ELECTRIC MACHINE II

ENEE 253

Lecture : 3 **Year : II**
Tutorial : 1 **Part : II**
Practical : 3/2

Course Objectives:
The objective of this course is to provide knowledge on constructional details, operating principle, performance characteristics of 3-phase synchronous generators, 3-phase synchronous motors and single-phase AC motors. It also covers general understanding of the dq0 model of synchronous machines; and insights of reluctance motors, permanent magnet motors and special purpose motors.

1 Three Phase Synchronous Machines (3 hours)

1.1 Basic concept of synchronous machines as generator and motor
1.2 Comparison with dc generator and dc motor
1.3 Constructional details: Armature core and windings, types of rotor, exciter
1.4 Advantages of stationary armature over rotating armature in DC machine

2 Three Phase Synchronous Generator (16 hours)

2.1 Working principle, necessity of constant speed operation, speed governor
2.2 EMF equation, distribution factor, pitch factor
2.3 Operation at no-load and Load conditions
2.4 Armature reaction and its affects with resistive load, inductive load and capacitive load, phasor diagrams
2.5 Concept of synchronous reactance and impedance
2.6 Voltage regulation, synchronous impedance, ampere-turn and zero power factor method
2.7 Parallel operation of two synchronous generators and load sharing with speed-droop characteristics
2.8 Transient condition, Transient and sub transient reactance
2.9 Synchronous generator connected to an infinite bus
2.10 Limits of active and reactive power generation-capability curve
2.11 Losses and efficiency

3 Three Phase Synchronous Motor (10 hours)

3.1 Operating principle, synchronous speed operation and torque production
3.2 Starting methods
3.3 No-load and load operation: Power angle (δ), phasor diagram
3.4 Effect of excitation on power factor of motor, V and inverted V curves
3.5 Power-angle characteristic of cylindrical rotor machine
3.6 Power-angle characteristic of salient pole rotor machine, two reaction model
3.7 Hunting in synchronous motor
3.8 Losses and efficiency
3.9 Synchronous condenser

4 DQ model of synchronous machines (4 hours)

4.1 Circuit equations of synchronous machines
4.2 Concept of d-axis and q-axis in synchronous machine and need of dq0 model of synchronous machine
4.3 Park's transformation, abc-dq0
4.4 DQ0 model of salient pole synchronous machine: Transformed circuit equations
4.5 Power equation in dq0 model, power invariance in abc and dq0 reference frame

5 Single Phase AC Motor and Special Purpose Motors (12 hours)

5.1 Single phase induction motors, construction, operating principle and double revolving field theory
5.2 Self-starting split phase induction motors
  5.2.1 Capacitor start motor, its operating principle and characteristic curve
  5.2.2 Capacitor start and run motor, its operating principle and characteristic curve
  5.2.3 Shaded pole motor, its operating principle and characteristic curve
5.3 Single phase synchronous motors (Reluctance and hysteresis motors)
5.4 Switched reluctance motor: Construction, operating principle and torque speed characteristic
5.5 Permanent Magnet Synchronous Motor (PMSM): Principle of operation, construction (Surface-mounted PMSM, Interior-PMSM), EMF and torque equation, torque-speed characteristics, features and application of PMSMs
5.6 Brushless DC Motor: Constructional feature of brush less DC (BLDC) motors, Comparison of brushless DC motor relative to induction motor drives, principle of operation of brushless dc motor, classification of BLPM DC motor, EMF and torque equation, torque-speed characteristics, features and applications of BLDC motors

5.7 Special purpose motors: Universal, stepper and servo motors

Tutorial **(15 Hours)**

1. Exercises on synchronous machine concepts, construction, and advantages of stationary armature over rotating armature.
2. Problems on Three-Phase Synchronous Generator
3. Problems on Three-Phase Synchronous Motor
4. Practice on DQ0 model, Park's transformation, equivalent circuits, and power equations in DQ0 frame.
5. Problems on single-phase induction motors, self-starting methods

Practical **(22.5 hours)**

1. To study no-load characteristic of 3-phase synchronous generator
2. To study Load characteristic of 3-phase synchronous generator with resistive, inductive and capacitive loads.
3. To study effect of excitation on performance of three phase synchronous motor and to plot V-curve
4. To study the characteristics of single-phase split phase motor and capacitor start and run motor and compare their characteristics
5. Study of the T-S characteristics of PMSM

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hour	Marks Distribution *
1	3	6
2	16	20
3	10	12
4	4	6
5	12	16
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Nagrath, I. J., Kothari, D. P. (2017). *Electrical Machines*. Tata McGraw-Hill.
2. Gupta, J. B. (2009). *Theory and Performance of Electrical Machines*. S.K. Kataria and Sons.
3. Fitzgerald, A. E., Kingsley, C. Jr., Umas, S. D. (2000). *Electric Machinery*. Tata McGraw-Hill.
4. Mohan, N. (2012). *Electric Machine and Drives*. Wiley.
5. Bhimbra, P. S. (2021). *Electrical Machines*. Khanna Publishers.