### **ELECTRICAL MACHINES – II**

**Preamble:** This course covers the topics on 3-phase induction motor, 1-phase induction motor and synchronous machines which have wide application in power systems. The main aim of the course is to provide a detailed analysis of operation and performance of 3-phase induction motor, 1-phase induction motor and synchronous machines. In addition, it also covers voltage regulation and parallel operation of synchronous generators.

### **Learning Objectives:**

- Understand the principle of operation and performance of 3-phase induction motor.
- Quantify the performance of induction motor and induction generator in terms of torque and slip.
- To understand the torque producing mechanism of a single phase induction motor.
- To understand the principle of emf generation, the effect of armature reaction and predetermination of voltage regulation in synchronous generators.
- To study parallel operation and control of real and reactive powers for synchronous generators.
- To understand the operation, performance and starting methods of synchronous motors.

#### Unit – I

### **Three Phase Induction Motor:**

Constructional details – Types of rotors – Principle of operation – Slip – Equivalent circuit – Slip-torque characteristics - Condition for maximum torque – Losses and efficiency – Load test - No load and blocked rotor tests - Circle diagram – Separation of no load losses – Double cage rotors – Induction generator – Synchronous induction motor.

### Unit – II

#### **Starting and Speed Control of Three Phase Induction Motor:**

Need for starting – Types of starters – Rotor resistance, Autotransformer and Star-delta starters – Speed control – Change of voltage, torque, number of poles and slip – Cascaded connection – Slip power recovery scheme.

#### Unit – III

#### **Synchronous Generator:**

Constructional details – Types of rotors – emf equation – Synchronous reactance – Armature reaction – Voltage regulation – EMF, MMF and ZPF methods –Two reaction theory – Determination of direct and quadrature axis synchronous reactance using slip test – Operating characteristics - Capability curves.

#### Unit – IV

### **Parallel Operation of Synchronous Generators:**

Parallel operation with infinite bus and other alternators – Synchronizing power – Load sharing – Control of real and reactive power– Numerical problems

## Unit – V

# **Synchronous Motor – Operation, Starting and Performance:**

Synchronous Motor principle and theory of operation– Phasor diagram – Starting torque– Variation of current and power factor with excitation –Synchronous condenser –Mathematical analysis for power developed– Hunting and its suppression – Methods of starting – Applications.

## Unit – VI:

## Single Phase Motors & Special Motors:

Single phase induction motor – Constructional features-Double revolving field theory – Elementary idea of cross-field theory – split phase motors – shaded pole motor Principle & performance of A.C. Series motor-Universal motor, Principle of permanent magnet and reluctance motors

# **Course Outcomes:**

- Able to explain the operation and performance of three phase induction motor.
- Able to analyse the torque-speed relation, performance of induction motor and induction generator.
- Able to explain design procedure for transformers and three phase induction motors.
- Implement the starting of single phase induction motors.
- To perform winding design and predetermine the regulation of synchronous generators.
- Avoid hunting phenomenon, implement methods of staring and correction of power factor with synchronous motor.

# **Text Books:**

- 1. Electrical Machines P.S. Bhimbra, Khanna Publishers
- 2. Electric Machinery by A.E.Fitzgerald, Charleskingsley, StephenD.Umans, TMH

### **References:**

- 1. Electrical Machines by D. P. Kothari, I .J .Nagarth, Mc Graw Hill Publications, 4th edition
- 2. Electrical Machines by R.K. Rajput, Lakshmi publications,5th edition
- 3. Electrical Machinery by Abijith Chakrabarthi and Sudhipta Debnath, Tata McGraw Hill education 2015
- 4. Electrical Machinery Fundamentals by Stephen J Chapman McGraw Hill education 2010
- 5. Electric Machines by Mulukutla S.Sarma & Mukeshk. Pathak, CENGAGE Learning.
- 6. Theory & Performance of Electrical Machines by J.B. Guptha. S.K. Kataria& Sons