SEMESTER WISE COURSE STRUCTURE
&
EVALUATION SCHEME AS PER NEP-2020

Course Structure & Syllabi

BATCHELOR OF TECHNOLOGY
ELECTRICAL ENGINEERING

(Effective from the Academic Session 2022-23 for new entrants)

DEPARTMENT OF ELECTRICAL ENGINEERING
SCHOOL OF ENGINEERING
HARCOURT BUTLER TECHNICAL UNIVERSITY
KANPUR-208002 (UP) – INDIA

HARCOURT BUTLER TECHNICAL UNIVERSITY KANPUR

School of Engineering

B.Tech. (Electrical Engineering), Semester wise Course Structure

(Applicable from Session 2022-2023 for new entrants)

Year I Semester I

S. No	Course Type	Course Title	Subject Code*	Credits	Periods			Sessional marks				ESE	Total marks
					L	T	P	MSE	TA	Lab	Total		
1.	BSC	Engineering Chemistry		4	3	0	2	15	20	15	50	50	100
2.	ESC	Introduction to Computer Science & Engineering		4	3	1	0	30	20	-	50	50	100
3.	ESC	Introduction to Electronics Engineering		4	3	1	0	30	20	-	50	50	100
4.	ESC	Introduction to Civil Engineering		4	3	1	0	30	20	-	50	50	100
5.	ESC	Introduction to Chemical Engineering & Chemical Technology		4	3	1	0	30	20	-	50	50	100
6.	ESC	Workshop Practice		2	0	0	4	-	20	30	50	50	100
	Total Credits: 22												600

Year I Semester II

S.No	Course Type	Course Title	Subject Code*	Credits	Periods			Sessional marks				ESE	Total marks
					L	T	P	MSE	TA	Lab	Total		
1.	BSC	Engineering Physics		4	3	0	2	15	20	15	50	50	100
2.	BSC	Engineering Mathematics-I		4	3	1	0	30	20	-	50	50	100
3.	ESC	Introduction to Electrical Engineering	NEE-101/102	4	3	0	2	15	20	15	50	50	100
4.	ESC	Introduction to Mechanical Engineering		4	3	1	0	30	20	-	50	50	100
5.	HSMC	Professional Communication		4	2	1	2	15	20	15	50	50	100
6.	ESC	Engineering Graphics		2	0	0	4	30	20	-	50	50	100
Total Credits: 22													600

HARCOURT BUTLER TECHNICAL UNIVERSITY KANPUR
School of Engineering
B.Tech. (Electrical Engineering), Semester wise Course Structure
(Applicable from Session 2023-2024 for new entrants)

Year II Semester III

S. No	Course Type	Course Title	Subject Code*	Credits	Periods			Sessional marks				ESE	Total marks
					L	T	P	MSE	TA	Lab	Total		
1.	BSC	Engineering Mathematics -II		4	3	1	0	30	20	-	50	50	100
2.	ESC	Solid State Devices & Circuits		4	3	0	2	15	20	15	50	50	100
3.	PCC	Electrical Machines -I	NEE-201	5	3	1	2	15	20	15	50	50	100
4.	PCC	Basic system Analysis	NEE-203	4	3	0	2	15	20	15	50	50	100
5.	PCC	Electrical measurement and measuring instruments	NEE-205	3	3	0	0	30	20	-	50	50	100
6.	PCC	Electromagnetic field theory	NEE-207	4	3	1	0	30	20	-	50	50	100
	Total Credits: 24												600

Year II Semester IV

S.No	Course Type	Course Title	Subject Code*	Credits	Periods			Sessional marks				ESE	Total marks
					L	T	P	MSE	TA	Lab	Total		
1.	BSC	Engineering Mathematics - III		4	3	1	0	30	20	-	50	50	100
2.	ESC	Digital Electronics		4	3	0	2	15	20	15	50	50	100
3.	PCC	Electrical Machines -II	NEE-202	5	3	1	2	15	20	15	50	50	100
4.	PCC	Electrical Circuit analysis	NEE-204	5	3	1	2	15	20	15	50	50	100
5.	PCC	Electrical Engineering Materials	NEE-206	3	3	0	0	30	20	-	50	50	100
6.	HSMC	Engineering Economics & Management		3	3	0	0	30	20	-	50	50	100
Total Credits: 24													600

HARCOURT BUTLER TECHNICAL UNIVERSITY KANPUR
School of Engineering
B.Tech. (Electrical Engineering), Semester wise Course Structure
(Applicable from Session 2024-2025 for new entrants)

Year III Semester V

S.No	Course Type	Course Title	Subject Code*	Credits	Periods			Sessional Marks				ESE	Total marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	Control Systems	NEE-301	4	3	0	2	15	20	15	50	50	100
2.	PCC	Microprocessors	NEE-303	5	3	1	2	15	20	15	50	50	100
3.	PCC	Power System -I	NEE-305	4	3	1	0	30	20	-	50	50	100
4.	PCC	Utilization of Electrical Energy & Traction	NEE-307	3	3	0	0	30	20	-	50	50	100
5.	PCC	Electrical Machine Design	NEE-309	4	3	0	2	15	20	15	50	50	100
6.	OEC-I	Refer List of OEC-I		2	2	0	0	30	20	-	50	50	100
	Total Credits: 22												600

Year III Semester VI

S.No	Course Type	Course Title	Subject Code*	Credits	Periods			Sessional marks				ESE	Total marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	Power Electronics	NEE-302	5	3	1	2	15	20	15	50	50	100
2.	PCC	Power Station Practice	NEE-304	4	3	1	0	30	20	-	50	50	100
3.	PCC	Power System -II	NEE-306	4	3	0	2	15	20	15	50	50	100
4.	PCC	Advanced Control Systems	NEE-308	4	3	1	0	30	20	-	50	50	100
5.	PEC-I	——		3	3	0	0	30	20	-	50	50	100
6.	HSMC	Entrepreneurship Development		2	2	0	0	30	20	-	50	50	100
	Total Credits: 22												600

HARCOURT BUTLER TECHNICAL UNIVERSITY KANPUR
School of Engineering
B.Tech. (Electrical Engineering), Semester wise Course Structure
(Applicable from Session 2025-2026 for new entrants)

Year IV Semester VII

S.No	Course Type	Course Title	Subject Code*	Credits	Periods			Sessional marks				ESE	Total marks
					L	T	P	MSE	TA	Lab	Total		
1.	PEC-II	Refer List of PEC-II		4	3	1	0	30	20	-	50	50	100
2.	PEC-III	Refer List of PEC-III		3	3	0	0	30	20	-	50	50	100
3.	PEC-IV	Refer List of PEC-IV		3	3	0	0	30	20	-	50	50	100
4.	Seminar	————		2	0	0	4	-	50	-	50	50	100
5.	Industrial Training	————		2	0	0	4	-	50	-	50	50	100
6.	Minor Project	————		6	0	0	12	-	50	-	50	50	100
7.	OEC-II	Refer List of OEC-II		2	2	0	0	30	20	-	50	50	100
	Total Credits: 22												700

Year IV Semester VIII

S.No	Course Type	Course Title	Subject Code*	Credits	Periods			Sessional marks				ESE	Total marks
					L	T	P	MSE	TA	Lab	Total		
1.	PEC-V	Refer List of PEC-V		4	3	1	0	30	20	-	50	50	100
2.	OEC-III	Refer List of OEC-III		2	2	0	0	30	20	-	50	50	100
3.	Project	——		16	0	0	32	-	200	-	200	200	400
	Total Credits: 22												600

*To be allotted by Academic Section

LIST OF PROGRAMME ELECTIVE COURSES	
	PEC-I
1	a. HVDC Transmission Systems (NEE-310)
	b. Electrical Energy Conservation and Auditing (NEE-312)
	c. Special Electrical Machines (NEE-314)
	d. Wind and Solar Energy Systems (NEE-316)
2	**PEC –II**
	a. Special Topics in Control Systems (NEE-401)
	b. Power System Design (NEE-403)
	c. Advanced Power Electronics (NEE-405)
	d. Power System Dynamics and Control (NEE-407)
3	**PEC –III**
	a. Optimal Control System (NEE-409)
	b. Power System Protection (NEE-411)
	c. Electrical Drives (NEE-413)
	d. Robotics and Automation (NEE-415)
4	**PEC-IV**
	a. Power Quality and FACTS (NEE-417)
	b. Real Time Simulation Techniques of Power Electronic Converters (NEE-419)
	c. Modeling and Simulation of Electrical Machines (NEE-421)
	d. Industrial Control Systems (NEE-423)
5	**PEC –V**
	a. Electrical Vehicles (NEE-402)
	b. Power System Security and Analysis (NEE-404)
	c. Advanced Electric Drives (NEE-406)
	d. Neural Network and Fuzzy Systems (NEE-408)
	e. High Power Converters (NEE-410)

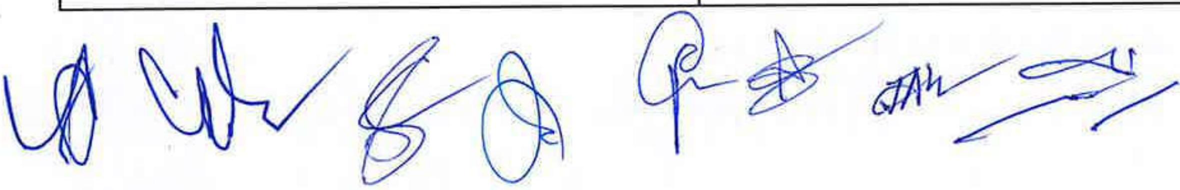
LIST OF OPEN ELECTIVES COURSES	
1	**OEC-I**
	a. Human Values
	b. Cyber Security
	c. Indian Knowledge Tradition
	d. Environment & Ecology
	e. One Course Offered by each degree awarding departments (Same as 'h' in this table)
	f. One course offered by School of basic & applied sciences
	g. One course offered by School of Humanities & Social sciences
	h. Non-Conventional Energy Sources
2	**OEC-II**
	a. Soft Computing
	b. Artificial Intelligence
	c. 3-D Printing
	d. Logistics & Supply Chain Management
	e. One Course Offered by each degree awarding departments (Same as 'h' in this table)
	f. One Course offered by School of Basic & Applied Sciences
	g. One Course offered by School of Humanities & Social Sciences
	h. Power Plant Engineering
3	**OEC-III**
	a. Robotics
	b. Data Sciences
	c. Machine Learning
	d. Sustainable Development
	e. One Course Offered by each degree awarding departments (Same as 'h' in this table)
	f. One Course offered by School of Basic & Applied Sciences
	g. One Course offered by School of Humanities & Social Sciences
	h. Industrial Measurements

List of Courses for B. Tech. (Honours)

Honours (Control System)	Honours (Power System)	Honours (Power Electronics)
1. Process Control and Instrumentation 2. Advanced Digital Control 3. SCADA and Distributed Control Systems 4. Smart Sensors and Actuators 5. Robotics and Automation 6. Special Topics in Control Systems 7. Advanced Measurements and Instrumentation Systems	1. HVDC Transmission Systems 2. Power System Design 3. Power System Protection 4. Power System Security and Analysis 5. Power Quality and FACTS 6. Power System Dynamics and Control	1. Advanced Power Electronics 2. Electrical Drives 3. Real Time Simulation Techniques of Power Electronic Converters 4. Advanced Electric Drives 5. Electrical Vehicles 6. High Power Converters

List of Courses for Minor Degree

Minor-I	Minor-II
1. Electrical Circuit Analysis 2. Power System-I 3. Control Systems 4. Non-Conventional Energy Sources 5. Electrical Machines-I	1. Power Electronics 2. Power System-II 3. Electrical Machines-II 4. Advanced Control Systems 5. Electrical Engineering Materials



Year I Semester I/II

NEE-101/102	INTRODUCTION TO ELECTRICAL ENGINEERING	L T P: 3 0 2	Credits: 4	Type: ESC

OBJECTIVE:
The objective of this course is to make students learn the basic principles of DC and AC circuits, magnetic circuits and electromechanical energy conversion. The students will acquire a foundation of electrical engineering which will enable them to understand and critically interpret the primary research in electrical engineering.

Course outcome
On the successful completion of the course, students will be able to

CO1	Apply Mesh and Nodal Methods of Analysis and Network Theorem in DC Network	K2, K4
CO2	Understand and analyze the ac circuit and calculate the various parameters	K2, K3, K4, K5
CO3	Understand and analyze the 3-phase connections of source and load, and, measurement of 3-phase power	K2, K4, K5
CO4	Understand the magnetic circuit with working & applications and to calculate the various parameters of magnetic circuits and transformer efficiency	K1, K2, K4, K5
CO5	Understand the basic principles of AC & DC Machines	K2, K4

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix): NEE-101/102

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	2	-	2	-	-	-	-	3
CO2	3	3	1	3	2	-	2	-	-	-	-	3
CO3	3	3	1	3	2	-	2	-	-	-	-	3
CO4	3	3	1	3	2	-	2	-	-	-	-	3
CO5	3	3	1	3	2	-	2	-	-	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation put "-".

Course Content:

Module I
DC Circuit Analysis and Network Theorems: Circuit Concepts: Concepts of Network, Active and Passive elements, voltage and current sources, concept of linearity and linear network, unilateral and bilateral elements. R L and C as linear elements. Source Transformation. Kirchhoff's Law, loop and nodal methods of analysis; star – delta transformation; Network Theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem. (Simple Numerical Problems)

Module II
Steady State Analysis of Single Phase AC Circuits: Sinusoidal, Square and Triangular waveforms–average and effective values, form and peak factors, concept of phasors, phasor representation of sinusoidally varying voltage and current. Analysis of series, parallel, and series – parallel RLC Circuits: Apparent, Active & Reactive Powers, Power factor, causes and problems of low power factor, power factor improvement. Resonance in Series and Parallel Circuits. (Simple Numerical Problems)

Module III
Three Phase AC Circuits: Three Phase System – its necessity and advantages, meaning of phase sequence and star and delta connections, balanced supply and balanced load, line and phase voltage/ current relations, three phase power and its measurement. (Simple Numerical Problems)

Module IV
Magnetic Circuits and Transformer: Magnetic Circuit: Magnetic circuit concepts, analogy between Electric & Magnetic circuits, Magnetic circuits with DC and AC excitations, Magnetic leakage. B-H curve, Hysteresis and Eddy Current losses, Magnetic circuit calculations.
Single Phase Transformer: Principle of Operation, Construction, e.m.f. equation, Power losses, efficiency. (Simple Numerical Problems)

Module V
Electro Mechanical Energy Conversion: Basic Principles of electro mechanical energy conversion.
DC Machines: Types of DC machines, e.m.f. equation of generator and torque equation of motor, Speed-Torque characteristics of DC Series and Shunt Motors, Applications of dc motors. (Simple Numerical Problems).
Three Phase Induction Motor: Types, Principle of Operation, Slip – torque Characteristics, applications. (Simple Numerical Problems)

List of Experiments:
1. Verification of Kirchhoff's laws.
2. Verification of Superposition Theorem.
3. Verification of Thevenin's Theorem.
4. Verification of Maximum Power Transfer Theorem.
5. Measurement of power and power factor in a 1 – Ø ac series inductive circuit and study improvement of power factor using capacitor.
6. Study of phenomenon of resonance in RLC series circuit and obtain the resonant frequency.
7. Measurement of power in 3 – Ø circuit by Two Wattmeter method and determination of its power factor.
8. Determination of parameter of ac 1 – Ø series RLC Circuit.
9. Determination of Efficiency by load test of a 1 – Ø Transformer.
10. To study running and speed reversal of a 3 – Ø induction motor and record its speed in both direction.

Note:
a. Department may add any three experiments in the above list.
b. Minimum eight experiments are to be performed out of the above list.

Text books:

1. V. Del Toro, "Principles of Electrical Engineering" Prentice Hall International, 2015.
2. I. J. Nagarath, "Basic Electrical Engineering" Tata Mc - Graw Hill, 2019.
3. A. E. Fitzgerald, D. Higginbotham & A. Grabel, "Basic Electrical Engineering" Mc - Graw Hill, 1981.
4. B. L. Theraja and A. K. Theraja, "Basic Electrical Engineering", 1999.

Reference books:

1. Edward Hughes, "Electrical Technology", Longman Scientific & Technical, 1995.
2. T. K. Nagsarkar & M. S. Sukhija, "Basic Electrical Engineering" Oxford University Press, 2017.
3. H. Cotton, "Advanced Electrical Technology" Wheeler Publishing, 2011.
4. W. H. Hayt & J. E. Kennely, "Engineering Circuit Analysis" Mc-Graw Hill, 2011.

NPTEL web links:

1. https://nptel.ac.in/courses/108105112
2. https://nptel.ac.in/courses/108105053

Evaluation Scheme:

S. No.	Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
					MSE	TA	Lab	Total		
1	ESC	NEE 101/102	Introduction to Electrical Engineering	4(3-0-2)	15	20	15	50	50	100

Year II Semester III

NEE-201	ELECTRICAL MACHINES-I	L T P: 3 1 2	Credits: 5	Type: PCC

OBJECTIVE:

This course will provide a good understanding to the students in the area of electrical machines. The course includes understanding of principles of electromagnetic conversion and DC machines. This course also gives an insight into single and three phase transformers.

Prerequisites: Engineering Mathematics, Introduction to Electrical Engineering.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Able to understand and apply electromagnetic energy conversion principles	K1, K2
CO2	Exhibit the knowledge of armature reaction, commutation, compensating and interpoles winding.	K2, K3, K4
CO3	Able to understand starting, speed control and testing of dc machine.	K2, K3, K4
CO4	Able to understand various tests and performance parameter of single phase trans former.	K2, K3, K4
CO5	Able to understand various connections of three phase transformer and parallel operation of transformer.	K2, K3, K4,
CO6	To understand and perform various experiments on transformer and dc machines.	K4, K5

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	2
CO2	2	1	2	1	1	2	1	-	1	-	1	2
CO3	2	1	1	-	1	3	1	-	1	-	1	2
CO4	1	2	1	1	1	2	1	-	2	-	1	2
CO5	2	2	2	1	1	2	1	-	2	-	2	2
CO6	2	1	1	1	1	1	1	-	1	-	1	2
Avg.	2.0	1.3	1.2	0.7	0.8	2.0	1.0	0.0	1.2	0.0	1.0	2.0

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Principles of Electro-mechanical Energy Conversion: (8 Lectures)

Energy in magnetic systems (defining energy & Co-energy), determination of mechanical force, mechanical energy in singly excited system, introduction of doubly excited systems, expression for field energy, coenergy and torque for doubly excited system. Torque in AC machines with cylindrical air gap.

Module 2

D.C. Machines: (6 Lectures)

Construction of DC Machines, Armature winding, Armature Reaction, Commutation, Inter-poles and Compensating Windings, Performance Characteristics of D.C. generators, Voltage build in DC shunt generators.

Module 3

D.C. Machines: (9 Lectures)

Performance Characteristics of D.C. motors, starting of D.C. motors; 3-point and 4-point starters, Speed control of D.C. Motors: Field Control, armature control and Voltage Control (Ward Leonard method); Losses, Efficiency and Testing of D.C. machines (Hopkinson's and Swinburn's Test).

Module 4

Single Phase Transformer: (8 Lectures)

Phasor diagram, efficiency and voltage regulation, all day efficiency. Testing of Transformers: O.C. and S.C. tests, Sumpner's test, Polarity test. Auto Transformer: Single phase and three phase auto transformers, volt-ampere relation, efficiency, Merits & demerits and applications.

Module 5

Three Phase Transformers: (9 Lectures)

Construction, three phase transformer, Phasor groups and their connections, open delta connection, three phase to 2 phase, 6 phase or 12 phase connections, and their applications, parallel operation and load sharing of single phase and three phase transformers, excitation phenomenon and harmonics in transformers, three winding transformers.

List of Experiments:

(Note: At least eight experiments must be performed in a semester)

1. To obtain magnetization characteristics of separately excited dc generator.
2. To obtain external characteristics of dc shunt generator.
3. To perform Swinburne's test on dc shunt motor and to predict its efficiency as motor and generator at given output.
4. To obtain speed-torque characteristics of a dc series motor.
5. Speed control of dc shunt motor using (a) armature resistance control (b) field control.
6. Speed control of dc separately excited motor using Ward-Leonard method.
7. To study polarity and ratio test of single phase / 3-phase transformers.
8. To perform open circuit test and short circuit test on single phase transformer.
9. To perform Sumpner's test on single phase transformers.
10. To obtain 3-phase to 2-phase conversion by Scott connection.

Text Books

1. I. J. Nagrath & D. P. Kothari," Electrical Machines", Tata McGraw Hill
2. Ashfaq Husain, "Electrical Machines", Dhanpat Rai & Sons
3. A. E. Fitggerald, C. Kingsley Jr and Umans, "Electric Machinery", 6th Edition McGraw Hill, International Student Edition
4. B.R. Gupta & Vandana Singhal, "Fundamentals of Electrical Machines", New Age International

Reference Books

1. Irving L. Kosow, "Electric Machine and Transformers", Prentice Hall of India
2. M.G. Say, "The Performance and Design of AC machines", Pit man & Sons
3. Bhag S. Guru and Huseyin R. Hizirogulu, "Electric Machinery and Transformers" Oxford Universit Press, 2001

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-201	ELECTRICAL MACHINES-I	5(3-1-2)	15	20	15	50	50	100

NEE-203	BASIC SYSTEM ANALYSIS	L T P: 3 0 2	Credits: 4	Type: PCC

OBJECTIVE:

The objective of this course is to make students learn in the area of basic systems. The course includes study of signals and various types of systems. This course also gives an insight into the analysis and solution of functions in time and frequency domain.

Prerequisites: Engineering Mathematics, Basic Electrical Engineering.

Course Outcomes:

On the successful completion of the course, students will be able to

CO1	Able to understand the basic concept of signals and systems.	K1, K2
CO2	Able to understand and apply the knowledge of Fourier transform for the electric network analysis	K2, K3
CO3	Able to understand and apply the knowledge of Laplace transform for the electric network analysis	K2, K3
CO4	Able to understand and apply the State-Variable technique for the analysis of Linear systems.	K2, K3
CO5	Able to understand and apply the application of Z- transform for the solution of discrete systems.	K2, K3
CO6	Demonstrate fundamental understanding for finding the solution of functions in time and frequency domain.	K4, K5

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	-	-	1	1	-	1	1	2
CO2	2	2	2	2	1	1	-	-	-	1	1	2
CO3	2	2	2	1	1	1	-	-	-	-	1	2
CO4	2	2	1	1	1	-	-	-	-	-	1	2
CO5	2	2	2	2	1	-	-	-	-	-	2	2
CO6	2	2	2	1	1	1	1	-	-	-	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Introduction to Signals and Systems: (8 Lectures)

Introduction to continuous time signals and systems: Basic continuous time signals, unit step, unit ramp, unit impulse and periodic signals with their mathematical representation and characteristics. Introduction to various types of systems.

Analogous System: Linear mechanical elements, force-voltage and force-current analogy, modeling of mechanical and electro-mechanical systems: Analysis of first and second order linear systems by classical method.

Module 2

Fourier Transform Analysis: (6 Lectures)

Exponential form and Trigonometric form of Fourier series, Fourier symmetry, Fourier Transform Analysis, Transform of common functions and periodic wave forms: Applications of Fourier Transform to network analysis.

Module 3

Laplace Transform Analysis: (6 Lectures)

Laplace Transform Analysis, Laplace Transform of periodic functions, Initial and Final Value Theorems, Inverse Laplace Transform, Convolution Theorem, Superposition Integral, Application of Laplace Transform to analysis of networks, waveform synthesis and Laplace Transform of complex waveforms.

Module 4

State -Variable Analysis: (5 Lectures)

State Space representation of linear systems, Transfer Function and state Variables , State Transition Matrix, Solution of state equations for homogeneous and non-homogeneous systems , Applications of State-Variable technique to the analysis of linear systems.

Module 5

Z-transform Analysis: (5 Lectures)

Z-Transform Analysis: Concept of Z-Transform, Z-Transform of common functions, Inverse Z-Transform Initial and Final Value theorems , Applications to solution of difference equations, Pulse Transfer Function.

Text Books

1. David K. Cheng; "Analysis of Linear System", Narosa Publishing Co.
2. ME Van-Valkenberg; " Network Analysis", Prentice Hall of India
3. C.L.Wadhwa, "Network Analysis and Synthesis", New Age International Publishers,2007.
4. Samarajit Ghosh, "Network Theory: Analysis and Synthesis" Prentice Hall of India, 2008 Reference

Reference Books

1. Choudhary D. Roy, "Network & Systems", Wiley Eastern Ltd.
2. Donald E.Scott, "Introduction to circuit Analysis" Mc. Graw Hill
3. B.P. Lathi, "Linear Systems & Signals" Oxford University Press, 2008.
4. I. J. Nagrath, S.N. Saran, R. Ranjan and S. Kumar, "Singnals and Systems, "Tata.Mc. Graw Hill, 2001

Basic System Analysis Lab:

(Note: Minimum seven experiments out of the following list)

MATLAB based Experiments:

1. Solution of linear equations for under damped and over damped cases.

2. Determination of Eigen values and eigenvectors of a square matrix.

3. Determination of roots of a polynomial.

4. Determination of polynomial using method of least square curve fitting.

5. Determination of polynomial fit, analyzing residuals, exponential fit and error bounds from the given data.

6. Solution of differential equations using 4th order Runge-Kutta method.

7. Solution of differential equation using revised Euler method.

8. Solution of difference equations.

9. Determination of time response of an R-L-C circuit.

10. Department may add any three experiments in the above list.

Text / Reference Books:

1. Almos Gilat, "MATLAB: An Introduction with Applications" Wiley India Ltd., 2004.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-203	Basic System Analysis	4(3-0-2)	15	20	15	50	50	100

NEE-205	ELECTRICAL MEASUREMENT AND MEASURING INSTRUMENTS	L T P: 3 0 0	Credits: 3	Type: PCC

Objective:

This course will provide a good understanding about analysis to the students in the area of electrical measurements and measuring instruments. The course includes understanding of principles of measurements, error analysis, analog instruments, digital measurements and CRO. This course also gives an insight into instrument transformers, potentiometers, various bridges and magnetic measurements.

Prerequisites: Engineering Mathematics, Introduction to Electrical Engineering

Course Outcomes:

On the successful completion of the course, students will be able to

CO1	Able to know and analyse principles of measurements	K1, K2
CO2	Able to understand and apply concepts of analog instruments and digital measurements	K2, K3
CO3	Able to understand and apply knowledge of CRO	K2, K3
CO4	Exhibit the knowledge of magnetic measurement and instrument transformers	K2, K4
CO5	Calculate measurement errors and do error analysis	K2, K3, K4
CO6	Demonstrate fundamental understanding of measurement, Bridges	K4, K5

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	2	-	-	-	-	2
CO2	2	1	2	1	1	2	2	-	1	-	1	3
CO3	2	1	1	-	1	3	2	-	1	-	1	2
CO4	3	1	1	1	1	2	2	-	2	-	1	3
CO5	2	1	2	1	1	3	2	1	2	-	2	2
CO6	3	1	1	1	1	3	2	-	1	-	1	3

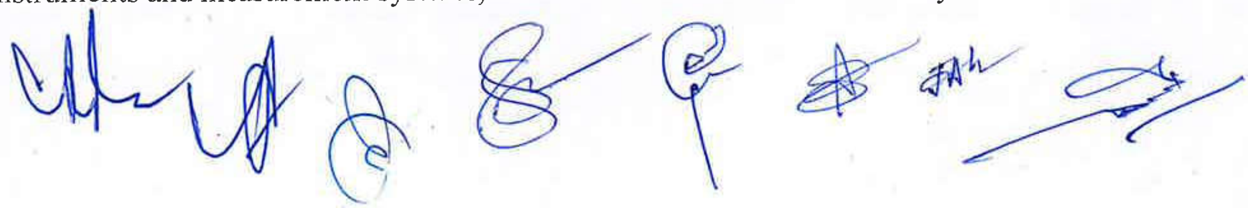
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content

Module 1

Principles of Measurement and Error Analysis: (6 Lectures)

Methods of measurement, Measurement system, Classification of instrument system, Characteristics of instruments and measurement systems, Errors in measurement and its analysis.



Module 2

Analog Instruments: (6 Lectures)

Classification, Principle of operation of Permanent Magnet Moving Coil and Moving Iron Instruments Voltmeters and Ammeters, Errors in Voltmeters and Ammeters, Electrodynamometer type Instruments, Power measurement.

Module 3

Digital Measurements and Cathode Ray Oscilloscopes (CROs): (7 Lectures)

Digital Measurement of Electrical Quantities, Block Diagram study of Digital Voltmeter, Frequency Meter, Basic CRO Circuit (Block Diagram), Cathode Ray Tube (CRT) and its Components, Applications of CRO in measurements of Phase and Frequency, Dual-Trace and Dual-Beam Oscilloscopes.

Module 4

Potentiometers and Bridges: (6 Lectures)

D.C. and A.C. Potentiometers, D.C. and A.C. Bridges, Measurement of Inductance, Capacitance and Quality factor, Measurement of Low, Medium, and High Resistances.

Module 5

Instrument Transformers and Magnetic Measurements (5 Lectures)

Principle of operation of Current Transformer and Potential Transformer, Error Analyses, Magnetic measurements, Ballistic Galvanometer, Flux meter, Advantages and Applications.

Text Books:

1. A. K. Sawhney, "Electrical and Electronic Measurements & Instrumentation", Dhanpat Rai & Sons.
2. E. W. Golding & F. C. Widdis, "Electrical measurement & measuring instruments" A. H. Wheeler & Co. Pvt Ltd. India.
3. A. D. Helfrick & W. D. Cooper, "Electronic Instruments & Measurement Technique" Prentice Hall of India.

Reference Books:

1. David A. Bell, "Electronic Instrumentation & Measurement" Prentice Hall of India.
2. M. B. Stout, "Basic Electrical measurement" Prentice Hall of India.
3. H. S. Kalsi, "Electronic Instrumentation" Tata Mc-Graw Hill.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-205	Electrical Measurement and Measuring Instruments	3(3-0-0)	30	20	-	50	50	100

NEE-207	ELECTROMAGNETIC FIELD THEORY	L T P: 3 1 0	Credits: 4	Type: PCC

OBJECTIVE:

The purpose of the course is to familiarize the students with the fundamentals of Electrostatics, Magneto statics, Time-varying fields and Electromagnetic Waves.

Prerequisite: Engineering Mathematics, Engineering Physics

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Able to understand the concept of different coordinate systems and their inter conversion, area and volume of different shapes.	K1, K2
CO2	Interpret the deeper meaning of the Maxwellian field equations, transformation properties, domain of validity, and limitations	K2, K3, K4
CO3	Explain the technique of deriving and evaluating formulae for the electromagnetic fields from very general charge and current distributions.	K2, K3, K4
CO4	Explain the plain wave transmission in different materials and its mathematical analysis.	K2, K3, K4
CO5	Apply the basic concept of electromagnetic waves and their reflection & transmission.	K2, K3, K4, K5

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	-	-	-	-	-	-	-	2
CO2	3	2	2	1	-	1	-	-	-	-	-	2
CO3	3	2	2	2	-	1	-	-	-	-	-	2
CO4	3	3	3	3	2	1	1	-	1	-	1	2
CO5	3	3	3	3	2	1	1	-	1	-	1	2

Course Content:

Module 1

Coordinate Systems and Transformation: (8 Lectures)

Basics of Vectors: Addition, subtraction and multiplications; Cartesian, Cylindrical, Spherical transformation.

Vector Calculus:

Differential length, area and volume, line surface and volume integrals, Del operator, Gradient, Divergence of a vector, Divergence theorem, Curl of a vector, Stokes's theorem, Laplacian of a scalar.

Module 2

Electrostatic fields: (8 Lectures)

Coulomb's law and field intensity, Electric field due to charge distribution, Electric flux density, Gauss Law-Maxwell's equation, Electric dipole and flux line, Energy density in electrostatic fields, Electric field in material space: Properties of materials, convection and conduction currents, conductors, polarization in dielectrics, Dielectric-constants, Continuity equation and relaxation time, boundary conditions, Electrostati boundary value problems: Poisson's and Laplace's equations., Methods of Images.

Module 3

Magneto statics: (8 Lectures)

Magneto-static fields, Biot-Savart's Law, Ampere's circuit law, Maxwell's equation, Application c Ampere's law, Magnetic flux density- Maxwell's equation, Maxwell's equation for static fields, magneti scalar and vector potential.

Module 4

Magnetic forces: (8 Lectures)

Materials and devices, Forces due to magnetic field, Magnetic torque and moment, a magnetic dipole Magnetization in materials, Magnetic boundary conditions, Inductors and inductances, Magnetic energy.

Module 5

Waves and Applications: (8 Lectures)

Maxwell's equation, Faraday's Law, transformer and motional electromotive forces, Displacement curren Maxwell's equation in final form Electromagnetic wave propagation: Wave propagation in loss dielectrics. Plane waves in lossless dielectrics Plane wave in free space. Plain waves in good conductors, Power and the pointing vector, Reflection of a plain wave in a normal incidence. Transmission Lines and Smith Chart.

Text Books:

1. Hayt, W.H. and Buck, J.A., "Engineering Electromagnetic" Tata McGraw Hill Publishing
2. Mathew Sadiku, "Electromagnetic Field Theory", Oxford University Press.

Reference Books:

1. Jordan E.C. and Balmain K.G., "Electromagnetic Wave and radiating Systems" Prentice Hall International, 2nd Edition.
2. Kraus, F. "Electromagnetic" Tata Mc. Graw Hill 5th Edition.
3. Ramo S, Whinnery T. R. and Vanduzer T, "Field and Waves in Communication Electronics" John Wiely and Sons 3rd Edition.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-207	Electromagnetic Field Theory	4 (3-1-0)	30	20	-	50	50	100

Year II Semester IV

NEE-202	ELECTRICAL MACHINES-II	L T P: 3 1 2	Credits: 5	Type: PCC

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of electrical machine. The course includes: Basic Concepts, Modeling, Components, Analysis of synchronous machines and induction machines.

Prerequisites: Engineering Mathematics, Engineering Physics, Introduction to Electrical Engineering, Electrical Circuit Analysis and Electrical Machine-I.

Course Outcomes:

On the successful completion of the course, students will be able to

CO1	Understand the basics and needs of electrical machines	K1, K2
CO2	Able to solve problems of electrical machines	K3, K4
CO3	Understand and analyse the basic operation of Synchronous Machine	K2, K4, K5
CO4	Understand and analyse the basic operation of Induction Machine	K2, K4, K5
CO5	Understand and analyze the basic operation of single phase induction motor and to understand basic operation of universal motor	K2, K4, K5
CO6	To understand and perform various experiments on transformer an DC machines.	K3, K4

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	2	-	-	1	-	-	2
CO2	3	3	1	1	1	3	1	-	2	-	-	2
CO3	3	3	1	2	1	3	1	-	2	-	-	2
CO4	3	3	1	1	1	3	1	-	2	-	-	2
CO5	3	3	1	2	1	3	1	-	2	-	-	2
CO6	3	3	2	2	2	3	1	-	3	-	1	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Synchronous Machine-I: (10 Lectures)

Constructional features, EMF Equation, Winding coefficients, equivalent circuit and phasor diagram, Armature reaction, O. C. & S. C. tests, Voltage Regulation using Synchronous Impedance Method, MMF Method, Potier"s Triangle Method, Parallel Operation of synchronous generators, operation on infinite bus, synchronizing power and torque co-efficient.

Module 2

Synchronous Machine-II: (7 Lectures)

Two Reaction Theory, Power flow equations of cylindrical and salient pole machines, operating characteristics Synchronous Motor: Starting methods, Effect of varying field current at different loads, V-Curves, Hunting & damping, synchronous condenser.

Module 3

Three-phase Induction Machine-I: (9 Lectures)

Constructional features, Rotating magnetic field, Principle of operation Phasor diagram, equivalent circuit torque and power equations, Torque- slip characteristics, no load & blocked rotor tests, efficiency, Induction generator & its applications.

Module 4

Three-phase Induction Machine II: (7 Lectures)

Starting, Deep bar and double cage rotors, Cogging & Crawling, Speed Control (with and without emf injection in rotor circuit). Induction generator & its applications.

Module 5

Single phase Induction Motor: (7 Lectures)

Double revolving field theory, Equivalent circuit, No load and blocked rotor tests, Starting methods, Universal motor

Electrical Machines - II Laboratory

(Note: The minimum of 08 experiments are to be performed from the following)

Hardware based experiments

1. To perform no load and blocked rotor tests on a three phase squirrel cage induction motor.
2. To perform load test on a three phase induction motor.
3. To perform no load and blocked rotor tests on a single phase induction motor and determine equivalent circuit.
4. To study speed control of three phase induction motor by keeping V/f ratio constant.
5. To study speed control of three phase induction motor by varying supply voltage.
6. To perform open circuit and short circuit tests on a three phase alternator and determine voltage regulation at full load and at unity, 0.8 lagging and leading power factors by (i) EMF method (ii) MMF method.
7. To determine V-curves and inverted V-curves of a three phase synchronous motor.
8. To determine X_d and X_q of a three phase salient pole synchronous machine using the slip test and draw the power-angle curve.

9. To study synchronization alternators with the infinite bus by using (i)dark lamp method (ii) two bright and one dark lamp method

Software based experiments (Develop Computer Program in "C" language or use MATLAB or other commercial software)

1. To determine speed-torque characteristics of three phase slip ring induction motor and study the effect of including resistance, or capacitance in the rotor circuit.
2. To determine speed-torque characteristics of single phase induction motor and study the effect of voltage variation.
3. To determine speed-torque characteristics of a three phase induction motor by (i) keeping v/f ratio constant (ii) increasing frequency at the rated voltage.
4. Draw O.C. and S.C. characteristics of a three phase alternator from the experimental data and determine voltage regulation at full load, and unity, 0.8 lagging and leading power factors.
5. To determine steady state performance of a three phase induction motor using equivalent circuit.

Text Books

1. D. P. Kothari & I.J.Nagrath, "Electric Machines", Tata Mc Graw Hill
2. P. S. Bimbhra, "Electrical Machinery", Khanna Publisher
3. Ashfaq Hussain"Electric Machines" Dhanpat Rai & Company

Reference Books

1. Fitzerald, A. E., Kingsley and S. D. Umans" Electric Machinery", Mc Graw Hill.
2. P.S. Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers
3. M. G. Say, "Alternating Current Machines", Pitman & Sons

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-202	Electrical Machines-II	5 (3-1-2)	15	20	15	50	50	100

NEE-204	ELECTRICAL CIRCUIT ANALYSIS	L T P: 3 1 2	Credits: 5	Type: PCC

OBJECTIVE:

This course will provide a good understanding about analysis to the students in the area of electrical circuits. The course includes understanding of graph theory, and Laplace Transform. This course also gives an insight into two port networks and network synthesis.

Prerequisites: Engineering Mathematics, Basic Electrical Engineering

Course Outcomes

On the successful completion of this course, students will be able to

CO1	Able to know and demonstrate fundamental understanding of circuit and apply concepts of graph theory	K1, K2
CO2	Able to understand and analyze electrical circuits using network theorems	K3, K4, K5
CO3	Able to understand and apply knowledge of series and parallel circuits, resonance, Steady-state and transient state response	K2, K3
CO4	Exhibit the knowledge of two port networks parameters	K2, K3, K4
CO5	Able to calculate circuit properties and do network synthesis and filter design	K4, K6

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	2	-	-	-	-	2
CO2	2	1	2	1	1	2	2	-	1	-	1	2
CO3	2	1	1	-	1	3	2	-	1	-	1	2
CO4	3	2	1	1	1	2	2	-	2	-	1	2
CO5	2	2	2	1	1	2	2	1	2	-	2	2
CO6	3	1	1	1	1	1	2	-	1	-	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Graph theory: (8 Lectures)

Graph of a Network, definitions: Tree, Co-tree, Link, Basic loop and Cut set, Incidence matrix, Cut set matrix, Tie set matrix, Loop and node equation based analysis, Concept of duality and dual networks.

Module 2

Network Theorems: (8 Lectures)

Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power transfer theorem, Reciprocity theorem, Compensation theorem, Analysis with dependent current and voltage sources, Node and Mesh Analysis..

Module 3

Electrical Circuit Analysis using Laplace Transforms: (8 Lectures)

Solution of first and second order Series and Parallel R-L, R-C, R-L-C circuits, Initial and final conditions in network elements, Forced and free response, Time constants, Steady-state and transient state response, Transfer function representation, Poles and Zeros, Frequency response (Magnitude and phase plots), Series and Parallel resonances.

Module 4

Two Port Network and Network Functions: (8 Lectures)

Two port networks, Terminal pairs, relationship of two port variables, Impedance parameters, Admittance parameters, Transmission parameters and Hybrid parameters, Interconnections of two port networks.

Module 5

Network Synthesis: (8 Lectures)

Positive Real Function: Definition and properties, Properties of L-C, R-C and R-L driving point functions, Synthesis of L-C, R-C and R-L driving point immittance functions using Foster and Cauer first and second forms.

Filter: Passive and active filter fundamentals, Low pass, High pass (Constant K-type) Filters, Introduction to Active filters

List of Experiments:

(Note: At least ten experiments to be conducted out of which three must be software based)

1. Verification of principle of superposition ac sources.
2. Verification of Thevenin, Norton
3. Maximum power transfer theorems in ac circuits
4. Verification of Tellegin's theorem for two networks of the same topology
5. Determination of transient response of current in RL and RC circuits with step voltage input
6. Determination of transient response of current in RLC circuit with step voltage input for underdamped, critically damp and overdamped cases
7. Determination of 'Z' and 'h' parameters (dc only) for a network and computation of Y and ABCD parameters
8. Determination of image impedance and characteristic impedance of T and ∏ networks
9. Verification of parameter properties in inter-connected two port networks : series, parallel and cascade
10. To determine attenuation characteristics of a low pass/high pass active filters.

Software based experiments:

11. To determine node voltages and branch currents in R and R-L network.
12. To obtain Thevenin's equivalent circuit of R and R-L network.
13. To obtain transient response of a series R-L-C circuit for step voltage & current input.
14. To obtain transient response of a series R-L-C circuit for alternating square voltage waveform.
15. To determine line and load currents in a three phase delta circuit connected to a 3-phase balanced ac supply

Text Books:

1. M. E. Van Valkenberg, "Network Analysis, PHI, 2006.

2. D. Roy Choudhary, "Networks and Systems", New Age International Publications, 1998.

3. W. H. Hayt and J. E.Kemmerly". Engineering Circuit Analysis, McGraw Hill Edu., 2013.

Reference Books:

1. C. K. Alexander and M. N. O., Sadiku. Electric Circuits". McGraw Hill Education. 2004.

2. K. V. V. Murthy and M.S. Kanaih, "Basic Circuit Analysis", Jaico Publications, 1999.

3. Peikari – Fundamentals of Network Analysis & Synthesis, Wiley.

4. V. Atre, "Network Theory and Filter design", TMH

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-204	Electrical Circuit Analysis	5(3-1-2)	15	20	15	50	50	100

NEE-206	ELECTRICAL ENGINEERING MATERIALS	L T P: 3 0 0	Credits: 3	Type: PCC

OBJECTIVE:

The objective of this course is to make students learn in the area of electrical engineering materials. The course includes study of dielectrics, semi-conductors, conductors, insulators and photonic devices. Th course also gives an insight into magnetic properties of materials.

Prerequisites: Engineering Physics, Basic Electrical Engineering.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Able to understand and apply the concept of dielectrics.	K1, K2
CO2	Able to understand and apply knowledge of magnetic properties of materials.	K2 ,K3
CO3	Able to understand the mechanism of conductivity of metals and performance of high-conducting materials.	K2, K4, K5
CO4	Able to understand the merits and applications of semiconductor materials and photonic devices.	K2, K4, K3
CO5	Able to apply the knowledge of Insulating materials	K2, K3
CO6	Able to analyze Electrical Engg. materials based on their characteristics.	K2, K4

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	-	-	2	2	-	-	-	-	2
CO2	2	1	2	1	1	2	1	-	-	-	1	2
CO3	2	1	1	1	1	2	2	-	1	-	1	2
CO4	3	2	1	1	1	2	2	-	1	-	1	2
CO5	2	2	2	1	1	2	2	1	1	-	2	2
CO6	3	1	1	1	1	1	2	-	1	1	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Dielectrics: (5 Lectures)

Dielectric properties, Polarization and dielectric constant. Piezoelectricity, Behaviour of dielectrics in alternating fields.

Module 2

Magnetic Properties of Materials: (5 Lectures)

Classification of magnetic materials, Magnetic dipole moment of current loop, Orbital magnetic dipole moment, Lenz's law.

Module 3

Conductivity of metals and Conductive Materials: (7 Lectures)

Free electron theory of metals, Ohm's law, Relaxation time, Collision time and mean free path, Electron scattering and the resistivity of metals, Superconductivity, Fermi level, Generation and recombination, carrier life-time, diffusion length. Scattering and mobility of carriers, Einstein relation, LASER, High conductive materials-copper, Aluminium, Tungsten, Nickel, Brass, Bronze and other alloys

Module 4

Semiconductor Materials and Photonic devices: (6 Lectures)

Types of semiconductors, properties of semi-conducting materials, measurement of semiconductor parameters, refining of semiconductor materials, Microelectronic circuits and ICs, Basic steps in IC fabrication, Photonic devices, Photo-transistor, Photo diode, Light emitting diode..

Module 5

Insulating Materials: (5 Lectures)

Gaseous materials-Oxide gases, Electronegative gases, Hydrocarbon gases; Liquid materials-mineral oils, Silicon liquids, Hydrocarbon liquids; Solid materials - Paper and boards, Resins (Polymers), Rubbers-natural and synthetic, glass, Ceramics, Asbestos.

Text Books:

1. S. P. Seth, P.V. Gupta, "A course in Electrical Engineering Materils", Dhanpat Rai and Sons.
2. A. J. Dekker, "Electrical Engineering Materials", PHI.
3. R. K. Shukla & A. Singh,"Electrical Engineering Materials" , Tata Mcgraw Hill,New Delhi.
4. R.K. Rajput," Electrical Engg. Materials," Laxmi Publications.

Reference Books:

1. J.K. Shackelford & M.K. Muralidhara, "Introduction to Material Science for Engineers", Pearson Education.
2. Ian P. Jones, "Materials Science for Electrical & Electronics Engineers", Oxford NPTEL Lectures.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-206	Electrical Engineering Materials	3(3-0-0)	30	20	-	50	50	100

Year III Semester V

NEE-301	CONTROL SYSTEMS	L T P: 3 0 2	Credits: 4	Type: PCC

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of control system. The course includes: Basic Concepts, Modeling, Components, Response Analysis, Stability, Analysis and Design of Control Systems.

Prerequisites: Engineering Mathematics, Engineering Physics, Introduction to Electrical Engineering and Electrical Circuit Analysis.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Explain the needs and effects of control system	K1, K2
CO2	Obtain mathematical model of a given control system in transfer functions and state space, and apply the same	K3, K4
CO3	Identify and also justify the type of a given control system from its model, characteristics and responses	K4, K5
CO4	Understand Time - response analysis and time-domain Analysis	K2
CO5	Understand Frequency - response analysis	K2
CO6	Analyze the system's stability and performance in terms of the key characteristics and practical implementation, compensation.	K3, K6

K1 - Remember, K2 - Understand, K3 - Apply, K4 - Analyze, K5 - Evaluate, K6 - Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	1	-	2	2	2	-	1	1	-	3
CO2	3	2	2	2	1	2	2	-	2	1	1	3
CO3	3	2	2	3	2	2	2	-	2	1	1	3
CO4	3	3	3	2	2	2	2	-	1	1	1	3
CO5	3	3	2	3	2	2	2	-	2	1	1	3
CO6	3	3	3	2	2	2	2	-	2	1	1	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Basic Concepts (7 Lectures):

Systems - Types of control systems, Notion of feedback, Open and Closed loop systems, Fundamental control actions (ON/OFF, Hysteresis control), Servomechanism, Physical examples, Reduction of parameter variation and effects of disturbance by using negative feedback, Digital Control vs. Analog Control and examples, Environmental considerations, Local, national and global needs.

Module 2

Control System Components and Modeling (8 Lectures):

Servo Motors and actuators (control valves, solenoids), Stepper Motor, Modelling and representations of control systems: Ordinary differential equations, Transfer functions, Block diagrams, Signal flow graphs, Brief introduction of State-space representations, Examples of Control System models, Industry applications.

Module 3

Time - Response Analysis (9 Lectures):

Test Signals, Time response of first order and second order systems, Time domain specifications, Steady state errors and error constants, Effect of addition of Poles and Zeros, Dominant poles and zeros of Transfer function, PID Controllers - Derivative error, derivative output, integral error, Rate feedback control, Design specifications of second order systems, Design considerations for higher order systems, Performance indices Research papers study.

Module 4

Time-Domain Analysis and Stability (7 Lectures):

Review of State variable technique, conversion of State variable model to Transfer Function model and vice-versa, Diagonalization, Controllability and Observability, Solution of state equations, Stability: Concept, Algebraic criteria and conditions, Characteristic equation, Routh-Hurwitz criteria and limitations, Root locus concept and construction, Research papers study.

Module 5

Frequency - Domain Analysis and Stability (9 Lectures):

Frequency responses and Frequency domain specifications - Concepts of gain margin and phase margin, Correlation between time and frequency responses, Nyquist stability criterion, Nyquist plot, Bode plots Nichol's chart, Concepts of Lead, Lag and Lead-lag compensators and their implementation, Research papers study, Industry examples.

Control System Laboratory

(Note: The minimum of 08 experiments are to be performed from the following).

Hardware based experiments:

1. To determine response of first order and second order systems for step input for various values of constant "K" using linear simulator unit and compare theoretical and practical results.

2.To study P, PI and PID temperature controller for an oven and compare their performance.

3.To study and calibrate temperature using resistance temperature detector (RTD)

4.To study DC position control system

5.To determine speed-torque characteristics of an ac servomotor.

6. To study Solar and Wind Energy Systems on FESTO set up LabVolt Series 8960 - 2A

7. To study Industrial Training Control System on FESTO set up LabVolt Series 3103 - 40

Software based experiments (Use MATLAB):

1. To determine time domain response of a second order system for step input and obtain performance parameters.

2. To convert transfer function of a system into state space form and vice-versa.

3. To plot root locus diagram of an open loop transfer function and determine range of gain „k" fir stability.

4. To plot a Bode diagram of an open loop transfer function.

5. To draw a Nyquist plot of an open loop transfer functions and examine the stability of the closed loop system.

Text Books

1. B.C. Kuo, and F.Golnaraghi, "Automatic Control Systems", 9th Edition. Wiley India Pvt limited 2014 (Student edition)

2. Yaduvir Singh and S. Janardhanan, "Modern Control Engineering", Cengage Learning, 2006

3. I J Nagrath and M Gopal, "Control Systems Engineering", 5th Edition, New Age International, 2007

Reference Books

1. Katsuhiko Ogata, "Modern Control Engineering", 5th edition, PHI, 2010

2. Norman S. Nise, "Control Systems Engineering", 6th edition, John Wiley, 2010. (Indian edition)

3. M Gopal, Control Systems-Principles and Design, 4th Edition, McGraw Hill India, 2012

NPTEL web links for Study Material / Course:

https://archive.nptel.ac.in/courses/107/106/107106081

Evaluation Scheme:

Sl. No.	Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
					MSE	TA	Lab	Total		
1	PCC	NEE-301	Control Systems	4 (3-0-2)	15	20	15	50	50	100

NEE-303	MICROPROCESSORS	L T P: 3 1 2	Credits: 5	Type: PCC

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of microprocessor. The course includes: Fundamentals and basic Concepts of microprocessor, assembly language programming of microprocessor, interfacing of microprocessor with various peripherals.

Prerequisites: Computer Concept & C Programming, Digital Electronics.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Students will understand the fundamentals of Microprocessor Architecture.	K1, K2
CO2	Students will understand the 8-bit microprocessor.	K1, K2
CO3	Students will understand the 16-bit microprocessor.	K1, K2
CO4	Students will demonstrate the ability to do assembly language programming.	K3, K4
CO5	Do interfacing design of peripherals with microprocessor.	K5, K6

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	-	1	-	-	-	-	-	2
CO2	3	2	2	1	-	1	-	-	-	-	-	2
CO3	3	2	2	2	-	1	-	-	-	-	-	2
CO4	3	3	3	3	2	1	1	-	1	-	1	2
CO5	3	3	3	3	2	1	1	-	1	-	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-'

Course content

Module 1

Fundamentals of Microprocessors: (8 Lectures)

Microprocessor and Microprocessor Development Systems: Evolution of Microprocessor, Microprocessor architecture and its operations, memory, inputs-outputs (I/Os), data transfer schemes interfacing devices, architecture advancements of microprocessors, typical microprocessor development system.

Fundamentals of Microprocessor Architecture: 8-bitMicroprocessor architecture, Internal Block Diagram CPU, ALU, address, data and control bus, Clock and RESET circuits, Stack and Stack Pointer, Program Counter, I/O ports, Memory Structures, Data and Program Memory.

Module 2

8 Bit Microprocessor: (8 Lectures)

8085 microprocessor: pin configuration, internal architecture. Timing & Signals, ALU, machine cycles. Buses and CPU Timings, Bus size and signals, machine cycle timing diagram, instruction timing, processor timing. Instruction Set of 8085, Addressing Modes; Register addressing, direct addressing; register indirect addressing, immediate addressing, and implicit addressing. Instruction format, op-codes, mnemonics, no. of bytes, no. of machine cycles and T states, addressing modes. Instruction Classification; Data transfer arithmetic operations, logical operations, branching operation, machine control, Writing assembly Language programs, Assembler directives.

Module3

16-bit Microprocessors: (8 Lectures)

Architecture: Architecture of INTEL 8086 (Bus Interface Unit, Execution unit), register organization, memory addressing, memory segmentation, Operating Modes, Interrupts, Hardware and software interrupts, responses and types. Subroutines Immediate addressing, Register addressing, Direct addressing, Indirect addressing, Relative addressing, Indexed addressing,

Module 4

Instruction Set and Programming: (8 Lectures)

Addressing modes: Introduction, Instruction syntax, Data types, , Instruction Set of 8086, Addressing Modes, Instruction format, data transfer, arithmetic , logic string, branch control transfer, processor control, 8085 and 8086 Instruction set, Instruction timings. Data transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Subroutine instructions, Bit manipulation instruction. Assembly language programs.

Module 5

Peripheral Interfacing: (8 Lectures)

I/O programming: Programmed I/O, Interrupt Driven I/O, DMA, Peripheral Devices: 8237 DMA controller, 8255-Programmable peripheral interface, 8253Programmable timer/counter. 8259 programmable Interrupt Controller.

Text Books:

1. R. S. Gaonkar, ", Microprocessor Architecture: Programming and Applications with the 8085", Penram International Publishing, 1996.
2. D. V. Hall, "Microprocessors & Interfacing", McGraw Hill Higher Education, 1991.
3. Brey, Barry B. / "INTEL microprocessors" / Prentice Hall (India) .
4. Liu and Gibson G.A. / "Microcomputer Systems: The 8086/8088 Family" / Prentice Hall (India).
5. D. A. Patterson and J. H. Hennessy, "Computer Organization and Design: The Hardware/Software interface", Morgan Kaufman Publishers, 2013.

Reference Books:

1. Ray, A.K. & Bhurchandi, K.M./ "Advanced Microprocessors and Peripherals: Architecture, Programming and Interfacing"/ Tata McGraw Hill.
2. Singh, B.P. / "Advanced Microprocessors and Microcontrollers" / New Age International
3. Ayala, Kenneth J. / "The 8086 Microprocessor Programming & Interfacing the PC"/Pen ram International Publishing (India) Limited.

Web Reference:

1. Video/Web contents on NPTEL

List of Experiments:

(Note: At least ten experiments to be conducted)

1. To study 8085 based microprocessor system
2. To study 8086 based microprocessor system
3. To perform 8-bit addition and subtraction on 8-bit processor 8085
4. To perform 8-bit multiplication and division on 8-bit processor 8085
5. To perform 16-bit addition and subtraction on 16-bit processor 8086
6. To perform 16-bit multiplication and division on 16-bit processor 8086
7. To develop and run a program for finding out the largest number from a given set of numbers.
8. To develop and run a program for finding out the smallest number from a given set of numbers.
9. To develop and run a program for arranging in ascending order of a set of numbers
10. To develop and run a program for arranging in descending order of a set of numbers
11. To obtain interfacing with PPI 8255 in I/O mode and BSR mode
12. To obtain interfacing with 8253 and generation of square wave
13. Understanding of Debug command on Advanced Microprocessors

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-303	Microprocessors	5(3-1-2)	15	20	15	50	50	100

NEE-305	POWER SYSTEM-I	L T P: 3 1 0	Credits: 4	Type: PCC

OBJECTIVE:

This course will provide a good understanding to the students in the area of power system. The course includes calculations of resistance, inductance, capacitance of transmission line, power system components, performance analysis of transmission lines, various aspects of insulators and tower of power systems.

Prerequisites: Engineering Mathematics, Introduction to Electrical Engineering, Electrical Circuit Analysis.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Able to know about various components of power system and supply System	K1, K2
CO2	Able to calculate inductance and capacitance of various configurations of transmission lines	K2, K3, K4
CO3	Understand various aspects of corona & interference and to evaluate various aspects of insulators used in power system network	K4, K5
CO4	Able to do mechanical and electrical design calculations of a transmission Line	K2, K3, K4
CO5	Able to identify various aspects of grounding and familiarization with EHVAC, HVDC systems	K1, K2

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	3
CO2	3	1	2	1	1	2	1	-	1	-	1	2
CO3	3	1	1	-	1	2	1	-	1	-	2	2
CO4	3	2	1	1	1	2	1	-	2	-	1	3
CO5	3	2	2	1	1	2	1	-	2	-	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Power System Components: (8 Lectures)

Single line diagram of power system, brief description of power system, Supply system, different kinds of supply systems, choice of transmission voltage, Transmission lines: Configurations, types of conductors, resistance of line, skin effect, Kelvin's law, Proximity effect.

Module 2

Over Head Transmission Lines: (8 Lectures)

Calculation of inductance and capacitance of single phase, three phase, single circuit and double circuit transmission lines, Representation and performance of short, medium and long transmission lines, Ferranti effect, Surge impedance loading.

Module 3

Corona and Interference: (8 Lectures)

Phenomenon of corona, corona formation, calculation of potential gradient, corona loss, factors affecting corona, methods of reducing corona and interference, Electrostatic and electromagnetic interference with communication lines, Overhead line Insulators: Type of insulators and their applications, potential distribution over a string of insulators, methods of equalizing the potential, string efficiency

Module 4

Mechanical Design of transmission line: (8 Lectures)

Catenary curve, calculation of sag & tension, effects of wind and ice loading, sag template, vibration dampers Insulated cables: Type of cables and their construction, dielectric stress, grading of cables, insulation resistance, capacitance of single phase and three phase cables, dielectric loss, heating of cables

Module 5

Neutral grounding and electrical design of transmission line: (8 Lectures)

Necessity of neutral grounding, various methods of neutral grounding, earthing transformer, grounding practices, Electrical design of transmission line: Design consideration of EHV transmission lines, choice of voltage, number of circuits, conductor configuration, insulation design, selection of ground wires, EHV AC and HVDC Transmission: Introduction to EHV AC and HVDC transmission and their comparison, kinds o DC links, incorporation of HVDC into AC system

Text Books

1. W. D. Stevenson, "Element of Power System Analysis", McGraw Hill,
2. C. L. Wadhwa, "Electrical Power Systems" New age international Ltd. Third Edition
3. Asfaq Hussain, ""Power System", CBS Publishers and Distributors,
4. B. R. Gupta, "Power System Analysis and Design" Third Edition, S. Chand & Co.

Reference Books

1. M. V. Deshpandey, "Elements of Power System Design", Tata McGraw Hill,
2. Soni, Gupta & Bhatnagar, "A Course in Electrical Power", Dhanpat Rai & Sons,
3. S. L. Uppal, "Electric Power", Khanna Publishers

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-305	Power System-I	4(3-1-0)	30	20	-	50	50	100

NEE-307	UTILIZATION OF ELECTRICAL ENERGY AND TRACTION	L T P: 3 0 0	Credits: 3	Type: PCC

OBJECTIVE:

The objective of this course is to make students to learn to apply their knowledge in the application utilization of Electrical Energy and Tractions.

Pre-requisites of the course: Introduction to Electrical Engineering, Electrical Machines-I & Electrical Machines-II

Course outcome

On the successful completion of the course, students will be able to

CO1	Understand, apply and analyze the Electric Heating	K2, K3, K4
CO2	Remember, understand, apply and analyze the Electric welding and electrolyte process	K1, K2, K3, K4,
CO3	Remember, understand, apply, analyze and Evaluate the Illumination, refrigeration and air-conditioning	K1, K2, K3, K4, K5
CO4	Remember, Understand, Apply, Analyze, Evaluate and Create the Electric Traction	K1, K2, K3, K4, K5, K6
CO5	Remember, Understand, Apply, Analyze, Evaluate and Create the Electric Traction Drives and Elevators	K1, K2, K3, K4, K5, K6

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	2	1	2	3	1	1	2	3
CO2	3	3	2	3	2	1	2	3	1	1	2	3
CO3	3	3	2	3	2	1	2	3	1	1	2	3
CO4	3	3	2	3	2	1	2	3	1	1	2	3
CO5	3	3	2	3	2	1	2	3	1	1	2	3

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High) If there is no correlation put "-".

Course Content:

Module 1

Electric Heating: (6 Lectures)

Advantages and methods of electric heating, Resistance heating, Electric arc heating, Induction heating and Dielectric heating.

Module 2: (6 Lectures)
Electric Welding:
Electric Arc Welding Electric Resistance Welding Electronic welding controls.
Electrolyte Process: Principles of electro deposition, Laws of electrolysis, and applications of electrolysis

Module 3: (6 Lectures)

Illumination:
Various definitions, Laws of illumination, requirements of good lighting Design of indoor lighting and outdoor lighting systems
Refrigeration and Air Conditioning:
Refrigeration systems, domestic refrigerator, water cooler Types of air conditioning, Window air conditioner

Module 4
Electric Traction: (6 Lectures)
Types of electric traction, Review of existing electric traction systems in India, systems of track electrification Traction mechanics- types of services, speed time curve and its simplification, average and schedule speeds Tractive effort, specific energy consumption, mechanics of train movement, coefficient of adhesion and its influence

Module 5
Electric Traction Drives (6 Lectures)
Salient features of traction drives, Series – parallel control of dc traction drives (bridge transition) and energy saving Power Electronic control of dc and ac traction drives Diesel electric traction.
Elevators: Function, application, Types, its motors and safety, Factors on which shape and size of car depends.

Text Books:

1. H. Partab, "Art and Science of Electrical Energy" Dhanpat Rai & Sons
2. J.B. Gupta, "Utilization of Electric Power and Electric Traction", Kataria & Sons publishers, Delhi,IX Edtion, 2004
3. C.L. Wadhwa, "Generation, Distribution and Utilization of electrical Energy", New Age International

(P) Limited Publishers, 3rd Edition, 2010.

Reference Books:

1. H. Partab, " Modern Electric Traction" Dhanpat Rai & Sons.
2. G.K. Dubey, "Fundamentals of Electric Drives" Narosa Publishing House.

Evaluation Scheme:

S. No.	Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
					MSE	TA	Lab	Total		
1	PCC	NEE-307	Utilization Of Electrical Energy and Traction	3(3-0-0)	30	20	-	50	50	100

NEE-309	ELECTRICAL MACHINE DESIGN	L T P: 3 0 2	Credits: 4	Type: PCC

ONJECTIVE:

This course will provide a good understanding and hold to the students in the area of electrical machin design. The course includes understanding of transformers, induction motor and synchronous machines. Thi course also gives an insight into computer aided designs.

Prerequisites: Basic Electrical Engineering, Electrical Machine-I, Electrical Machine-II, Engineerin Physics

Course Outcomes: On the successful completion of the course, students will be able to

CO1	Able to understand basic concept of design.	K1, K2, K3
CO2	Able to design using CAD.	K1, K2, K3, K4
CO3	Exhibit the knowledge of design of transformer.	K1, K2, K3, K4, K5, K6
CO4	Exhibit the knowledge of design of three phase induction Motor.	K1, K2, K3, K4, K5, K6
CO5	Exhibit the knowledge of design three phase synchronous Machine.	K1, K2, K3, K4, K5, K6

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	2	1	-	1	-	1	2
CO2	2	2	3	1	3	2	1	-	2	-	1	3
CO3	2	2	3	2	2	2	1	1	2	-	1	3
CO4	2	2	3	2	2	2	1	1	2	-	1	3
CO5	2	2	3	2	2	2	1	1	2	-	1	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Basic principles of electrical machine design: (8 Lectures)

General design procedure, Specific electric and magnetic loadings, Output equation, Separation of D and L, Factors affecting size of rotating machines.

Module 2

Transformer Design: (8 Lectures)

Output equation, overall dimensions. Design of core, yoke and windings, Estimation of no load current of transformer.

Module 3

Design of Rotating Machine - I (8 Lectures):

Output equations of rotating machines, Stator design of three phase AC machines, Length of air gap.

Module 4

Design of Rotating Machine - II (8 Lectures):

Rotor design of three-phase induction motors, Design of field system of synchronous machines.

Module 5

Computer Aided Design: (8 Lectures)

Philosophy of computer aided design, Advantages and limitations, Flow charts and computer programs for the design of transformer.

List of design problems:

(Minimum four design problems from the following list are to be completed and submitted. specification of each design problem will be given in the Lab class.)

1. Design of core type single phase transformer.

2. Design of shell type single phase transformer.

3. Design of three phase power transformer.

4 Design of three phase distribution transformer.

4. Design of three phase squirrel cage type induction motor.

5. Design of three phase slip ring type induction motor.

7. Design of Turbo Alternator.

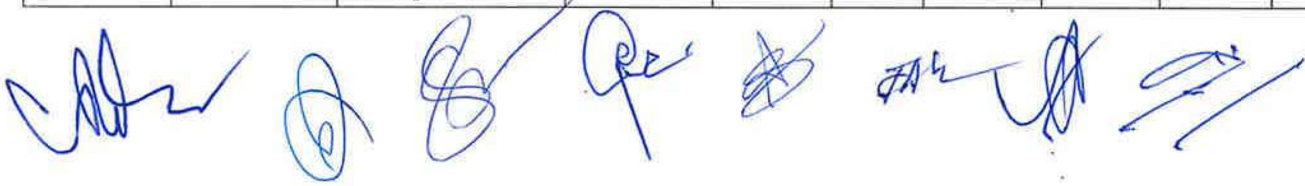
8. Design of Hydro Alternator.

Text Books / Reference Books:

1. A. K. Sawhney, "A Course in Electrical Machine Design" Dhanpat Rai & Sons
2. K.G. Upadhyay," Conventional and Computer Aided Design of Electrical Machines" Galgotia Publications
3. M.G. Say, "The Performance and Design of AC Machines", Pitman & Sons
4. A. Nagoor Kani, "Electrical Machine Design" CBS Publishers & Distributers Pvt Ltd
5. A.E. Clayton and N.N. Hancock, "The Performance and Design of D. C. Machines" Pitman & Sons
6. S.K. Sen, "Principle of Electrical Machine Design with Computer Programming" Oxford and IBM Publications

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-309	Electrical Machine Design	4(3-0-2)	15	20	15	50	50	100



Year III Semester VI

NEE-302	POWER ELECTRONICS	L T P: 3 1 2	Credits: 5	Type: PCC

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of Power Electronics. The course includes: Fundamentals and basic Concepts of Power Electronics, DC-DC converters, AC-DC Converters, Inverters, Modulation Techniques. At the end of this course students will demonstrate the ability to Understand the differences between signal level and power level devices. Analyze controlled rectifier circuits. Analyze the operation of DC-DC choppers. Analyze the operation of voltage source inverters and AC regulators.

Prerequisites: Electrical Circuit Analysis, Solid State Devices and Circuits, Digital Electronics.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Demonstrate the ability to understand various power electronics devices and difference between signal level and power level devices.	K1, K2:
CO2	Demonstrate the ability to analyze and design AC-DC Rectifiers.	K3, K4
CO3	Demonstrate the ability to analyze and design DC-DC Converters.	K3, K4
CO4	Demonstrate the ability to analyze and design AC-AC Controllers.	K3, K4:
CO5	Demonstrate the ability to analyze and design of Inverters.	K1, K5

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1	-	-	-	-	-	-	-	-
CO2	2	2	3	1	-	-	-	-	-	-	-	-
CO3	3	3	3	2	2	-	-	-	-	-	-	1
CO4	3	3	3	2	2	1	-	-	-	-	-	1
CO5	3	3	3	3	3	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-'

Course Content:

Module 1

Fundamentals of Power Electronics and Power Semiconductor Devices: (8 Lectures)

Concept of power electronics, application of power electronics, types of power electronic circuits and devices. Thyristor V- I characteristics, two transistor model and methods of turn-on, Operation and steady state characteristics of Power MOSFET, IGBT, GTO, MCT and TRIAC, Protection of thyristor, series and parallel operation of thyristors, commutation techniques of thyristor.

Module 2

Phase Controlled Converters: (8 Lectures)

Single phase half wave controlled rectifier with resistive, inductive and RLE loads, Single phase fully controlled and half controlled converters, effect of freewheeling diode and source inductance on the performance of converters. Three phase half wave converters, Three-phase fully controlled and half controlled bridge converters, input current harmonics and power factors, techniques of power factor improvement and input harmonic spectrum, dual converters.

Module 3

DC-DC Converters: (8 Lectures)

Principle of operation, Power circuit of step down and step up choppers, relation between duty ratio and average output voltage, control strategies, types of choppers circuits based on quadrant of operation.

Module 4

AC Controllers: (8 Lectures)

Principle of on- off and phase control, single phase AC voltage controllers with R and R-L loads, sequential controller, three phase AC voltage controllers, principle of operation of cycloconverters, single phase to single phase step up and step down cycloconverters, three phase to single phase cyclo-converters, three phase to three phase cycloconverters.

Module 5

Inverters: (8 Lectures)

Principle of operation of single-phase voltage source inverter with R and R- L loads, switch states, pole voltage and instantaneous output voltage, square wave operation of the inverter, power circuit of a three-phase voltage source inverter, switch states, pole voltage and instantaneous output voltages, average output voltages over a sub-cycle, methods of voltage control and harmonic reduction of inverters, three-phase sinusoidal modulation, brief idea of multi level inverters, current source inverters.

Text Books:

1. M.H. Rashid, "Power Electronics: Circuits, Devices & Applications", Prentice Hall of India Ltd. 3rd Edition,2004.

2. M.D. Singh and K. B. Khanchandani, "Power Electronics" Tata MC Graw Hill, 2005.

3. V. R. Moorthy, " Power Electronics : Devices, Circuits and Industrial Applications" Oxford University Press,2007.

4. P.S. Bimbhra, "Power Electronics" Khanna Publishers Delhi, 2010.

Reference Books:

1. Chakrabarti & Rai, "Fundamentals of Power Electronics &Drives" Dhanpat Rai & Sons.

2. Ned Mohan, T.M.Undeland and W.P.Robbins, "Power Electronics:Converters, Applications and Design", Wiley India Ltd.2008.
3. S.N.Singh, "A Text Book of Power Electronics" Dhanpat Rai & Sons.
4. M.S. Jamil Asghar, "Power Electronics" Prentice Hall of India Ltd., 2004
5. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2007.
6. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.

Web Reference:

1. Video/Web contents on NPTEL

List of Experiments:

(Note: At least ten experiments to be conducted)

1. To study V-I characteristics of SCR and measure holding and latching currents.
2. To study characteristics of MOSFET
3. To study characteristics of IGBT
4. To study characteristics of TRIAC
5. To study single-phase half wave controlled rectified with (i) resistive load (ii) inductive load with and without freewheeling diode.
6. To study single phase (i) fully controlled (ii) half controlled bridge rectifiers with resistive and inductive loads.
7. To study single-phase AC voltage regulator with resistive and inductive loads
8. To study operation of Buck chopper
9. To study operation of Boost chopper
10. To study single-phase bridge inverter.

Software based experiments (MATLAB)

1. Simulation study of single phase half controlled rectifier and draw load voltage, load current waveform for R, R-L and R-L-E load.
2. Simulation study of single phase fully controlled bridge rectifier and draw load voltage, load current and input current waveforms R, R-L and R-L-E load. Also calculate THD of input current.
3. Simulation study of single phase full wave ac voltage controller and draw load voltage and load current waveforms for R and R-L load.
4. Simulation study of step-down DC chopper with PWM with R, R-L and R-L-E load. Also calculate voltage ripples in output voltage and load current with and without filter.
5. Simulation study of single phase square wave bridge inverter with R and RL loads

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-302	Power Electronics	5(3-1-2)	15	20	15	50	50	100

NEE-304	POWER STATION PRACTICE	L T P: 3 1 0	Credits: 4	Type: PCC

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of power stations. The course includes calculations of capital costs, operation costs, various factors, tariffs, power factor corrections and power plant economics. This course also gives an insight into various types of conventional and non-conventional power plants.

Prerequisites: Engineering Mathematics, Engineering Physics and Basic Electrical Engineering

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Able to know about various components of power plants	K1, K2
CO2	Able to calculate capital costs, operation costs, various factors, tariffs, power factor corrections, power Output and power plant economics	K1, K3, K4
CO3	Evaluating various aspects of power plants, sub-stations, power factor corrections and power plant economics	K4, K5
CO4	Understand various aspects of power plant economics and their affects on power plant performance	K2, K4
CO5	Able to do basic mechanical and electrical design Calculations of some devices of power plants	K2, K3
CO6	Able to identify various aspects of non-conventional energy resources	K1, K2

K1 - Remember, K2 - Understand, K3 - Apply, K4 - Analyze, K5 - Evaluate, K6 - Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	3
CO2	3	1	2	1	1	2	1	-	1	-	1	2
CO3	3	1	1	-	1	2	1	-	1	-	2	2
CO4	3	2	1	1	1	2	1	-	2	-	1	3
CO5	3	2	2	1	1	2	1	-	2	-	2	3
CO6	3	1	1	1	1	1	1	-	1	-	1	2

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Introduction, Thermal Power Plant and Hydro Electric Plants: (8 Lectures)

Introduction. Electric energy demand and growth in India, Electric energy resources

Thermal Power Plant: Site selection, general layout and operation of plant, detailed description and use of different parts, Indian perspective, Case Study(s)

Hydro Electric Plants: Classifications, location and site selection, detailed description of various components, general layout and operation of Plants, Impulse, Reaction, Kaplan and Francis turbines, Indian perspective, Case Study(s)

Module 2

Nuclear Power Plant, Gas Turbine Plant and Diesel Power Plant: (7Lectures)

Nuclear Power Plant: Location, site selection, general layout and operation of plant, Different types of reactors, Moderator material, fissile materials, control of nuclear reactors and shielding, disposal of nuclear waste material, Indian perspective, Case Study(s)

Gas Turbine Plant: Operational principle of gas turbine plant, Efficiency, Open and Closed-cycle plants, regeneration, Applications, Indian perspective, Case Study(s)

Diesel Plants: Diesel plant layout, Components & their functions, Applications

Module 3

Power Plant Economics and Tariffs: (7 Lectures)

Power Plant Economics and Tariffs: Load curve, Load duration curve, Different factors related to plants and consumers, Cost of electrical energy, Depreciation, Generation cost, Effect of Load factor on unit cost, Fixed and operating cost of different plants, Objectives and forms of Tariff; Causes and effects of low power factor, Advantages of power factor improvement, Different methods for power factor improvements, Case Study(s).

Module 4

Sub-stations Layout and Economic Operation of Power Systems: (4 Lectures)

Types of substations, Bus-bar arrangements, Typical layout of substation, Economic load scheduling of thermal plants, Penalty factor, Loss coefficients, Case Study(s)

Module 5

Non- Conventional Energy Sources: (14 Lectures):

Power Crisis, Future energy demand

MHD generation: Working principle, Open and Closed cycles, MHD systems, advantages, Case Study(s)
Solar power plant: Solar energy collectors, Photovoltaic cell. Case Study(s)
Wind Energy: Windmills, Power output, Case Study(s)
Geothermal Energy: Earth energy, Heat extraction, Case Study(s)
Tidal energy: Tidal phenomenon, Tidal power Schemes, Case Study(s)
Ocean Thermal Energy: Energy conversion, Case Study(s)

Text Books

1. B. R. Gupta,"Generation of Electrical Energy", S. Chand Publication, 2000
2. Soni, Gupta & Bhatnagar, "A text book on Power System Engg.", Dhanpat Rai & Co., 2002
3. P.S.R. Murthy, "Operation and control of Power System" BS Publications, Hyderabad, 1999

Reference Books

1. W. D. Stevenson, "Elements of Power System Analysis", McGraw Hill, 1994
2. S. L. Uppal, "Electrical Power", Khanna Publishers, 2000

NPTEL web links for Study Material / Course:

https://archive.nptel.ac.in/courses/112/107/112107291

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-304	Power Station Practice	4 (3-1-0)	30	20	-	50	50	100

NEE-306	POWER SYSTEM-II	L T P: 3 0 2	Credits: 4	Type: PCC

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of power system. The course includes concepts, modeling, components, calculations, simple designing and analysis of power system.

Prerequisites: Introduction to Electrical Engineering, Power System-I

Course Outcomes

On the successful completion of the course. students will be able to

CO1	Understanding basics and needs of representation of power system components	K1, K2
CO2	Able to solve problems of faults analyses, stability analyses of power system	K2, K3
CO3	Understanding basic concepts of load flow	K3, K4
CO4	Understanding and analyse the basic components of power system stability	K2, K4, K5
CO5	Handling problems of fault analysis using computer	K2, K4, K5
CO6	Able to learn power system and its concepts for life long	K2, K4, K5

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	2	-	-	1	-	-	2
CO2	3	3	1	1	1	3	1	-	2	-	-	2
CO3	3	3	1	2	1	3	1	-	2	-	-	2
CO4	3	3	1	1	1	3	1	-	2	-	-	2
CO5	3	3	1	2	1	3	1	-	2	-	-	2
CO6	3	3	2	2	2	3	1	-	3	-	1	3

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-

Course Content:

Module 1

Representation of Power System Components and Symmetrical fault analysis: (6 Lectures)

Representation of Power System Components:

Synchronous machines, Transformers, Transmission lines, One line diagram, Impedance and reactance diagram, per unit System.

Symmetrical fault analysis:

Transient in R-L series circuit, calculation of 3-phase short circuit current and reactance of synchronous machine, internal voltage of loaded machines under transient conditions.

Module 2

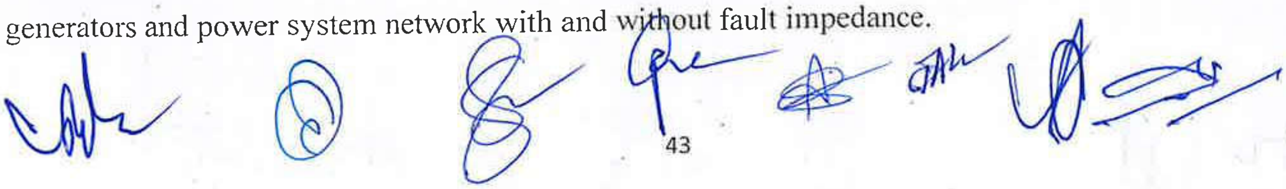
Symmetrical components and Unsymmetrical faults (6 Lectures):

Symmetrical components:

Symmetrical Components of unbalanced phasors, power in terms of symmetrical components, sequence impedances and sequence networks

Unsymmetrical faults:

Analysis of single line to ground fault, line-to-line fault and Double Line to ground fault on an unloaded generators and power system network with and without fault impedance.



Module 3

Building of Z_{bus} and introduction to computer method for fault analysis: (6 Lectures)

Formation of Y_{bus} and Z_{bus} building algorithm, Introduction to computer method for short circuit calculations.

Module 4

Load Flow: (6 Lectures)

Introduction, bus classifications, Development of load flow equations, Load flow solution using Gauss, Gauss -Siedel and Newton-Raphson method.

Module 5

Power System Stability: (6 Lectures)

Stability and Stability limit, Steady state stability study, Swing equation, Transient stability studies by equal area criterion and step-by-step method, Factors affecting steady state and transient stability and methods of improvement.

Experiment list for Power System-II Lab

Students will write a program using MATLAB / other software's and solves the given problem for the following problem /analysis.

1. Formulation of $\mathbf{Y}_{bus}$ /$\mathbf{Z}_{bus}$ matrix.
2. Symmetrical fault analysis.
3. Line to ground fault analysis.
4. Double line fault analysis.
5. Double line to ground fault analysis.
6. Load flow analysis using the Gauss-Seidel method.
7. Load flow analysis using the Newton-Raphson method.
8. To solve the swing equation.

Text Books:

1. W. D. Stevenson, Jr. "Elements of Power System Analysis", Mc Graw Hill
2. C. L. Wadhwa, "Electrical Power System", New Age International
3. J. Nagrath and D. P. Kothari, "Power System Enginerring", TMH

Reference Books:

1. Chakraborthy, Soni,Gupta & Bhatnagar, "Power System Engineering", Dhanpat Rai & Co.
2. T. K Nagsarkar & M.S. Sukhija, "Power System Analysis" Oxford University Press, 2007.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-306	Power System-II	4(3-0-2)	15	20	15	50	50	100

NEE-308	ADVANCED CONTROL SYSTEMS	L T P: 3 1 0	Credits: 4	Type: PCC

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of advanced control. The course includes understanding of control elements, linear and non-linear control, mathematical modeling, stability analyses and compensation. This course also gives an insight into contemporary industrial control systems.

Prerequisites: Introduction to Electrical Engineering, Engineering Mathematics, Measurement and Instrumentation, Control Systems.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Able to know modelling of control systems	K1, K2, K4
CO2	Able to understand the concepts of digital control systems and stability analysis	K1, K2, K3, K4
CO3	Demonstrate fundamental understanding of non-linear control Systems	K2, K3, K5
CO4	Exhibit the knowledge of optimal control	K1, K2, K3, K4
CO5	Exhibit the knowledge of the adaptive control	K2, K3, K4

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	2
CO2	2	1	3	1	1	2	2	-	1	-	1	2
CO3	2	1	1	-	1	3	1	-	1	1	1	2
CO4	1	2	1	2	1	2	1	-	2	-	1	2
CO5	2	2	2	1	1	2	2	1	2	-	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

State Space Analysis of Continuous System: (7 Lectures)

Review of state variable representation of continuous system, State transition matrix, Solution of State equations, Concept of Controllability and Observability, Design of state observer and controller.

Module 2

Analysis of Discrete System: (8 Lectures)

Discrete system and discrete time signals, state variable model and transfer function model of discrete system, conversion of state variable model to transfer function model and vice-versa, modeling of sample-hold circuit, solution of state difference equations, steady state accuracy, stability on the z-plane and Jury stability criterion, bilinear transformation, Routh-Hurwitz criterion on r-th planes.

Module 3

Analysis of Non-linear System : (10 Lectures)

Lyapunov's stability theorems. Methods for generating Lyapunov functions.

Non-linear System: Types of non linearities. phenomena related to non - linear systems. Analysis of non-linear systems-Linearization method, second order non-linear system on the phase plane, types of phase portraits, singular points, system analysis by phase-plane method, describing function and its applications.

Module 4

Optimal Control: (8 Lectures)

Introduction, formation of optimal control problem, Calculus of variations, minimization of functions, Pontryagin's Minimum Maximum Principle, Linear Quadratic Problem - Hamilton Jacobi equation, Riccati equation and its solution.

Module 5

Adaptive Control: (7 Lectures)

Introduction, Modal reference adaptive control systems, Self tuning regulators, Introduction to neural network, fuzzy logic and genetic algorithms.

Text Books / Reference Books:

1. M. Gopal, "Digital Control and State variable Methods", Tata Mc Graw Hill
2. Ajit K. Mandal, "Introduction to Control Engineering: Modelling, Analysis and Design" New Age International.
3. Yaduvir Singh & S. Janardhanan, "Modern Control Engineering", Cengage Learning
4. S.Rajasekaran & G.A.Vjayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Alogorithms: Synthesis and Applications" Prentice Hall of India.
5. Donald E. Kiv, "Optimal Control Theory: An Introduction" Prentice Hall
6. B. C. Kuo, "Digital Control Systems" Sounders College Publishing
7. C. H. Houpis, G. B. Lamont, "Digital Control Systems: Theory, Hardware, Software", Mc Graw Hill.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PCC	NEE-308	Advanced Control Systems	4(3-1-0)	30	20	-	50	50	100

List of Programme Electives-I

NEE-310	HVDC TRANSMISSION SYSTEMS	L T P: 3 0 0	Credits: 3	Type: PEC-I

OBJECTIVE:

This course will provide a good understanding to the students in the area of high voltage DC transmission system. The course includes various methods of improving power system stability using HVDC system and converters used in HVDC system.

Prerequisites: Introduction to Electrical Engineering, Power System-I & Power System-II

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Advantages of DC transmission over AC transmission.	K1, K2
CO2	Operation of Line Commutated Converters and Voltage Source Converters	K1, K2, K3, K4
CO3	Control strategies used in HVDC transmission system.	K2, K3, K4
CO4	Components used in HVDC system.	K1, K2, K4
CO5	Improvement of power system stability using an HVDC control.	K1, K2, K3, K4, K5

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	1	1	-	1	-	1	2
CO2	2	2	3	2	1	2	1	-	2	-	1	3
CO3	2	1	3	1	1	2	1	-	1	1	1	2
CO4	2	1	3	1	1	2	1	-	1	1	1	2
CO5	2	1	3	1	1	2	1	-	1	1	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course content:

Module 1

DC Transmission Technology (6 hours)

Comparison of AC and dc Transmission (Economics, Technical Performance and Reliability). Application of DC Transmission. Types of HVDC Systems. Components of a HVDC system. Line Commutated Converter and Voltage Source Converter based systems.

Module 2

Analysis of Line Commutated and Voltage Source Converters (6 hours)

Line Commutated Converters (LCCs): Six pulse converter, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap. Voltage Source Converters (VSCs): Two and Three-level VSCs. PWM schemes.

Module 3

Control of HVDC Converters: (6 hours)

Principles of Link Control in a LCC HVDC system. Control Hierarchy, Firing Angle Controls – Phase-Locked Loop, Current and Extinction Angle Control, Starting and Stopping of a Link. Power control, Frequency Control, Stability Controllers. Reactive Power Control.

Module 4

Components of HVDC Systems: (6 hours)

Smoothing Reactors, Reactive Power Sources and Filters in LCC HVDC systems. DC line faults in LCC systems. DC line faults in VSC systems. DC breakers. Monopolar Operation, Ground Electrodes.

Module 5

Stability Enhancement using HVDC Control (6 hours)

Basic Concepts: Power System Stability and its improvement. Multi-Terminal and Multi-Infeed Systems. Series and Parallel MTDC systems using LCCs. MTDC systems using VSCs. Modern Trends in HVDC Technology. Introduction to Modular Multi-level Converters.

Text / References:

1. K. R. Padiyar, "HVDC Power Transmission Systems", New Age International Publishers, 2011.

2. J. Arrillaga, "High Voltage Direct Current Transmission", Peter Peregrinus Ltd., 1983.

3. E. W. Kimbark, "Direct Current Transmission", Vol.1, Wiley-Interscience, 1971.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-I	NEE-310	HVDC Transmission Systems	3(3-0-0)	30	20	-	50	50	100

NEE-312	ELECTRICAL ENERGY CONSERVATION AND AUDITING	L T P: 3 0 0	Credits: 3	Type: PEC-I

OBJECTIVE:

The objective of this course is to make students learn in the area of electrical energy conservation and auditing. The course includes: Basic Energy scenario, concepts of Energy management, Electricity tariffs and various methods of improving energy efficiency.

Prerequisites: Engineering Mathematics, Engineering Physics, Introduction to Electrical Engineering.

Course Outcomes:

On the successful completion of the course, students will be able to

CO1	Understand the energy scenario and importance of Electrical energy conservation.	K1, K2
CO2	Understand the concepts of energy management.	K3, K4
CO3	Analyze the Electricity tariff, load management related to Electrical systems.	K4, K5
CO4	Understand the methods of improving energy efficiency in different Electrical systems.	K2, K5
CO5	Understand the concepts of different energy efficient devices.	K2, K4, K6

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	-	-	2	-	-	1	-	-	2
CO2	3	2	1	-	-	2	2	-	-	1	-	1
CO3	2	3	3	2	2	3	2	1	2	2	1	1
CO4	2	2	3	2	3	3	2	-	1	1	-	1
CO5	3	2	3	2	3	2	-	-	1	1	1	-

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module -1: Energy Scenario (5 Hours):

Introduction and Motivation for Energy Conservation, Principles of Energy Conservation, Energy Conservation in Industries, Energy Conservation in Electrical Generation, Transmission and Distribution, Energy conservation Act-2001 and its features.

Module-2: Basics of Electrical Energy and its various forms (5 Hours):

Electricity tariff, load management and maximum demand control, Thermal Basics-fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

Module-3: Energy conservation in Electrical Systems (6 Hours):

Energy saving opportunities in electric motors, Energy conservation by VSD, Energy conservation in electric furnaces, ovens and boilers., lighting techniques – Natural , CFL, LED lighting sources and fittings.

Module-4: Energy efficiency in Electrical systems (8 Hours):

Electricity billing, energy saving opportunities with energy efficient motors, Electricity Act-2003, Renewable energy Act 2015, Case studies of implemented energy cost optimization projects in electrical utilities.

Module-5: Energy Audit (6 Hours):

Aim of Energy Audit, Energy Flow Diagram, Strategy of Energy Audit, Comparison with Standards, Energy Management Team, impact of renewable energy on energy audit recommendations. Instruments for Energy Audit.

Text Books:

1. S. Sivaganaraju, Electric Energy Generation, Utilisation and Conservation, Pearson Publisher, New Delhi.

2. V. K. Mehta, Electrical Power, Khanna and Khanna Publishers, New Delhi

3. S. C. Tripathy, "Utilization of Electrical Energy and Conservation", McGraw Hill, 1991.

4. Gupta B. R.: Generation of Electrical Energy, Eurasia Publishing House Pvt. Ltd., New Delhi.

Reference Books:

1. S. L. Uppal, Electrical Power, Khanna and Khanna Publishers, New Delhi

2. Paul O Callaghan, Energy Management, Tata Mcgraw Hill, New Delhi

3. Success stories of Energy Conservation by BEE, New Delhi.

4. J. Nanda and D.P. Kothari: Recent Trends in Electric Energy Systems, Prentice Hall of India Pvt. Ltd, New Delhi.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-I	NEE-312	Electrical Energy Conservation and Auditing	3(3-0-0)	30	20	-	50	50	100

NEE-314	SPECIAL ELECTRICAL MACHINES	L T P: 3 0 0	Credits: 3	Type: PEC-I

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of special electrical machines. At the end of this course, students will have the ability to demonstrate and implement concepts, and the knowledge gained about Special AC Machines, Devices, Linear Machines, Linear Electric Motors and Advanced Motors and Drive.

Prerequisites:

Engineering Mathematics, Electrical Machine - I, Electrical Machine - II

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Demonstrate fundamental understanding of Special AC Machines	K4, K5
CO2	Develop the mathematical models	K2, K4
CO3	Exhibit the knowledge of Devices	K2, K3, K4
CO4	Able to know Linear Machines	K1, K2
CO5	Able to understand and apply knowledge of Linear Electric Motors	K2, K3
CO6	Exhibit the knowledge of Advanced Motors and Drive Systems	K1, K2

K1 - Remember, K2 - Understand, K3 - Apply, K4 - Analyze, K5 - Evaluate, K6 - Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	2
CO2	2	1	2	1	1	2	1	-	1	-	1	2
CO3	2	1	1	-	1	3	1	-	1	-	1	2
CO4	1	2	1	1	1	2	1	-	2	-	1	2
CO5	2	2	2	1	1	2	1	-	2	-	2	2
CO6	2	1	1	1	1	1	1	-	1	-	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Special AC Machines: (6 Lectures)

Constructional aspects, design and analysis of reluctance, shaded pole, hysteresis, printed circuit, and claw motors, Servomotors and A.C. Tacho - generators, Research Paper(s) Study, Industrial Applications, Local, National and Global needs.

Module 2

Devices: (6 Lectures)

Introduction of permanent magnet materials, angled field and axial field devices, cross-field machines, special forms of rotating amplifiers, electromagnetic clutches, coupling and brakes, eddy current devices, Environmental Considerations, Industrial Applications, Local, National and Global needs.

Module 3

Linear Machines: (6 Lectures)

Linear devices and actuators, Linear electric machines: Classification, application, constructional aspects, design and method of analysis of various types, Goodness factor, Industrial Applications.

Module 4

Linear Electric Motors: (6 Lectures)

Transverse-edge, entry-end, exit end, short primary, short secondary effects in linear electric motors, Force, energy and power LEMs for low speed medium speed and high speed applications. Electromagnetic levitation and guidance schemes-attraction, repulsion, Industrial Applications.

Module 5

Advanced Motors and Drive Systems: (6 Lectures)

Principle, construction, operation and drive application of Square wave Permanent Magnet (PM) brushless motor drives, sine wave PM brushless motor drives, PM and synchronous reluctance based motors, switched reluctance motors, Energy efficient motors, Research Paper(s) Study, Industrial Applications, Local, National and Global needs.

Reference Books

1. B.K. Bose, Power Electronics and variable frequency drives, Prentice Hall, New Jersey, 2004.

2. T.J.E. Miller, Brushless permanent magnet and reluctance motor drives, Oxford University Press, UK, 2001.

3. S.A. Nasar, Linear induction motor, John Wiley, New York, 2000.

Text Books

1. J. C. Andreas, Energy Efficient Motors, Marcel Dekker, 1994.

2. J.M.P. Murphy, Power Electronics control of AC Drives, Pergamon Press, 1998.

NPTEL web links for Study Material / Course:

https://www.digimat.in/nptel/courses/video/108102156/L01.html

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-I	NEE-314	Special Electrical Machines	3(3-0-0)	30	20	-	50	50	100

NEE-316	WIND AND SOLAR ENERGY SYSTEMS	L T P: 3 0 0	Credits: 3	Type: PEC-I

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of wind and solar non-conventional energy resources. The course includes understanding of energy generation, conventional and non-conventional resources comparisons, mathematical modeling, performance analyses and applications. This course also gives an insight into contemporary energy issues.

Prerequisites: Fundamental knowledge of Electrical Machines and Power Electronics.

Course Outcomes:

On the successful completion of this course, students will be able to

CO1	Energy scenario and the consequent growths of the power generate renewable energy sources	K1, K2
CO2	Basic physics of wind power generation	K2, K3
CO3	Basic physics of solar power generation	K1, K2, K3
CO4	Power electronic interfaces for wind and solar generation	K2, K3, K4
CO5	Issues related to the grid-integration of solar and wind energy systems	K2, K3, K4

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1O	PO11	PO12
CO1	3	2	2	1	-	1	-	-	-	-	-	2
CO2	3	2	2	1	-	1	-	-	-	-	-	2
CO3	3	2	2	2	-	1	-	-	-	-	-	2
CO4	3	3	3	2	2	1	1	-	1	-	1	1
CO5	3	3	2	3	2	1	1	-	2	-	1	2

Course Content:

Module 1

Power Scenario: (6 Lectures)

Distribution of non-renewable and renewable installed capacity, Renewable energy types: solar, wind, small-hydro, marine, fuel cells, and biomass etc., Modes of operation: Standalone, grid connected and hybrid systems.

Module 2

Wind Energy Systems – I: (6 Lectures)

Introduction, Basic Principles of Wind Energy Conversion, History of Wind Energy, Wind Energy Scenario, The Power in the Wind, Forces on the Blades, Wind Energy Conversion, and Windmills.

Module 3

Wind Energy Systems – II: (6 Lectures)

Power and wind speed characteristics, Fixed speed and Variable speed wind turbines, Synchronous generator, PMSG, Induction generator, Doubly fed synchronous generator, Land vs. offshore wind turbines, Grid connected application, fully rated and partially rated converters control, rectifier-inverter system.

Module 4

Solar Energy Systems – I: (6 Lectures)

Solar Photovoltaic Systems: Introduction, Solar Cell Fundamentals, Solar Cell I-V and P-V Characteristics, Solar Module, and Array Construction, PV model and equations, efficiency, Series and parallel PV modules, partial shading condition, effect of bypass and blocking diodes, local and global maxima.

Module 5

Solar Energy Systems – II: (6 Lectures)

Open and closed loop MPPT methods, Hill-climbing/P&O and Incremental Conductance methods, DC-DC converters for MPPT, charge controller, Design methodology with and without energy storage, Grid connected and standalone PV system, Balance of system, PV string and array sizing, Battery bank, PCU, Inverter etc.

Text Books / Reference Books:

1. Chetan Singh Solanki, Solar Photovoltaics: Fundamental, Technologies and Applications, (2nd edition), PHI Learning Pvt. Ltd., 2011.

2. Chetan Singh Solanki, Solar Photovoltaics: Technology and Systems: A manual for Technicians, Trainers and Engineers, PHI Learning Pvt. Ltd., 2014.
3. Mukund R. Patel, Wind and Solar Power Systems, CRC Press LLC, 1999.
4. S. N. Bhandra, D. Kastha and S. Banerjee, Wind Electrical Systems, Oxford University Press, 2005.
5. M. H. Rashid, Power Electronics Handbook, Academic Press, Florida, 2001.
6. Deb Tanmoy, Electrical Power Generation Conventional and Renewable", Khanna Publisher.
7. Bansal N. K., Non-Conventional Energy Resources, Vikas Publishing House.
8. Saeed S. H. and Sharma D. K., Non-Conventional Energy Resources (2nd Edition), S. K. Kataria & Sons, 2009.
9. Sawhney G. S., Non-Conventional Energy Resources, Prentice Hall of India.
10. Khan B. H., Non-Conventional Energy Resources", Mc-Graw Hill Education (3rd edition)

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-I	NEE-316	Wind and Solar Energy Systems	3(3-0-0)	30	20	-	50	50	100

List of Programme Electives-II

NEE-401	SPECIAL TOPICS IN CONTROL SYSTEMS	L T P: 3 1 0	Credits: 4	Type: PEC-II

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of special topics in control systems. The course includes study of reduced order modeling, neural networks, fuzzy logic, optimal control system and non-linear systems. This course also gives an insight into artificial intelligence.

Prerequisites: Engineering Mathematics, Introduction to Electrical Engineering, Control Systems.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Able to know about reduced order modeling	K1, K2, K3, K4
CO2	Able to understand the concept of sliding mode control	K1, K2, K3, K5
CO3	Evaluating various aspects of neural networks	K1, K2, K3, K4, K5
CO4	Understand various aspects of fuzzy logic	K1, K2, K3, K4
CO5	Able to understand and apply the concepts of optimal and adaptive control.	K1, K2, K3, K4, K5

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	2
CO2	3	1	2	1	1	2	1	-	1	-	1	2
CO3	3	1	3	-	1	2	1	1	1	-	2	2
CO4	2	1	2	1	1	2	1	-	2	1	1	3
CO5	3	1	2	2	2	2	1	2	2	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Introduction to Reduced Order Modeling: (8 Lectures)

Model Order Reduction: Importance of Reduced-order models, Frequency domain Classical techniques, Introduction to Time domain techniques.

Module 2

Sliding Mode Control: (8 Lectures)

Sliding mode control: Concept of variable-structure controller and sliding control, reaching condition and higher order sliding mode. reaching mode. implementation of switching control laws. Reduction of chattering in sliding and steady state mode.

Module 3

Introduction to Neural Networks and its Applications: (8 Lectures)

Introduction, Neuron model, Activation functions, Perceptrons, Multilayer networks, Back propagation algorithm, Recurrent Neural Networks, Supervised and Unsupervised Learning, Prediction using Neural Networks.

Module 4

Introduction to Fuzzy Control Systems and its Applications: (8 Lectures)

Basics of Set Theory and Fuzzy Arithmetic, Crisp Sets versus Fuzzy Sets, Operation, Relation and composition of sets, Fuzzification and Defuzzification methods, Fuzzy Logic Controllers and its applications.

Module 5

Optimal and Adaptive Control: (8 Lectures)

Formulation of Optimal Control Problem, Performance Indices, Euler-Lagrange Equation, Linear Quadratic Regulator, Model Reference Adaptive Control and Self-Tuning Regulators, Riccati Equation and its Solution.

Text Books

1. H. K. Khalil: Nonlinear control Systems, Prentice Hall, NJ, 1996

2. D.E. Kirk: Optimal Control Theory: An introduction, Prentice Hall, NJ, 1970

3. Simon Haykin: Neural networks - A comprehensive foundation

4. Vijaylaxmi and Pai: Fuzzy Logic, Neural Netwroks and Genetic Algorithms, PHI

Reference Book

1. T. J. Ross: Fuzzy logic: With Engineering applications

2. J. J. E. Slotine: Applied Nonlinear Control

3. M. S. Mahmoud and M. G. Singh: Large scale systems modelling

4. G. Obinata and B. D. O. Anderson: Model reduction for control system design

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-II	NEE-401	Special Topics in Control Systems	4 (3-1-0)	30	20	-	50	50	100

NEE-403	POWER SYSTEM DESIGN	L T P: 3 1 0	Credits: 4	Type: PEC-II

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of power system design. The course includes understanding of conductors, insulators and substation. This course also gives an insight into testing and commissioning of overhead distribution line

Prerequisites: Introduction to Electrical Engineering, Power System-I, Power System-II, Electrical Machines-I, Electrical Machines-II.

Course Outcomes:

On the successful completion of the course, students will be able to

CO1	Able to understand concept of power system	K1, K2
CO2	Able to design transmission Line	K1, K2, K3, K4
CO3	Exhibit the knowledge of overhead line insulators	K4, K5
CO4	Exhibit the knowledge of testing and commissioning of overhead distribution line	K1, K2, K3, K4
CO5	Demonstrate fundamental understanding of design aspects of substation	K1, K2, K3, K4

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	1	1	-	1	-	1	2
CO2	2	2	3	2	1	2	1	-	2	-	1	3
CO3	2	1	3	1	1	2	1	-	1	1	1	2
CO4	2	1	3	1	1	2	1	-	1	1	1	2
CO5	2	1	3	1	1	2	1	-	1	1	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Introduction: (8 Lectures)

Introduction, Typical AC electrical power system, Main components of overhead lines, Introduction to desirable attributes of protection, circuit breakers, trip circuit of a circuit breaker, CTs & PTs, Functional characteristics of a relay, zone of protection, primary and backup protection.

Module 2

Conductor Selection: (8 Lectures)

Determination of size of conductor for overhead transmission line and cable, Cross arms, Pole brackets and clamps, Conductors configuration spacing and clearances, Span lengths.

Module 3

Insulators: (8 Lectures)

Overhead line insulators, Insulator materials, Types of insulators, Lightning Arrestors, Erection of supports, Fixing of insulators, Conductor erection, Positioning of conductors and attachment to insulators.

Module 4

Earthing, Testing and Commissioning: (8 Lectures)

Earthing of transmission lines, Guarding of overhead lines, Clearances of conductor from ground, Spacing between conductors, Testing and commissioning of overhead distribution line.

Module 5

Design and Estimation of Substation: (8 Lectures)

Introduction, Classification, Selection and location, Main Electrical Connections, Graphical symbols for various types of apparatus and circuit elements on substation main connection diagram, Key diagram of typical substations.

Text Books

1. Raina K.B. and Bhattacharya S.K., "Electrical Design, Estimating and Costing", New Age International, New Delhi, 2010
2. N. Alagappan & S. Ekambaram, "Electrical Estimating & Costing", TMH, 2006
3. Dr.S. L. Uppal., "Electrical Wiring, Estimating and Costing", 5th Edition, Khanna Publishers, 2003.

Reference Books

1. M.V. Deshpande, "Elements of Electrical Power Station Design", PHI, 2009
2. J. B. Gupta, "A Course in Electrical Installation Estimating and Costing", S. K. Kataria and Sons, India, 2013
3. ISI, National Electric Code, Bureau of Indian Standard Publications, New Delhi, 2011

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-II	NEE-403	Power System Design	4(3-1-0)	30	20	-	50	50	100

NEE-405	ADVANCED POWER ELECTRONICS	L T P: 3 1 0	Credits: 4	Type: PEC-II

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of Advanced Power Electronics. The course includes: Review of Power semiconductor devices, Conventional and higher number of pulse rectifiers, Improved Quality AC-DC Rectifier and Choppers, AC to AC Converters and Multi-Level Inverters.

Prerequisites: Power Electronics.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Demonstrate the ability to understand various power electronics devices and difference between signal level and power level devices.	K1, K2
CO2	Demonstrate the ability to analyze and design DC-DC Converters and Power Supplies.	K3, K4
CO3	Demonstrate the ability to analyze and design of DC-AC Converters.	K4, K5
CO4	Demonstrate the ability to analyze and design AC-DC Multipulse Controllers.	K3, K4, K5
CO5	Demonstrate the ability to analyze and design of AC-AC Converters.	K1, K5

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1O	PO11	PO12
CO1	2	1	1	1	-	-	-	-	-	-	-	-
CO2	2	2	3	1	-	-	-	-	-	-	-	-
CO3	3	3	3	2	2	-	-	-	-	-	-	1
CO4	3	3	3	2	2	1	-	-	-	-	-	1
CO5	3	3	3	3	3	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-'

Course Content:

Module 1

Review of Power Semiconductor Devices: (8 Lectures)

Review of Power diodes and SCR; Modern semiconductor devices: MOSFET, GTO, IGBT, GTO operating characteristics; driving circuits and protection, Comparison of switch ratings and Application area.

Module 2

DC-DC Converters and Power Supplies: (8 Lectures)

Non-isolated converters: Buck, Boost, Buck-boost, Cuk, Sepic, Bipolar and Unipolar modulations, Isolated Converters: Forward, Flyback, Push-pull, half bridge, Full Bridge.

Module 3

DC-AC Inverters (8 Lectures)

Square wave, PWM, Sinusoidal PWM, Bipolar and Unipolar, Linear and over modulations, three-phase square wave and SPWM, Multilevel Inverters.

Module 4

AC-DC Rectifiers (8 Lectures)

PWM converter, power factor improvement techniques, multi-pulse converters.

Module 5

AC-AC Conversion (8 Lectures)

Three-phase ac regulators, Single-phase and three-phase Cyclo-converters; Matrix converters.

Text / References Books:

1. M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 2009.

2. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.

3. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2007.

4. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.

5. Bose B.K., "Power Electronics and Variable Frequency Drives –Technology and Applications", IEEE Press, Standard Publisher Distributors 2001

6. Dubey G. K., Doradla S. R., Joshi A. and Sinha R. M. K., "Thyristorised Power Controllers", New Age International Private Limited, 2008.

Web Reference:

1. Video/Web contents on NPTEL

2. IEEE Journal Papers

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-II	NEE-405	Advanced Power Electronics	4(3-1-0)	30	20	-	50	50	100

NEE-407	POWER SYSTEM DYNAMICS AND CONTROL	L T P: 3 1 0	Credits: 4	Type: PEC

OBJECTIVE:

The objective of this course is to make students learn the basic principles of power system operation and modeling of various power system components. The students will acquire the knowledge of modeling of synchronous machine, induction machine, excitation system, prime mover and electrical loads etc., which will enable them to understand and critically interpret the primary research in the area of power system engineering.

Course outcome

On the successful completion of the course, students will be able to

CO1	The problem of power system operation and linear dynamical system	K1, K2, K4
CO2	Model Synchronous machines for the study of stability	K2, K3, K4
CO3	Model excitation systems and prime movers for the study of stability	K2, K3, K4
CO4	Model transmission lines and loads for dynamic analysis	K2, K3, K4
CO5	Analyze Power System stability and its improvement	K2, K4

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	2	-	2	-	-	-	-	3
CO2	3	3	1	3	2	-	2	-	-	-	-	3
CO3	3	3	1	3	2	-	2	-	-	-	-	3
CO4	3	3	1	3	2	-	2	-	-	-	-	3
CO5	3	3	1	3	2	-	2	-	-	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation put "-".

Course Content:

Module 1

Introduction to Power System Operations and Linear Dynamical System: (8 hours)

Introduction to power system stability and power system operations & control, stability problems in power system, analysis of dynamical system, concept of equilibrium, small and large disturbance stability.

Module 2

Modeling of Synchronous Machines: (8 hours)

Modeling of synchronous machine: physical characteristics, rotor position dependent model, d-q transformation, model with standard parameters, steady state analysis of synchronous machine, short circuit transient analysis of a synchronous machine.

Module 3

Modeling of Excitation Systems and Prime Movers: (8 hours)

Excitation system requirements, types of excitation system, modeling of excitation systems, excitation system control, automatic voltage regulator, modeling of prime mover systems, prime mover control systems, speed governors.

Module 4

Modeling of Transmission Lines and Loads for Dynamic Analysis: (8 hours)

Transmission line physical characteristics, transmission line modeling, load models - Induction machine model, frequency and voltage dependence of loads, other subsystems – HVDC and FACTS controllers.

Module 5

Stability Analysis of Power System: (8 hours)

Small signal and transient stability, angular stability analysis in single machine infinite bus system, angular stability in multi-machine systems, single machine load bus system, voltage stability, load sharing, governor droop, stability improvement.

Text / Reference Books

1. K.R. Padiyar, "Power System Dynamics, Stability and Control", B. S. Publications, 2002.
2. P. Kundur, "Power System Stability and Control", McGraw Hill, 1995.
3. P. Sauer and M. A. Pai, "Power System Dynamics and Stability", Prentice Hall, 1997

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-II	NEE-407	Power System Dynamics and Control	4(3-1-0)	30	20	-	50	50	100

List of Programme Electives-III

NEE-409	OPTIMAL CONTROL SYSTEM	L T P: 3 0 0	Credits: 3	Type: PEC-III

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of optimal control systems. The course includes study of optimal control of continuous-time systems and discrete time systems. This course also gives an insight into dynamic programming.

Prerequisites:

Engineering Mathematics, Engineering Physics, Basic Electrical Engineering, Measurement Science and Technique, Control System

Course Outcomes:

On the successful completion of this course, students will be able to

CO1	Able to know about types of optimal control systems	K1, K2
CO2	Able to do design of optimal control of continuous time systems	K1, K2, K3, K4
CO3	Able to do design of optimal control of discrete time systems	K2, K3, K4, K5
CO4	Understand various aspects of dynamic programming	K2, K3, K4
CO5	Able to understand and apply robust control	K2, K3, K4, K5

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	2	1	-	-	-	-	2
CO2	3	1	2	1	1	2	1	-	1	-	1	3
CO3	2	1	3	-	1	2	1	1	1	-	2	3
CO4	2	1	2	-	1	2	1	-	2	1	1	3
CO5	1	1	2	3	2	2	1	2	2	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course content:

Module 1

Introduction: (6 Lectures)

Problem formulation, State variable representation, Static optimization, Optimization without constraints, Optimization with equality constraints.

Module 2

Optimal Control of Continuous-Time System: (6 Lectures)

Calculus of variations, functional of a single function, functional involving several functions, Continuous-time Linear Quadratic Regulator (LQR). Steady state closed-loop control, and tracking problem.

Module 3

Optimal Control of Discrete-time System: (6 Lectures)

Solution of the general Discrete-time Optimization problem, Discrete-time LQR, Digital Control of Continuous-time systems, Frequency domain results.

Module 4

Dynamic Programming: (6 Lectures)

Bellman's principle of optimality, Computational procedure for solving control problems, Hamilton-Jacobi-Bellman equation, Linear regulator problems.

Module 5

Robustness and Multivariable Frequency-domain Techniques: (6 Lectures)

Robust output-feedback design, Observers and Kalman filter, Linear Quadratic Gaussian (LQG), Loop-transfer recovery (LTR).

Text Books:

1. A. P. Sage, "Optimal System Control," Prentice-Hall, Englewood Cliffs, New Jersey, 1968.

2. D. E. Kirk, "Optimal Control Theory- An Introduction," Dover Publications, 2012.

3. Frank L. Lewis, D. L. Vrabie, V. A. Syrmos, "Optimal Control," New York: Wiley, 3rdEdition, 1986.

Reference Books:

1. Lawrence C. Evans, "An Introduction to Mathematical Optimal Control Theory," University of California, Berkeley 2010

2. Richard Weber, "Optimization and Control," Universily of Cambridge, 2010

3. Brian D. O. Anderson and John B. Moore, "Optimal Control: Linear Quadratic Methods," Dover Publications Inc., 2007.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-III	NEE-409	Optimal Control System	3(3-0-0)	30	20	-	50	50	100

NEE-411	POWER SYSTEM PROTECTION	L T P: 3 0 0	Credits: 3	Type: PEC-III

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of Power System Protection. The course includes: construction and working of different types of relays, implementation of suitable protection schemes for different electrical equipments, applying the knowledge of arc extinction in developing various types of Circuit breakers and analyzing the causes of over voltage phenomenon and remedies for it.

Prerequisites: Introduction to Electrical Engineering, Power system-I, Power system-II, Electrical Machines-I, Electrical Machines-II.

Course Outcomes:

On the successful completion of the course, students will be able to

CO1	Able to design relay for various types of faults on the system	K1, K2, K6
CO2	Understand the protection schemes for different power system components	K2, K4
CO3	Apply the knowledge of the arc development and its extinction to design suitable CB	K1, K2, K3, K6
CO4	Understand the working principles and types of various circuit breakers used in power system protection	K1, K2
CO5	Analyze the causes of over voltages on system and use suitable device to control it	K2, K4

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	-	2	1	-	1	-	-	1
CO2	3	3	1	3	2	2	1	-	2	-	1	1
CO3	2	1	1	1	2	2	1	-	1	-	1	1
CO4	3	2	2	1	3	2	1	-	2	-	1	1
CO5	3	2	2	1	2	2	1	-	1	2	1	1

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course content:

Module 1

Protective Relays: (6 Lectures)

Introduction and philosophy of protective relaying, Basic principles, construction and characteristics of electromagnetic relays, over current relays, differential relays, distance relays, static relays.

Module 2

Protection Scheme: (6 Lectures)

Protection of generators, transformers, bus bars, transmission line and motors, Computer aided protection.

Module 3

Arc Interruption Theory: (6 Lectures)

Formation and extinction of arcs, arc properties, Re-striking and recovery voltage, Different methods and control devices for arc extinction, Resistance and Capacitor switching, Current chopping.

Module 4

Circuit Breakers: (6 Lectures)

Different types of circuit breakers their construction, working principle and field of application, C. B. duties, ratings and testing.

Module 5

Power System Transients: (6 Lectures)

Over voltages in transmission lines, lightning and switching surges, Transmission, reflection and refraction of surges, Ground wires, Spark gaps, Lightning arrestors, BIL and insulation coordination.

Text Books / Reference Books:

1. B. Ram and Vishwakarma Power System Protection & Switchgear,(TMH).
2. Ravindranath and Chander P. S. Protection & Switchgear, (Wiley Eastern).
3. C.R. Mason, Art and Science of Protection Relaying (Wiley Eastern).
4. Pataithankar and Bhide, Fundamentals of Power System Protection,(PHI).
5. Oza, Nair, Mehta and Makwana, Power System Protection & Switchgear, TMH.
6. Sunil S. Rao.: Power System Protection and Switch Gear, Khanna Publishers

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC	NEE-411	Power System Protection	3(3-0-0)	30	20	-	50	50	100

NEE-413	ELECTRICAL DRIVES	L T P: 3 0 0	Credits: 3	Type: PEC

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of Electric Drives. The course includes: Fundamentals of Electric Drives, Dynamics of Electric Drives, Converters & Chopper fed DC drives, Induction Motor Drives Fundamental, Power Electronic Control of AC Drives. At the end of this course students will demonstrate the ability to understand the Fundamentals of Electric Drive, characteristics of dc motors and induction motors, principles of speed-control of dc motors, speed-control of induction motors. Students will demonstrate the ability to design and analyse power electronic converters used for speed control of DC and AC motors.

Prerequisites: Power Electronics, Electrical Machines-I, Electrical Machines-II.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Understand the Fundamentals of Electric Drive	K1, K2
CO2	Understand the Dynamics of Electric Drives	K2, K4
CO3	Understand the principles of speed-control of dc motors	K3, K4
CO4	Understand the principles of speed-control of induction motors.	K3, K4
CO5	Design and Analyse power electronic converters used for speed Control of AC motors.	K5, K6

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1	-	-	-	-	-	-	-	-
CO2	2	2	2	1	-	-	-	-	-	-	-	-
CO3	3	3	3	2	2	-	-	-	-	-	-	1
CO4	3	3	2	2	2	1	-	-	-	-	-	1
CO5	3	3	3	3	3	2	1	-	-	-	-	1

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-'

Module 1

Fundamentals of Electric Drives: (6 Lectures)

Electric Drives and its parts, advantages of electric drives, Classification of electric drives, Speed-torque conventions and multi-quadrant operations, Constant torque and constant power operation, Types of load, Load torque: components, nature and classification.

Module 2

Dynamics of Electric Drives: (6 Lectures)

Dynamics of motor-load combination; Steady state stability of Electric Drive; Transient stability of electric Drive, Selection of Motor Power rating; Thermal model of motor for heating and cooling, classes of motor duty, determination of motor power rating for continuous duty, short time duty and intermittent duty. Load equalization.

Module 3

Converters & Chopper Fed DC Drives: (6 Lectures)

Single phase and three phase controlled converter fed separately excited dc motor drives, Chopper control of separately excited dc motor and dc series motor drive, Control structure of DC drive, closed loop control of DC Motor drive, inner current loop and outer speed loop.

Module 4

Induction Motor Drives Fundamental: (6 Lectures)

Review of three-phase voltage source inverter, constant V/f control of induction motor, steady-state performance analysis based on equivalent circuit, speed drop with loading, slip regulation.

Module 5

Power Electronic Control of AC Drives: (6 Lectures)

Three Phase induction Motor Drive, Static Voltage control scheme, static frequency control scheme (and cyclo-converter base), static rotor resistance and slip power recovery control schemes.

Text Books

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. S. K. Pillai, "A First Course on Electric Drives", New Age International.

Reference Books

1. W. Leonhard, "Control of Electric Drives", Springer Science & Business Media, 2001.

2. M.Chilkin, "Electric Drives", Mir Publishers, Moscow.

3. Mohammed A. El-Sharkawi, "Fundamentals of Electric Drives", Thomson Asia, Pvt. Ltd. Singapore.

4. N.K. De and Prashant K.Sen, "Electric Drives", Prentice Hall of India Ltd.

5. V.Subrahmanyam, "Electric Drives: Concepts and Applications", Tata McGraw Hill.

Web Reference:

1.Video/Web contents on NPTEL

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-III	NEE-413	Electrical Drives	3(3-0-0)	30	20	-	50	50	100

NEE-415	ROBOTICS AND AUTOMATION	L T P: 3 0 0	Credits: 3	Type: PEC-III

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of robotics. The course includes understanding of nonlinear control systems. This course also gives an insight into design of observer.

Prerequisites:

Engineering Mathematics, Control System, Measurement Science Techniques

Course Outcomes:

On the successful completion of the course, students will be able to

CO1	Able to know about robotic system	K1, K2
CO2	Able to understand and apply dynamics and control	K2, K3
CO3	Demonstrate fundamental understanding of system stability	K4, K5
CO4	Develop the mathematical model of robots	K2, K4
CO5	Exhibit the knowledge of nonlinear control, observer based control robust control	K2, K4, K3
CO6	Exhibit the knowledge of the robotic system design	K1, K2

K1 - Remember, K2 - Understand, K3 - Apply, K4 - Analyze, K5 - Evaluate, K6 - Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	2	1	-	-	-	-	1
CO2	2	1	2	1	1	2	1	-	1	-	1	2
CO3	2	1	1	-	1	3	1	-	1	-	1	2
CO4	1	2	1	1	1	2	1	1	2	1	1	2
CO5	2	2	2	1	1	2	1	-	2	-	2	3
CO6	2	1	1	1	1	1	1	1	1	-	1	2

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course content:

Module 1

Introduction and Overview of Robotic Systems and their Dynamics: (6 Lectures):

Forward and inverse dynamics, Properties of model, Introduction to nonlinear systems and control schemes, case study.

Module 2

System Stability and Types of Stability: (6 Lectures)

Lyapunov stability analysis, Both direct and indirect methods, Lemmas and theorems related to stability analysis, case study.

Module 3

Joint Space and Task Space Control Schemes: (6 Lectures)

Position control, Velocity control, Trajectory control and Force control, case study.

Module 4

Nonlinear Control Schemes: (6 Lectures)

Sliding mode control, Adaptive control, Observer based control, Robust control and Optimal control, case study.

Module 5

Nonlinear Observer Schemes: (6 Lectures)

Design based on acceleration, velocity and position feedback, Numerical simulations, case study.

Text Books

1. R Kelly, D. Santibanez, LP Victor and Julio Antonio, Control of Robot Manipulators in Joint Space, Springer, 2005.

2. A Sabanovic and K Ohnishi, Motion Control Systems, John Wiley & Sons (Asia), 2011

3. Yaduvir Singh and S. Janardhanan, "Modern Control Engineering", Cengage Learning, 2004

Reference Books

1. R M Murray, Z. Li and SS Sastry, A Mathematical Introduction to Robotic Manipulation, CRC Press,1994.

2, J J Craig, Introduction to Robotics: Mechanics and Controll, Prentice Hall, 2004.

3. J J E Slotine and W Li, Applied Nonlinear Control, Prentice Hall, 1991.

4. Sebastian Thrun, Wolfram Burgard, Dieter Fox, Probabilistic Robotics, MIT Press, 2005.

NPTEL web links for Study Material / Course:

https://nptel.ac.in/courses/112101098

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-III	NEE-415	Robotics and Automation	3 (3-0-0)	30	20	-	50	50	100

List of Programme Electives-IV

NEE-417	POWER QUALITY AND FACTS	L T P: 3 0 0	Credits: 3	Type: PEC-IV

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of Power Quality and FACTS. The course includes: Basic Concepts of Power Quality, working principle of devices, application of FACTS.

Prerequisites: Engineering Mathematics, Power Quality parameters, Power Electronics Converters.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Understand the basic concepts of power quality.	K1, K2
CO2	Understand the working principles of devices to improve power quality.	K2, K3
CO3	Understand the characteristics of ac transmission and the effect of shunt and series reactive compensation.	K2, K4
CO4	Understand the working principles of FACTS devices and their operating characteristics	K2, K4, K5
CO5	Understand the various applications of FACTS.	K2, K4, K6

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	-	-	2	-	-	1	-	-	2
CO2	3	2	2	1	2	2	-	-	1	-	1	2
CO3	3	2	1	-	2	2	-	-	1	-	1	-
CO4	2	2	1	-	2	2	-	-	1	-	1	-
CO5	3	2	2	1	3	2	-	-	1	-	1	-
Avg.	2.8	1.8	1.4	.2	1.8	2	-	-	1	-	.8	.8

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course content:

Module 1

Introduction to Power Quality: (6 Lectures)

Definition of Power Quality, Power Quality Issues, Voltage Sags, Swells, Interruptions, Power Quality v/s Equipment Immunity, Electric Power Quality Standards. Common Power Frequency Disturbances, Sub-synchronous resonance, Isolation Transformers, Voltage Regulators, Static Uninterruptible Power Source Systems.

Module 2

Effects of harmonics on Power System devices: (6 Lectures)

Definition of Harmonics, Causes of Voltage and Current Harmonics, Individual and Total Harmonic Distortion, Effect of Harmonics on Power System Devices. Guidelines for Harmonic Voltage and Current Limitation, Harmonic Current Mitigation.

Module 3

Power Quality measuring devices: (6 Lectures)

Power Quality Measurement Devices, Harmonic Analyzers, Transient-Disturbance Analyzers, Oscilloscopes, Data Loggers and Chart Recorders, True RMS Meters, Power Quality Measurements.

Module 4

Overview of FACTS Devices (6 Lectures):

The emergence of Flexible Alternating Current Transmission Systems (FACTS), Types of FACTS controller, Principle, configuration of SVC, STATCOM, TCSC, SSSC.

Module 5

Application of FACTS (6 Lectures):

Application of FACTS devices for power-flow control and stability improvement, Unified Power Flow Controllers (UPFC): Basic operating principles and characteristics, control UPFC installation applications, UPFC model for power flow studies.

Text Books / Reference Books:

1. Hingorani, N.G. and Gyragyi, L., Understanding FACTS :Concepts and Technology of Flexible AC Transmission System, Standard Publishers and Distributors (2005).

2. K.R. Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International Publisher, 2007.

3. A. Ghosh and G. Ledwich, Power Quality Enhancement using Custom Power Devices, Kluwer Academic Publisher, Boston, MA, 2002.

4. Bollen, M.H.J., Power Quality Problems: Voltage Sag and Interruptions, IEEE Press (2007).

Kennedy, B., Power Quality Primer, McGraw Hill (2000).

5. IEEE Standard 519-1992, IEEE recommended practices and requirements for harmonic control in electrical power systems, 1992.

6. G. J. Walkileh, "Power Systems Harmonics", Springer Verlag, New York, 2001.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-IV	NEE-417	Power Quality and Facts	3(3-0-0)	30	20	-	50	50	100

NEE-419	Real Time Simulation Techniques of Power Electronic Converters	L T P: 1 1 2	Credits: 3	Type: PEC-IV

OBJECTIVE:

This course includes the fundamentals of Opal RT Real Time Simulator. The course deals with simulation of various power converters in Real time environment.

Prerequisites: Power Electronics; Advanced Power Electronics, MATLAB Software.

Course Outcomes

On the successful completion of the course, students will be able to

CO1	Understand the basic concepts of real time simulation	K1, K2
CO2	Understand and perform real time simulation of Rectifier	K3, K4
CO3	Understand and perform real time simulation of Chopper	K3, K4:
CO4	Understand and perform real time simulation of Inverter	K3, K4
CO5	Understand and perform real time simulation of Multilevel Inverter	K5, K6:

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	3	-	-	-	-	-	-	1
CO2	3	3	3	2	3	1	-	-	-	-	-	1
CO3	3	3	3	2	3	1	-	-	-	-	-	1
CO4	3	3	3	2	3	1	-	-	-	-	-	1
CO5	3	3	3	2	3	1	-	-	-	-	-	1

Course content:

Module 1

Introduction of OPAL-RT Simulator: (6 Lectures)

Basic concept of Real-Time Simulations, Introduction, and Simulation: Variable Vs Fixed step, How to choose a Time step for an Application, difference between Offline simulation and Real time simulation, RT Lab/Real Time Simulator, Opal-RT Internal architecture.

Module 2

Rectifier Simulation: (6 Lectures)

Simulation of single phase uncontrolled rectifiers in real time environment, Simulation of single phase controlled rectifiers in real time environment, Simulation of three phase uncontrolled rectifiers in real time environment, Simulation of three phase controlled rectifiers in real time environment.

Module 3

Chopper Simulation: (6 Lectures)

Simulation of buck chopper in real time environment, Simulation of boost chopper in real time environment, Simulation of buck-boost chopper in real time environment.

Module 4

Inverter Simulation: (6 Lectures)

Simulation of single-phase voltage source inverter with R and R-L loads in real time environment, Simulation of three-phase VSI Inverter in real time environment, Implementation of three-phase sinusoidal modulation in real time environment.

Module 5

Simulation of Multilevel Inverters: (6 Lectures)

Simulation of NPC Multilevel Inverters in real time environment, Simulation of FC Multilevel Inverters in real time environment, Simulation of CHB Multilevel Inverters in real time environment.

Text Books:

1. OPAL-RT Manuals
2. M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
3. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2007.
4. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.
5. Bose B.K., "Power Electronics and Variable Frequency Drives –Technology and Applications", IEEE Press, Standard Publisher Distributors 2001
6. Dubey G. K., Doradla S. R., Joshi A. and Sinha R. M. K., "Thyristorised Power Controllers", New Age International Private Limited, 2008.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-IV	NEE-419	Real Time Simulation Techniques of Power Electronic Converters	3(1-1-2)	15	20	15	50	50	100

NEE-421	MODELLING AND SIMULATION OF ELECTRICAL MACHINES	L T P: 3 0 0	Credits: 3	Type: PEC-IV

OBJECTIVE:

This course includes the basic concepts of modelling of AC/ DC machine, dynamic modelling and phase transformation, analyze various methodologies in small signal machine modelling, simulation of dynamic modelling of synchronous machines

Prerequisites: Electrical Machines-I, Electrical Machines-II, Advanced Electric Drives.

Course Outcome

On the successful completion of the course, students will be able to

CO1	Understand the basic concepts of modelling of DC Machines	K1, K2, K4
CO2	Understand the dynamic simulation of the speed-controlled DC motor Drive	K1, K4, K5
CO3	Understand and modeling of AC motor model in different reference frame	K1, K4, K5
CO4	Understand modelling and simulation of 1-phase and 3-phase induction motor	K1, K3, K4, K5
CO5	Understand modelling and simulation of synchronous machine	K1, K4, K5

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	-	-	-	-	-	-	1
CO2	3	2	2	1	3	-	-	-	-	-	-	1
CO3	3	3	2	2	3	-	-	-	-	-	-	1
CO4	3	3	2	2	3	1	-	-	-	-	-	1
CO5	3	3	2	2	3	2	-	-	-	-	-	1

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-'

Module 1

Basic Concepts of Modeling: (6 Hours)

DC Machine modelling: Mathematical model of separately excited D.C motor –Steady state analysis - Transient State analysis - Sudden application of Inertia load - Transfer function of Separately excited D.C Motor-Mathematical model of D.C Series motor, Shunt motor-Linearization Techniques for small perturbations.

Module 2

Modeling of DC Motor Drive: (6 Hours)

Principles of DC Motor Speed Control, Four-Quadrant Operation, Phase-Controlled Converters, Control Modeling of the three-Phase Converter, Steady-State Analysis of the Three-Phase Converter-Controlled Motor Drive, Dynamic Simulation of the Speed-Controlled DC Motor Drive, Motor Equations, Speed Feedback, Speed Controller.

Module 3

Reference Frame Theory: (6 Hours)

Reference frame theory, Real time model of a two phase induction machine-Transformation to obtain constant matrices - three phase to two phase transformation - Power equivalence. Dynamic modelling of three phase Induction Machine, Generalized model in arbitrary reference frame.

Module 4

Small Signal Modeling: (6 Hours)

Small signal modeling of three phase induction machine, Small signal equations of induction machine, d-q flux linkage model derivation, control principle of induction machine, Single phase induction motor; Cross field theory of single phase induction machine.

Module 5

Modeling of Synchronous Machine: (6 Hours)

Synchronous machine inductances, voltage equations in the rotor's dq0 reference frame, electromagnetic torque-current in terms of flux linkages, simulation of three phase synchronous machine, modeling of PM synchronous motor.

Text Books:

1. R. Krishnan, "Electric Motor Drives - Modelling, Analysis& control", Pearson Publications, First edition, 2002.
2. P. C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, "Analysis of Electrical Machinery and Drive systems", IEEE Press, Second Edition.

Reference Books:

1. P. S. Bimbra, "Generalized Theory of Electrical Machines" Khanna publications, Fifth edition-1995.
2. Chee Mun Ong –"Dynamic simulation of Electric machinery using MATLAB / Simulink", Prentice Hall of India Publications

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-IV	NEE-421	Modeling and simulation of Electrical machines	3(3-0-0)	30	20	-	50	50	100

NEE-423	INDUSTRIAL CONTROL SYSTEMS	L T P: 3 0 0	Credits: 3	Type: PEC-IV

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of industrial control system. The course includes understanding of measurement, instrumentation and controller design for industrial control system. This course also gives an insight into computer based control systems.

Prerequisites:

Basic Electrical Engineering, Engineering Mathematics, Control Systems, Advanced Control System.

Course Outcomes:

After the successful completion of the course, students will be able to

CO1	Able to understand industrial issues related to the control system	K1, K2
CO2	Have knowledge to control solutions.	K1, K3
CO3	Demonstrate fundamental understanding of optimal control	K4, K5
CO4	Exhibit the knowledge of Digital Computer Based Control Systems	K1, K2, K3, K4
CO5	Exhibitthe knowledge of Microprocessor and Microcontroller Based Control Systems	K1, K2, K3, K4
CO6	Exhibitthe knowledge of Artificial Intelligence	K1, K2, K3, K4

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	-	2	1	-	-	-	-	2
CO2	2	2	3	1	1	2	2	-	1	-	1	3
CO3	2	1	1	-	1	3	1	-	1	1	1	2
CO4	1	2	1	2	1	2	3	-	2	-	1	3
CO5	2	2	2	1	1	3	2	1	2	-	2	2
CO6	2	1	2	1	1	3	1	-	1	-	1	3

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course content:

Module 1

Introduction: (5 Lectures)

Design specifications of second order systems: Derivative error, derivative output, integral error and PID compensations, design considerations for higher order systems, performance indices.

Module 2

Optimal Control: (7 Lectures)

Introduction, formation of optimal control problem, calculus of variations minimization of functions, constrained optimization, Pontryagin's Minimum Maximum Principle, Linear Quadratic Problem-Hamilton Jacobi equation, Riccati equation and its solution.

Module 3

Digital Computer Based Control Systems: (7 Lectures)

Digital Computers: General architecture and brief description of elements, instruction execution, instruction format, and instruction set, addressing modes, programming system, higher level languages, Buses and CPU Timings: Bus size and signals, machine cycle timing diagram, instruction timing, processor timing, Controller design.

Module 4

Microprocessor and Microcontroller Based Control Systems: (6 Lectures)

Evolution of Microprocessor and Microcontroller, Microprocessor and Microcontroller architecture and its operations, memory, inputs-outputs (I/Os), Data transfer schemes interfacing devices, Controller Design.

Module 5

Artificial Intelligence Based Control Systems: (5 Lectures)

Fuzzy Logic, Neural Networks, Genetic Algorithm, AI based Controller Design.

Text Books

1. Uffenbeck, John, Microcomputers and Microprocessors, PHI/ 3rd Edition.

2. Yaduvir Singh & S. Janardhanan, Modern Control Engineering, Cengage Learning.

3. S. Rajsekaran & G.A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications, Prentice Hall of India.

Reference Books

1. Liu and Gibson G.A., "Microcomputer Systems: The 8086/8088 Family" Prentice Hall (India)

2. K. Ogata, "Modern Control Engineering", Prentice Hall of India.

3. B.C. Kuo & Farid Golnaraghi, "Automatic Control System" Wiley India Ltd.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-IV	NEE-423	Industrial Control Systems	3(3-0-0)	30	20	-	50	50	100

List of Programme Electives-V

NEE-402	ELECTRICAL VEHICLES	L T P: 3 1 0	Credits: 4	Type: PEC-V

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of Electrical and Hybrid Vehicles. The course includes understanding of energy and its related issues. This course also gives an insight into other related contemporary issues.

Prerequisites:

Introduction to Electrical Engineering, Electrical Machines, Power Electronics and Drives

Course Outcome

On the successful completion of this course, the students will be able to

CO1	Able to understand need of electric vehicle and hybrid vehicle	K1, K2
CO2	Able to choose a suitable drive scheme	K2, K3
CO3	Demonstrate basic schemes of electric vehicle and hybrid vehicle	K4, K5
CO4	Develop control of DC and Induction Motor drives	K2, K3, K4
CO5	Exhibit the knowledge of energy storage systems	K1, K2

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1	2	2	3	1	1	-	1	2
CO2	2	2	3	2	3	2	3	1	1	-	1	3
CO3	2	2	1	1	2	2	3	1	1	1	1	2
CO4	2	2	3	2	2	2	1	-	2	-	1	3
CO5	2	2	2	1	2	2	2	1	2	-	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Introduction: (8 Lectures):

Introduction to electric vehicle and hybrid vehicle, Conventional Vehicles: Basics of vehicle performance, Vehicle power source characterization, Transmission characteristics.

Module 2

Electric Drive Trains (8 Lectures):

Basic concept, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

Module 3

Hybrid Electric Drive Trains: (8 Lectures):

Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies. Fuel efficiency analysis.

Module 4

Electric Propulsion Unit: (8 Lectures):

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives.

Module 5

Energy Storage: (8 Lectures):

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices.

Text Books

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

Reference Book

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-V	NEE-402	Electrical Vehicles	4(3-1-0)	30	20	-	50	50	100

NEE-404	POWER SYSTEM SECURITY AND ANALYSIS	L T P: 3 1 0	Credits: 4	Type: PEC-V

OBJECTIVE:

The objective of this course is to make students learn in the area of power system security and analysis. The course includes network matrices of power system, short circuit calculations, load flow studies for power systems, security analysis with different cases of contingencies. This course also gives an insight into voltage stability analysis.

Prerequisites: Power System-I. Power System-II

Course Outcomes:

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

CO1	Able to find the bus admittance and bus impedance matrices of the given power system network	K2, K5
CO2	Able to calculate fault currents in each phase.	K3, K5
CO3	Able to estimate contingency analysis .	K4, K5
CO4	Able to find Rank of various contingencies according to their severity.	K2, K4
CO5	Able to estimate closeness to voltage collapse and understand SCADA system.	K2, K4, K3, K5

K1-Remember, K2-Understand, K3-Apply, K4-Analyze, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	1	-	-	-	-	1
CO2	3	2	2	1	2	1	1	-	-	-	1	2
CO3	3	2	2	2	2	2	1	-	-	-	2	2
CO4	2	3	3	3	2	1	2	1	-	-	1	2
CO5	2	3	2	2	2	2	1	-	1	1	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course Content:

Module 1

Power System Network Matrices: (8 Lectures)

Graphs, Incidence matrices, Primitive network, formation of Bus admittance matrix by singular transformations, direct inspection method for determination of YBUS, Formation of Bus impedance matrix - Addition of a branch and Addition of a link. Simple problems.

Module 2

Fault Analysis: (8 Lectures)

Short circuit calculations using Bus impedance matrix, Fault Currents and Fault Voltages, Generalized methods of fault analysis.

Module 3

Security Analysis: (8 Lectures)

Factors affecting security, contingency analysis, Sensitivity factors: Generation shift factors, Line outage distribution factor.

Module 4: State estimation: (8 Lectures)

Sources of errors in measurement, Virtual and pseudo measurement, Observability, System state classification. Tracking state estimation.

Module 5

Voltage Stability: (8 Lectures)

Voltage stability analysis, voltage collapse proximity indices, Introduction to SCADA system.

Text Books:

1. J.J. Grainger &W. D. Stevenson, "Power system analysis", McGraw Hill ,2003

2. A. R. Bergen & Vijay Vittal , "Power System Analysis" ,Pearson , 2000

3. L.P. Singh , "Advanced Power System Analysis and Dynamics", New Age International, 2006

4. G.L. Kusic, "Computer aided power system analysis" ,Prentice Hall India, 1986

5. A.J. Wood, " Power generation, operation and control" , John Wiley, 1994

6. P.M. Anderson, "Faulted power system analysis" , IEEE Press , 1995

7. Stagg & El Abaid, "Computer methods in Power System Analysis", Mc.Graw Hill Book Company.

Reference Books:

1. A. Chakrabarti and Sunita Halder," Power System Analysis Operation and Control", PHI Learning

2. Abhijit Chakrabarti, D. P. Kothari, A.K. Mukhopadhyay and Abhinandan D., "Reactive Power Control and Voltage Stability in Power Transmission Systems", PHI Learning

3. Prabha Kundur , "Power System Stability and Control", Tata McGraw Hill Publication

4. Power System Stability by E W Kimbark, Wiley

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-V	NEE-404	Power System Security and Analysis	4(3-1-0)	30	20	-	50	50	100

NEE-406	ADVANCED ELECTRIC DRIVES	L T P: 3 1 0	Credits: 4	Type: PEC-V

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of Electric Drives. At the end of this course, students will demonstrate the ability to understand the operation of power electronic converters and their control strategies for Induction motor drives, Synchronous motor drives, Permanent magnet motor drives, Switched reluctance motor drives.

Prerequisites: Power Electronics, Electrical Machines, Electrical Drives.

Course Outcome

On the successful completion of this course, the students will be able to

CO1	Understand the operation of power electronic converters for AC drives	K1, K2:
CO2	Understand the operation and control of induction motor drives.	K2, K4:
CO3	Understand the operation and control of synchronous motor drives.	K2, K4:
CO4	Understand the operation and control of permanent magnet motor drives	K3, K4:
CO5	Understand the operation and control of switched reluctance motor drives	K3, K4:

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	-	-	-	-	-	-	-	-
CO2	2	2	2	1	-	-	-	-	-	-	-	-
CO3	3	3	2	2	2	-	-	-	-	-	-	1
CO4	3	3	2	2	2	1	-	-	-	-	-	1
CO5	3	3	3	2	3	2	1	-	-	-	-	1

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-'

Course content:

Module 1

Power Converters for AC Drives (8 Lectures)

PWM control of inverter, selected harmonic elimination, space vector modulation, current control of VSI, three level inverter, Different topologies, SVM for 3 level inverter, PWM converter as line side rectifier, current fed inverters with self-commutated devices. Control of CSI.

Module 2

Induction Motor Drives (8 Lectures)

Different transformations and reference frame theory, modeling of induction machines, voltage fed inverter control-v/f control, vector control, direct torque and flux control (DTC).

Module 3:

Synchronous Motor Drives (8 Lectures)

Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.

Module 4

Permanent Magnet Motor Drives (8 Lectures)

Introduction to various PM motors, BLDC and PMSM drive configuration, comparison, block diagrams, Speed and torque control in BLDC and PMSM.

Module 5

Switched Reluctance Motor Drives (8 Lectures)

Evolution of switched reluctance motors; various topologies for SRM drives, closed loop speed and torque control of SRM.

Text / References:

1. B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education, Asia, 2003.

2. P. C. Krause, O. Wasynczuk and S. D. Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley & Sons, 2013.

3. H. A. Taliyat and S. G. Campbell, "DSP based Electromechanical Motion Control", CRC press, 2003.

4. R. Krishnan, "Permanent Magnet Synchronous and Brushless DC motor Drives", CRC Press, 2009.

Web Reference: Video/Web contents on NPTEL

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-V	NEE-406	Advanced Electric Drives	4(3-1-0)	30	20	-	50	50	100

NEE-408	NEURAL NETWORK AND FUZZY SYSTEMS	L T P: 3 1 0	Credits: 4	Type: PEC-V

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of artificial intelligent techniques and soft computing. The course includes understanding of fuzzy logic and neural networks. This course also gives an insight into process control, development of hybrid algorithms.

Prerequisites: Engineering Mathematics, Control System.

Course Outcomes

On the successful completion of this course, the students will be able to

CO1	Able to know about artificial intelligence	K1, K2
CO2	Able to understand and apply knowledge representation	K2, K3

CO3	Demonstrate fundamental understanding of smart control	K4, K5
CO4	Develop the mathematical model of artificial intelligent techniques	K2, K4
CO5	Exhibit the knowledge of machine intelligence and real time control	K2, K3, K4
CO6	Exhibit the knowledge of the working on state-of-art controllers	K1, K2

K1 - Remember, K2 - Understand, K3 - Apply, K4 - Analyze, K5 - Evaluate, K6 - Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	2	1	-	-	-	-	1
CO2	2	1	2	1	1	2	1	-	1	-	1	2
CO3	2	1	1	-	1	3	1	-	1	-	1	2
CO4	1	2	1	1	1	2	1	1	2	1	1	2
CO5	2	2	2	1	1	2	1	-	2	-	2	3
CO6	2	1	1	1	1	1	1	1	1	-	1	2

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course content:

Module 1

Introduction of Neural Networks (8 Lectures):

Neuron, Nerve structure and synapse, Artificial Neuron and its model, Activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks, Various learning techniques, Auto-associative and Hetero-associative memory, Research paper(s) study.

Module 2

Back Propagation Algorithm (8 Lectures):

Perceptron model, Single layer artificial neural network, Multilayer perception model, Back propagation algorithm, Effect of learning rule co-efficient, Factors affecting back propagation training, Case study(s), Current applications.

Module 3

Introduction to Fuzzy Logic (8 Lectures):

Basic concepts, Fuzzy sets vs Crisp sets, Fuzzy set theory and operations, Properties of fuzzy sets, Research paper(s) study.

Module 4

Fuzzy Membership, Rules (8 Lectures):

Membership functions, interference in fuzzy logic, fuzzy if-then rules, Fuzzy implications and Fuzzy algorithms, Fuzzyfications and Defuzzifications, Fuzzy Controller, Case study(s), Current applications.

Module 5

Fuzzy Neural Networks (8 Lectures):

Type of fuzzy numbers, fuzzy neutron, fuzzy back propagation (BP), architecture, learning in fuzzy BP, inference by fuzzy BP, Case study(s), Current applications.

Text Books:

1. Kumar Satish, "Neural Networks" Tata Mc Graw Hill, 1999
2. Yaduvir Singh & S. Janardhanan, "Modern Control Engineering", Cengage Learning, 2004
3. S. Rajsekaran & G.A. Vijayalakshmi Pai, "Neural Networks,Fuzzy Logic and Genetic Algorithm: Synthesis and Applications" Prentice Hall of India, 1998

Reference Books:

1. Siman Haykin,"Neural Netowrks"Prentice Hall of India, 2003
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India, 2001

NPTEL web links for Study Material / Course:

https://onlinecourses.nptel.ac.in/noc21_ge07

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-V	NEE-408	Neural Network and Fuzzy Systems	4 (3-1-0)	30	20	-	50	50	100

NEE-410	HIGH POWER CONVERTERS	L T P: 3 1 0	Credits: 4	Type: PEC

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of Electric Drives. At the end of this course, students will demonstrate the ability to understand the operation of power electronic converters and their control strategies for Induction motor drives, Synchronous motor drives, Permanent magnet motor drives, Switched reluctance motor drives.

Prerequisites: Power Electronics, Electrical Machines, Electrical Drives.

Course Outcomes:

On the successful completion of this course, the students will be able to

CO1	Understand the Fundamentals of Harmonics	K1, K2
CO2	Understand the Causes of Harmonics	K2, K4:
CO3	Understand the Effect and Elimination/Suppression of Harmonics	K2, K4
CO4	Understand the operation and control of Active Power Filters	K3, K4:
CO5	Understand and analyze Shunt Active Filter	K3, K4:

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	-	-	-	-	-	-	-	-
CO2	2	2	2	1	-	-	-	-	-	-	-	-
CO3	3	3	2	2	2	-	-	-	-	-	-	1
CO4	3	3	2	2	2	1	-	-	-	-	-	1
CO5	3	3	3	2	3	2	1	-	-	-	-	1

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-'

Syllabus

Module 1

Fundamentals of Harmonics: (8 Lectures)

Representation of harmonics, waveform, harmonic power, measures of harmonic distortion; Current and voltage limits of harmonic distortions: IEEE, IEC, EN, NORSOK

Module 2

Causes of Harmonics: (8 Lectures)

2-pulse, 6-pulse and 12-pulse converter configurations, input current waveforms and their harmonic spectrum; Input supply harmonics of AC regulator, integral cycle control, cycloconverter, transformer, rotating machines, ARC furnace, TV and battery charger.

Module 3

Effect and Elimination/Suppression of Harmonics: (8 Lectures)

Effect of harmonics on rotating machines and equipments, High power factor converter, multi-pulse converters using transformer connections (delta, polygon)

Module 4

Active Power Filters: (8 Lectures)

Compensation principle, classification of active filters by objective, system configuration, power circuit and control strategy, Single-phase active filter, principle of operation, expression for compensating current, concept of constant capacitor voltage control; Three-phase active filter: Operation, analysis and modeling.

Module 5

Control of Grid-Connected Modular Multilevel Converters: (8 Lectures)

Control of grid-connected modular multilevel converter, Control of the MMC for High-Voltage DC (HVDC) transmission.

Text Books:

1. Derek A. P., "Power Electronic Converter Harmonics", IEEE Press, 1989.
2. Arrillaga J., Smith B. C., Watson N. R. and Wood A. R., "Power System Harmonic Analysis", 2nd Ed., Wiley India, 2008.
3. Sanjiv Kumar, "Investigation In To The Performance Of Multi-Pulse AC-DC Converters- A Practical Approach to Investigate The Converter Performance against IEEE-519 Standards", Lambert Academic Publishing, AV Akademikerverlag GmbH & Co. KG, under ISBN 978-3-659-24895-5, 2013.

Reference Books:

1. Bin Wu, "High-Power Converters And AC Drives", A John Wiley & Sons, Inc., Publication, IEEE Press, 2006.
2. Sankaran C., "Power Quality", CRC Press, 2001.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC-V	NEE-410	High Power converters	4(3-1-0)	30	20	-	50	50	100

List of Open Electives

OEC-I

NEE-	NON-CONVENTIONAL ENERGY SOURCES	L T P: 2 0 0	Credits: 2	Type: OEC

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of non-conventional energy resources. The course includes understanding of energy generation, conventional and non-conventional resources comparisons, mathematical modeling, performance analyses and applications. This course also gives an insight into contemporary energy issues.

Prerequisites: Introduction to Electrical Engineering, Engineering Mathematics, Engineering Physics

Course Outcome

On the successful completion of this course, the students will be able to

CO1	Able to understand energy, demand and supply issues	K1, K2
CO2	Able to found energy solutions	K2, K3
CO3	Demonstrate fundamental understanding of non-conventional Resources	K4, K5
CO4	Develop the mathematical model of energy systems	K2, K3, K4
CO5	Exhibit the knowledge of MHD, Solar and Wind	K1, K2, K3, K4
CO6	Exhibit the knowledge of Geothermal and OTEC	K1, K2

K1 - Remember, K2 - Understand, K3 - Apply, K4 - Analyze, K5 - Evaluate, K6 - Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	2
CO2	2	2	3	1	1	2	2	-	1	-	1	3
CO3	2	1	1	-	1	3	1	-	1	1	1	2
CO4	1	2	1	2	1	2	1	-	2	-	1	3
CO5	2	2	2	1	1	3	2	1	2	-	2	2
CO6	2	1	2	1	1	3	1	-	1	-	1	3

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course content:

Module 1: Power Situation (3 Lectures):

Power Crisis, Future energy demand

Module 2: MHD generation (4 Lectures):

MHD generation: Working principle, Open and Closed cycles, MHD systems, advantages, Case Study(s)

Module 3: Solar Power and Wind Energy (5 Lectures):

Solar power plant: Solar energy collectors, Photovoltaic cell. Wind Energy: Windmills, Power output. Case Study(s)

Module 4: Geothermal Energy (4 Lectures):

Geothermal Energy: Earth energy, Heat extraction, Case Study(s)

Module 5: Ocean Thermal Energy and Case Studies based on Solar, Wind and Geothermal Power Plants (4 Lectures):

Ocean Thermal Energy: Energy conversion, Tidal energy: Tidal phenomenon, Tidal power Schemes, Case Study(s)

Text Books:

1. Sawhney G. S., "Non-Conventional Energy Resources", Prentice Hall of India, 2006.

2. Khan B. H., Non-Conventional Energy Resources, Mc Graw Hill Education 3rd edition, 2008.

3. Singal R. K., Non-Conventional Energy Resources, S. K. Kataria & Sons, 2009.

Reference Books:

1. Deb Tanmoy, "Electrical Power Generation Conventional and Renewable", Khanna Publisher, 2000.

2. Bansal N. K., Non-Conventional Energy Resources, Vikas Publishing House, 2011.

3. Saeed S. H. and Sharma D. K., Non-Conventional Energy Resources (2nd Edition), S. K. Kataria & Sons, 2009.

NPTEL web links for Study Material / Course: https://archive.nptel.ac.in/courses/121/106/121106014

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
OEC-I	NEE	Non-conventional Energy Sources	2 (2-0-0)	30	20	-	50	50	100

OEC-II

NEE-	POWER PLANT ENGINEERING	L T P: 2 0 0	Credits: 2	Type: OEC-II

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of power stations. The course includes calculations of capital costs, operation costs, various factors, tariffs, power factor corrections and power plant economics. This course also gives an insight into various types of conventional and non-conventional power plants.

Prerequisites: Engineering Mathematics, Introduction to Electrical Engineering

Course Outcome

On the successful completion of this course, the students will be able to

CO1	Able to know about various components of power plants	K1, K2
CO2	Able to calculate capital costs, operation costs, various factors, tariffs, power factor corrections, power Output and power plant economics	K1, K3, K4
CO3	Evaluating various aspects of power plants, sub-stations, power factor corrections and power plant economics	K4, K5
CO4	Understand various aspects of power plant economics and their affects on power plant performance	K2, K4
CO5	Able to do basic mechanical and electrical design Calculations of some devices of power plants	K2, K3
CO6	Able to identify various aspects of non-conventional energy resources	K1, K2

K1 - Remember, K2 - Understand, K3 - Apply, K4 - Analyze, K5 - Evaluate, K6 - Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	3
CO2	3	1	2	1	1	2	1	-	1	-	1	2
CO3	3	1	1	-	1	2	1	-	1	-	2	2
CO4	3	2	1	1	1	2	1	-	2	-	1	3
CO5	3	2	2	1	1	2	1	-	2	-	2	3
CO6	3	1	1	1	1	1	1	-	1	-	1	2

Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course content:

Module 1

Introduction, Thermal Power Plant and Hydro Electric Plants (4 Lectures):

Introduction, Electric energy resources Thermal Power Plant: General layout and operation of plant, Indian perspective, Case Study(s) Hydro Electric Plants: General layout and operation of plant, Indian perspective, Case Study(s).

Module 2

Nuclear Power Plant, Gas Turbine Plant and Diesel Power Plant (3 Lectures):

Nuclear Power Plant: General layout and operation of plant, Indian perspective, Case Study(s) Gas Turbine Plant: General layout and operation of plant, Indian perspective, Case Study(s) Diesel Plants: Diesel plant layout, Components & their functions, Applications

Module 3

Power Plant Economics and Tariffs (4 Lectures):

Power Plant Economics and Tariffs: Cost of electrical energy, Depreciation, Generation cost, Effect of Load factor on unit cost, Fixed and operating cost of different plants, Objectives and forms of Tariff, Case Study(s).

Module 4

Sub-stations Layout and Economic Operation of Power Systems (2 Lectures):

Types of substations, Layout of substation, Case Study(s)

Module 5

Non- Conventional Energy Sources (7 Lectures):

Solar power plant: Solar energy collectors, Photovoltaic cell, Case Study(s)

Wind Energy: Windmills, Power output, Case Study(s)

Text Books:

1. B. R. Gupta,"Generation of Electrical Energy", S. Chand Publication, 2000

2. Soni, Gupta & Bhatnagar, "A text book on Power System Engg.", Dhanpat Rai & Co., 2002

3. P.S.R. Murthy, "Operation and control of Power System" BS Publications, Hyderabad, 1999

Reference Books:

1. W. D. Stevenson, "Elements of Power System Analysis", McGraw Hill, 1994

2. S. L. Uppal, "Electrical Power", Khanna Publishers, 2000

NPTEL web links for Study Material / Course:

https://archive.nptel.ac.in/courses/112/107/112107291

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
OEC-II	NEE	Power Plant Engineering	2(2-0-0)	30	20	-	50	50	100

OEC-III

NEE-	INDUSTRIAL MEASUREMENTS	L T P: 2 0 0	Credits: 2	Type: OEC-III

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of industrial measurements. The course includes understanding of measurement and instrumentation. This course also gives an insight into sensors and various measurement schemes.

Prerequisites: Engineering Mathematics, Engineering Physics, Basic Electrical Engineering.

Course Outcomes

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

CO1	Able to know about industrial measurements	K1, K2
CO2	Able to understand and apply knowledge about electrical transducers	K2, K3, K4
CO3	Demonstrate fundamental understanding of telemetry systems	K2, K3, K4, K5
CO4	Develop Data Acquisition System	K2, K3, K4
CO5	Exhibit the knowledge of Display Devices and Recorders	K2, K3

K1 - Remember, K2 - Understand, K3 - Apply, K4 - Analyze, K5 - Evaluate, K6 - Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	2	1	-	-	-	-	1
CO2	2	1	2	1	1	2	1	-	2	-	1	2
CO3	2	1	1	-	2	3	1	-	1	-	1	2
CO4	2	2	1	1	1	2	1	1	2	1	1	2
CO5	2	2	2	1	1	2	1	-	2	-	2	3
CO6	2	1	1	1	2	1	1	1	2	-	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course content:

Module 1

Measurement 1: (4 Lectures)

Definition, advantages, classification, characteristics, factors affecting the choice of transducers, Strain gauges, Thermocouples, LVDT.

Module 2

Measurement – II: (4 Lectures)

Capacitive, Piezoelectric, Hall Effect transducers, Measurement of Pressure, Temperature and Liquid level.

Module 3

Telemetry: (4 Lectures)

General Telemetry System, Land line & Radio frequency Telemetering system, Transmission Channels and Media.

Module 4

Signal Conditioning and Data Acquisition System: (4 Lectures)

Signal conditioning, Active Filters, Instrumentation amplifiers, Analog Data Acquisition System and Digital Data Acquisition System.

Module 5

Display Devices and Recorders: (4 Lectures)

Display devices, storage oscilloscope, strip chart & X-Y recorders, Digital tape recorders. Recent Developments: Computer aided measurements, smart sensors, smart transmitters.

Text Books / Reference Books

1. A. K. Sawhney, "Advanced Measurements & Instrumentation", Dhanpat Rai & Sons
2. B.C. Nakra & K.Chaudhry, "Instrumentation, Measurement and Analysis", Tata Mc Graw Hill
3. Curtis Johns, "Process Control Instrumentation Technology", Prentice Hall
4. E.O. Decblin, "Measurement System – Application & design", Mc Graw Hill.
5. Rajendra Prasad,"Electronic Measurement and Instrumentation Khanna Publisher.
6. M.M.S. Anand, "Electronic Instruments and Instrumentation Technology" PHI Learning.

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
OEC-III	NEE	Industrial Measurements	2(2-0-0)	30	20	-	50	50	100

Honors (Control System)

NEE-	PROCESS CONTROL AND INSTRUMENTATION	L T P: 3 1 0	Credits: 4	Type: PEC

OBJECTIVE:

This course will provide a good understanding and hold to the students in the area of instrumentation and process control. The course includes understanding of electrical transducers, telemetry, data acquisition systems, data display and recording devices. This course also gives an insight into process control, development of mathematical models, control modes, actuators, and introduction to advanced control systems.

Prerequisites:

Engineering Mathematics, Electrical Measurement and Measuring Instruments, Control Systems.

Course Outcomes

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

CO1	Demonstrate fundamental understanding of process control	K4, K5
CO2	Develop the mathematical model of various chemical processes	K2, K4
CO3	Exhibit the knowledge of different control modes and their application in controlling various processes	K2, K3, K4
CO4	Able to know about electrical transducers and telemetry	K1, K2
CO5	Able to understand and apply data acquisition system, display devices and recorders	K2, K4
CO6	Exhibit the knowledge of the working of electric, hydraulic and pneumatic controllers and actuators	K1, K2

K1 - Remember, K2 - Understand, K3 - Apply, K4 - Analyze, K5 - Evaluate, K6 - Create

Course Articulation Matrix (CO-PO Matrix):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	2
CO2	2	1	2	1	1	2	1	-	1	-	1	2
CO3	2	1	1	-	1	3	1	-	1	-	1	2
CO4	1	2	1	1	1	2	1	-	2	-	1	2
CO5	2	2	2	1	1	2	1	-	2	-	2	2
CO6	2	1	1	1	1	1	1	-	1	-	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) if there is no correlation, put "-"

Course content

Module 1

Process Control (9 Lectures):

Introduction: Classification and definition of process variables.

Mathematical Modeling, Lumped and distributed parameters, Analogies, Thermal, Electrical and chemical systems. Modeling of CSTR, Modeling of heat exchanger. Interacting and non-interacting type of systems. Dead time elements, Research paper (s) study

Module 2

Control Modes (6 Lectures):

Characteristics and comparison of on-off, Proportional (P), Integral (I), Differential (D), PI, PD, PID, Tuning of controllers Ziegler-Nichols, Cohen-Coon methods, Current applications

Module 3

Electrical Transducer and Telemetry (9 Lectures):

Definition, advantages, classification, characteristics, factors affecting the choice of transducers, Piezoelectric, Hall effect and opto-electronic transducers. General telemetry system, land line & radio frequency telemetering system, transmission channels and media, receiver & transmitter, Current applications

Module 4

Data Acquisition System, Display Devices and Recorders (6 Lectures):

Analog and Digital Data Acquisition Systems and Recent developments, Display devices, Storage Oscilloscope, Spectrum Analyzer, Current applications

Module 5

Actuators (10 Lectures):

Hydraulic, Pneumatic actuators, Solenoid, E-P converters, Control valves, Types, Functions, Quick opening, Linear and equal percentage valve, Valves types, principles, application and selection, Recent Developments. Introduction to advanced control schemes like Cascade, Feed forward, Ratio, Selective, Override, Split Range and Auctioneering Control, Current applications

Text Books

1. A. K. Sawhney, "Advanced Measurements & Instrumentation", Dhanpat Rai & Sons (2001)

2. Yaduvir Singh & S. Janardhanan, "Modern Control Engineering", Cengage Learning (2007)

3. B.C. Nakra & K.Chaudhry, "Instrumentation, Measurement and Analysis", Tata Mc Graw Hill 2nd Edition (1998).

4. Johnson C. D., Process Control Instrumentation Technology, Prentice Hall of India Private Limited (1992)

5. Stephanopoulos G., Chemical Process Control, Prentice Hall of India Private Limited (1983)

6. Harriot P., Process Control, Tata McGraw Hill (1982)

Reference Books

1. E.O. Decblin, "Measurement System – Application & design". Mc Graw Hill (1996)

2. W.D. Cooper and A.P. Beltried, "Electronics Instrumentation and Measurement Techniques" Prentice Hall International (2000)

3. Liptak B.G., Instrument Engineers Handbook, Butterworth, Heinemann (2002)

4. Seborg D.E. and Edgar T., Process Dynamics and Control, John Wiley and Sons (1989)

NPTEL web links for Study Material / Course:

https://nptel.ac.in/courses/103103037

Evaluation Scheme:

Course Type	Subject Code	Course title	Credits (L T P)	Sessional Marks				ESM	Total Marks
				MSE	TA	Lab	Total		
PEC	NEE-	Process Control and Instrumentation	3 (3-1-0)	30	20	-	50	50	100

NEE ……	ADVANCED DIGITAL CONTROL	3L:1T:0P	Credit: 04	Course Type: PCC

Objectives:

The objective of this course is to provide the knowledge about advanced digital signals, z-transform, stability analysis, state space analysis, and design simulation.

Course Outcomes (COs):

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

CO1	Solve problems related to State space representation of discrete time systems and determine the stability of discrete time systems using different techniques like Jury stability, bilinear transformation and Lyapunov.	K1, K2
CO2	Solve problems related to design of discrete time control system by conventional methods.	K3, K4, K6
CO3	Apply knowledge in designing Controllers and Observers	K1, K2, K3, K4
CO4	Explain the concepts of Kalman filter, Regulators and adaptive control.	K1, K3, K5
CO5	Develop adequate knowledge in the digital simulation concepts and expose to the custom designed chips.	K2, K5, K6

K1: Remember, K2: Understand, K3: Apply, K4: Analyze, K5: Evaluate, K6: Create

CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	-	-	-		-	-	1
CO2	3	3	2	2	1	-	-	-	-	-	-	1
CO3	3	2	3	3	3	2	2	2	-	1	-	1

CO4	2	2	2	2	2	-	-	-	1	1	1	1
CO5	3	2	2	3	3	2	1	-	2	2	1	2

1: Slight; 2: Moderate (medium); 3: Substantial (High); for no correlation '-' put

Course content:

Module 1

State Space Analysis: (8 Lectures)

Introduction to Z-Transforms and inverse Z-Transforms, State space representation of discrete time systems, pulse transfer function matrix, solving discrete time state space equations, state transition matrix and its properties, methods for computation of state transition matrix, discretization of continuous time state-space equations.

Stability Analysis: Stability analysis of closed loop systems in the Z-plane, Jury stability criterion test-Stability analysis by use of the bilinear transformation and Routh stability criterion. Stability analysis using Lyapunov theorems.

Module 2

Design of Discrete Time Control System by Conventional Methods: (8 Lectures)

Design of digital control systems based on Root locus techniques-Design of digital control based on the frequency response methods-Bilinear transformation and design procedure in the w-plane, lead, lag and Lead-lag compensators. Design of digital control through dead beat response methods.

Module 3 (8 Lectures)

State Feedback Controllers and Observers: Concept of controllability and observability-Design of state feedback controller through pole placement-Necessary and sufficient conditions, Ackerman's formula, State observers-Full order and Reduced Order observer.

Module 4:

Linear Quadratic Regulators: (8 Lectures)

Min / Max principle, Linear Quadratic Regulators, Kalman Filters, Introduction to State Estimation through Kalman filters, Introduction to adaptive controls.

Module 5:

Digital Simulation: (8 Lectures)

Introduction, Digital Simulation- Digital Modeling with Sample and Hold Devices, State Variable Formulation, Numerical Integration, Rectangular Integration, Frequency Domain Characteristics-Frequency Warping, Frequency Pre-warping.

Text Books:

1. B.C. Kuo, Digital Control Systems, Oxford University Press, 2nd edition 2012.

2. Madan Gopal, Digital control and State variable Methods, McGraw Hill Education, 4th edition 2017.
3. K. Ogata, Discrete-time Control Systems, Pearson Education India, 2nd edition 2015.
4. Ghosh Arun K., Introduction to Linear and Digital Control Systems, PHI learning private ltd., 2017.

Reference Books:

1. Robert N. Clark, Control System Dynamics, Cambridge University Press, 1996.
2. V.I. George, Digital Control Systems, Cengage press, 1st edition 2012.
3. Gene F. Franklin, Digital Control Dynamic Systems, Addison-Wesley, 2nd edition 1980.
4. Hugh F. Vanlandingham, Introduction to Digital Control System, Macmillan USA, 1985.

EEE ..	SCADA and Distributed Control Systems	3L:1T:0P	Credit: 04	Course Type: PCC

Course Objectives:

The objective of this course is to provide the basic knowledge on SCADA and DCS.

Course Outcomes (COs): After successful completion of this course, the students will be able to:

CO1	Understand the basics of SCADA, PLC and interfacing between SCADA and PLC	K1, K2, K5
CO2	Understand the components of SCADA and its architecture.	K2, K4, K6
CO3	Remember and apply various communications for SCADA	K2, K3, K4
CO4	Learn the architecture of DCS	K1, K3, K5
CO5	Understand and apply the various interfaces in DCS	K2, K3, K6

K1: Remember, K2: Understand, K3: Apply, K4: Analyze, K5: Evaluate, K6: Create

CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	-	-	-		-	-	1
CO2	2	3	2	2	1	-	-	-	1	-	-	-
CO3	3	3	3	3	3	2	2	1	-	1	-	1
CO4	3	2	1	2	2	-	1	-	1	1	1	-
CO5	3	3	2	3	3	2	1	-	2	2	1	1

1: Slight; 2: Moderate (medium); 3: Substantial (High); for no correlation '-' put

Course content:

Module-1: (8 Lectures)

Introduction to SCADA and PLC: Data acquisition system, evaluation of SCADA, communication technologies, monitoring and supervisory functions. PLC: Block diagram, programming languages, Ladder diagram, Functional Block diagram, Applications, Interfacing of PLC with SCADA.

Module-2

SCADA system components & Architecture: (8 Lectures)

Schemes. Remote Terminal Unit, Intelligent Electronic Devices, Communication Network, SCADA server. Various SCADA Architectures, advantages and disadvantages of each system, single unified standard architecture IEC 61850 SCADA / HMI Systems.

Module 3

SCADA Communication: (8 Lectures)

Various industrial communication technologies- wired and wireless methods and fiber optics, open standard communication protocols. Application examples of SCADA.

Module 4:

Distributed Control System: (8 Lectures)

Various Architectures – Comparison – Local control unit – Process interfacing issues – Communication facilities.

Module 5:

Interfaces In DCS: (8 Lectures)

Low level and high level operator interfaces – Displays - Engineering interfaces – Low level and high level engineering interfaces – Factors to be considered in selecting DCS.

Text Books:

1. Rajesh Mehra and Vikrant Vij, PLC and SCADA, Theory and Practices, Laxmi Publication Pvt. Ltd, 2019.
2. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications, USA, 2004
3. Dieter K. Hammer, Lonnie R. Welch, Dieter K. Hammer, Engineering of Distributed Control Systems, Nova Science Publishers, USA, 1st Edition, 2001
4. Bisht T.K., SCADA and Energy Management System, S.K. Kataria & Sons, 2013.

Reference Books:

1. William T. Shaw, Cybersecurity for SCADA systems, Penn Well Books, 2006
2. David Bailey, Edwin Wright, Practical SCADA for industry, Newnes, 2003
3. Dobrivoje PoPovic, Distributed Computer Control Systems in Industrial Automation, CRC Press, 1990
4. G. Jamkar, Industrial Automation Using PLC SCADA & DCS, Global Education Limited, 2018