SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35

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Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME: 23EET203-ELECTRICAL MACHINES I

II YEAR / III SEMESTER

Unit 1 – ELECTROMECHANICAL ENERGY CONVERSION

Topic 5: Magnetic force- co-energy in singly excited magnetic field systems

What We'll Discuss

TOPIC OUTLINE

Single Excited Systems Analysis

Singly-Excited and Doubly Excited Systems

Excitation means providing electrical input to an electromechanical energy conversion device such as electric motors. The excitation produces working magnetic field in the electrical machine. Some electrical machines require single electrical input whereas some others require two electrical inputs.

Therefore, depending on the number of electrical inputs to electromechanical energy conversion systems, they can be classified into two types –

- Singly-Excited System
- Doubly-Excited System

Singly-Excited and Doubly Excited Systems

Singly Excited System

As its name implies, a **singly-excited system** is one which consists of only one electrically energized coil to produce working magnetic field in the machine or any other electromechanical energy conversion device. Hence, the singly-excited system requires only one electrical input.

A singly excited system consists of coil wound around a magnetic core and is connected to a voltage source so that it produces a magnetic field. Due to this magnetic field, the rotor (or moving part) which is made up of ferromagnetic material experiences a torque which move it towards a region where the magnetic field is stronger, i.e., the torque exerted on the rotor tries to position it such that it shows minimum reluctance in the path of magnetic flux.

The reluctance depends upon the rotor angle. This torque is known as **reluctance torque** or **saliency torque** because it is caused due to saliency of the rotor.

Analysis of Singly Excited System

We made following assumption to analyze the singly-excited system −

- For any rotor position, the relationship between flux linkage (ψ) and current (i) is linear.
- The coil has negligible leakage flux, which means all the magnetic flux flows through the main magnetic path.
- Hysteresis loss and eddy-current loss are neglected.
- All the electric fields are neglected and the magnetic field is predominating.

Analysis of Singly Excited System

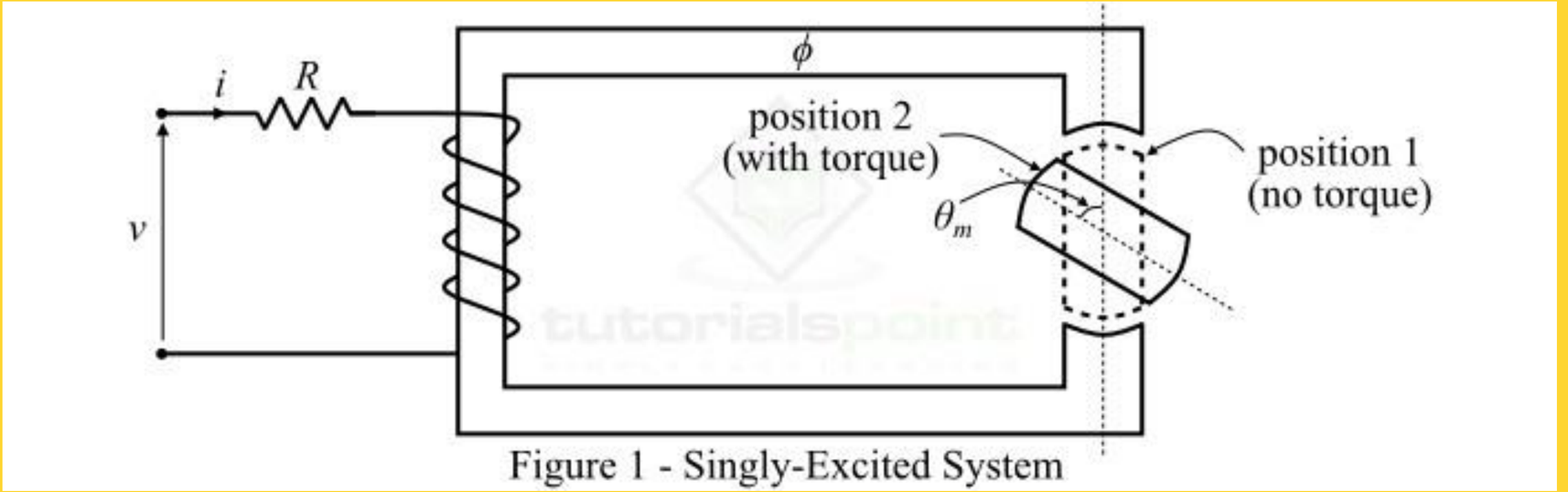

Figure 1 - Singly-Excited System

Consider the singly-excited system as shown in Figure-1. If *R* is the resistance of the coil circuit, the by applying KVL, we can write the voltage equation as,

$$v=iR+d\psi/dt\cdots(1)$$

On multiplying equation (1) by current ii, we have,

$$vi=i_2R+id\psi/dt\cdots(2)$$

Analysis of Singly Excited System

We are assuming initial conditions of the system zero and integrating the equation (2) on both side with respect to time, we obtain,

$$\int_0^T vidt = \int_0^T (i^2R + id\psi/dt)\, dt \int_0^T vidt = \int_0^T (i^2R + id\psi/dt)dt$$

$$\Rightarrow \int_0^T vidt = \int_0^T i^2Rdt + \int_0^\psi id\psi \cdots (3)$$

Analysis of Singly Excited System

Equation-3 gives the total electrical energy input the singly-excited system and it is equal to two parts namely,

- First part is the electrical loss (Wel).
- Second part is the useful electrical energy which is the sum of field energy (Wf) and output mechanical energy (Wm).

Therefore, symbolically we may express the Equation-3 as,

$$Win=Wel=(Wf+Wm)\cdots(4)$$

The **energy stored in the magnetic field** of a singly-excited system is given by,

$$Wf=\int\psi 0id\psi=\int\psi 0\psi Ld\psi=\psi 22L\cdots(5)$$

For a rotor movement, where the rotor angle is θmθm, the **electromagnetic torque** developed in the singly-excited system is given by,

$$\tau e=i22\partial L\partial\theta m\cdots(6)\tau e=i22\partial L\partial\theta m\cdots(6)$$

The most common examples of singly-excited system are induction motors, PMMC instruments, etc.

THANK YOU