stress. Such internal mechanical stresses cause no acceleration of that body as the forces balance one another. Pressure, the distribution of many small forces applied over an area of a body, is a simple type of stress that if unbalanced can cause the body to accelerate. Stress usually causes deformation of solid materials, or flow in fluids.





torque measurement

□ Torque, moment, or moment of force is rotational force. Just as a linear force is a push or a pull, a torque can be thought of as a twist to an object. In three dimensions, the torque is a pseudovector; for point particles, it is given by the cross product of the position vector (distance vector) and the force vector.







pressure measurement

Pressure measurement is the analysis of an applied force by a fluid (liquid or gas) on a surface. Pressure is typically measured in units of force per unit of surface area. Many techniques have been developed for the measurement of pressure and vacuum. Instruments used to measure and display pressure in an integral unit are called pressure gauges or vacuum gauges. A manometer is a good example as it uses a column of liquid to both measure and indicate pressure. Likewise the widely used Bourdon gauge is a mechanical device which both measures and indicates and is probably the best known type of gauge.

- A vacuum gauge is a pressure gauge used to measure pressures lower than the ambient atmospheric pressure, which is set as the zero point, in negative values (e.g.: -15 psi or -760 mmHg equals total vacuum). Most gauges measure pressure relative to atmospheric pressure as the zero point, so this form of reading is simply referred to as "gauge pressure". However, anything greater than total vacuum is technically a form of pressure. For very accurate readings, especially at very low pressures, a gauge that uses total vacuum as the zero point may be used, giving pressure readings in an absolute scale.
- Other methods of pressure measurement involve sensors which can transmit the pressure reading to a remote indicator or control system (telemetry).

Pressure measuring device



pressure cell

Rheology under pressure is used to simulate process conditions, to measure above the boiling point, or to prevent sample evaporation. The pressure cell specifications are therefore tailored to each application. In the petrochemical industries, high pressures of up to 1000 bar and temperatures of up to 300 °C are required, whereas work with low-viscosity solvents requires a sensitive, yet fully closed system. To cover these diverse applications, a range of different pressure cells and measuring systems is available.





Fig.16.8 Force-balance-type Differential Pressure Transmitter

flow measurement

Flow measurement is the quantification of bulk fluid movement. Flow can be measured in a variety of ways. Positive-displacement flow meters accumulate a fixed volume of fluid and then count the number of times the volume is filled to measure flow. Other flow measurement methods rely on forces produced by the flowing stream as it overcomes a known constriction, to indirectly calculate flow. Flow may be measured by measuring the velocity of fluid over a known area. For very large flows, tracer methods may be used to deduce the flow rate from the change in concentration of a dye or radioisotope.



Ultrasonic flow meter

Principle

Density is measured according to absorption method. A radioactive source (Cs-137) contained in a lead-shield, steelenclosed housing is mounted on one side of pipe with a scintillation detector on the opposite side. Gamma energy emitted from the source passes through the pipe and the process material. The amount of energy reaching the detector changes with the density change of the material being measured. Density is determined based on energy attenuation and fluid concentration or solid content is calculated via density



Measurement of temperature

Temperature measurement, also known as thermometry, describes the process of measuring a current local temperature for immediate or later evaluation. Datasets consisting of repeated standardized measurements can be used to assess temperature trends



Write down what temperature it is in Fahrenheit and Celsius.



Thermocouple

- A thermocouple is an electrical device consisting of two dissimilar electrical conductors forming electrical junctions at differing temperatures. A thermocouple produces a temperature-dependent voltage as a result of the thermoelectric effect, and this voltage can be interpreted to measure temperature. Thermocouples are a widely used type of temperature sensor
- Commercial thermocouples are inexpensive, interchangeable, are supplied with standard connectors, and can measure a wide range of temperatures. In contrast to most other methods of temperature measurement, thermocouples are self powered and require no external form of excitation. The main limitation with thermocouples is accuracy; system errors of less than one degree Celsius (°C) can be difficult to achieve.
- Thermocouples are widely used in science and industry. Applications include temperature measurement for kilns, gas turbine exhaust, diesel engines, and other industrial processes. Thermocouples are also used in homes, offices and businesses as the temperature sensors in thermostats, and also as flame sensors in safety devices for gas-powered appliances

pH meter

A pH meter is a scientific instrument that measures the hydrogen-ion activity in water-based solutions, indicating its acidity or alkalinity expressed as pH. The pH meter measures the difference in electrical potential between a pH electrode and a reference electrode, and so the pH meter is sometimes referred to as a "potentiometric pH meter". The difference in electrical potential relates to the acidity or pH of the solution. The pH meter is used in many applications ranging from laboratory experimentation to quality control.





рН

In chemistry, pH (potential of hydrogen) is a numeric scale used to specify the acidity or basicity of an aqueous solution. It is approximately the negative of the base 10 logarithm of the molar concentration, measured in units of moles per liter, of hydrogen ions. More precisely it is the negative of the base 10 logarithm of the hydrogen ion. Solutions with a pH less than 7 are acidic and solutions with a pH greater than 7 are basic. Pure water is neutral, at pH 7 (25 °C), being neither an acid nor a base. Contrary to popular belief, the pH value can be less than 0 or greater than 14 for very strong acids and bases respectively.

- Measurements of pH are important in agronomy, medicine, biology, chemistry, agriculture, forestry, food science, environmental science, oceanography, civil engineering, chemical engineering, nutrition, water treatment and water purification, and many other applications.
- The pH scale is traceable to a set of standard solutions whose pH is established by international agreement. Primary pH standard values are determined using a concentration cell with transference, by measuring the potential difference between a hydrogen electrode and a standard electrode such as the silver chloride electrode. The pH of aqueous solutions can be measured with a glass electrode and a pH meter, or an indicator

Vibration

Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point. The word comes from Latin vibrationem ("shaking, brandishing"). The oscillations may be periodic, such as the motion of a pendulum—or random, such as the movement of a tire on a gravel road.

- Vibration can be desirable: for example, the motion of a tuning fork, the reed in a woodwind instrument or harmonica, a mobile phone, or the cone of a loudspeaker.
- In many cases, however, vibration is undesirable, wasting energy and creating unwanted sound. For example, the vibrational motions of engines, electric motors, or any mechanical device in operation are typically unwanted. Such vibrations could be caused by imbalances in the rotating parts, uneven friction, or the meshing of gear teeth. Careful designs usually minimize unwanted vibrations.
- The studies of sound and vibration are closely related. Sound, or pressure waves, are generated by vibrating structures (e.g. vocal cords); these pressure waves can also induce the vibration of structures (e.g. ear drum). Hence, attempts to reduce noise are often related to issues of vibration.

Vibration level



Two Wattmeter Method of Power Measurement

Two Wattmeter Method can be employed to measure the power in a 3 phase, three wire star or delta connected the balanced or unbalanced load. In Two wattmeter method the current coils of the wattmeter are connected with any two lines, say R and Y and the potential coil of each wattmeter is joined on the same line, the third line i.e. B



The total instantaneous power absorbed by the three loads Z1, Z2 and Z3, are equal to the sum of the powers measured by the Two wattmeters, W1 and W2.

Measurement of Power by Two Wattmeter Method in Star Connection



Circuit Globe

Considering the above figure (A) in which Two Wattmeter W1 and W2 are connected, the instantaneous current through the current coil of Wattmeter, W1 is given by the equation shown below.

$W_1 = i_R$

Instantaneous potential difference across the potential coil of Wattmeter, W1 is given as

$W_1 = e_{RN} - e_{BN}$ Instantaneous power measured by the Wattmeter, W1 is

$$W_1 = i_R (e_{RN} - e_{BN}) \dots \dots \dots \dots (1)$$

The instantaneous current through the current coil of Wattmeter, W2 is given by the equation

 $W_2 = i_Y$

Instantaneous potential difference across the potential coil of Wattmeter, W2 is given as

 $W_2 = e_{YN} - e_{BN}$

Instantaneous power measured by the Wattmeter, W2 is

 $W_2 = i_Y (e_{YN} - e_{BN}) \dots \dots \dots (2)$

Therefore, the Total Power Measured by the Two Wattmeters W1 and W2 will be obtained by adding the equation (1) and (2).

$$\begin{split} W_1 + W_2 &= i_R (e_{RN} - e_{BN}) + i_Y (e_{YN} - e_{BN}) \\ W_1 + W_2 &= i_R e_{RN} + i_Y e_{YN} - e_{BN} (i_R + i_Y) \text{ or} \\ W_1 + W_2 &= i_R e_{RN} + i_Y e_{YN} + i_B e_{BN} \quad (i.e. i_R + i_Y + i_B = 0) \\ W_1 + W_2 &= P \end{split}$$

Where P – the total power absorbed in the three loads at any instant

Measurement of Power by Two Wattmeter Method in Delta Connection

Considering the delta connected circuit shown in the figure below.



Circuit Globe

The instantaneous current through the coil of the Wattmeter, W1 is given by the equation

 $W_1 = i_R = i_1 - i_3$

Instantaneous Power measured by the Wattmeter, W1 will be

 $W_1 = e_{RB}$

Therefore, the instantaneous power measured by the Wattmeter, W1 will be given as

 $W_1 = e_{RB} (i_1 - i_3) \dots \dots \dots (3)$

The instantaneous current through the current coil of the Wattmeter, W2 is given as

 $W_2 = \ i_Y = \ i_2 - \ i_1$

The instantaneous potential difference across the potential coil of Wattmeter, W2 is

 $W_2 = e_{YB}$

Therefore, the instantaneous power measured by Wattmeter, W2 will be

 $W_2 = e_{YB} (i_2 - i_1) \dots \dots (4)$

Hence, to obtain the total power measured by the Two Wattmeter the two equations, i.e. equation (3) and (4) has to be added

$$\begin{split} & W_1 + W_2 = e_{RB} \left(i_1 - i_3 \right) + e_{YB} \left(i_2 - i_1 \right) \\ & W_1 + W_2 = i_1 e_{RB} + i_1 e_{YB} - i_3 e_{RB} - i_1 e_{YB} \\ & W_1 + W_2 = i_2 e_{YB} + i_3 e_{BR} - i_1 (e_{YB} + e_{BR}) \quad (i.e. - e_{RB} = e_{RB}) \\ & W_1 + W_2 = i_1 e_{RY} + i_2 e_{YB} + i_3 e_{BR} \quad (i.e \; e_{RY} + \; e_{YB} + \; e_{BR} = 0) \\ & W_1 + W_2 = P \\ & Where P \text{ is the total power absorbed in the three loads} \end{split}$$

at any instant

Measurement of Three Phase Power: Three Wattmeter Method

Three Wattmeter method is employed to measure power in a 3 phase, 4 wire system.However, this method can also be employed in a 3 phase, 3 wire delta connected load, where power consumed by each load is required to be determined separately.

The connections for star connected loads for measuring power by Three wattmeter method is shown below.



The pressure coil of all the Three wattmeters namely W1, W2 and W3 are connected to a common terminal known as the neutral point. The product of the phase current and line voltage represents as phase power and is recorded by individual wattmeter.

The total power in a Three wattmeter method of power measurement is given by the algebraic sum of the readings of Three wattmeters. i.e

Total power $P = W_1 + W_2 + W_3$

Where W1 = V1I1

W2 = V2I2

W3 = V3I3

Except for 3 phase, 4 wire unbalanced load, 3 phase power can be measured by using only Two Wattmeter Method