Signals & Systems: 3130511

Course Objectives:

To develop an understanding of fundamental characteristics of signals and systems in both time, frequency and complex domains and to develop mathematical skills to solve problems involving convolution, filtering, modulation and sampling.

Unit I. Dynamic Representation of Systems: Definition & Classification of signals. Complex exponentials, Special Signals Singularity functions (impulse and step functions). Basic operations on signals. Systems Attributes, Causality, linearity, Stability, time invariance. Linear Time-Invariant Systems: Differential equation representation. Discrete form of special functions. Convolution Integral and its properties.

Unit II. Fourier Analysis of Continuous Time Signals and Systems: Continuous-Time Fourier Series and its properties, Continuous-Time Fourier Transform and properties, Parseval's theorem, Frequency response of LTI systems.

Unit III. Fourier Analysis of Discrete Time Signals & Systems: Discrete-Time Fourier series and its properties, Discrete-Time Fourier Transform (including DFT) and properties, Frequency response of discrete time LTI systems, Fast Fourier Transform (FFT).

Unit IV. Laplace Transform: Laplace Transform and its inverse: Definition and existence conditions, Region of Convergence and properties, Significance of poles & zeros, Application of Laplace transform for the analysis of continuous time LTI system (stability etc.). **Z-Transform:** Z-Transform and its inverse: Definition and existence conditions, Region of convergence and properties, Application of Z-Transform for the analysis of Discrete time LTI Systems.

Unit V. Sampling: The sampling theorem, reconstruction of signal from its samples, sampling in the frequency domain, sampling of discrete-time signals.

Recommended Books:

1. Signal and systems by Oppenheim AV, Willisky AS and Nawab SH, Pearson
2. Signals and systems by Hwel. P. Hsu, Schaum's outlines, TME
3. Digital Signal Processing Principles by Proakis JP, Manolaxis, Pearson
4. Fundamentals of Signals & Systems by Michael J Roberts, McGraw Hill

Course Outcomes

After the completion of this course, students will be able to:

CO 1. **Classify** signals and systems based on their properties and key system properties like linearity, time invariance, causality, stability and convolution.

CO 2. **Analyze** the spectral characteristics of continuous-time periodic and a periodic signal using Fourier analysis.

CO 3. **Analyze** discrete-time signals and systems in the frequency domain using Discrete-Time Fourier Transform (DTFT), Discrete Fourier Transform (DFT), and FFT.

CO 4. **Apply** the Laplace transform and Z- transform for analysis of continuous-time and discrete-time signals and systems.

CO 5. **Apply** the principles of signal sampling and reconstruction techniques to recover continuous-time signals from their samples in time and frequency domains

Control Systems: 3130512

Course Objective:

To expose the students to the mathematical modeling of the various physical systems, the concept of time-domain response (transient and steady-state response) and frequency-domain analysis of the systems, stability analysis of the systems, specifications of controller and compensator design and its implementations.

Unit I. Modeling of Physical Systems: Open loop and Closed loop systems. Transfer Function of Electrical and Mechanical Systems, Transfer function of dc motor. Feedback characteristics of control systems, effect of feedback sensitivity to parameter variations. Block diagram representation and reduction techniques, Signal flow graphs, Mason's rule. Control systems and its components, error sensing devices: Potentiometers, Tachogenerators, Synchro, and A.C. & D.C. servomotor.

Unit II. Time Response Analysis: Transient Response Analysis: Transient and steady-state response. Transient response analysis for first and second order systems and their qualitative analysis; error analysis and error constants. Derivative and Integral error compensation. Introduction to P, PI, PD, PID Controller.

Unit III. Frequency Response Analysis: Frequency domain specifications of second order system. Polar plot, Bode plots, M Circles, N Circles. Compensator Design: Lead, lag and lag-lead compensation using frequency response methods.

Unit IV. Stability: Stability: Absolute and relative stability, Routh Hurwitz stability criteria, Root Locus concepts: construction of root loci, effects of pole/zero on root loci, Nyquist plot & Nyquist stability criterion.

Unit V. State Variable Analysis: Concept of state, state variables and state models, derivation of state models from differential equations, relationship between transfer function and state equations, state equations and state transition matrix, concepts of controllability & observability.

Recommended Books:

1. Control System Engineering by I.J. Nagrath and M. Gopal, New Age International Publication.
2. Control Systems by U. A. Bakkshi, Technical Publication, Pune.
3. Linear Control Systems by B. S. Manke, Khanna Publishers
4. Automatic Control System by S.C. Gupta, New Age International Publication.
5. Control System Engineering by Norman Wiley Publication.
6. Automatic Control System by B.C. Kuo, Oxford University Press & Pearson Education.
7. Modern Control Engineering by K. Ogata, Pearson Education, Asia.

Course Outcomes

After the completion of this course students will be able to:

CO 1. **Analyze** physical systems by representing through block diagrams and signal flow graphs for assessing feedback, sensitivity, and system response characteristics.

CO 2. **Evaluate** time-domain performance of first and second-order systems using time response analysis with & without basic PID controllers for error compensation.

CO 3. **Construct** frequency response plots such as Bode, Polar, and Nyquist for control system performance with compensators.

CO 4. **Evaluate** the stability of a closed-loop control system in time-domain as well as in frequency-domain

CO 5. **Analyze** the response of dynamic systems by developing state-space models and predict system performance based on controllability and observability using state variable techniques.

Power Electronics: 3130513

Course Objective:

To provide fundamental knowledge of power semiconductor devices, passive components, and power conversion circuits (AC-DC, DC-DC, DC-AC), along with their applications. The course also introduces soft switching techniques and EMI considerations for advanced study in power electronics.

Unit I. Power Semiconductor Devices: Classification of Power electronic switches, Power diodes, Transistors, Power MOSFET, IGBT, Thyristor TRIAC and GTO, Thyristor static and dynamic characteristics, two transistor equivalent model, Turn on and turn-off. Design of Firing circuits and protection, Series and parallel operation.

Unit II. Controlled Rectifiers: Principle of phase-controlled converter operation, Single phase half wave, full wave and semi converters. Three phase half wave, full wave and semi converters and inverters, Power factor improvement, Symmetrical angle control. Pulse width modulation control, Effect of load and source inductance.

Unit III. Chopper: Principles of single quadrant, Two quadrant, four quadrant chopper, Control strategies, Pulse width modulation, Frequency modulation, Thyristor commutation schemes, switched mode power supplies, buck-boost regulators, Soft switching techniques.

Unit IV. AC Voltage Controller: Principle of Ac phase control, Single and three phase ac voltage controllers, practical cyclo-converter circuits, Single phase to single phase, three phase to single phase, three phase to three phase out put voltage control circuit, Cyclo-converter, Circulating and Non Circulating type, Dual converters.

Unit V. Inverter Circuits: Principle of operation of voltage source inverter, Single phase and three phase inverters, Voltage control using PWM technique, Forced commutated thyristors, Current source inverters, Series inverter, Inverter applications. EMI in Power Electronics System.

Recommended Books:

1. Power Electronics by P.S. Bimbhra, Khanna Publishers,5th Ed., 2012
2. Power Electronics: Circuits, Devices & Applications by MH Rashid, Pearson, 5th Ed. 2012
3. Power Electronics by Cyril W. Lander ,McGraw-Hill; 2nd Ed.,1987
4. Power Electronics Principles and Applications by JosephVidyathil, TMH,2010
5. Bose, B.K., Handbook of Power Electronics, IEEE Publications.

Course Outcomes:

After completing this course, the student will be able to:

- **CO 1. Explain** the structure, characteristics, and switching behavior of power semiconductor devices and their use in firing circuits and protection schemes.
- **CO 2. Analyze** single-phase and three-phase controlled rectifier circuits and assess their performance under various load and control conditions.
- **CO 3. Evaluate** chopper circuits, including their modes of operation, control strategies, and applications in switched-mode power supplies.
- **CO 4. Compare** AC voltage controllers and cyclo-converters for various phase configurations and types, including dual converter operation.
- **CO 5. Design** inverter circuits with voltage and current source configurations using PWM techniques and analyze their EMI implications.

Switchgear & Protection: 3130514

Course Objectives:

To expose the student to the need for protection and various protective devices, their construction, operating principle, torque equation, characteristics and field of application for different types of equipment to identify reasons for mal operation and their remedies

Unit-I Arc Interruption: Arc properties, Formation and extinction of arc, Restrikingand recovery voltage RRRV, different methods and control devices for arc extinction, Current chopping, Interruption of capacitive currents, Resistance switching. Type and classification of circuit breakers. Oil circuit breaker.

Unit-II Air blast and SF6 circuit breakers: Vacuum circuit breakers, duties and rating Maintenance and testing of OCB 's. Isolators, HRC fuse. Protective Relays: introduction, Definition of terms associated with protective relaying. Construction and characteristics of electromagnetic relays.

Unit-III Elements of static relays: Comparator, induction, distances and differential relays, microprocessor based digital relaying. Modern trends in power system protection, Auto reclosure, under and over frequency relays and their applications. Digital Protection. Numerical protection Introduction, block diagram of numerical relay, numerical over current protection. Introduction toDirect relay to relay digital logic communication, Digital message security, Relay interface with utility.

Unit-IV Protection schemes: Protection of generators and transformers, percentage differential relay, Buchholz relay, different protections provided for generator and transformer, transmission line protection using over current relays, distance relays and carrier current protection, protection of motors and bus bars.

Unit-V Protection against Over Voltages: Power System transients, over voltage in transmission lines, fault clearance and lightning and switching surges, ground wire, lightning arrestors, basic impulse insulation level(BIL), insulation coordination, grounding of P.S. current limiting reactors, their uses and location protection against traveling waves.

Recommended Books:

1. Switchgear protection and power systems by Sunil S. Rao, Khanna publication, 13th edition, 2008.
2. Power system protection & Switchgear by Badriram, TMH publication, 2nd edition, 2011.
3. Switchgear and protection by Ravindranath and Chander, Newage publication, 2nd edition, 2012
4. Switchgear and protection by Deshpande , TMH Publication, 2004
5. Digital Protection by L.P. Singh New Age Publication, 2nd edition, 1997.

Course Outcomes:

After completing this course, the students will be able to:

CO 1. Explain the arc interruption process, properties of circuit interruption, and classification and functioning of circuit breakers including oil circuit breakers.

CO 2. Describe the construction, operation, and testing of air blast, SF_6, and vacuum circuit breakers, isolators, fuses, and electromagnetic relays.

CO 3. Analyze the working of static and digital relays, including numerical protection schemes and modern trends in relay technology.

CO 4. Evaluate protection schemes for power system components such as generators, transformers, transmission lines, motors, and busbars using appropriate relays and protection devices.

CO 5. Evaluate protection techniques against overvoltage due to transients, lightning, and switching surges, and explain insulation coordination and grounding practices.

Data Science: 3130515

Course Objectives:

To provide the fundamental knowledge of Data Science, basic representation and exploratory data analysis used in Data Science.

Unit I: Need for data science, benefits and uses, facets of data, data science process, Introduction of basics python tool, Setting working Directory, Creating and saving a script file, File execution, removing variables from environment, clearing environment, Commenting script files, Variable creation, Data types and associated operations, Arithmetic and logical operators.

Unit II: Control structures, loop, Functions, data structures: Lists, Arrays, Tuples, Dictionary, Sets, NumPy library, Data Collection: Getting to know your data, Types of Data, Data collection strategies, Data Pre-processing, Feature engineering, Exploratory Data Analytics.

Unit III: Descriptive Statistics, Mean, Standard Deviation, Skewness and Kurtosis, inferential statistics: hypothesis testing, probability: probability theory, conditional probability, Pandas library, data frame and data frame related operations, Reading files.

Unit IV: Data Cleaning and Preparation, Handling Missing Data, Data Transformations using pandas and sklearn library, Removing Duplicates, Replacing Values, Detecting Outliers. Data visualization on different dataset using matplotlib and seaborn libraries, Scatter plot, Line plot, Bar plot, Histogram, Box plot, Pair plot.

Unit V: Supervised learning: Regression, classification, Linear regression, logistic regression.Unsupervised learning: Clustering, Reinforcement learning, Data Science in Power Systems; Data Science in Renewable Energy Systems, Data Science in Smart Grids and IoT; Future Trends in Data Science, Real-world examples of data science in electrical engineering

Recommended Books:

1. Mastering Python for Data Science, Samir Madhavan
2. Introduction to Linear Algebra - by Gilbert Strang
3. Applied Statistics and Probability for Engineers – by Douglas Montgomery
4. Pattern Recognition and Machine Learning, Christopher M. Bishop

Course Outcomes:

After completing the course, the student will be able to:

- **CO 1.** **Explain** the need for data science and use basic Python tools to write and run simple programs.
- **CO 2.** **Use** control structures and data structures in Python, and apply basic data collection and preprocessing methods.
- **CO 3.** **Analyze** data by applying statistics and probability with Pandas library.
- **CO 4.** **Create** simple charts and graphs using Data cleaning techniques for effective interpretation.
- **CO 5.** **Use** machine learning methods and explain how data science is applied in electrical systems like smart grids and power systems.

Control System Lab: 3130512

List of Experiments

1. To determine the Operational Characteristics of real time Air Temperature Controller.
2. To determine the operational characteristics of nonlinear element relay in a closed loop control system.
3. To find the error voltage generated for input DC voltages using potentiometer error detector.
4. To plot the frequency domain characteristics of the lead lag process.
5. To design and analyze an electronic PID controller for a closed loop control system.
6. To improve the performance of the closed loop control system with PI controller.
7. To observe and analyze the plant dynamic response using process reaction curve method.
8. To plot step response and obtain the time response specifications for given 2nd order system,
9. To plot step response of a given TF and system in state-space. Take different values of damping ratio $\boldsymbol{\zeta}$ and natural undamped frequency $\boldsymbol{w_n}$.
10. To plot ramp response of a given TF and system in state-space.

Course Outcomes

After the completion of the course, the student will be able to:

CO 1. **Collect** experimental data accurately and effectively in ethical manner

CO 2. **Integrate** theoretical knowledge from coursework into practical applications and experiments

CO 3. **Communicate** experimental results effectively through oral presentations and written documentation

CO 4. **Demonstrate** responsibility and professionalism in the completion of lab tasks and assignments

CO 5. **Show** willingness to learn new techniques, tools, or methods to enhance practical engineering skills

Skill Based Mini Project
Control Systems Lab: 3130512

1. Design an intelligent traffic light & density control
2. Design an automatic sliding door with light control system
3. Develop a system for DC Motor Speed Control Using PID Controller
4. Design temperature control system for Electric Oven
5. Design an object detection system using vibration damping control
6. Design of Sensor System for Measuring Wheel Loads of Vehicles on Highways
7. Design of water level controller using ultrasonic sensor
8. Develop Root Locus and Bode Plot Analysis Tool using MATLAB GUI or Python (using control systems library)
9. Develop Light Intensity Based Fan Speed Controller
10. Comparative study on Position Sensing Techniques for an Unmanned Aerial Vehicle
11. Design and develop a line follower robot
12. Elevator Control System (Model)
13. Design and develop a race car which is controlled using different wireless protocols
14. Design and develop a smart safety helmet for driver health monitoring
15. Design and develop an early accident detection system for the vehicles
16. Design and develop smart safety gadgets for physically/mentally disabled persons.
17. Design and develop smart pet feeder system

Power Electronics Lab: 3130513

List of Experiments

1. To observe the performance of SCR using
   (i) R-triggering Circuit (Half-wave phase control)
   (ii) RC-triggering Circuit (Half-wave phase control and full wave phase control)
2. TRIAC/ SCR Triggering with series transistor-controlled ramp based on UJT/PUT
3. To determine the dv/dt capacity of SCR and design Snubber Circuits.
4. To observe the performance of Half controlled bridge rectifier (semi converter)
   (i) With Reactive load.
   (ii) With reactive load & freewheeling diode.
5. To observe the performance of fully controlled bridge converter operates under rectification & inverter mode.
6. To study the operation of AC phase controller using R and RL load
7. To observe the performance of MOSFET based Buck Boost converter in open and closed loop.
8. Study of Force Commutation of SCR
   (i). Class-A or self-commutation by resonating the load.
   (ii). Class-B or self-commutation by LC Circuit.
   (iii). Class-C or Complementary commutation.
   (iv). Class-D or Auxiliary commutation.
   (v). Class-E or External pulse commutation.
9. Realization of Half-wave Rectifier and Full-wave Rectifier with RL, RLE, FD Load using MATLAB.
10. Realization of Voltage Source Inverter with three phase Load in MATLAB.
    (i). 180^{o} Conduction Mode
    (ii). 120^{o} Conduction Mode

Course Outcomes:

After completing the LAB course, the students will be able to

CO 1. Demonstrate the ability to operate lab equipment and instruments relevant to the electrical engineering
CO 2. Collect experimental data accurately and effectively in ethical manner
CO 3. Integrate theoretical knowledge from coursework into practical applications and experiments
CO 4. Communicate experimental results effectively through oral presentations and written documentation
CO 5. Demonstrate responsibility and professionalism in the completion of lab tasks and assignments
CO 6. Show willingness to learn new techniques, tools, or methods to enhance practical engineering skills

Skill based Mini Project
Power Electronics Lab: 3130513

1. Design circuit using Power Diode and analysis reverse recovery.
2. Develop circuit for synchronize pulse generation
3. Analysis switching circuit using GTO
4. Design the diode circuit with RL load.
5. Design the diode circuit with LC load.
6. Design the bidirectional power supply
7. Design firing circuit for SCR.
8. Design Half controlled bridge rectifier
9. Design Full controlled bridge rectifier.
10. Analyze AC phase controller using DSO for different load
11. Design variable DC Supply.
12. Design circuit for Amplitude modulation for Chopper
13. Design circuit for Frequency modulation for Chopper
14. Analyze the THD for rippled AC voltage using DSO
15. Analysis of PWM techniques for VSI Inverters

Switchgear & Protection Lab: 3130514

1. To plot the characteristics & analyze the performance of under voltage relay
2. To plot the characteristics & analyze the performance of microprocessor based over voltage relay
3. To plot the characteristics & analyze the performance of electromechanical over current relay
4. To plot the characteristics of percentage biased differential relay (Static) at different biasing
5. To plot the characteristics of percentage biased differential relay (Electro-mechanical) at different biasing
6. To test the over current relay using the relay test bench
7. To operate Motor protection simulation panel
8. To operate Feeder protection simulation panel
9. To simulate distance relay and plot the characteristic by using MATLAB
10. To simulate IDMT relay and plot the characteristic using MATLAB

Course Outcomes:

After completing the lab course the students will be able to: -

CO 1. **Validate** the characteristics & performance of various Relays

CO 2. **Prepare** an organized written report.

CO 3. **Develop** the ability to work in a team

CO 4. **Learn** professional ethics.

Skill based Mini project
Switchgear & Protection Lab: 3130514

1. Modeling and simulation of Differential Protection Relay Based on MATLAB Simulation
2. Modeling and Simulation of Inverse Time Overcurrent Relay using MATLAB/Simulink
3. Heat protection of a circuit using relay
4. Home safety system using relay and LDR
5. Current regulated short circuit protection using relay
6. Overcurrent protection relay circuit
7. Auto Blinking LED using Relay
8. Electronic circuit breaker
9. Solid state circuit breaker using matlab
10. Security system using laser light
11. Design of Automatic DC and AC phase changer circuit
12. Small motor protection
13. Over current protection using relay circuit matlab
14. Liquid level control using Relay
15. Design a Overvoltage Relay using MATLAB Simulink
16. Flickering light using relay
17. Reverse polarity protection with relay
18. Water level management using relays
19. Under voltage and over voltage protection
20. Overcurrent relay modelling by using matlab software
21. Fire alarm with relay
22. Automatic street light Control using Relay
23. Relay based Liquid level Control
24. Design and Simulation of Overcurrent Protection System for Low Voltage Switchgear
25. DC short circuit protection using relay
26. Fault Detection and Diagnosis in High Voltage Switchgear using Intelligent Techniques
27. Generator Protection: A Case Study
28. Current Chopping in a circuit Breaker
29. Three phase appliance protector
30. Analysis and optimization of a distribution network with switchgear using MATLAB optimization tools.

Data Science: 2130515

List of Experiments

1. To program using arithmetic operators & logical operators each.
2. Write a function using recursion to print a factorial of number.
3. To write a program in python for demonstrating various functions (creating, appending, extending, etc.) of a list and dictionary.
4. To write a program to create one array using two existing NumPy arrays.
5. To write a program for the creation and manipulation of NumPy arrays- Indexing, Slicing, Reshaping, Joining and Splitting.
6. To write a program to create a 10 x 10 array with random values and find the minimum and maximum values.
7. To write a program to create the following data frame and fill in the missing values with last three digits of your enrolment number. Also, perform various operations (like describe, replacing values, removing null values, etc.)

Name	Institute	Height	Weight
AAA	MITS	6	75
BBB	JEC	NaN	80
CCC	SATI	6.5	NaN
DDD	RGPV	5.9	NaN

8. To write a program to import sample Dataset files (.csv,.xls) to Pandas Data Frame and perform the File Handling operations:
9. To write a program to visualize the following data using Line Plots, Bar Plots, Histograms, Density Plots and Scatter Plots, pie charts etc
10. To write a linear regression program for the following data set.
11. To write a program to perform different image processing operations on a given image.

Skill based Mini project
Data Science: 3130515

1. Exploratory Data Analysis on Real-World Datasets
2. Salary Prediction Using Linear Regression
3. E-Commerce Customer Purchase Behavior Analysis
4. Cab Pickup Demand and Traffic Pattern Analysis
5. Credit Card Fraud Detection Using Logistic Regression
6. Speech Emotion Recognition from Audio Features
7. Email Sentiment Analysis Using NLP
8. Fake Logo Detection Using Image Features
9. Movie Ratings and Recommendation Engine
10. Customer Churn Prediction in Telecom Sector
11. Traffic Sign Recognition Using Machine Learning
12. Airline Passenger Satisfaction Analysis
13. Facial Recognition-Based Attendance System
14. Speech-to-Text Analytics for Meeting Minutes
15. OTT Platform Data Analytics (e.g., Netflix, Amazon Prime)
16. Stock Market Trend Analysis and Prediction
17. Weather Pattern Analysis and Forecasting
18. Supermarket Sales Data Analysis
19. Bank Loan Default Prediction
20. YouTube Channel Performance Analytics
21. Healthcare Data Analysis for Disease Trends
22. Real Estate Price Prediction
23. Airbnb Data Analysis and Host Insights
24. Crime Rate Analysis and Visualization by Region
25. Retail Inventory Demand Forecasting
26. Email Classification (Spam Detection)
27. IPL/Football Match Data Analysis
28. Online Course Platform Analytics

Department of Electrical Engineering

The list of courses for Self-learning/Presentation to be offered from SWAYAM/NPTEL/MOOC

Course Name	Offered By	Duration of the course	Start date	End date	Url
Design and Simulation of Power Conversion using Open Source Tools	IISc Bangalore	4 Weeks	July 21, 2025	August 15, 2025	https://onlinecourses.nptel.ac.in/noc25_ee167/preview
Fundamentals of Electronic Device Fabrication	IIT Madras	4 Weeks	July 21, 2025	August 15, 2025	https://onlinecourses.nptel.ac.in/noc25_mm41/preview
Intelligent Feedback and Control	IIT Bombay	4 Weeks	August 18, 2025	September 12, 2025	https://onlinecourses.nptel.ac.in/noc25_ge57/preview
Python for Data Science	IIT Madras	4 Weeks	August 15, 2025	September 20, 2025	https://onlinecourses.nptel.ac.in/noc25_cs104/preview
C Programming and Assembly Language	IIT Madras	4 Weeks	July 21, 2025	August 15, 2025	https://onlinecourses.nptel.ac.in/noc25_cs114/preview
Strategic Communication for Sustainable Development	IIT Kharagpur	4 Weeks	July 21, 2025	August 15, 2025	https://onlinecourses.nptel.ac.in/noc25_mg140/preview
Gender Justice and Workplace Security	IIT Kharagpur	4 Weeks	August 18, 2025	September 12, 2025	https://onlinecourses.nptel.ac.in/noc25_mg131/preview
Water, Society and Sustainability	IIT Kharagpur	4 Weeks	July 21, 2025	August 15, 2025	https://onlinecourses.nptel.ac.in/noc25_hs144/preview