Lecture Notes

for

B.TECH. FIRST YEAR, IInd Semester

(Mechanical, EC, Electrical Engg.)

Subject Code: EE201

Subject: Basic Electrical Engineering

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EE-201 Basic Electrical Engineering

Syllabus

Unit-I: Electrical Circuit Analysis:
Introduction, Circuit Concepts: Concepts of network. Active and passive elements. Voltage and current sources. Concept of linearity and linear network. Unilateral and bilateral elements. Source transformation, Kirchhoff‟s laws, Loop and nodal methods of analysis. Star-delta transformation,
AC fundamentals: Sinusoidal, square and triangular waveforms - Average and effective values. Form and peak factors, Concept of phasors, phasor representation of sinusoidally varying voltage and current.
Unit-II: Steady- State Analysis of Single Phase AC Circuits:
Analysis of series and parallel RLCCircuits, Concept of Resonance in series & parallel circuits, bandwidth and quality factor; Apparent, active & reactive powers. Power factor, Concept of power factor improvement and its improvement (Simple numerical problems)
Network theorems (AC & DC with independent sources): Superposition theorem, Thevenin‟s theorem, Norton‟s theorem, Maximum Power Transfer theorem (Simple numerical problems)
Unit-III: Three Phase AC Circuits:
Three phase system-its necessity and advantages, Star and delta connections, Balanced supply and balanced load, Line and phase voltage/current relations. Three-phase power and its measurement (simple numerical problems).
Measuring Instruments: Types of instruments, Construction and working principles of PMMC and moving iron type voltmeters & ammeters, Single phase dynamometer wattmeter, Use of shunts and multipliers (Simple numerical problems on shunts and multipliers), Single phase energy meter.
Power system : basic concept, power line diagram, concept of grid.
Unit-IV: Magnetic Circuits:
Magnetic circuit concepts, analogy between electric & magnetic circuits, B-H curve, Hysteresis and eddy current losses, Magnetic circuit calculations (Series & Parallel).
Single Phase Transformer: Principle of operation, Construction, EMF equation, Phaser diagram Equivalent circuit. Power losses, Efficiency (Simple numerical problems), Introduction to auto transformer.
Unit-V: Electrical Machines:
DC machines:Principle & Construction, Types, EMF equation of generator and torque equation of motor, applications of DC motors (simple numerical problems)
Three Phase Induction Motor:Principle & Construction, Types, Slip-torque characteristics. Applications (Numerical problems related to slip only)
Single Phase Induction motor: Principle of operation and introduction to methods of starting, applications.
Three Phase Synchronous Machines: Principle of operation of alternator and synchronous motor and their applications.

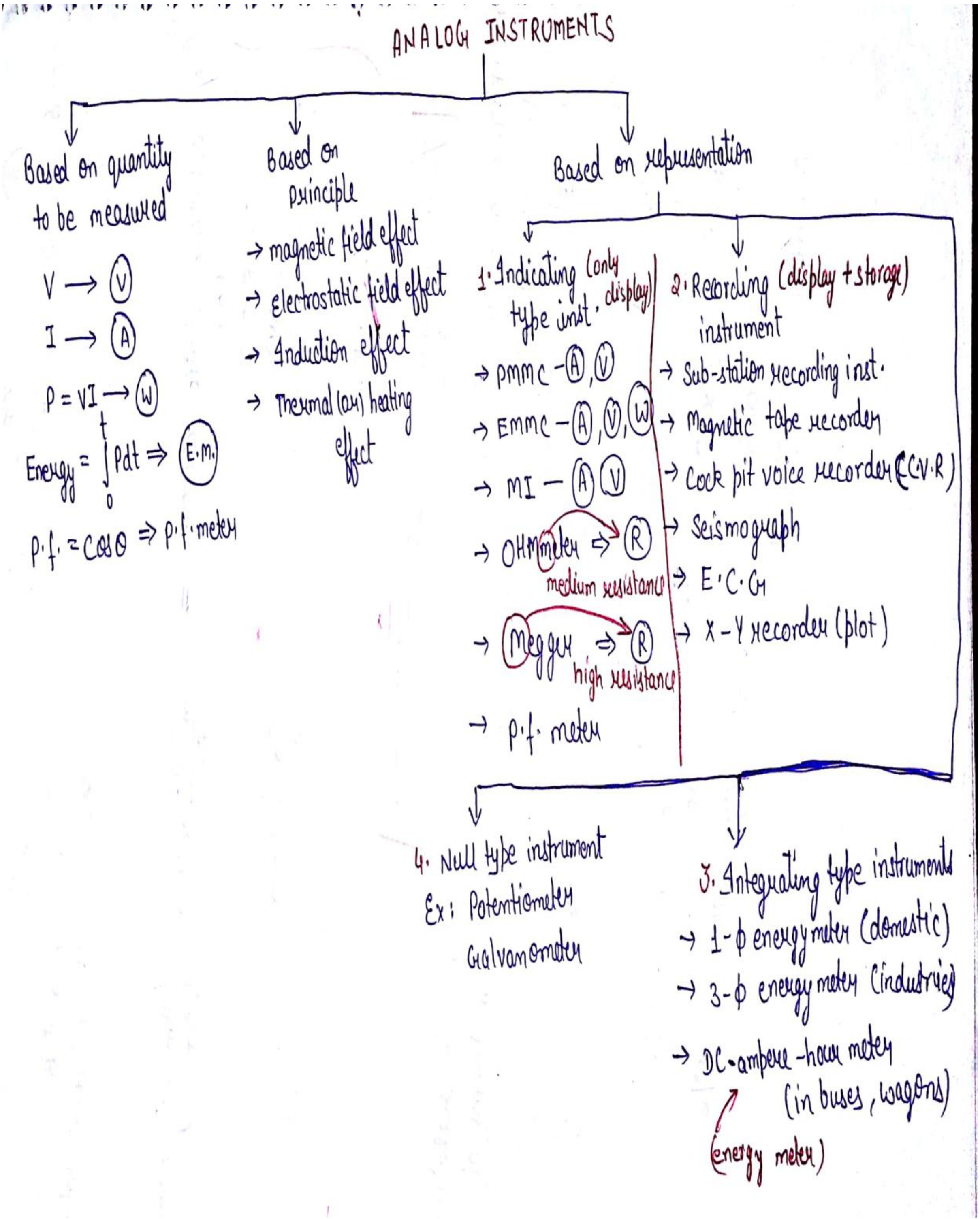
Text Books:
1 . Basic Electrical Engineering, S N Singh; Prentice Hall International
2. Basic Electrical Engineering, Kuldeep Sahay, New Age International Publishers

3 . Fundamentals of Electrical Engineering, B Dwivedi, A Tripathi; Wiley India
4. Principles of Electrical Engineering, V. Del Toro,; Prentice Hall International
5. Electrical Engineering, J. B. Gupta, Kataria and Sons
6. Basic Electrical Engineering, T.K. Nagsarkar,M.S. Shukhija; Oxford University Press.

Reference Books:
1. Electrical and Electronics Technology, Edward Hughes; Pearson
2. Engineering Circuit Analysis, W.H. Hayt& J.E. Kimerly; Me GrawHill

Unit- 3 (Part-II) (Measuring Instruments)

Classification of Instrument



Various forces/torques required in measuring instruments

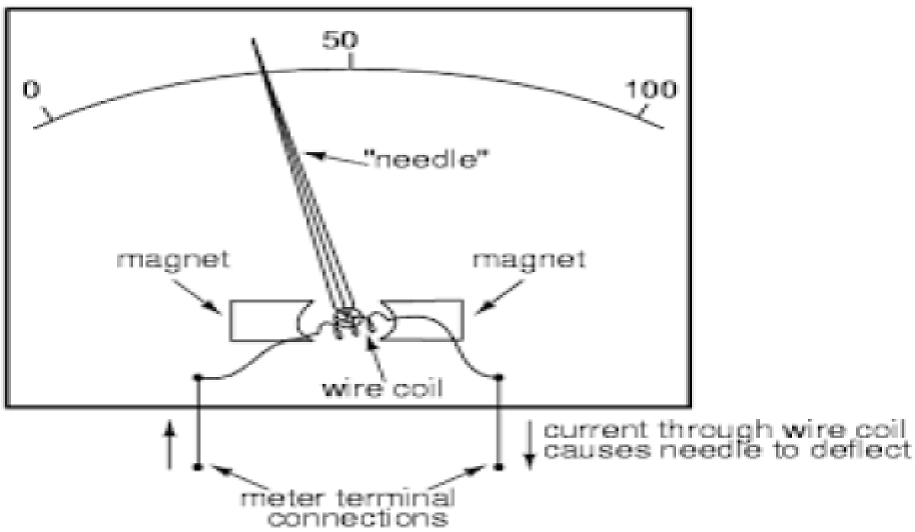
- Deflecting torque/force: The defection of any instrument is determined by the combined effect of the deflecting torque/force, control torque/force and damping torque/force. The value of deflecting torque must depend on the electrical signal to be measured; this torque/force causes the instrument movement to rotate from its zero position.
- Controlling torque/force: This torque/force must act in the opposite sense to the deflecting torque/force, and the movement will take up an equilibrium or definite position when the deflecting and controlling torque are equal in magnitude. Spiral springs or gravity usually provides the controlling torque.
- Damping torque/force: A damping force is required to act in a direction opposite to the movement of the moving system. This brings the moving system to rest at the deflected position reasonably quickly without any oscillation or very small oscillation. This is provided by i) air friction ii) fluid friction iii) eddy current. It should be pointed out that any damping force shall not influence the steady state deflection produced by a given deflecting force or torque. Damping force increases with the angular velocity of the moving system, so that its effect is greatest when the rotation is rapid and zero when the system rotation is zero. Details of mathematical expressions for the above torques are considered in the description of various types of instruments.

Permanent magnet moving coil instruments (PMMC)

The permanent magnet moving coil instruments are most accurate type for direct current measurements. The action of these instruments is based on the motoring principle. When a current carrying coil is placed in the magnetic field produced by permanent magnet, the coil experiences a force and moves. As the coil is moving and the magnet is permanent, the instrument is called permanent magnet moving coil instrument. This basic principle is called D'Arsonval principle. The amount of force experienced by the coil is proportional to the current passing through the coil.

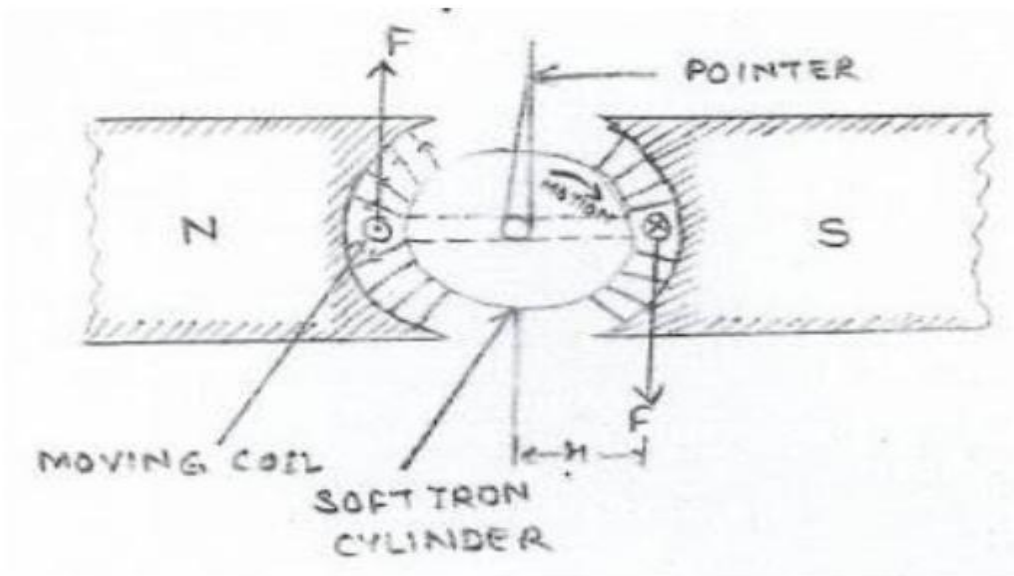
The PMMC instrument is shown in the below images.

Permanent magnet, moving coil (PMMC) meter movement



The moving coil is either rectangular or circular in shape. It has number of turns of fine wire. The coil is suspended so that it is free to turn about its vertical axis. The coil is placed in uniform, horizontal and radial magnetic field of a permanent magnet in the shape of a horse-shoe. The iron core is spherical if coil is circular and is cylindrical if the coil is rectangular. Due to iron core, the deflecting torque increase, increasing the sensitivity of the instrument. The controlling torque is provided by two phosphor bronze hair springs. The damping torque is provided by eddy current damping. It is obtained by movement of aluminum former, moving in the magnetic field of the permanent magnet. The pointer is carried by the spindle and it moves over a graduated scale. The pointer has light weight so that it deflects rapidly. The mirror is placed below the pointer to get the accurate reading by removing the parallax. The weight of the instrument is normally counter balanced by the weights situated diametrically opposite and rapidly connected to it. The scale markings of the basic d.c PMMC instruments are usually linearly spaced as the deflecting torque and hence the pointer deflections are directly proportional to the current passing through the coil.

The top view of PMMC instrument is shown in the below image.



Advantages of PMMC

The various advantages of PMMC instruments are,

- It has uniform scale.
- With a powerful magnet, its torque to weight ratio is very high. So operating current of PMMC is small.
- The sensitivity is high.
- The eddy currents induced in the metallic former over which coil is wound, provide effective damping.
- It consumes low power, of the order of 25 W to 200 mW.
- It has high accuracy. Instrument is free from hysteresis error.
- Extension of instrument range is possible.

- Not affected by external magnetic fields called stray magnetic fields.

Disadvantages of PMMC

The various disadvantages of PMMC instruments are ,

- PMMC is Suitable for direct current measurement only.
- Ageing of permanent magnet and the control springs introduces the errors.
- The cost is high due to delicate construction and accurate machining.
- The friction is due to jewel-pivot suspension.

Construction and Basic principle operation of Moving-iron Instruments

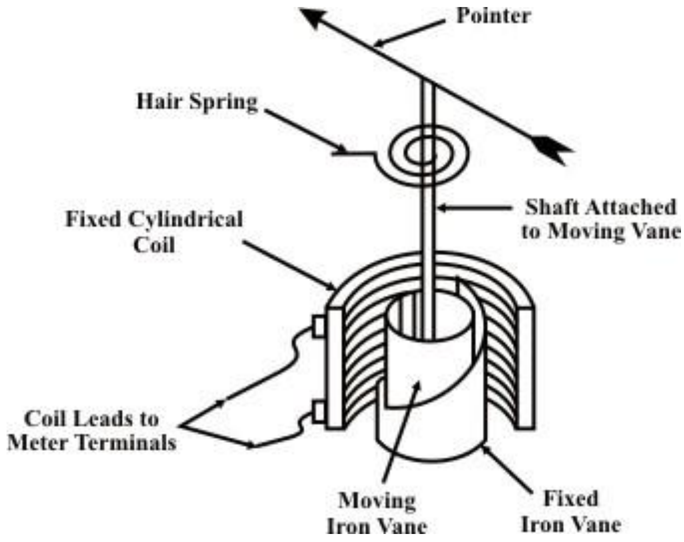
We have mentioned earlier that the instruments are classified according to the principles of operation. Furthermore, each class may be subdivided according to the nature of the movable system and method by which the operating torque is produced. Specifically, the electromagnetic instruments are sub-classes as (i) moving-iron instruments (ii) electro-dynamic or dynamometer instruments, (iii) induction instruments.

There are two general types of moving-iron instruments namely (i) Repulsion (or double iron) type (ii) Attraction (or single-iron) type. The brief description of different components of a moving-iron instrument is given below.

- **Moving element:** a small piece of soft iron in the form of a vane or rod
- **Coil:** to produce the magnetic field due to current flowing through it and also to magnetize the iron pieces.
- **In repulsion type**, a **fixed** vane or rod is also used and magnetized with the same polarity.
- **Control torque** is provided by spring or weight (gravity)
- **Damping torque** is normally pneumatic, the damping device consisting of an air chamber and a moving vane attached to the instrument spindle.
- **Deflecting torque** produces a movement on an aluminum pointer over a graduated scale.

Construction of Moving-iron Instruments

The deflecting torque in any moving-iron instrument is due to forces on a small piece of magnetically 'soft' iron that is magnetized by a coil carrying the operating current. In repulsion (Fig.) type moving–iron instrument consists of two cylindrical soft iron vanes mounted within a fixed current-carrying coil. One iron vane is held fixed to the coil frame and other is free to rotate, carrying with it the pointer shaft. Two irons lie in the magnetic field produced by the coil that consists of only few turns if the instrument is an ammeter or of many turns if the instrument is a voltmeter. Current in the coil induces both vanes to become magnetized and repulsion between the similarly magnetized vanes produces a proportional rotation. The deflecting torque is proportional to the square of the current in the coil, making the instrument reading is a true 'RMS' quantity Rotation is opposed by a hairspring that produces the restoring torque. Only the fixed coil carries load current, and it is constructed so as to withstand high transient current. Moving iron instruments having scales that are nonlinear and somewhat crowded in the lower range of calibration. Another type of instrument that is usually classed with the attractive types of instrument is shown in Fig..



Repulsion Type

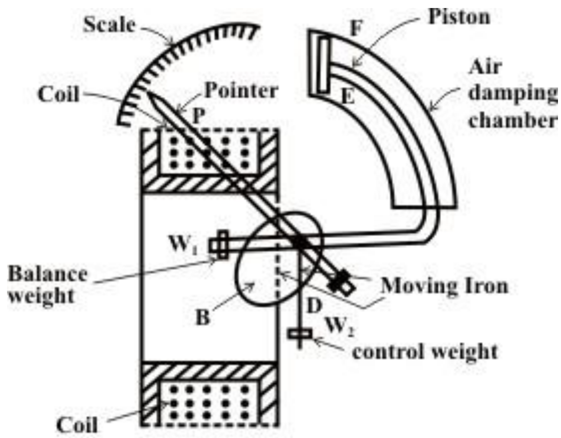


Fig. 42.8: Attraction type

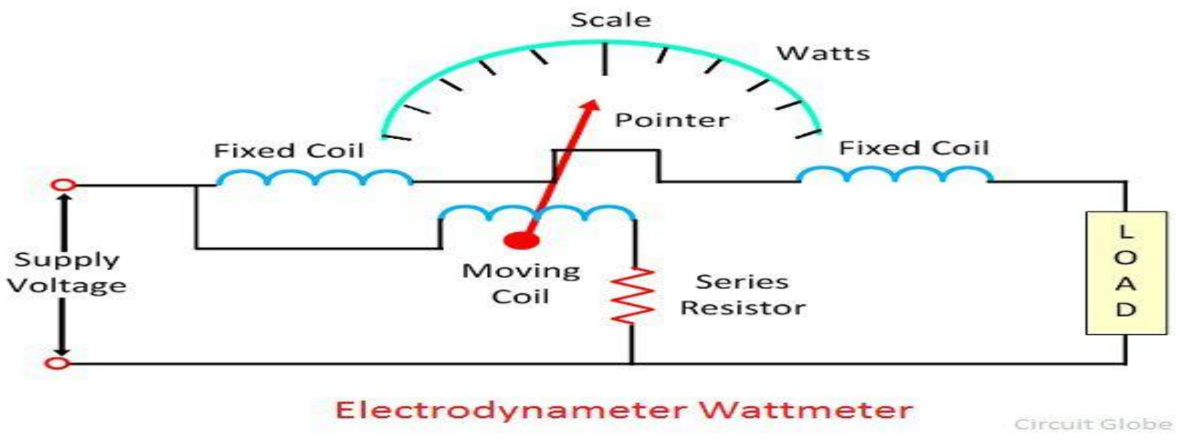
Construction of Electrodynamometer

Fixed coil: The fixed coil connects in series with the load. It is considered as a current coil because the load current flows through it. **For making the construction easy the fixed coil divide into two parts.**

Moving Coil – **The moving coil consider as the pressure coil of the instruments.** It connects in parallel with the supply voltage. The current flows through them is directly proportional to the supply voltage. The pointer mounts on the moving coil. The movement of the pointer controls with the help of the spring.

Control – **The control system provides the controlling torque to the instruments.** The gravity control and the spring control are the two types of control system. Out of two, the Electrodynamometer Wattmeter uses spring control system.

Damping – The damping is the effect which reduces the movement of the pointer. **In this Wattmeter the damping torque produces because of the air friction.**



Single phase induction type energy meter

Single phase induction type energy meter is also popularly known as **watt-hour meter**. This name is given to it. This article is only focused about its constructional features and its working. Induction type energy meter essentially consists of following components:

1.Driving system

2. Moving system

3. Braking system and

4. Registering system

It consists of two electromagnets, called "shunt" magnet and "series" magnet, of laminated construction. A coil having large number of turns of fine wire is wound on the middle limb of the shunt magnet. This coil is known as "pressure or voltage" coil and is connected across the supply mains. This voltage coil has many turns and is arranged to be as highly inductive as possible. In other words, the voltage coil produces a high ratio of inductance to resistance.

An adjustable copper shading rings are provided on the central limb of the shunt magnet to make the phase angle displacement between magnetic field set up by shunt magnet and supply voltage is approximately 90 degree.The copper shading bands are also called the power factor compensator or compensating loop. The series electromagnet is energized by a coil, known as **"current" coil** which is connected in series with the load so that it carry the load current. The flux produced by this magnet is proportional to, and in phase with the load current.

1. Mechanism of rotation of an aluminum disc which is made to rotate at a speed proportional to the power.
2. Mechanism of counting and displaying the amount of energy transferred.

The metallic disc is acted upon by two coils. One coil is connected 0r arranged in such a way that it produces a magnetic flux in proportion to the voltage and the other produces a magnetic flux in proportion to the current. The field of the voltage coil is delayed by 90 degrees using a lag coil. A permanent magnet exerts an opposing force proportional to the speed of rotation of the disc – this acts as a brake which causes the disc to stop spinning when power stops being drawn rather than allowing it to spin faster and faster. This causes the disc to rotate at a speed proportional to the power being used.

The aluminum disc is supported by a spindle which has a worm gear which drives the register. The register is a series of dials which record the amount of energy used.The dials may be of the cyclometer type, an odometer-like display that is easy to read where for each dial a single digit is shown through a window in the face of the meter, or of the pointer type where a pointer indicates each digit.It should be noted that with the dial pointer type, adjacent pointers generally rotate in opposite directions due to the gearing mechanism.