Electrical Machines and Power Devices(304201)

Teaching Scheme:
Lectures: 4 Hrs/Week

Examination Scheme:
In Semester Assessment:
Phase I : 30

End Semester Examination:
Phase II: 70

Course Objectives:

- To understand construction, switching characteristics and protection of power devices.
- To understand construction, switching characteristics and protection of thyristors.
- To understand construction and operating principle of DC machines.
- To understand construction and operating principle of AC machines (1φ and 3φ).

Course Outcomes:

After successfully completing the course students will be able to

- Explain construction, switching characteristics and justify the selection of power devices and thyristors.
- Explain operating principle and suggest protection circuit for power devices and thyristors.
- Explain construction and operating principle of DC machines and AC machines (1φ and 3φ).
- Students shall be able to identify the causes of bad commutation and suggest remedies.

Unit I : Power Devices 8L

Power Diodes: Construction, Switching characteristics; Power BJT, PBJT: Construction, Operation, Steady state characteristics, switching characteristics, switching limits, Break down voltages; Power MOSFET: PMOSFET, Construction, Operation, Static characteristics, switching characteristics, forward and reverse bias, safe Operating Area, Parallel operation; IGBT: Construction, Operation, Steady state characteristics, Switching characteristics, Safe operating area.

Unit II : Thyristors 6L

Thyristor: Construction, Operation, transistor analogy, static characteristics, switching characteristics, thyristor turn-on, thyristor turn-off. DIAC / TRIAC – construction and operating Principle, key terminologies and specifications, TRIAC drivers (MOC3011), Applications. GTO: Construction, Operation, Turn off mechanism, Applications. di/dt and dv/dt protection.

Unit III : Protection of Devices and circuits 6L

Cooling and heat sinks. Thermal modeling of power switching devices – electrical equivalent of thermal model, mathematical thermal equivalent circuit, coupling of electrical and thermal components. Snubber circuits, reverse recovery transients, supply and load side transients. Voltage protection by selenium diodes and MOVs. Current protections – fusing, fault current with AC source, fault current with DC source. Electromagnetic Interference – sources of EMI, minimizing EMI generation, EMI shielding.

Unit IV : DC Machines 7L

Electromagnetic conversion, DC machines - Construction, Evolution of DC machines, armature windings, armature voltage, developed torque, magnetization curve of DC machines, classifications of DC Machines. DC Generators – Separately excited DC generators, shunt (self-excited) generator, compound DC machines, series generator, Interpoles or commutator poles. DC Motors – shunt motors, series motor, starter. Permanent magnet DC motors (PMDC), Commutation: Process of Commutation, time of commutation, reactance voltage, straight line commutation, under and over voltage commutation, causes of bad commutation and remedies, inter poles, compensation (descriptive treatment only).

Unit V : Induction Machines 7L

Induction (Asynchronous) machines – constructional features, rotating magnetic field –graphical method, analytical method, Induced voltages, poly phase induction machines – stand still operation, phase shifter, Induction regulator, running operation, Three modes of operation – Motoring, generating, plugging. Equivalent circuit, various equivalent configurations, Thevenin equivalent circuit. No load test, blocked –rotor test and equivalent circuit parameters, performance characteristics, effects of rotor resistance, classes of squirrel-cage motors. Synchronous Machines – construction, synchronous generators, synchronous motors, equivalent circuit model, power and torque characteristics and applications.

Unit VI : Special Machines 7L

Brushless DC motors (BLDC), switched reluctance motors (SRM), Servomotors – DC servomotors, AC servo motors, analysis – transfer function and block diagram. Stepper motors – variable Reluctance stepper motor, permanent magnet stepper motor. Single-phase motors – single phase induction motors – double revolving field theory, equivalent circuit of a single phase induction motor, starting of single phase induction motors, single phase series (universal) motors.

Text Books

1. P. C. Sen, “Principles of Electrical machines and power electronics”, 2nd edition, John Wiley & Sons.
2. M H Rashid, “Power Electronics – circuits, devices and applications”, 3rd edition, Pearson Education.

Reference Books

1. A E Fitzgerald, Charles Kingsley Jr., Stephen D Umans, “Electric machinery”, 6th Edition, TMH.
2. Ashfaq Hussain, “Electric Machines”, Dhanpat Rai and Co.
3. I J Nagrath, D P Kothari, “Electric Machines”, 2nd edition, TMH.