# Department of Electrical Engineering
## 6th Semester

| Branch Code | Course Code | Course Name | L | T | P | Credits | TH/PR | ESE | IA |
|---|---|---|---|---|---|---|---|---|---|
| 103 | 100606 | Digital Signal Processing | 3 | 0 | 0 | 3 | TH | 70 | 30 |
| 103 | 100609 | Electronics Design Laboratory | 1 | 0 | 0 | 1 | TH | 70 | 30 |
| 103 | 100607 | Introduction to VLSI Design | 3 | 0 | 0 | 3 | TH | 70 | 30 |
| 103 | 100604 | MOOCs / SWAYAM / NPTEL Courses - 2 | 2 | 0 | 0 | 2 | TH | 70 | 30 |
| 103 | 103601 | Power Systems – II (Operation and Control) | 3 | 0 | 0 | 3 | TH | 70 | 30 |
| 103 | 100608 | Professional Skill Development | 3 | 0 | 0 | 3 | TH | 70 | 30 |
| 103 | 1036xx | Program Elective - III | 3 | 0 | 0 | 3 | TH | 70 | 30 |
| 103 | 1036xx | Program Elective- II | 3 | 0 | 0 | 3 | TH | 70 | 30 |
| 103 | 100605 | Workshop/heads on Training/Soft Skill | 3 | 0 | 0 | 0 | TH | 0 | 0 |
| 103 | 100606P | Digital Signal Processing | 0 | 0 | 2 | 1 | PR | 30 | 20 |
| 103 | 100609P | Electronics Design Laboratory | 0 | 0 | 4 | 2 | PR | 30 | 20 |
| 103 | 100607P | Introduction to VLSI Design | 0 | 0 | 2 | 1 | PR | 30 | 20 |
| 103 | 103601P | Power Systems – II (Operation and Control) | 0 | 0 | 2 | 1 | PR | 30 | 20 |

**Program Electives**

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|---|---|---|---|---|---|---|---|
| 103 | 100611 | Computer Architecture | 3 | 0 | 0 | 3 | PROG ELECTIVE - II |
| 103 | 103603 | Line Commutated and Active Rectifiers | 3 | 0 | 0 | 3 | PROG ELECTIVE - II |
| 103 | 100613 | Electrical Drives | 3 | 0 | 0 | 3 | PROG ELECTIVE - II |
| 103 | 103605 | High Voltage Engineering | 3 | 0 | 0 | 3 | PROG ELECTIVE - III |
| 103 | 103606 | Industrial Electrical Systems | 3 | 0 | 0 | 3 | PROG ELECTIVE - III |
| 103 | 100612 | Digital Control Systems | 3 | 0 | 0 | 3 | PROG ELECTIVE - III |

| 103601 | Power Systems – II | 3L:0T:0P | 3 credits |
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**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.

**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.

**103601P: Power Systems-II Laboratory (0:0:2 – 1 credit)**

Hands-on and computational experiments related to the course contents of EE20. This should include programming of numerical methods for solution of the power flow problem and stability analysis. Visit to load dispatch centre is suggested.

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| **100609** | **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.

Basic concepts on measurements; Noise in electronic systems; Sensors and signal conditioning circuits; 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.

| 100608 | Professional Skill Development | 3L:0T: 0P | 3 credits |
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**Objectives of the course:**

1. To learn various interpersonal skills
2. To help in developing various professionals skills.
3. To cover the facets of verbal and non-verbal languages, public speech, reading gestures and body languages, preparing for group discussion and enhancing presentations skills.
4. To enable learners to speak fluently and flawlessly in all kinds of communicative Contexts with speakers of all nationalities.

**Detail contents:**

**Module 1 Lecture 10 hrs.**

**Communication skills:** Public speaking, Group discussion, Gestures and body language & professional presentation skills

**Module 2 Lecture 10 hrs.**

**Interpersonal skills**: Group dynamics, Negotiation skills, Leadership, Emotional intelligence

**Module 3 Lecture 10 hrs.**

**Employability and Corporate Skills**: Time management and effective planning, Stress management, People skills, Team work, development of leadership qualities, Decision making and Negotiation skills, Positive attitude, Self-motivation, Professional ethics, Business etiquettes, balancing board room.

**Module 4 Lecture 10 hrs.**

**Business writing skills,** Resume Writing. Interview Skills, Technical Presentation, Guest Lecture, Professional Ethics, Project Management, Entrepreneurship.

**Suggested reference books:**


1. "Personality Development and Soft Skills", Barun Mitra, Oxford University Press.
2. "Managing Soft Skills for Personality Development", B.N. Ghosh, McGraw Hill.
3. "Communication Skills and Soft Skills: An Integrated Approach", E. Suresh Kumar, Pearson
4. "Communication to Win", Richard Denny, Kogan Page India Pvt. Ltd.

| 100606 | Digital Signal Processing | 3L:0T:0P | 3 credits |
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**Course Outcomes:**
At the end of this course, students will demonstrate the ability to

Represent signals mathematically in continuous and discrete-time, and in the frequency domain.

Analyse discrete-time systems using z-transform.

Understand the Discrete-Fourier Transform (DFT) and the FFT algorithms.

Design digital filters for various applications.

Apply digital signal processing for the analysis of real-life signals.

**Module 1: Discrete-time signals and systems (6 hours)**
Discrete time signals and systems: Sequences; representation of signals on orthogonal basis; Representation of discrete systems using difference equations, Sampling and reconstruction of signals aliasing; Sampling theorem and Nyquist rate.

**Module 2: Z-transform (6 hours)**
z-Transform, Region of Convergence, Analysis of Linear Shift Invariant systems using z-transform, Properties of z-transform for causal signals, Interpretation of stability in z-domain, Inverse z-transforms.

**Module 2: Discrete Fourier Transform (10 hours)**
Frequency Domain Analysis, Discrete Fourier Transform (DFT), Properties of DFT, Convolution of signals, Fast Fourier Transform Algorithm, Parseval's Identity, Implementation of Discrete Time Systems.

**Module 3: Design of Digital filters (12 hours)**
Design of FIR Digital filters: Window method, Park-McClellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Low-pass, Band-pass, Band-stop and High-pass filters. Effect of finite register length in FIR filter design. Parametric and non-parametric spectral estimation. Introduction to multi-rate signal processing.

**Module 4: Applications of Digital Signal Processing (6 hours)**
Correlation Functions and Power Spectra, Stationary Processes, Optimal filtering using ARMA Model, Linear Mean-Square Estimation, Wiener Filter.

**Text/Reference Books:**
1. S. K. Mitra, "Digital Signal Processing: A computer based approach", McGraw Hill, 2011.
2. A.V. Oppenheim and R. W. Schafer, "Discrete Time Signal Processing", Prentice Hall, 1989.
3. J. G. Proakis and D.G. Manolakis, "Digital Signal Processing: Principles, Algorithms And Applications", Prentice Hall, 1997.
4. L. R. Rabiner and B. Gold, "Theory and Application of Digital Signal Processing", Prentice Hall, 1992.
5. J. R. Johnson, "Introduction to Digital Signal Processing", Prentice Hall, 1992.
6. D. J. DeFatta, J. G. Lucas andW. S. Hodgkiss, "Digital Signal Processing", John Wiley & Sons, 1988.

**100606P: Digital Signal Processing Laboratory (0:0:2 – 1 credit)**
Hands-on/Computer experiments related to the course contents of PCC-EEE23.

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| **100607** | **Introduction to VLSI Design** | **3L: 0T: 0P** | **3 credits** |

**Course Outcomes:**

At the end of this course, students will demonstrate the ability to

1. Understand the mathematical methods and circuit analysis models in analysis of CMOS digital electronics circuits, including logic components and their inter connect. .
2. Understand the CMOS technology-specific layout rules in the placement and routing of transistors and interconnect, and to verify the functionality, timing, power, and parasitic effects
3. Understand the concepts and techniques of modern integrated circuit design and testing (CMOS VLSI).

**Module 1:** Introduction MOSFET, threshold voltage, current, Channel length modulation, body bias effect and short channel effects, MOS switch, MOSFET capacitances, MOSFET models for calculation-Transistors and Layout, CMOS layout elements, parasitics, wires and vias-design rules-layout design SPICE simulation of MOSFET I-V characteristics and parameter extraction (10 hours)

**Module 2:** CMOS inverter, static characteristics, noise margin, effect of process variation, supply scaling, dynamic characteristics, inverter design for a given VTC and speed, effect of input rise time and fall time, static and dynamic power dissipation, energy & power delay product, sizing chain of inverters, latch up effect-Simulation of static and dynamic characteristics, layout, post layout simulation (10 hours)

**Module 3:** Static CMOS design, Complementary CMOS, static properties, propagation delay, Elmore delay model, power consumption, low power design techniques, logical effort for transistor sizing, ratioed logic, pseudo NMOS inverter, DCVSL, PTL, DPTL & Transmission gate logic, dynamic CMOS design, speed and power considerations, Domino logic and its derivatives, C2MOS, TSPC registers, NORA CMOS – Course project (10 hours)

**Module 4:** Circuit design considerations of Arithmetic circuits, shifter, CMOS memory design - SRAM and DRAM, BiCMOS logic - static and dynamic behaviour -Delay and power consumption in BiCMOS Logic. (10 hours)

**Text / References:**

1. David A. Hodges, Horace G. Jackson, and Resve A. Saleh, “Analysis and Design of Digital Integrated Circuits”, McGraw-Hill, Third edition, 2004..
2. R. J. Baker, H. W. Li, and D. E. Boyce, “MOS circuit design, layout, and simulation”, Wiley-IEEE Press, 2007.
3. Sung-Mo Kang & Yusuf Leblebici, “CMOS Digital Integrated Circuits - Analysis & Design”, Tata McGraw Hill, Third edition, 2003.
4. Wayne Wolf, “Modern VLSI design”, Pearson Education, 2003
5. Christopher Saint and Judy Saint, “IC layout basics: A practical guide”, Tata McGraw Hill Professional, 2001.

**100607P: Introduction to VLSI Design Laboratory (0:0:2 – 1 credit)**

Hands-on/Computer experiments related to the course contents of PCC-EEE21

| 100613 | Electrical Drives | 3L:0T:0P | 3 credits |
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- Understand the characteristics of dc motors and induction motors.
- Understand the principles of speed-control of dc motors and induction motors.
- Understand the power electronic converters used for dc motor and induction motor speed control.

**Course Outcomes:**
At the end of this course, students will demonstrate the ability to

**Module 1: DC motor characteristics (5 hours)**
Review of emf and torque equations of DC machine, review of torque-speed characteristics of separately excited dc motor, change into rque-speed curve with armature voltage, example load torque- speed characteristics, operating point, armature voltage control for varying motor speed, flux weakening for high speed operation.

**Module 2: Chopper fed DC drive (5 hours)**
Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper, efficiency of dc drive, smooth starting.

**Module 3: Multi-quadrant DC drive (6 hours)**
Review of motoring and generating modes operation of a separately excited dc machine, four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; steady-state operation of multi-quadrant chopper fed dc drive, regenerative braking.

**Module 4: Closed-loop control of DC Drive (6 hours)**
Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, for controller design, current controller specification and design, speed controller specification and design.

**Module 5: Induction motor characteristics (6 hours)**
Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency, typical torque-speed curves of fan and pump loads, operating point, constant flux operation, flux weakening operation.

**Module 6: Scalar control or constant V/f control of induction motor (6 hours)**
Review of three-phase voltage source inverter, generation of three-phase PWM signals, sinusoidal modulation, space vector theory, conventional space vector modulation; constant V/f control of induction motor, steady-state performance analysis based on equivalent circuit, speed drop with loading, slip regulation.

**Module 7: Control of slip ring induction motor (6 hours)**
Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery.

**Text / References:**
1. G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall,1989.
2. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall, 2001.
3. G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press, 2002.
4. W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.

| 103605 | High Voltage Engineering | 3L:0T:0P | 3 credits |
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**At the end of the course, the student will demonstrate**

- Understand the basic physics related to various breakdown processes in solid, liquid and gaseous insulating materials.
- Knowledge of generation and measurement of D. C., A.C., & Impulse voltages.
- Knowledge of tests on H. V. equipment and on insulating materials, as per the standards.
- Knowledge of how over-voltages arise in a power system, and protection against these over- voltages.

**Module 1: Breakdown in Gases (8 Hours)**
Ionization processes and de-ionization processes, Types of Discharge, Gases as insulating materials, Breakdown in Uniform gap, non-uniform gaps, Townsend's theory, Streamer mechanism, Corona discharge.
**Module 2: Breakdown in liquid and solid Insulating materials (7 Hours)**
Breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials.
**Module 3: Generation of High Voltages (7 Hours)**
Generation of high voltages, generation of high D. C. and A.C. voltages, generation of impulse voltages, generation of impulse currents, tripping and control of impulse generators.
**Module 4: Measurements of High Voltages and Currents (7 Hours)**
Peak voltage, impulse voltage and high direct current measurement method, cathode ayoscillo graphs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements.
**Module 5: Lightning and Switching Over-voltages (7 Hours)**
Charge formation in clouds, Stepped leader, Dart leader, Lightning Surges. Switching over-voltages, Protection against over-voltages, Surge diverters, Surge modifiers.
**Module 6: High Voltage Testing of Electrical Apparatus and High Voltage Laboratories (7 Hours)**
Various standards for HV Testing of electrical apparatus, IS, IEC standards, Testing of insulators and bushings,testingofisolatorsandcircuitbreakers,testingofcables,powertransformersandsomehigh voltage equipment, High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, safety precautions in H. V.Labs.
**Text/Reference Books**

1. M. S. Naidu and V. Kamaraju, "High Voltage Engineering", McGraw Hill Education,2013.
2. C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers,2007.
3. D. V. Razevig (Translated by Dr. M. P. Chourasia), "High Voltage Engineering Fundamentals", Khanna Publishers,1993.