Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NEED502	Power System Transients	3	0	0	3

Course Objective

- This syllabus has been designed with an eye on energy industry, and the topics considered are intricately related to power system network operations. Apart from few basic modules, many of the topics introduced are crucial for power system network operation. The syllabus is designed so that a student gets necessary mathematical foundation while gaining advanced knowledge related to power systems transient. However, strong fundamental knowledge about power system analysis and network theorems are the prerequisite for the course.

Learning Outcomes

Upon successful completion of this course, students will acquire knowledge:

- To gain knowledge in sources of transients like lightning, switching and temporary over voltages.
- To model power system components and estimate the over voltages in power system
- To analyze travelling wave phenomena against different over voltages
- To coordinate the insulation of power system and protective devices.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Internal and external causes of over voltages:** Lightning strokes – Mathematical model to represent lightning, travelling waves in transmission lines – Circuits with distributed constants – Wave equations – Reflection and refraction of travelling waves – Travelling waves at different line terminations, Travelling wave method – Beweley's Lattice diagram – analysis in time and frequency domain.	7L	Knowledge gain on the modelling of lightning stroke and travelling wave analysis on transmission lines.
2	Travelling wave attenuation and distortion, transients due to faults, electromagnetic induction, magnetic flux, and currents, transient electromagnetic phenomena, lightning induced transients, computation of lightning events, lightning protection using shielding and surge arresters, transient voltages and grounding practices, lightning performance of transmission towers, Influence of surge impedance, Tower Footing Resistance in lightning performance of double circuit lines, back-flashover.	8L	Knowledge gain on travelling wave phenomena and induced electromagnetic transients during faults especially due to lightning strokes to power transmission lines and Towers.
3	**Sources of Transients and their effect on Power System network:** Switching transients –double frequency transients – abnormal switching transients – Transients in switching a three-phase reactor- three phase capacitor. Voltage and current chopping, Line energization, and de-energization transients; voltage distribution in transformer winding – voltage surges in transformers, generators and motors, Transient parameter values for transformers, reactors, generators and transmission lines. Basic ideas about protection –surge diverters-surge absorbers-protection of lines and sub-stations.	8L	Knowledge gain on the behaviours of different switching transients.
4	**Insulation coordination:** Basic Insulation Level (BIL), Critical Flashover Voltage (CVO), Over voltage protective devices – shielding wires, Lightning arresters, rods gaps and surge diverters, principles of insulation coordination-recent advancements in insulation coordination – design of EHV system.	6L	Knowledge gain on recent trends on insulation coordination.
5	Representation of transient wave shapes, modelling power apparatus for transient analysis, capacitor switching, reactor switching, magnetizing inrush and ferro resonance, transmission lines, the wave equation, and line terminations, Generation, properties and application of high AC and DC-impulse voltages, currents.	7L	Knowledge gain on the modeling of different power apparatuses for transient analysis.
6	**Computation of power system transients:** Computation of transients using electromagnetic transient program-Modelling of power system components- Simple case studies - Application of simplified method: single line station, two-line station, gas insulated substations, comparison with IEEE and IEC guides	6L	Knowledge gain on the modeling of transients using EMTP or PSCAD/EMTDC software and their impacts on power system network.
	Total Contact Hours	**42L**	

Text Books:

1. A. Greenwood, "Electrical Transients in Power Systems", Wiley.
2. J. A. Martinez-Velasco, "Power System Transients: Parameter Determination", CRC Press.

Reference Books:

1. E. Haginomori, T. Koshiduka, J. Arai, and H. Ikeda, 'Power System Transient Analysis: Theory and Practice using Simulation Programs (ATP-EMTP)', John Wiley & Sons, 2016.