Semester VI (Third year]
Branch/Course Electrical Engineering

Course Code	Paper Title	L	T	P	Credits	branch
	Electronics Design Laboratory	1	0	4	3	103
	MOOCs / SWAYAM / NPTEL Courses - 2	3	0	0	3	103
	Power Systems – II (Operation and Control)	3	0	0	3	103
	Power Systems Laboratory – II	0	0	2	1	103
	Professional Skill Development	3	0	0	3	103
	Program Elective – III	3	0	0	3	103
	Program Elective- II	3	0	0	3	103
	Workshop/heads on Training/Soft Skill	3	0	0	0	103

PCC-EE23	**Power Systems – II**	**3L:0T:0P**	**3 credits**

Course Outcomes:

At the end of this course, students will demonstrate the ability to
- Use numerical methods to analyse a power system in steady state.
- Understand stability constraints in a synchronous grid.
- Understand methods to control the voltage, frequency and power flow.
- Understand the monitoring and control of a power system.
- Understand the basics of power system economics.

Module 1: Power Flow Analysis (7 hours)
Review of the structure of a Power System and its components. Analysis of Power Flows: Formation of Bus Admittance Matrix. Real and reactive power balance equations at a node. Load and Generator Specifications. Application of numerical methods for solution of non-linear algebraic equations – Gauss Seidel and Newton-Raphson methods for the solution of the power flow equations. Computational Issues in Large-scale Power Systems.

Module 2: Stability Constraints in synchronous grids (8 hours)
Swing Equations of a synchronous machine connected to an infinite bus. Power angle curve. Description of the phenomena of loss of synchronism in a single-machine infinite bus system following a disturbance like a three—phase fault. Analysis using numerical integration of swing equations (using methods like Forward Euler, Runge-Kutta 4th order methods), as well as the Equal Area Criterion. Impact of stability constraintson Power System Operation. Effect of generation rescheduling and series compensation of transmission lines on stability.

Module 3: Control of Frequency and Voltage (7 hours)
Turbines and Speed-Governors, Frequency dependence of loads, Droop Control and Power Sharing. Automatic Generation Control. Generation and absorption of reactive power by various components of a Power System. Excitation System Control in synchronous generators, Automatic Voltage Regulators. Shunt Compensators, Static VAR compensators and STATCOMs. Tap Changing Transformers.
Power flow control using embedded dc links, phase shifters and

Module 4: Monitoring and Control (6 hours)
Overview of Energy Control Centre Functions: SCADA systems. Phasor Measurement Units and Wide-Area Measurement Systems. State-estimation. System Security Assessment. Normal, Alert, Emergency, Extremis states of a Power System. Contingency Analysis. Preventive Control and Emergency Control.

Module 5: Fault Analysis and Protection Systems (10 hours)
Method of Symmetrical Components (positive, negative and zero sequences). Balanced and Unbalanced Faults. Representation of generators, lines and transformers in sequence networks. Computation of Fault Currents. Neutral Grounding.

Text/References:

1. J. Grainger and W. D. Stevenson, "Power System Analysis", McGraw Hill Education,1994.
2. O. I. Elgerd, "Electric Energy Systems Theory", McGraw Hill Education,1995.
3. A. R. Bergen and V. Vittal, "Power System Analysis", Pearson Education Inc.,1999.
4. D. P. Kothari and I. J. Nagrath, "Modern Power System Analysis", McGraw Hill Education,2003.
5. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, "Electric Power Systems", Wiley, 2012.

PCC-EE24: Power Systems-II Laboratory (0:0:2 – 1 credit)

Hands-on and computational experiments related to the course contents of EE20. This should include

programmingofnumericalmethodsforsolutionofthepowerflowproblemandstabilityanalysis.Visit to load dispatch centre is suggested.

PCC-EE25	Electronics Design Laboratory	1L:0T:4P	3 credits

Course Outcomes:

At the end of the course, students will demonstrate the ability to
- Understand the practical issues related to practical implementation of applications using electronic circuits.
- Choose appropriate components, software and hardware platforms.
- Design a Printed Circuit Board, get it made and populate/solder it with components.
- Work as a team with other students to implement an application.

Basicconceptsonmeasurements;Noiseinelectronicsystems;Sensorsandsignalconditioningcircuits; Introduction to electronic instrumentation and PC based data acquisition; Electronic system design, Analog system design, Interfacing of analog and digital systems, Embedded systems, Electronic system design employing microcontrollers, CPLDs, and FPGAs, PCB design and layout; System assembly considerations. Group projects involving electronic hardware (Analog, Digital, mixed signal) leading to implementation of an application.

Text/Reference Books
1. A. S. Sedra and K. C. Smith, "Microelectronic circuits", Oxford University Press, 2007.
2. P. Horowitz and W. Hill, "The Art of Electronics", Cambridge University Press, 1997.
3. H. W. Ott, "Noise Reduction Techniques in Electronic Systems", Wiley, 1989.
4. W.C. Bosshart, "Printed Circuit Boards: Design and Technology", Tata McGraw Hill, 1983.
5. G.L. Ginsberg, "Printed Circuit Design", McGraw Hill, 1991.