EE8403 - Measurements and Instrumentation Engineering.

UNIT-I.

Functional elements of an instruments - Static and dynamic characteristics - Errors in measurement - Statistical evaluation of measurement data - Standards and calibration - Principle and types of analog and digital voltmeters, ammeters.

UNIT-II.

Principle and types of multi meters - Single and three phase watt meters and energy meters - magnetic measurements - Determination of B-H curve and measurements of iron loss - Instrument transformers - Instruments for measurement of frequency and Phase.

UNIT-III. → Comparative methods of measurements.

DC. potentiometers, DC. bridges (wheatstone bridge, kelvin and kelvin double bridge) and AC bridges (Maxwell, Anderson and Schering bridges), transformer ratio bridges, self balancing bridges, Interference and Screening - Multiple earth loops - Electromagnetic Interference - Grounding Techniques.

UNIT-IV. → Storage and Display devices.

Magnetic disk and tape - Recorders - digital plotters and printers, CRT, digital CRO, LED, LCD and DOT matrix display - Data loggers.

UNIT-V. → Transducers and Data Aquisition System.

Classification of transducers - Selection of transducers - Resistive, Capacitive and inductive Transducers - piezoelectric, Hall effect, optical and digital transducers - Elements of data aquisition system - Smart sensors - Thermal Imagers.

Unit-II.

2 Marks (important Questions).

1.) List any 4 characteristics of a measurement System :- (Dec. 2017)

i) Accuracy
ii) precision
iii) Sensitivity
iV) Linearity.

2.) Define resolution :- (Dec/2017)

It is the ability of the measurement system to detect and faithfully indicate small changes in the characteristics of the measurement result.

3.) A voltmeter reads 152 volts for a particular measurement. If the true value of the measurement is 154 volt. Determine the Percentage static relative error and static correction :- (April 2018)

$$\% \text{ Static error} = \left(\frac{\text{measured Value} - \text{True value}}{\text{True value}}\right) \times 100$$

$$= \left(\frac{\text{measured value} - \text{True value}}{\text{True value}}\right) \times 100$$

$$= \left(\frac{152 - 154}{154}\right) \Rightarrow -1.298\%.$$

4.) What is average deviation? What does indicate on a measuring instrument? (April/2018)

Average deviation is a measure of the difference between observed value of the variable and some other value, often the variables mean. It indicates deviation in observed variable.

5.) Define the terms accuracy and precision: (may/2017) :-

Accuracy :-

Degree of closeness with which an instrument reading approaches the true value of quantity being measured.

Precision :-

It is the measure of consistency (or) repeatability of measurements.

6.) What is calibration? (may/2017).

Calibration is used to maintain instrument accuracy. It is the process configuring an instrument to provide a

UNIT - II

2 - Marks

1.) Define Creeping: (Dec/2017)

It is defined as the tendency to

of a material after being subjected

high level of stress. eg.) temperatures,

to change its form in relation to time

2.) why type of frequency meter is used over a wide range of voltage? why? (April/e

Western type frequency meter is

used over a wide range of voltage,

because it is not of deflection type.

3.) what makes the scale of MI instruments cramped at both lower and upper end? (April/2018)

Scale is almost uniform in

the lower and higher ends

between

i.e.) scale is usable over 80° of its

length.

1) State the reasons for the two types of errors in a Potential transformer? (may/2019)

The voltage applied to the Primary of the potential transformer first drops due to the internal impedance of the Primary. Then it appears across the Primary winding and transformed Proportionally its turns ratio, to the Secondary winding.

2) List out various causes which occur error in a dynamometer wattmeter. (may/2019)

i) Error due to eddy currents.
ii) Error due to mutual inductance
iii) Error due to connections
iv) Error due to Pressure coil.

3) How are basic instruments converted to high range ammeter? (may 2016).

In ammeter the range can be extented by Connecting a a Shunt resistor. The value of Shunt resistor is given by.

result, of a sample within acceptable range.

7.) Name the dynamic characteristic of measurement system? (may/2016).

i) speed of response
ii) fidelity
iii) Lag
IV) Dynamic error.

.) Define static sensitivity? (Nov/2016).

It is defined as the ratio of the change in output to the corresponding change in input under static conditions.

.) what are the sources of errors in DC voltage measurement? (Dec/2018).

Radio frequency interference
Thermal emf errors
noise caused by magnetic fields.

10.) classify the Types of errors :-

a) Gross errors
b) Systematic errors
i) Instrumental errors
ii) Environmental errors
iii) Observational errors.
c.) Random errors :

11.) Define Stantand ?
A standard is defined as the physical representation of a unit of measurement. The term standard is applied to a piece of equipment having known measure of Physical quantity.

12.) classify the types of Standards :-

i) International Standards
ii) Primary Standards
iii) Secondary Standards
iv) Working Standards.

$$R_{sh} = \frac{R_m}{m-1}$$, where $m = I / I_m$

'm' → multiplying Power
'Rm' → Internal resistance.

7.) Write any 4 types of analog ammeter used for instrumentation. (NOV. 2016).

i) Moving coil Ammeter
ii) Moving iron Ammeter
iii) Hot wire Ammeter
iv) Electrodynamic Ammeter.

8.) Define transformation ratio of an instrument transformer.

$$\text{Transformation Ratio} = \frac{\text{Primary Current}}{\text{Secondary Current}}$$

1.) what is the function of multimeter?

A multimeter can be hand held device useful for basic fault finding and field services work (or) a bench instrument which

* Consumes more power, ...

* Can measure to a very high degree of accuracy.

10.) what is Analog voltmeter?

Analog voltmeters are Instruments that measure voltage (or) voltage drop in a circuit. They display values on a dial, usually with a needle (or) moving pointer.

11.) what is digital ammeter?

Digital ammeter designs use of analog to digital converter (ADC) to measure the voltage across the shunt resistor, the digital display is calibrated to read the current through the shunt.

UNIT- III -2 Marks.

1. what is Potentiometer:-

A potentiometer is an instrument designed to measure an unknown voltage by comparing it with a known voltage.

2. Application of potentiometer:-

* Measurement of small emfs (upto 2V.)
* Comparison of emf of 2 cells.
* Measurement of resistance
* Measurement of current.

3. What are the types of DC bridges?

* wheatstone Bridge
* kelvin's Bridge.
* Kelvin's double bridge.

4. what is kelvin's Bridge :-

wheatstone bridge is not suitable for measurement of very low resistance. kelvin's bridge is a modification of wheatstone bridge and is used to measure values of resistance below 1 Ω.

5. what is Schering Bridge ?

The schering bridge is one of the most important AC bridge, is used for measurement of of capacitors, it is also measures the insulating Properties of the electrical cables and equipments,

6. what is earth Loop ?

Earth loops form a distint Part of the gaurding system of electrical Equipment.

* The operating cost is quite low.

7.

LED	LCD.
* Consumes more power	* Consumes less power.
* High cost	* Low cost.
* More life time	* Less life time.
* capable of generating its own light	* Requires an

8. Mention the application of LVDT :-

LVDT. are used to measure,

* Displacement

* Force
* weight
* pressure
* Position.

9. Define smart sensor :-

Smart sensors are sensors with Integrated electronoics that can perform one (or) more of the following functions.

i) Logic functions

ii) Two- way communication.

iii) Make decision.

. What are the materials used for piezo electric transducers?

Common piezo electric materials include ammonium di-hydrogen Phosphate, quartz and ceramics made with barium titanate, Pottasium di- hydrogen phosphate and lithium sulphate are used in real applications.

1. Define Recorder :-

It is used to record all electrical and non-electrical quantities as a function of time.

2. What is Magnetic tape recorder :-

Magnetic tape recorder is a recorder which records analog data in such a manner that they can be reproduced in electrical form again.

What are the various methods of recording data ?

* Direct Recording
* Frequency modulation recording.
* Pulse duration recording.

4. Basic Components of magnetic tape recorder :-

* Recording Head.
* Magnetic tape
* Reproducing Head.
* Tape transport mechanism.
* conditioning devices.

5. List the main parts of Cathode ray tube :-

* Electron gun assembly
* Deflection plate assembly
* Fluorescent screen
* Glass envelop.

State the features of ink jet printers :-

* They can print from 2 (or) 4 Pages per minute.

UNIT-V - 2 Marks :-

1. **Define Transducer :-**

A Transducer is defined as a device that receives energy from one system and transmits it to another, often is a different form.

2. **Write the parameters of electrical transducers :-**

i) Linearity
ii) Sensitivity
iii) Dynamic rage
iv) Repeatability.
v) Physical size.

Define : Viscosity :-

Viscosity is defined as the prop which determines the magnitudes of the resistance of the fluid to schering for

4. Write the types of potentiometer :-

The types of potentiometer are,

i) Translatory
ii) Rotational
iii) Helipot.

5. In what Principles, Inductive transducer works ?

i) Variation of self- Inductance.
ii) Variation of mutual Inductance.

6. Write a Short notes on LVDT :-

LVDT- [Linear Variable Differential Transformer] converts the mechanical energy into electrical energy. It has single Primary windings, and two secondary winding wound on a hollow cylindrical former.

7. List the advantages of "LVDT" :-

* High range of displacement Measurement
* Friction and electrical isolation.
* Immunity from external effects.
* Ruggedness.

8. Define Inductive Transducers :-

Inductive Transducers is defined as a device that converts physical motion into a change in Inductance. It may be either of "active" (or) "passive" type.

9. Give the Principle of Capacitive Transducers:-

$$C = KA/d.$$

where,

K = dielectric Constant
A = Total Area of capacitor surfaces.
d = distance between 2 capacitive surfaces.

· What is meant by Digital Transducers :-

Digital Transducers are also called as encoders. They are normally in the form of linear (or) rotary displacement transducers. Hence they require analog to digital converter to realize the digital data.

EE8403 - Measurement and Instrumentations.

UNIT-I :

Fundamentals of (Functional elements of an instrument) - Static and dynamic Characteristics - Errors in measurement - Statistical evaluation of measurement data - Standards and Calibration - Principle and types of analog and digital voltmeters, ammeters.

Measurement & Instruments :-

An "electronic instrument" is one which is Based on electronic (or) electrical principles for its measurement function. The measurement of any electronic (or) electrical quantity or variable is termed as an electronic measurement.

Measurements :-

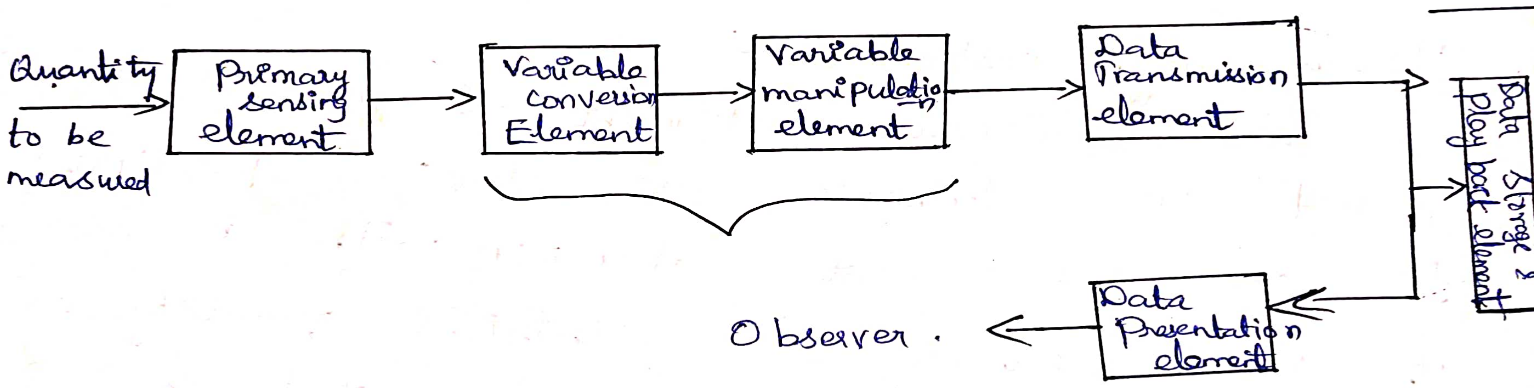
It is an act (or) the result of comparision between the quantity whose magnitude is unknown and a predefined standard. The compare result is expressed in numerical value.

"Measurement is a power by which one can convert physical parameter to meaningful numbers".

Instrument :-

An Instrument is a device for measuring the value (or) magnitude of a quantity (or) variable.

Functional Elements of an Instrument :-



The block diagram indicates the necessary elements and their functions in general measuring system. The entire operation of an instrument can be studied interms of these functional elements.

The various elements can be grouped as,

1> Primary sensing element
2> Data conditioning element
3> Data Presentation element.

Primary sensing element :-

An element of an instrument which makes first, the contact with the quantity to be measured is called Primary sensing element. Thus first detection of measurand is done by the Primary sensing element. In ammeter, coil carrying current to be measured is a Primary Sensing element. In most of the cases, a transducer follows primary Sensing element which converts the measurand into a corresponding electrical Signal.

"Transducer" is an electronic device that converts energy from one form to another. The process of converting energy from one form to another is called Transduction. [Transducer converts non-electrical quantity into electrical Signal].

Variable Conversion Element :

The output of the primary Sensing element is in electrical form such as Voltage, frequeny or any other electrical Parameter. Such an output may not be suitable for the actual measurement system.

For example if the measurement system is digital then the analog signal obtained from the primary sensing element is not suitable for the digital system. The analog to digital converter is required which is nothing but variable conversion element.

The original information about the measurand must be retained as it is while doing such conversion.

Variable Manipulation element :-

The level of the output from the previous stage may not be enough to drive the next stage. Thus variable manipulation element manipulates the signal, preserving the original nature of the signal.

Data Transmission Element :-

To transmit data from one to another, it is necessary to Physically seperate the functional elements of an instrument. The element which performs this function is called as "Data Transmission element".

Data Presentation Element :-

The information about the measuring quantity is to be conveyed to the Personal handling the instrument (or) the system for monitoring, control (or) analysis purpose.

The conveyed information should be intelligible form to the personnel (or) instrumentation system

For data monitoring, visual display devices can be used which may be analog (or) digital indicating instruments like ammeter, voltmeters etc..

For data recording, records like magnetic tape, high speed camera, T.V equipment, storage

For control and analysis purposes, micro computers and micro processors can be used.

Data storage / play back Element :-

The signal conditioning and transmmission stage is commonly know as intermediate stage.

To re-create the stored data data storage / Play back function is required.

Example:

magnetic tape recorder.

1.2 Static characteristics of measurement system:-

The set of criteria defined for the instruments, which are used to measure the quantities which are slowly varying with time (or) mostly constant. ie.) do not.

The static characteristics are,

i) Accuracy
ii) Precision
iii) Sensitivity
iv) linearity
v) Reproducibility
vi) Repeatability
vii) Resolution
viii) Threshold
ix) Drift
x) Stability
xi) Tolerence
xii) Range (or) Span.

Accuracy:-

It is the degree of closeness with the reading approaches the true value of the quantity to be measured.

Precision:-

It is the measure of reproducibility i.e.,) given a fixed value of a quantity, Precision is a measure of the degree of agreement within a group of measurements. The Precision is composed of 2 types.

a) Conformity:

consider a resistor having true value as 2385692, which is being measured by an ohm meter. But the reader Can read consistently, a value as 2.4 M due to the non-availability of Proper Scale. The error created due to the limitation of the scale reading is a "Precision error".

b) Number of Significant figures:-

The Precision of the measurement is obtained from the number of significant figures, in which the reading is expressed. The significant figures convey the actual information about the magnitude and the measurement precision of the quantity.

Sensitivity :-

The sensitivity denotes the smallest change in the measured variable to which the instrument responds. It is defined as the ratio of the changes in the output of an instrument to a change in the value of the quantity to be measured.

Linearity :-

The linearity is defined as the input characteristics symmetrically & linearly.

Reproducibility :-

It is the degree of closeness with which a given value may be repeatedly measured. It is specified interms of scale readings over a given period of time.

Repeatability :

It is defined as the variation of scale reading and random in nature.

Drift :

Drift may be classified into 2 Categories :

i) Zero drift

ii) span drift (or) sensitivity drift.

iii) Zonal drift.

Zero drift :

It is defined as,

If the whole calibration gradually shifts due to slippage, permanent set, (or) due to undue warming up of electronic tube circuits, Zero drift sets in.

Resolution :-

If the input is slowly increased from some arbitrary input value, it will again be found that output does not change at all untill a certain increment is exceeded. This increment is called resolution.

Threshold :-

If the instrument input is increased very gradually from zero there will be some minimum value below which no

Stability :-

It is the ability of an instrument to retain its performance throughout is specified operating life.

Tolerance :-

The maximum allowable error in the measurement is specified in terms of some value which is called tolerance.

Range (or) Span :-

The minimum and maximum value of a quantity for which an instrument is designed to measure is called its range (or) span.

CALIBRATIONS

Introduction :-

Calibration is the process of making an adjustment (or) making a scale so that the readings of an instrument agree with the accepted & certified standard.

5. In other words, it is the Procedure for determining the correct values of measurand by comparison with the measured (or) standard ones.

5.1 Types of Calibration.

There are two methodologies for obtaining the comparison between "test instrument" and "standard instrument". These methodologies are.

i) Direct comparisons
ii) Indirect comparisons.

5.1.a → Direct comparisons :

i) In a Direct Comparison, a source (or) generator applies a known i/p to the meter under test.

ii) The ratio of what meter is indicating & the known generator values gives the meters error.

iii) In such case, the meter is the test instrument while the generator is the Standard instrument.

iv) The deviation of meter from the standard value is compared with the allowable performance limit.

v) with the help of direct comparison a generator (or) source also can be calibrated.

3.1.b: Indirect comparisions :-

=> In Indirect comparisons, the test instrument is compared with the response standard instrument of same type.

i.e) if test instrument is meter, standard instrument is also meter, if test instrument is generator, the standard instrument is also generator & so on. If the test instrument is a meter, then the same i/p is applied to the test meter as well as a standard meter.

=> In case of generator calibration, the output of the generator tester as well as standard, or set to same nominal levels. Then the transfer meter is used which measures the outputs of both standard and test generator.

STANDARDS

1. **Standard :-**

All the instruments are calibrated at the time of manufacturer against measurement standards. A standard of measurement is a physical representation of a unit of measurement. A standard means "known accurate measure of Physical Quantity".

The standards are classified into 4 types. They are,

4.1
i) International Standards
ii) Primary Standards
iii) Secondary Standards
iv) working Standards.

1.1.a
International Standards :

International standards are defined as the international agreement. These standards as mentioned above are maintained at the international bureau of weights and measures and are periodically evaluated and checked by absolute measurements in terms of fundamental units of Physics.

These international standards are not available to the ordinary users for the calibration purpose.

For the improvement in the accuracy of absolute measurements the international units are replaced by ~~the~~ the absolute units in 1948. Absolute units are more accurate than the international units.

4.1.b Primary Standards:

These are highly accurate ~~than~~ absolute standards, which can be used as ultimate reference standards. These Primary standards are maintained at national standard laboratories in different countries

These standards representing fundamental units as well as some electrical and mechanical derived units are calibrated independently by absolute measurements at each of the national laboratories.

4.1.c

Secondary Standards :

As mentioned above, the Primary Stands are not available for use outside the national laboratories. The various industries need some reference standards.

So, to Protect highly accurate Primary Standards the secondary standards are maintained. which are designed and constructed from the absolute Standards.

These are used by the measurements and Calibration laboratories in industries and are maintained by the particular industry to which they belong. Each industry has its own standards.

4.1.d

Working Standards :-

The following tools are the basic of measurement laboratory and are used to check and calibrate the instruments used in laboratory for accuracy and performance

International Standards
↓
National Standard laboratories
↓
Industries and Secondary laboratories
↓
measurement laboratory
↓
Process instrument

5. Statistical analysis :-

The statistical evaluation of measurement data is important because it allows an analytical determination of uncertainity of the final test result. The large number of measurements is usually required for statistical Analysis.

Systematic errors should be small when compared to Random errors, because statistical analysis of data cannot remove a fixed bias contained in all measurements.

The experimental data is obtained in two forms of tests :

i) Multi Sample test
ii) Single Sample test.

Multi Sample test :-

The repeated measurement of a given quantity are done using different test conditions such as different instruments, different ways of measurement and by employing different observers.

Single Sample test :-

A single measurement done under identical conditions expecting for time is known as single sample test.

5.1.a Arithmetic mean :-

The most probable value of measured variable is the arithmetic mean of the number of readings taken. The best approximation is possible when the number of readings of the same quantity is very large.

The arithmetic mean is given by,

$$\bar{X} = \frac{x_1 + x_2 + x_3 + x_4 + \cdots + x_n}{n}$$

$$\bar{X} = \frac{\sum_{n=1}^{n} x_n}{n}$$

where,

$\bar{X}$ = arithmetic mean,

$x_1, x_2 \ldots x_n$ = readings (or) samples (or) variates

n = Total number of readings.

5.1.b **Deviation:**

The departure of the observed readings from the arithmetic mean of the group of readings is termed as deviation.

Let the deviation of reading x_1 be d_1 and that of reading x_2 be d_2, x_n be d_n, etc...

Then

$$d_1 = x_1 - \bar{x}$$

$$d_2 = x_2 - \bar{x}$$

$$d_n = x_n - \bar{x}$$

and

$$\bar{x} = \frac{\sum (x_n - d_n)}{n}$$

Algebraic sum of deviation is,

$$= d_1 + d_2 + \cdots + d_n$$

1.c **Average deviation:**

It is defined as the sum of the absolute values of deviations divided by the number of readings.

Average deviation may be expressed as,

$$\bar{D} = \frac{|d_1| + |d_2| + \cdots + |d_n|}{n} = \frac{\sum |d|}{n}$$

Sol: d

Standard Deviation :-

Standard deviation of an infinite number of data is defined as the square root of the sum of the individual deviation squared, divided by the number of readings.

Standard deviation may be expressed as,

$$S.D = \sigma = \sqrt{\frac{d_1^2 + d_2^2 + \dots + d_n^2}{n}}$$

$$S.D = \sqrt{\frac{\sum d^2}{n}}$$

when the number of observations is greater than 20, Standard deviation is denoted by symbol σ. while if the number of observations is less than 20, Standard deviation is denoted by symbol s.

$$s = \sqrt{\frac{d_1^2 + d_2^2 + \dots + d_n^2}{n-1}}$$

$$s = \sqrt{\frac{\sum d^2}{n-1}}$$

Variance :-

The square of the standard deviations is called Variance.

$$V = (\text{Standard Deviations})^2.$$

$$\sigma^2 = \frac{d_1^2 + d_2^2 + \dots + d_n^2}{n} = \sigma^2 = \frac{\Sigma d^2}{n}$$

when the number of observations is less than 20,

$$V = \frac{\Sigma d^2}{n-1}$$

6. Errors:

6.1 Sources of Errors:

In the process of measurement, the errors are bound to occur. If the source of errors are known, then the effects of errors and can be made to reduce the errors partly to eliminate them. The various possible sources of errors are,

i) Faulty design of the instrument which directly leads to the serious measurement errors.

ii) Due to insufficient knowledge of the quantity to be measured and design conditions can cause errors.

iii) For the instruments frequent maintainance is necessary. If such maintainance is not done then the errors may occur.

iv) If there are irregulars in quantity to be measured or sudden changes in the parameter to be measured then errors may exist.

v) The unskilled operator of the instrument can cause serious errors.

vi) The certain limitations while designing the instrument can cause errors.

vii) The effects of environmental condition temperature changes, stay capacitances also can cause the errors. The proper care taken considering the sources of errors can help to reduce the percentage of errors and to improve the accuracy of measurements.

Types of errors:

The static error is defined earlier as the difference between the true value of the variable and the value indicated by the instrument. The static error may arise due to number of reasons.

Errors
- Gross errors
- Systematic error
  - Instrumental
  - Environmental
  - Observational.
- Random errors

6.1.a Gross errors:

The Gross errors are mainly occur due to ~~cleartan~~ carelessness (or) lack of experience of a human being. These cover human mistakes in readings, recordings and calculating results. These errors also occur due to incorrect adjustments of instruments. These errors cannot be treated mathematic calle. These errors are also called "Personal errors". Some gross errors are easily detected while others are very difficult to detect.

The complete elimination of gross errors is not possible but one can minimise them by the following ways:-

i) Taking great care while taking the reading, recordings and reading and calculating the result.

ii) without depending on only one reading At least three (or) even more readings must be taken and preferably by different persons. The readings must be taken under the conditions in which the instruments are switched On and OFF.

6.1.b Systematic errors :

The systematic errors are mainly resulting due to the short coming of the instrument and the characteristics of the material used in the instrument, such as defective (or) own parts, ageing effects, environmental effects, etc.

A constant uniform deviation of the operation of an instrument is known as "Systematic error".

b.1.c Instrumental errors :-

Due to mechanical structure, these errors are inherent in instruments. They may be due to constructions, Calibration (or) operation of the instruments (or) measuring devices. This error may cause the instrument to read too low (or) too high.

The reasons for these errors are:

i) Improper calibration
ii) Friction in bearings of meter movement
iii) Ageing of permanent magnets
iv) Defective (or) worn out parts.

These errors can be reduced by Proper maintainance, use and careful handling of instruments.

.d Environmental errors:

instrument readings are largely affected due to changes in sourroundings such as temperature change, Pressure change, change in humidity, variations (or) external magnetic (or) electrostatic field.

To reduce these errors Provide

i) Air conditioning, sheilding
ii) Proper Earthing and spring mo

b.1.e Observational errors:

Errors occur due to improper observation made by The observer are known as observational errors.

This type of error is due to parallax which will be incurred unless the line of vision of the observer is exactly above the pointer.

To minimize parallax errors, accurate meters are provided with mirrored scales.

b.1.f Random Errors:

Errors due to a mutitude of small faulto-s which change (or) fluctuate from one measure-ment to another and are surely to change. The happening (or) disturbances about which we are unware are lumped together and Called "random (or) residual".

The errors Caused by these happeni are called Random errors. They are of real Concern only in measurements requiring a high degree of accuracy.

They can be analyzed statistically.

UNIT-II

Principle and types of multi meters - Single and three phase watt meters and energy meters - Magnetic measurements - Determination of B-H curve and measurements iron loss - instrument transformers - Instruments for measurement of frequency and phase.

Principle of multimeter :-

For the measurement of d.c as well as a/c voltage and current, resistance, an electronic multimeter is commonly used. It is also known as voltage-ohm meter (VOM)(or) "multimeter". The important salient features of VOM are listed below,

i) The basic circuit of VOM include balanced bridge, d.c amplifier.

ii) To limit the magnitude of the signal "range switch" is provided. By properly adjusting i/p attenuator i/p signal can be limited.

iii) It also includes rectifier section which converts a.c i/p signal to the d.c voltage.

iv) It facilitates resistance measurement with the help of internal battery and additional circuitry.

v) The various parameters measurement is possible by selecting required function using "FUNCTION" switch.

vi) The measurements of various parameters is indicated with the help of indicating me

A multimeter measures a.c and d.c voltages and d.c currents and resistance.

UNIT - II

2 - Marks

1.) Define Creeping: (Dec / 2017)

It is defined as the tendency of a material after being subjected to high level of stress. eg.) temperatures, to change its form in relation to time

2.) why type of frequency meter is used over a wide range of voltage? why? (April/20..)

Western type frequency meter is used over a wide range of voltage, because it is not of deflection type.

3.) what makes the scale of MI instruments cramped at both lower and upper end? (April/2018)

Scale is almost uniform in between the lower and higher ends i.e.) scale is usable over 80° of its length.

4.) State the reasons for the two types of errors in a pontial transformer? (may/2019)

The voltage applied to the Primary of the potential transformer first drops due to the internal impedance of the Primary. Then it appears across the Primary winding and transformed Proportionally its turns ratio, to the Secondary winding.

5.) List out various Causes which occur error in a dynamometer wattmeter. (may/2019)

i) Error due to eddy currents.
ii) Error due to mutual inductance
iii) Error due to Connections
iv) Error due to Pressure coil.

) How are basic instruments converted to high range ammeter? (may 2016).

In ammeter the range can be entented by Connecting a a shunt resistor The value of shunt resistor is given by.

$$R_{sh} = \frac{R_m}{m-1}, \text{ where } m = I/I_m$$

'm' → multiplying Power
'Rm' → Internal resistance.

7.) Write any 4 types of analog ammeter used for instrumentation. (NOV. 2016).

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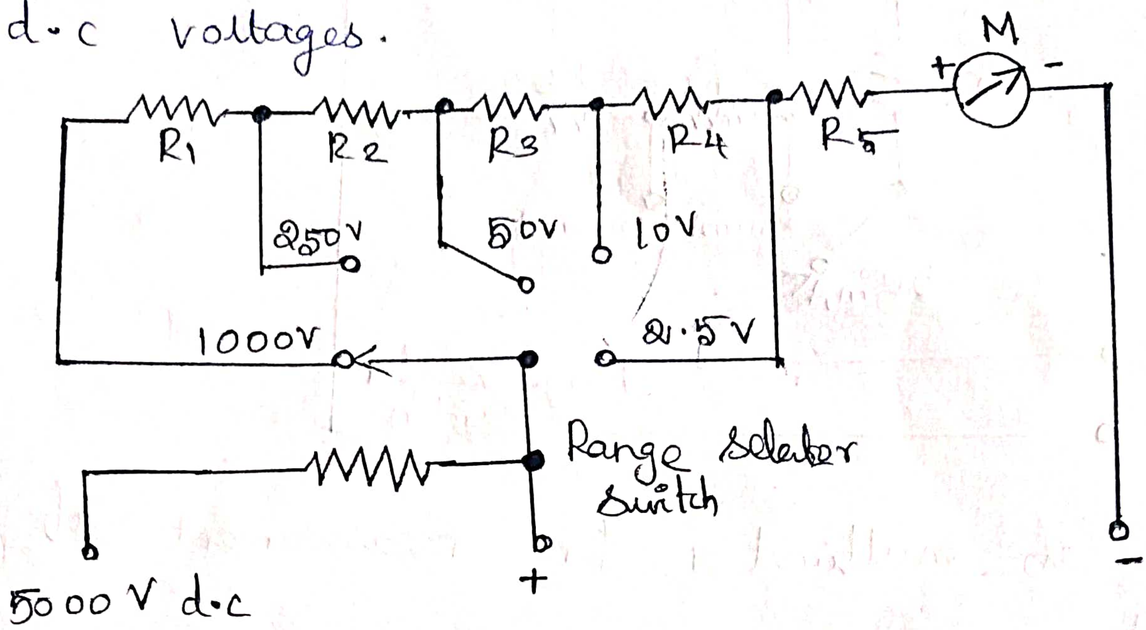
Use of multimeter for D.c voltage Measurement :-

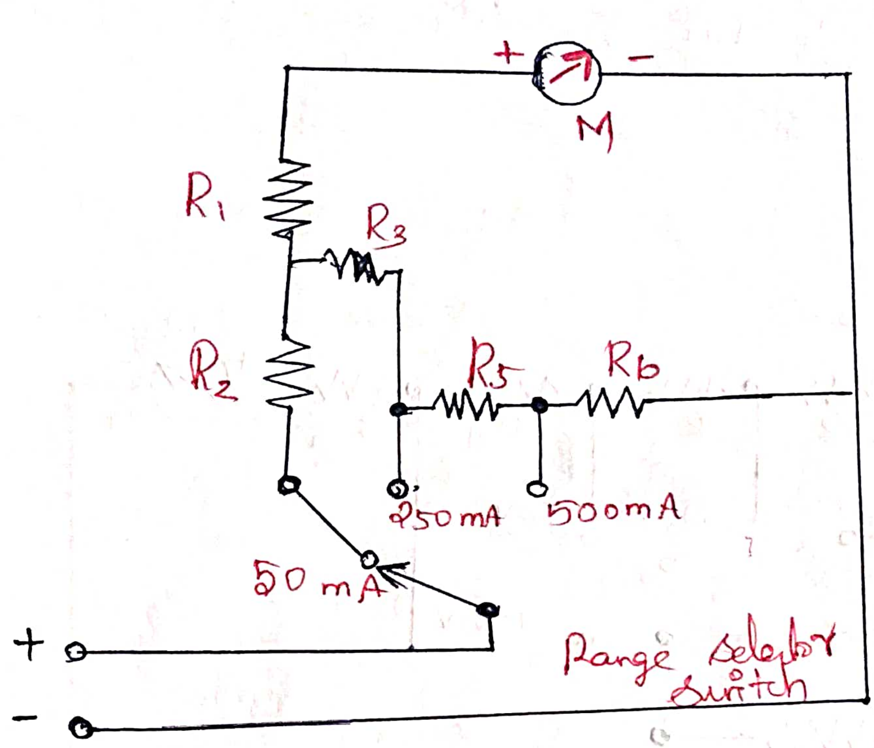
The below figure shows the arrangement used in multimeter to measure the d.c voltages.



For getting different ranges of voltages, different series resistances are connected in series which can be put in the circuit with the range selector switch. We can get different ranges to measure the d.c voltages by selecting the proper resistance in series with the basic meter.

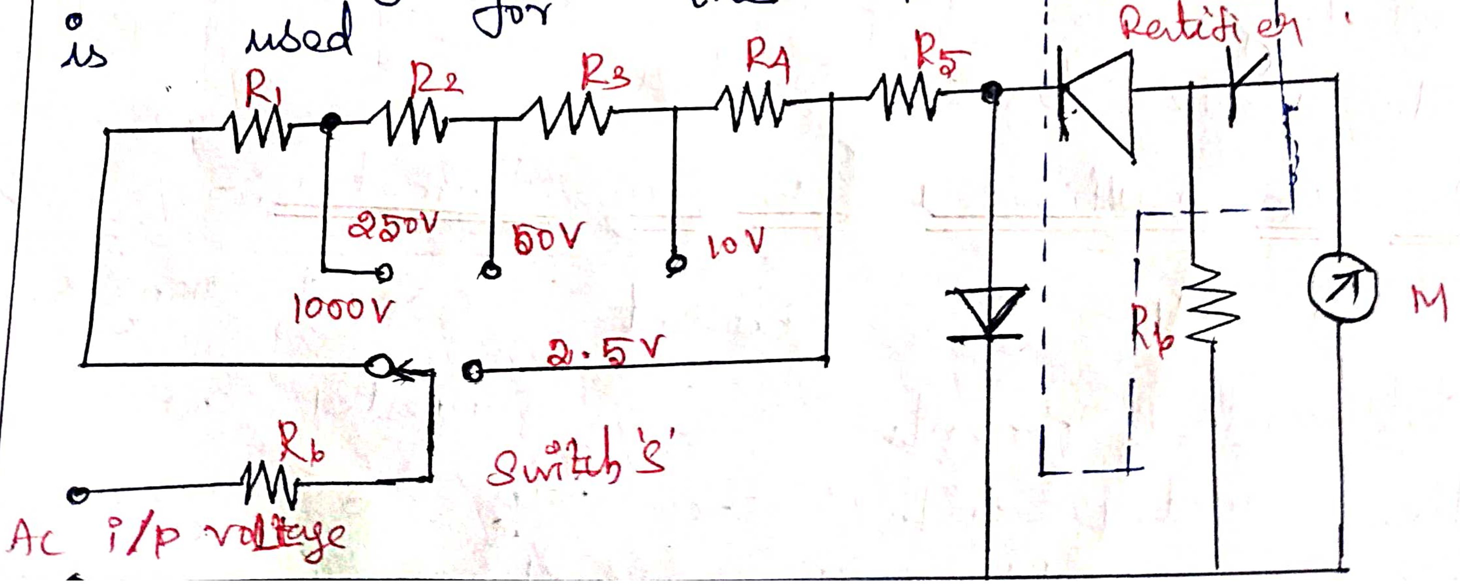
Use of multimeter as an Ammeter :-

To get different current ranges, different shunts are connected across the meter with the help of range selector switch. The working is same as ~~s~~ that of "PMMC ammeter".



Use of multimeter for measurement of A.C Voltage:

The rectifier used in the circuit rectifies a.c voltage into d.c voltage for measurement of a.c voltage before current passes through the meter. The other diode is used for the protection purpose.



This is because the average power multiplied by time measure the transfer of energy over a time interval, if a steady state condition enist.

wattmeter gives direct indication of Power and there is no need of multiplying two readings as in the case when Voltmeter and ammeter are used. So, the wattmeters are used for measurement of Power in Ac circuits.

Single Phase wattmer (or) Electrodynamometer Wattmeter

These instruments are similar in design and construction to electrodynamometer type ammeter and voltmeter.

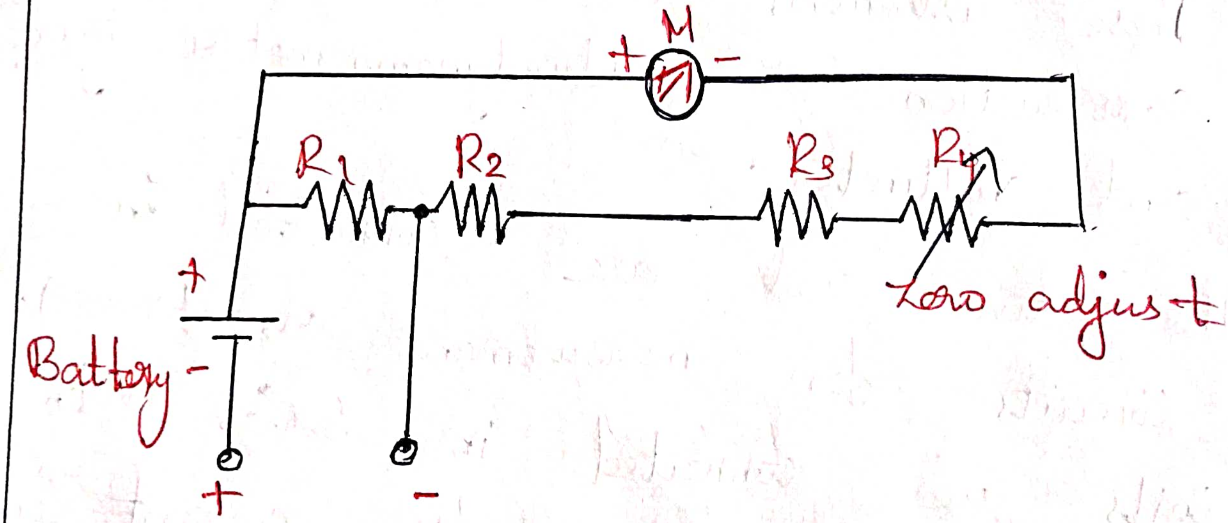
The two coils are connected in different circuits for measurement of power. Fixed coils are connected in series with the load and so carry the current in the circuit.

The moving coil is connected across the voltage and therefore Carries Voltage.

A high non-inductive resistance is connected in series with the moving coil

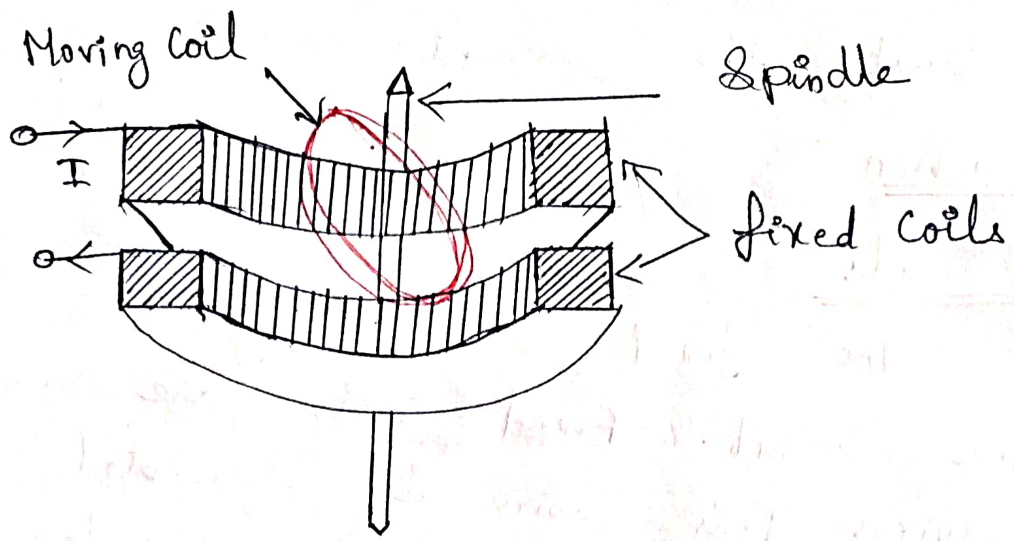
Use of multimeter for Resistance measurement

Before any measurement is made, the instrument is short circuited and "zero adjust" control is varied untill the meter reads zero resistance. i.e. It shows full scale current. Now the circuit takes the form of a variation of the shunt type ohm meter. Scale manipulations of 100 and 10,000 can also be used for measuring high resistances. voltages are applied to the circuit with the help of battery.



Single and Three Phase Wattmeters :-

In alternator current the instantaneous Power varions continuously as the current and voltage go through a cycle.



Moving Coil:-

Moving coil is mounted on a provided Spindle and is entirely embraced by the fixed current coils. It is also called as 'pressure coil' (or) 'voltage coil' (or) simply called as PC of wattmeter.

The spring control is used for the movement. The current of the moving coil is carried by the spring, it is limited to values which can be carried safely by the springs without the appreciable heating.

Both the fixed and moving coils are air cored.

voltage rating of wattmeter is about "600v" by the power requirements of voltage circuit.

Most of this Power is absorbed by the resistance in series with moving coil.

to limit the current.

Construction :

Fixed Coils :

The fixed coils carry the current of the circuit. Fixed coils are wound with heavy wires. This wire is laminated especially when carrying heavy current in order to avoid eddy current losses in conductors.

The fixed coils of earlier wattmeters were designed to carry a current of 100 A but in modern designs limit the current ranges to about '20 A'.

usually between to use '5 A' wattmeter with current transformer of suitable range. In case of precision wattmeters, the two halves of fixed coil which are connected in series for basic measuring range.

It can be connected in parallel to increase wattmeter current range to twice current range.

If the current lags voltage by an angle φ then the current through coil is,

$$i_p = \sqrt{2} I \sin(\omega t - \varphi)$$

Torque $T_i = \sqrt{2} I_p \sin\omega t \times \sqrt{2} I \sin(\omega t - \varphi) \frac{dM}{d\varphi}$

$$= 2 I_p I \sin(\omega t - \varphi) \frac{dM}{d\varphi}$$

$$= I_p I \cos\varphi - \cos(2\omega t - \varphi) \frac{dM}{d\varphi}$$

Average deflection torque is given as,

$$T_d = 1/T \int_0^T T_i \, d(\omega t)$$

$$= 1/T \int_0^T I_p I \left(\cos\varphi - \cos(2\omega t - \varphi) \frac{dM}{d\varphi}\right) \cdot d(\omega t)$$

$$= I_p I \cos\varphi \cdot \frac{dM}{d\varphi}$$

$$= \frac{VI}{R_p} \cos\varphi \frac{dM}{d\varphi}$$

Controlling Torque $T_c = K\theta$

$K \rightarrow$ spring Constant

$\theta \rightarrow$ final steady deflection

At balance position,

$$K\theta = I_p I \cos\varphi \frac{dM}{d\theta}$$

$$\theta = I_p I \cos\varphi \left(\frac{dM}{d\theta}\right) K$$

$$= (VI \cos\varphi / R_p K) \frac{dM}{d\theta}$$

$$= K_1 VI \cos\varphi \frac{dM}{d\theta}$$

$$= K_1 \cdot P \cdot \frac{dM}{d\theta}$$

$$K_1 = 1/R_p K$$

Control:

⇒ "Spring control" is used for the instrument.

Damping:

⇒ Air friction damping is used.

⇒ The moving system which carried a light aluminium vane which moves in sector shaped box.

Scales and pointers:

⇒ They are equipped with the mirror type scales and kife edge pointers.

$$T_i = i_1 i_2 \frac{dM}{d\theta}$$

i_1, i_2 → instantaneous values of current in two coils.

let,

V & I → RMS value of voltage & current

$$v = \sqrt{2} V \sin \omega t$$

If pressure coil current has very high resistance,

$$\therefore I_p = V/R_p$$

$$= \frac{\sqrt{2} V \sin \omega t}{R_p}$$

$$= \sqrt{2} I_p \sin \omega t \qquad \left[I_p = \frac{V_p}{R_p} \right]$$

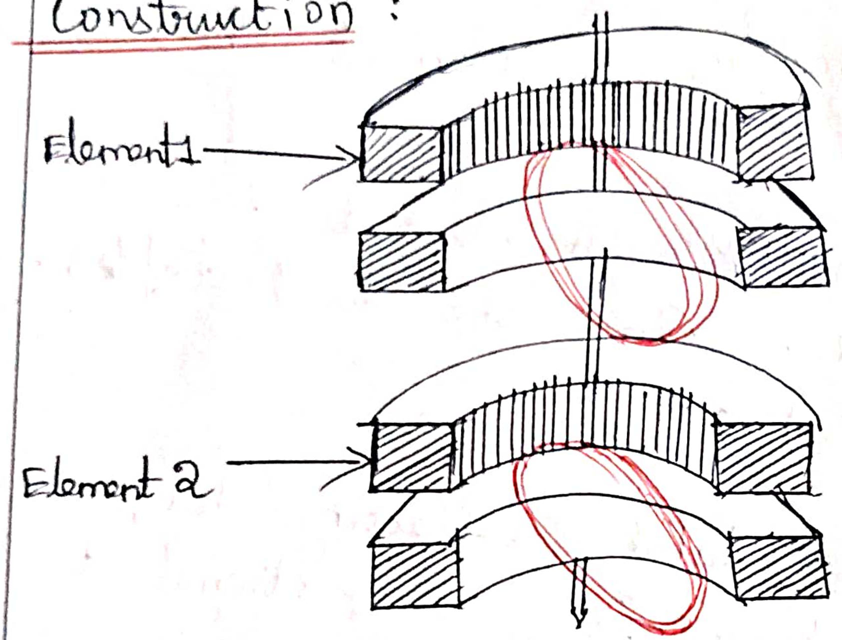
I_p → RMS value of current in pressure coil

R_p → Resistance of pressure coil.

Three Phase wattmeter:

The dynamometer type three-phase wattmeter consist of two separate wattmeter movements mounted together in one case with the two moving coils mounted on the same spindle.

Construction:



The current and the Pressure coil mounted together is known as an element. Therefore, a three phase wattmeter has 2 elements.

The connections of two element of three-phase wattmeter is shown in above diagram.

Theory and operation:

The torque on each element is proportional to the power being measured by each element.

The total torque deflecting the moving system is the sum of the deflecting torque of the two elements.

Deflecting Torque of element one is proportional to P_1.

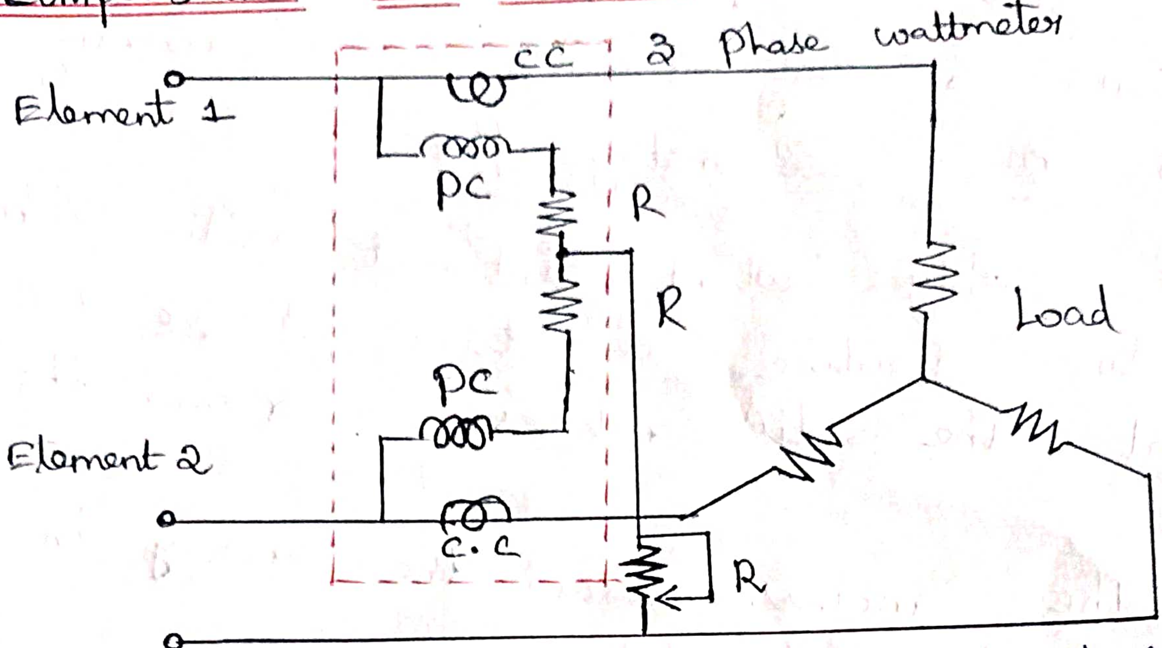
Deflecting Torque of element two is proportional to P_2. So, the total deflecting torque $\propto (P_1 + P_2) \propto P$.

Hence, the total deflecting torque on the moving system is proportional to the total power.

There should not be any mutual interferrence between the two elements.

A laminated iron shield placed between the 2 elements to eliminate the mutual effects.

Compensation of mutual effects :



The compensation of mutual effects can be done by using "Weston's Method".

The arrangement is given in above.

In the above diagram the Resistance 'R' may be adjusted to compensate for errors caused by the mutual interference.

Single Phase Energy meter :-

The Induction type instruments are mostly used as energy meter and it is a integrating instrument which is used to measure quantity of electricity.

It works on principle of induction. the Production of eddy currents in a moving System by a alternating flux.

These eddy current interact with each other to Produce a driving torque because of that the disc rotates to record the energy.

These meters record the energy in kilo-watt hours (kwh).

Construction :-

The single phase energy meter has four main parts of operating systems. they are,

i) Driving System
ii) Moving System
iii) Braking System
iv) Registering System.

Driving System:-

The driving system consist of 2 electromagnets whose core is made up of silicon steel laminations.

The coil of one of the electromagnet is called current coil, which is excited by load current.

The coil of another electromagnet is connected across supply and it carries current proportional to supply voltage. This coil is called pressure coil.

These 2 electromagnets are called series and shunt magnets respectively. Copper shading bands is adjustable. The function of these band is to bring the flux produced by the shunt magnets exactly in quadrature with the applied voltage.

Moving System:-

Moving system consist of light aluminium disc mounted in a light alloy shaft.

The position of this disc is in between series and shunt magnets.

The moving system runs on a hundred steel pivot and the pivot is supported by Jwel bearing.

A pinion engages the shaft with the counting mechanism. There is no spring & controlling torque.

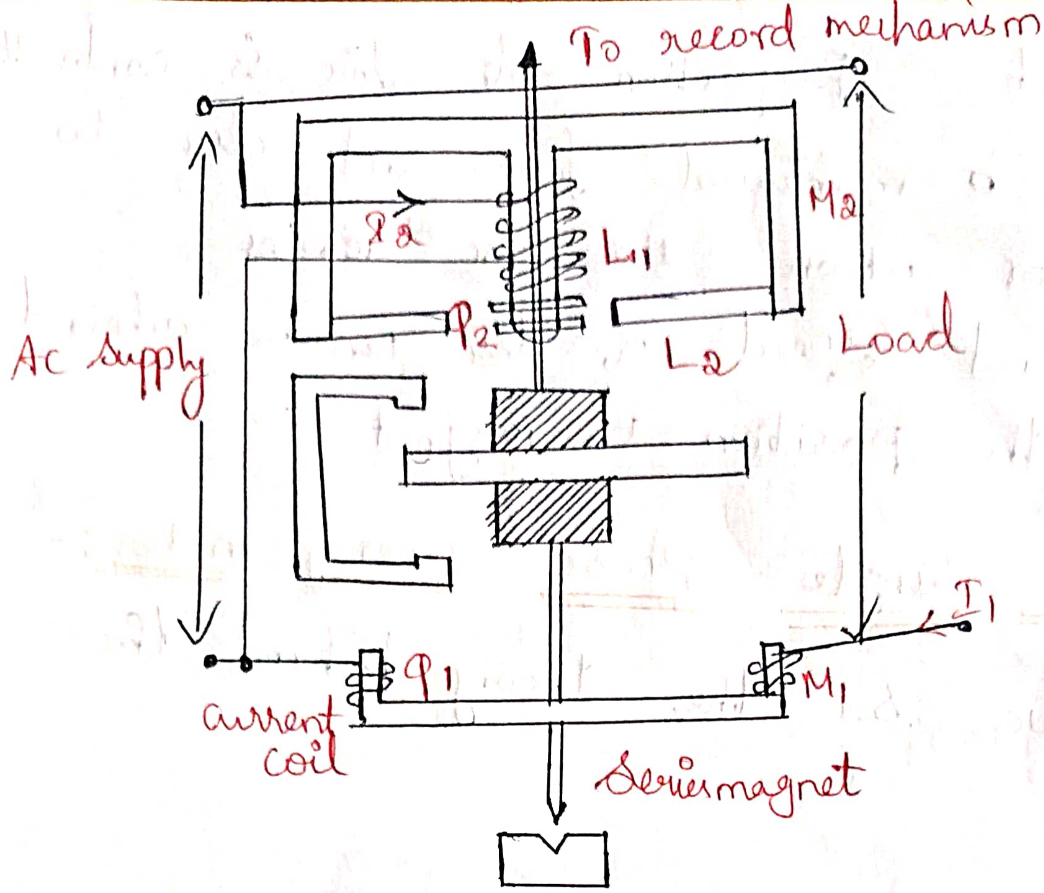
Braking System :-

A permanent magnet positioned near edge of the aluminium disc for braking mechanism. The disc moves in the field of this magnet and a breaking torque is obtained.

Registering mechanism :-

The function of this mechanism is to records continuously a number which is proportional to the revolution made by the aluminium disc.

By the suitable system, a train of reduction gears the position on the shaft drives a series of pointers. These pointers ~~roll~~ rotates on round dials which are equally marked with equal divisions



Working Principle :-

The working Principle of single Phase energy meter is given below:

The supply voltage is applied across the Pressure coil and the Pressure coil is carried by shunt magnet 'M_2'. The series magnet 'M_1' carries load current.

Both these coils produce alternating fluxes ϕ_1 and ϕ_2.

The eddy current induced by electromagnet 'M_1' react with magnetic field produced by 'M_2'.

The eddy current induced by electro magnet 'M_2' is react with magnetic field produced by 'M_1'.

Thus each proportion of disc is controlled by the mechanical force. and due to the motor action the disc rotates.

Desired speed of disc can be acheived by adjusting the position of magnet.

Theory of single phase energy meter :-

let we see the theory behind the working.

let,

$V \Rightarrow$ supply voltage

$\phi_1 \Rightarrow$ Flux Produced by I_1

$\phi_2 \Rightarrow$ Flux Produced by I_2

$I_1 \Rightarrow$ Current through coil 1

$I_2 \Rightarrow$ Current through coil 2.

Now I_2 lags 'V' by 90° as the pressure coil proportional to 'V'.

$E_1 \rightarrow$ Induced emf in disc due to ϕ_1

$E_2 \rightarrow$ Induced emf in disc due to ϕ_2

$I_{eh} \rightarrow$ Eddy current Produced due to E_1

$I_{se} \rightarrow$ Eddy Current Produced due to E_2.

$T \rightarrow$ Torque.

The net deflecting torque can be given as,

$$T_d \propto T_2 - T_1$$

$$\propto \phi_2 I_{se} (\phi_2 \wedge I_{se}) - \phi_1 I_{sh} (\phi_2 \wedge I_{sh})$$

From the phasor diagram,

$$\phi_2 \wedge I_{se} = \phi \;\&\; (\because \phi_2 \wedge I_{sh}) = \phi$$

$$T_d \propto \phi_2 I_{se} \cos\phi - \phi_1 I_{sh} \cos(180 - \phi)$$

$$T_d \propto \phi_2 I_{se} \cos\phi - \phi_1 I_{sh} \cos\phi$$

as, $\cos(180 - \phi_1) = -\cos\phi$

But the flux,

$$\phi_2 \propto I_2 \propto V$$

$$I_{sh} \propto E_2 \propto I_2 \propto V$$

$$I_{se} \propto E_1 \propto I_1 \propto V$$

$$\phi_1 \propto I_1$$

$$T_d \propto k_1 V I_1 \cos\phi + k_2 I_1 V \cos\phi$$

$$T_d \propto (k_1 + k_2) V I_1 \cos\phi$$

$$T_d \propto V I_1 \cos\phi$$

Now the net braking torque is proportional to speed 'N'.

$$T_d \propto N$$

For constant speed, the braking torque equal to the following deflecting torque.

$T_b = T_d$

$N \propto VI_1 \cos\phi$

Multiplying both sides by number of revolutions in time 't'.

$N_t \propto VI_1 t \cos\phi \propto P_t$.

Number of revolutions in time t $\propto$ energy supplied.

P_t => energy supplied in time t in time 't'.

while 'N t' number of revoution

Advantages :-

=> The frictional errors are less.

=> We can get accurate reading

=> It requires less maintainance

=> It is cheap in cost because of its simple construction.

Dis-advantages :-

=> It can be used for only a.c circuits

=> Creeping can cause errors.

Three Phase Energy Meter :

In a three phase, foure wire system the energy measurement is done by three phase energy meter.

In three phase 3 wire system energy can be measured by two element energy meter.

So these meters are classified as,

=> Three element energy meter
=> Two element energy meter.

Three element Energy Meter :

The Three element energy meter is used for 3φ, 4 wire systems.

This meter consist of three element and the construction of every individual element is same as that of single phase energy meter.

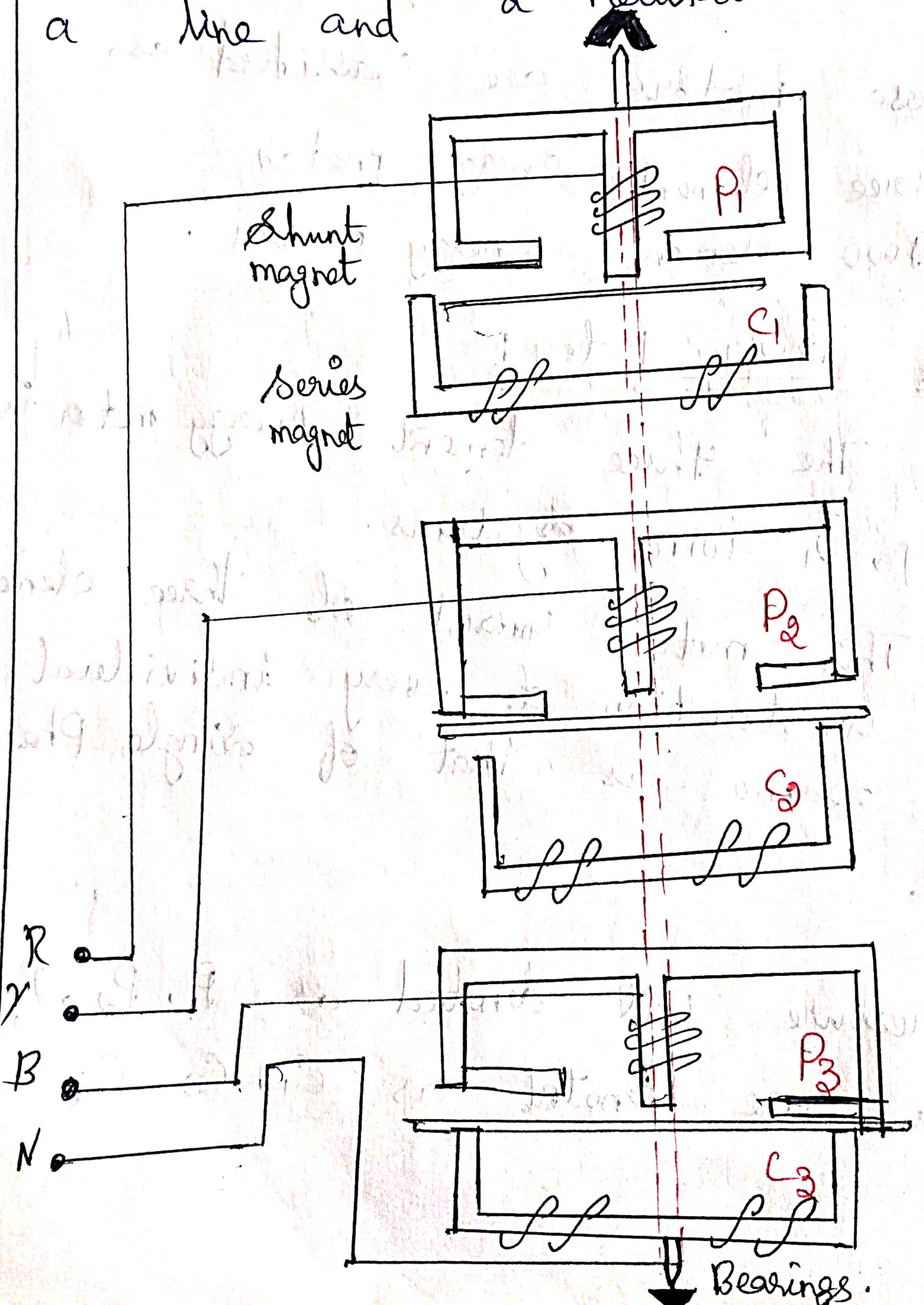
Pressure coil denoted as P_1, P_2, P_3

Current coils are denoted as C_1, C_2, C_3.

In a common case all the elements are mounted and the common spindle, gearing and the registering mechanisms are used.

Here we used 4 wire system, the 4th wire is a neutral wire.

The pressure coil connected across a line and a neutral.



In three Phase energy meter elements are mounted in the same spindle which drives the registering mechanism.

There They may errors produced in the 3 Phase energy meter, because due to the interaction between eddy currents Produced by one element wit the flux produced by another element.

These errors may be reduced by the suitable adjustments.

Two element energy meter :-

Two element energy meter used 3 φ, 3 wire system.

The meter Provided with 2 discs, each for an element.

The series magnets carries current coil and shunt magnets carries Pressure coil.

The Pressure coils are connected in Parallel and the current coils are connected in series.

The operations and connections are same as single phase energy meter.

The torque produced in 2 element energy meter is same as that of single phase energy meter in each element.

The total torque produced in the registering mechanism connected to the moving system is sum of the torques of the individual elements.

Magnetic Measurements :-

Magnetic measurements are the measurements of different characteristics of a magnetic materials. ~~are~~

These magnetic materials are used in the operation of electrical machines and hence the measurement of various characteristics of magnetic material is important in the view of designing and manufacturing of electrical machines.

Determination of B-H Curve:

To obtain B-H curves in magnetic material, there are 2 methods are available

i) Method of reversal

ii) step by step method.

Method of reversal:-

The test is done by taking a ring with known dimension. A thin tabe is wound on the ring.

The search coil insulated by the tape. Paraffined wax is wound over the tape. Another layer of tape wound on search coil. Then the magnetic winding wound uniformly on the specimen.

Before, the test the full specimen is de-magnetized. The galvano meter switch 'K' is closed and the reversing switch 'S' ~~unknown~~ thrown backward and forward for twenty times.

The ballistic galvanometer key is now opened, the flux corresponding to the value of 'H' in the specimen measured from the ballistic galvanometer by reversing the switch 'S'.

The value of H can be obtained as :

$$H = \frac{NI_1}{l}$$

where,

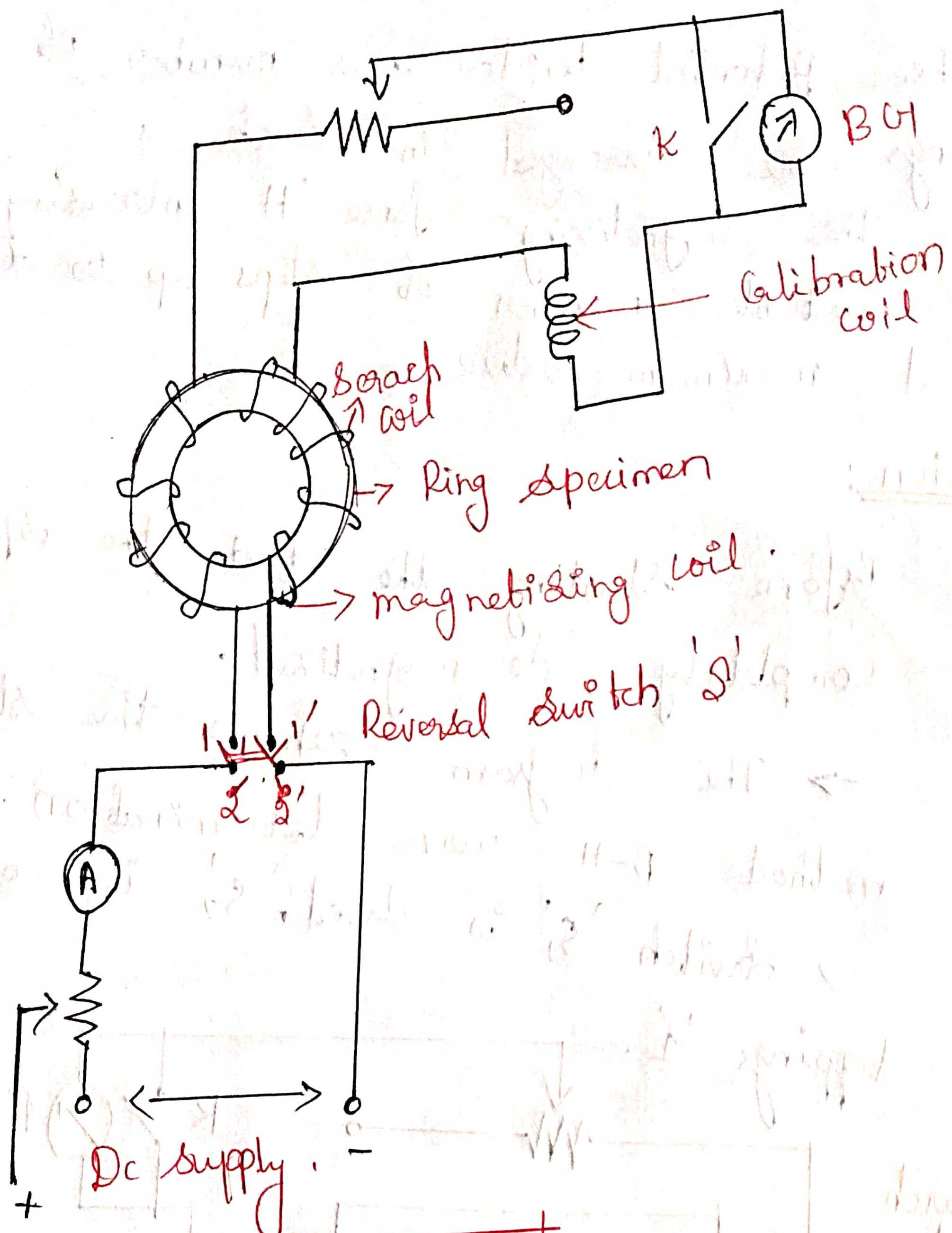
N = Number of turns on the winding

I = corresponding magnetizing current

l = Mean circumference length of specimen in m.

The flux density B is obtained by dividing the flux measured by the area of cross section of specimen.

The procedure is repeated for the different values of H by increasing upto the maximum testing point value. The graph B against H gives the required B-H curve for the specimen.



Step by step method:

The another method of determination of B-H curve is given as,

In step by step method reversal of magnetizing current is not used.

The magnetizing current in the winding is supplied through a potential divider.

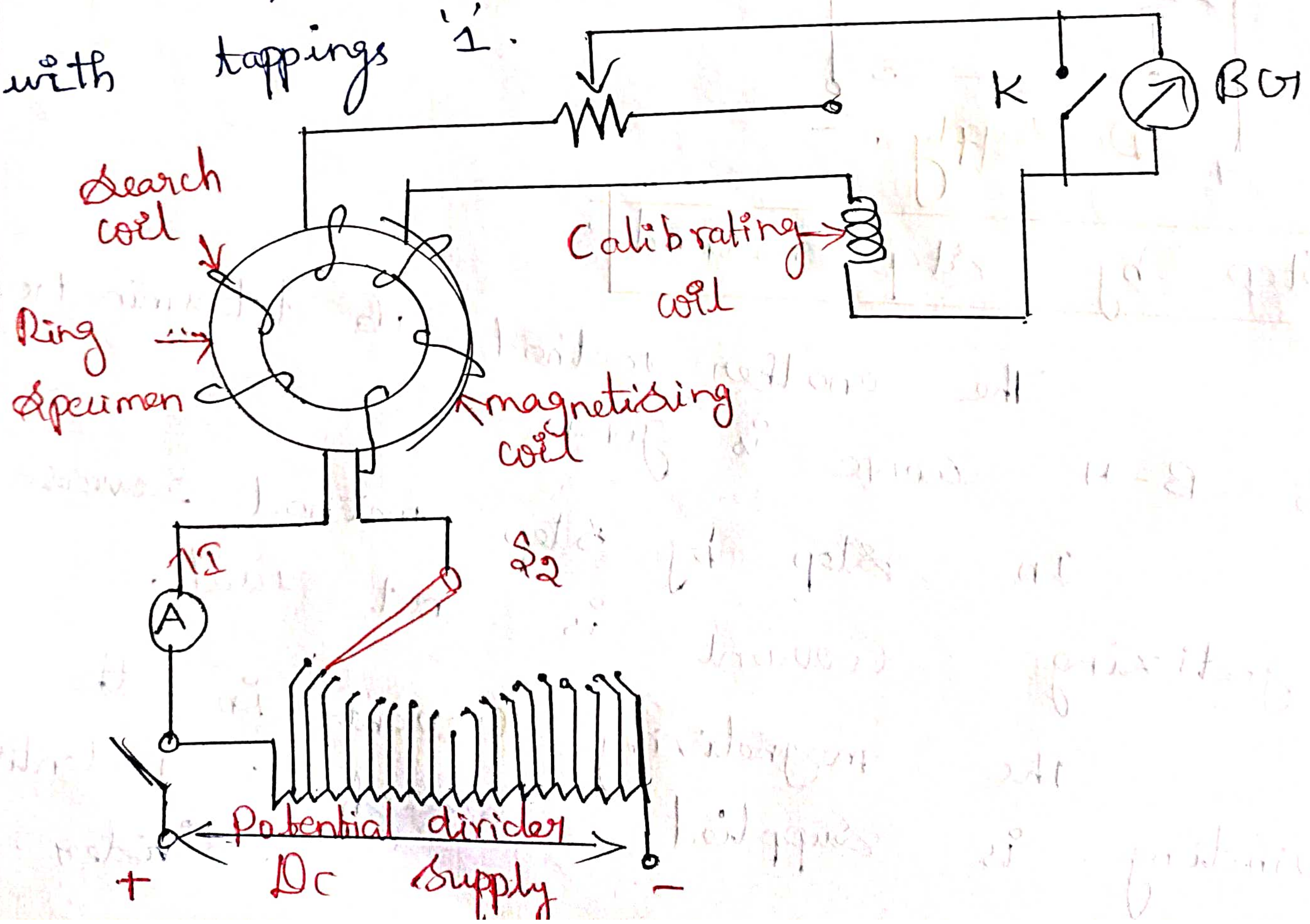
The potential divider has number of tappings are arranged in such a way that the magnetizing force 'H' increasing in suitable number of steps up to the required maximum value.

Operation :

Before starting the test the specimen is completely de-magnetized.

⇒ The diagram shows the step by step method B-H curve determination.

⇒ Switch 'S_1' is closed, 'S_2' is connected with tappings '1'.



⇒ Due to this some change in flux and hence there will be increase in flux density from 0 to B_1 is shown in curve.

⇒ Recording the value of magnetizing current and corresponding value of magnetizing force 'H_1' is obtained.

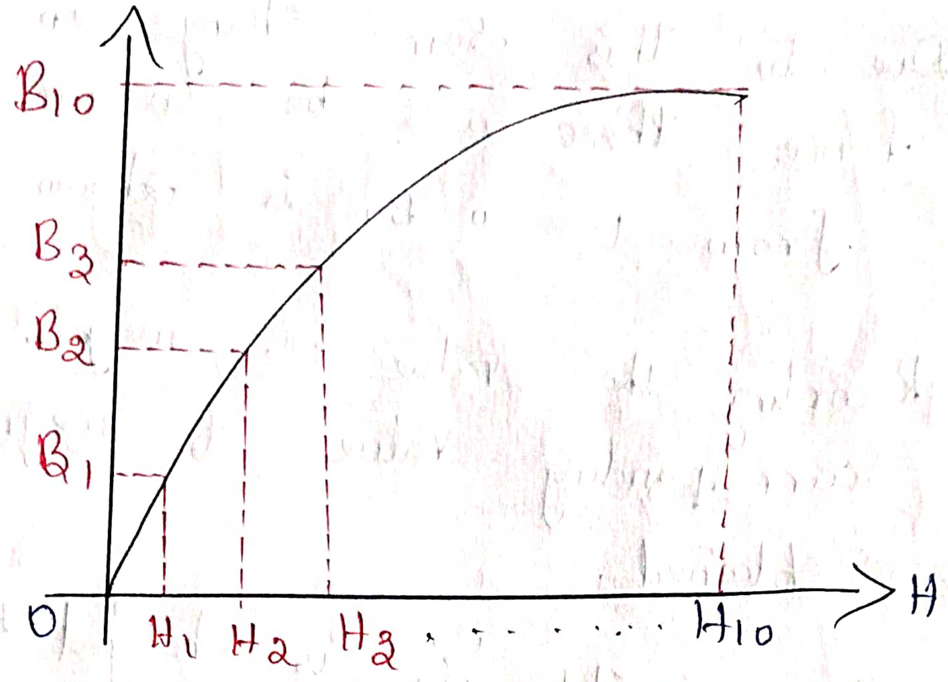
⇒ The switch 'S_2' is changed to the tapping '2', which increases the magnetizing force to 'H_2'.

⇒ Due to this increase in flux & hence flux density by the amount 'ΔB'.

⇒ The 'B_2' at 'H_2' obtained as $B_1 + \Delta B$

⇒ 'S_2' switch changed for various tappings till the maximum value of H is achieved. The graph of 'B' against 'H' is plotted.

This is known as B-H curve for the specimen under test.



(B-H Curve from step by step method).

Instrument Transformer:

Instrument transformers are used in the area of high voltage and heavy current areas.

It is called as specially constructed accurate ratio transformers because this can be used in the irrespective of voltage and current rating of A.C circuits.

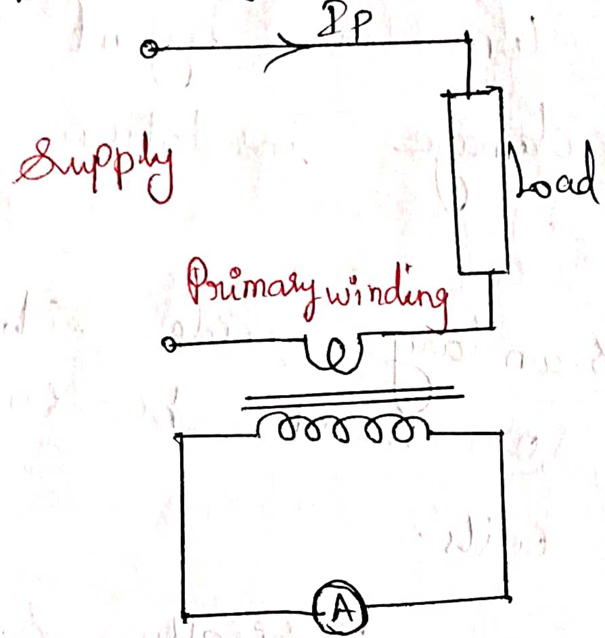
These transformer extend the range of low range instruments and also isolate them from high voltage and high current A.C circuits.

They are generally classified into two types.

i) Current Transformer

ii) Potential Transformer.

(i) Current Transformer :-



⇒ The diagram shows the current transformer connection.

⇒ In current transformer it is very that secondary of C.T should not be kept open.

⇒ Because if we kept open on secondary side current through secondary becomes zero.

⇒ Hence Ampere turns produced by secondary which opposes primary ampere turns become zero.

=> Because of that there is no counter mmf, unopposed Primary mmf, which Produces high flux in the core.

=> This Produce excessive core loss & heating the core to beyond limits. This may damage insulation of the winding.

So, on secondary side either it should be shorted (or) must be connected with low resistance coils.

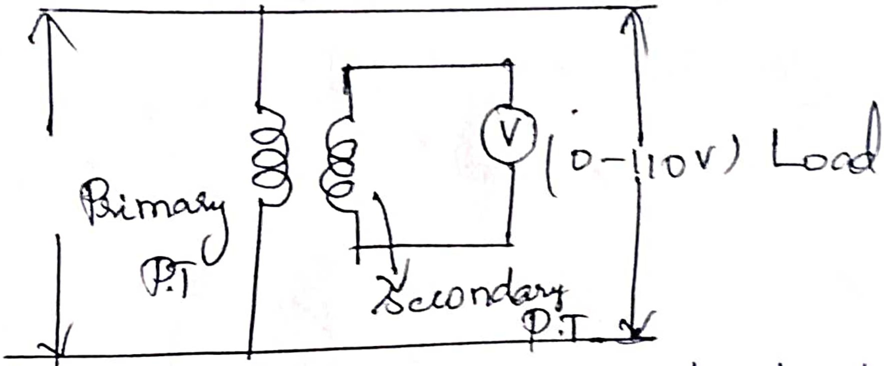
The C.T are basically step up Transformers, stepping the voltage from Primary to secondary, obviously current considerably gets stepped down. For Example,

=> In C.T, 500 : 5 range [Primary - 500A ; Secondary - 5A] but the step up voltage is 100 times.

$$\frac{I_1}{I_2} = N_1/N_2$$

=> The above equation shows current and

(ii) Potential transformer (P.T) :-



⇒ figure shows the potential transformer.

⇒ The construction these transformer is similar to the normal transformer.

⇒ The P.T is accurate ratio step down transformer.

⇒ The winding are low power rating winding.

⇒ The Primary connected to high voltage and secondary connected to low range (110V) Voltmeter Coil.

⇒ One end of secondary always grounded for the safety Purpose.

Ratio of P.T is,

$$V_1/V_2 = N_1/N_2$$

UNIT- III.

Comparative methods of measurements:-

Dc Potentiometers, D.c (wheat stone, kelvin and Kelvin Double bridge) & A.c bridges (Maxwell, Anderson and shering bridges), Transformers ratio and bridges, self-balancing bridges. Interference & Screening - Multiple earth and loops - Electrostatic and electromagnetic Interference - Grounding techniques.

D.c potentiometers :-

Potentiometer :-

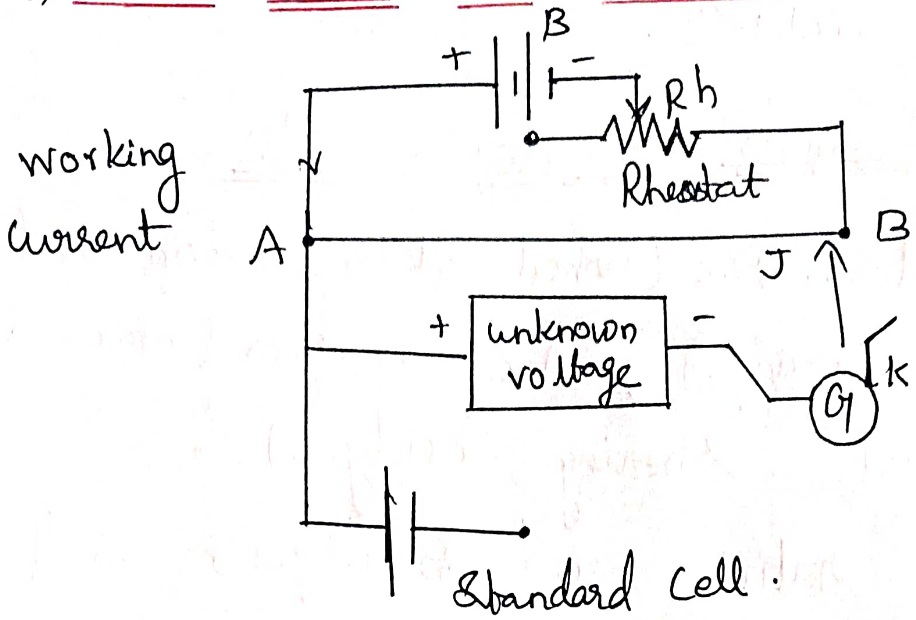
A Potentiometer is an instrument which is used to measure an unknown voltage by comparing it with a known voltage.

Types of D.C Potentiometer :-

i) Slide wire DC Potentiometer.

ii) Cromptons DC Potentiometer.

(i) Slide wire DC Potentiometer :-



* It consist of slidwire AB of uniform cross section, made up of manganin.
* A and B entremes are connected to a battery through a Variable resistance.
* The Battery supplies the working current through the rheostats sliding wire.
* current through sliding wire may be vary by changing the rehostat.
* unknown emf is connected in series with a galvanometer 'G' and switch 'K' to contact 'J'.
* Sliding contact is moved till the galvanome shows zero deflection. ie) unknown voltage

'E' is equal to voltage drop 'E_1' across the position, J of the slide wire.

* measure the length AJ with the help of Scale Provided.

unknown Emf $E = i r l$.

$i \rightarrow$ current, $r \rightarrow$ resistance per unit length

$l \rightarrow$ length.

Standardisation :-

* Process of adjusting the working current so as to match the voltage drop across a portion of sliding wire against a standard reference source is Known as "Standardisation".

* let total length of slide wire = 200 c.m and resistance of 200 Ω.

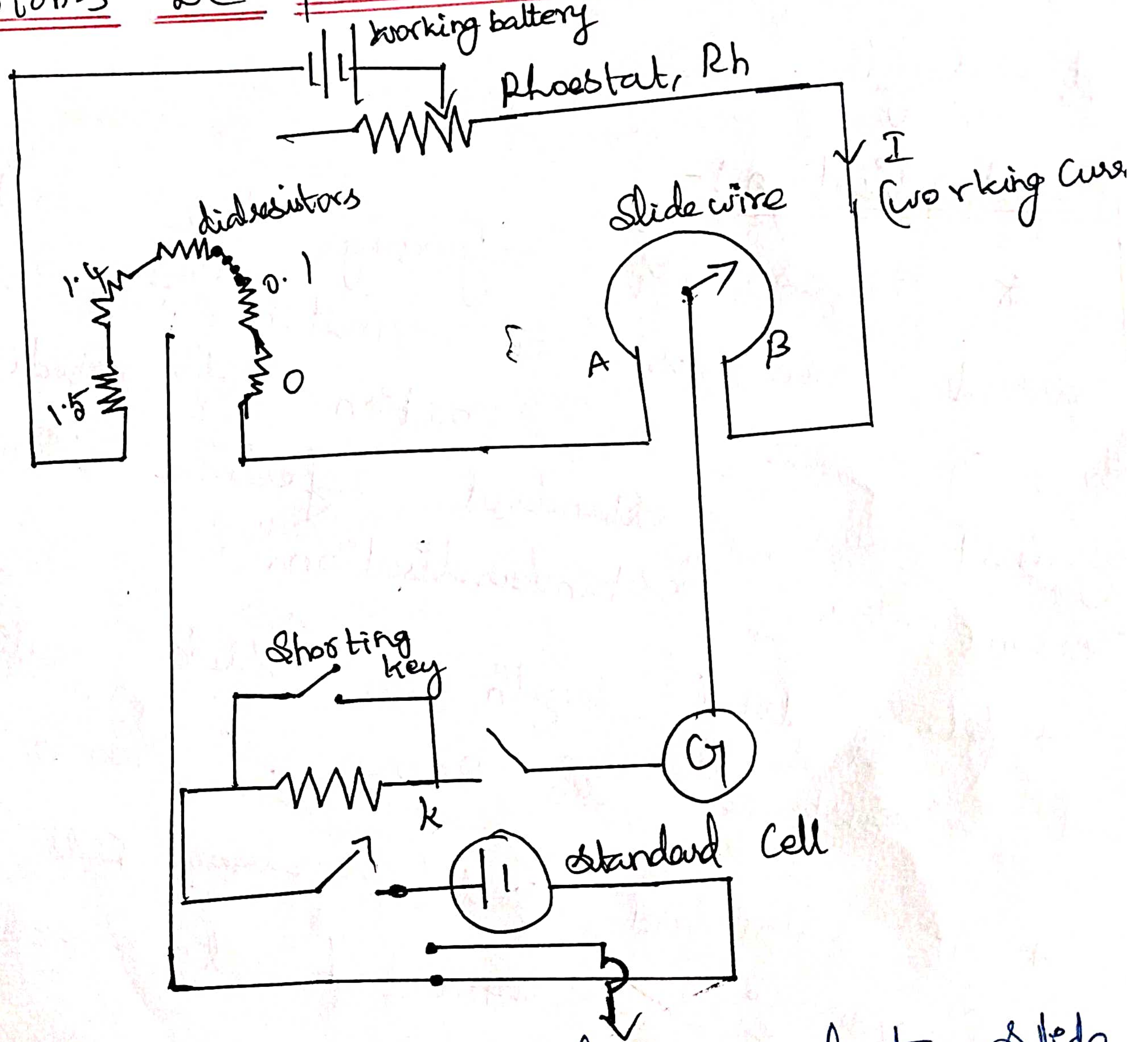
* A Standard cell (westen cell of emf 1.0186 v) is Connected to galvanometer G through switch k.

* Now, the sliding Contact is Placed at 101.86 c.m along the sliding wire. Adjust the value of Rheostat till the galvanometer,

shows null deflection.

* Voltage drop along 101.86 c.m portion of the slide wire equals the emf of standard western cell. This is known as "Standardisation".

(ii) Crompton's DC potentiometer :-



* Potentiometer, consists of graduate slide wire AB.

* Slide is connected in series with large number of coils.

* coils are selected such that a resistance of each coil is equal to the resistance slide wire AB (dial element).

* 'P₁' and 'P₂' are 2 sliding contacts P₁ over slide wire and P₂ over slides of resistance coils.

* Galvanometer 'G' and switch 'K' are connected in series between P₁ and P₂ via double through switch.

* A key and protective resistance is used in the galvanometer circuit.

* First, potentiometer is standardised by using standard cell. (say western cell, emf = 1.0186 V).

* Here, the resistor is adjusted such that coil resistance is put at 1.0 V and slide wire at 0.0186 V.

* Double through switch 'S' is known to calibrate position and the rheostat is adjusted to zero deflection of the Galvanometer. The protective resistance

is shorted to increase the sensitivity.

* Final adjustment using rhoestat is made for zero deflection.

* After completion of standardisation, switch 'S' is thrown there by connecting unknown emf into the potentiometer circuit.

* Now, the potentiometer ~~is~~ is balanced by means of main dial and slide wire adjustment.

* As, the balanced is approached, the protective resistance is shorted and final adjustment is made.

* Now, the value of unknown emf read directly from dial adjustment slide wire.

Bridges :-

Bridge circuit use comparison measurement method and operate on null - indication Principle.

Dc Bridge :-

i) used to measure resistances.

ii) used for excitation. (Dc voltage).

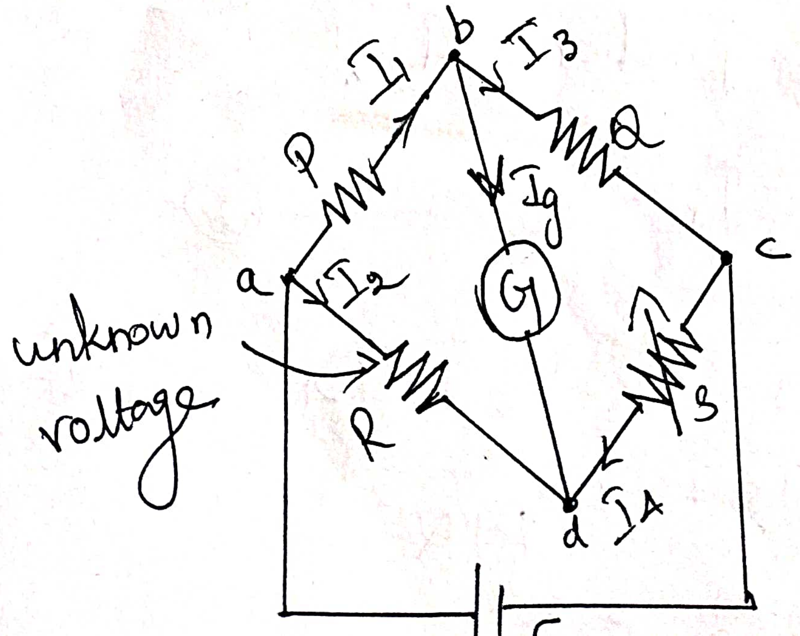
Ac Bridge :-

i) used to measure impedance (L & C)

ii) Ac voltage is used for excitation.

- Less than 1 Ω → low resistance
- 1 Ω to 0.1 MΩ → medium resistance
- Greater than 0.1 MΩ → High resistance.

Wheatstone Bridge :-



→ used for measurement of medium resistance.

→ used comparision measurement method and Operate on null - indication principle.

→ 4 arms with resistances P, Q, R and S

R → unknown resistance,

P, Q, S → known Resistance.

→ Battery connected between 'a' and 'c' & galvanometer between 'b' and 'd'.

→ Resistance 'S' is adjusted, so that the galvanometer shows null deflection. Now bridge is said to be balanced.

→ Apply kcl at junction 'b'

$$I_1 - I_g - I_3 = 0 \quad \text{——— (1)}$$

Apply kcl at junction 'd'.

$$I_2 + I_g - I_4 = 0 \quad \text{——— (2)}$$

(1) ⇒ $I_1 = I_3$ & $I_2 = I_4$ if $I_g = 0$

$$I_1 = I_3 = E/P+Q,$$

$$I_2 = I_4 = E / R+S$$

when galvanometer reads zero,

$$I_1 P = I_2 R$$

$$\frac{EP}{P+Q} = \frac{ER}{R+S}$$

$$P(R+S) = R(P+Q)$$

$$PR + PS = PR + QR$$

$$PS = QR$$

$$P/Q = R/S$$

unknown Resistance,

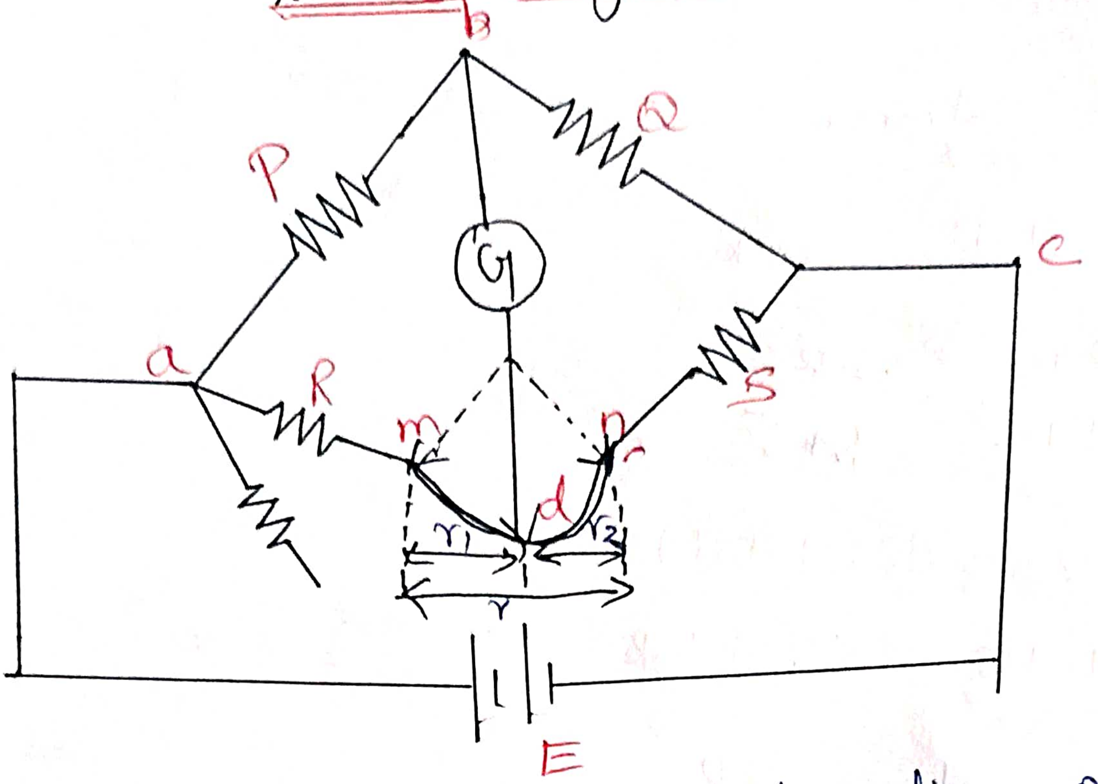
$$R = S \cdot P/Q$$

Applications:-

↳ Measure resistance of motor windin[g] (transformers, etc...

↳ Telephone companies to locate Cable fault.

Kelvin Bridge :-



↳ Kelvin bridge is a modification of the wheatstone bridge.

↳ used to measure values of resistance below 1 Ω.

↳ Let 'r' resistance of load that connects the unknown resistance 'R' and standard resistance 'S'.

↳ when the galvanometer, is connected to point 'm' the resistance 'r' get added to the unknown resistance 'R'.

↳ If, the galvanometer is connected to point 'd' between 'm' and 'n' in such a way that the ratio of